Risk Assessment of *Sus scrofa* – wild boar/feral pig/hybrid

Name of Organism:	*Sus scrofa* Linnaeus, 1758 – Wild Boar/Feral Pig/Hybrid
Objective:	Assess the risks associated with this species in Ireland
Version:	Final 23/09/2014
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Expert reviewer	Ruth Carden

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About the risk assessment

This risk assessment is based on the **N**on-native species **AP**plication based **R**isk **A**nalysis (NAPRA) tool (version 2.66). NAPRA is a computer based tool for undertaking risk assessment of any non-native species. It was developed by the European and Mediterranean Plant Protection Organisation (EPPO) and adapted for Ireland and Northern Ireland by Invasive Species Ireland. It is based on the Computer Aided Pest Risk Analysis (CAPRA) software package which is a similar tool used by EPPO for risk assessment.

Notes: Confidence is rated as low, medium, high or very high.
Likelihood is rated as very unlikely, unlikely, moderately likely, likely or very likely.
The percentage categories are 0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%.
N/A = not applicable.

This is a joint project by Inland Fisheries Ireland and the National Biodiversity Data Centre to inform risk assessments of non-native species for the European Communities (Birds and Natural Habitats) Regulations 2011. It is supported by the National Parks and Wildlife Service.

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Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
1	What is the reason for performing the risk assessment?	-	A risk assessment is required as this species is listed as a "Non-native species subject to restrictions under Regulations 49 and 50" in the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011, SI 477/2011.
2	Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	YES	*Sus scrofa* Linnaeus, 1758 – wild boar Taxonomy: Kingdom: Animalia Phylum: Chordata Subphylum: Class: Mammalia Order: Cetartiodactyla Family: Suidae Subfamily: Genus: Sus Species: scrofa ***Sus scrofa* Linnaeus, 1758 – wild boar. According to the ICZN (1995), *Sus scrofa* Linnaeus, 1758 refers to both the wild forms and domestic pigs. Herein, where *Sus scrofa* is referred to, it will be taken to infer both non-genetically pure wild and domestic forms of pig including their hybrids. It is important to note that this risk assessment of non-genetically pure wild boar (*Sus scrofa*) also encompasses feral pigs (*Sus domesticus*) and hybrids as relative literature of the *Sus* sp. in the wild are recorded as one group in terms of records, behaviour, origins and risks (CABI, 2014; Ferdia Marnell, per. comm., 6th February 2014).** *Sus scrofa* Synonyms: *Sus andamanensis* Blyth, 1858; *Sus aruensis* Rosenberg, 1878; *Sus babi* Miller, 1906; *Sus ceramensis* Rosenberg, 1878; *Sus enganus* Lyon, 1916; *Sus floresianus* Jentink, 1905; *Sus goramensis* De Beaux, 1924; *Sus natunensis* Miller, 1901; *Sus nicobaricus* Miller, 1902; *Sus niger* Finsch, 1886; *Sus papuensis* Lesson & Garnot, 1826; *Sus ternatensis* Rolleston, 1877; *Sus tuancus* Lyon, 1916 (Oliver and Leus, 2008). Common name *Sus scrofa* (English): wild boar, Eurasian wild pig, Ryukyu Islands wild pig, feral hog, razor back, wild hog, wild pig (CABI, 2014; Oliver and Leus, 2008). *Sus scrofa*, in origin a wild boar, is a single taxonomic entity. Wild boar are the direct ancestor to the domestic pig, with which it shares a close genetic affinity and can hybridise with (Larson *et al.* 2007; Scandura *et al.* 2011). Wild boar (*Sus scrofa*) and domestic pigs (*Sus domesticus*) can

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			interbreed and produce fertile hybrids. Hybrids may be morphologically similar (depending on the type of domesticated breed used and the hybrid generation being studied) to wild boar (Lui, 2000). Hybrids can successfully breed with wild boar and domestic pigs or with other hybrids (Lui, 2000; Grossi *et al*., 2006). Domestic pigs can also establish feral populations in the wild i.e. feral pigs. Animals descended from wild boar, domestic pigs, or a combination of the two, are present in many parts of the world (CABI, 2014).
3	If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	YES	
4	Describe the organism.	-	Goulding *et al*. (2008) describes *S. scrofa* as a "powerfully built animal with body weight carried forwards on strong shoulders, tapering down to small rump (shoulder height c.700 mm). Head large with a long narrow snout, small ears held erect. Course coat has brindled appearance, with a mane of bristles from the neck down to middle of back and thick brown underlying pelage. Tail straight with long hairs, tassled at tip. Males larger than females and only males grow tusks, when aged 2 years and older. Piglets have characteristic coat of longitudinal brown and cream stripes. Skull distinctive, continuous tooth row with bunodont molars and large canines. Signs distinctive; side toes almost as large as central toes (other artiodactyls have reduced side toes that only show on soft ground), so tracks routinely 4-toed. Snuffling creates extensive disturbed soil and vegetation. Wallows also evident". Generally, hybrids have the typical appearance of wild boar (Booth, 1988) although there is a great amount variability. It is important to note that these morphological descriptors are broad and general since there are specific environmental and geographic differences based on quality of forage available and climate. For example, some wild *Sus scrofa* are larger or smaller in different parts of the world due to local adaptations to their environment.
5	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	YES	In Ireland, a preliminary risk assessment was previously carried out. This was a prioritisation risk assessment as part of the Risk Analysis and Prioritisation for Invasive and Non-native Species in Ireland and Northern Ireland (ISI, 2012). It designated *Sus scrofa* as a "high risk" invasive species.

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6	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?	PARTIAL	Only a preliminary risk assessment was previously conducted in Ireland (refer to Question 5)
7	Where is the organism native?		Wild boar is native to Eurasia and North Africa (Barrios-Garcia and Ballari, 2012): Afghanistan; Albania; Algeria; Andorra; Armenia (Armenia); Austria; Azerbaijan; Bangladesh; Belarus; Belgium; Bhutan; Bosnia and Herzegovina; Bulgaria; Cambodia; China; Croatia; Cyprus; Czech Republic; Estonia; Finland; France; Georgia; Germany; Greece; Hong Kong; Hungary; India; Indonesia (Bali, Irian Jaya, Jawa, Lesser Sunda Is., Sumatera); Iran, Islamic Republic of; Iraq; Israel; Italy (Sardegna, Sicilia - Introduced); Japan; Jordan; Kazakhstan; Korea, Democratic People's Republic of; Korea, Republic of; Kyrgyzstan; Lao People's Democratic Republic; Latvia; Lebanon; Liechtenstein; Lithuania; Luxembourg; Macedonia, the former Yugoslav Republic of; Malaysia; Moldova; Monaco; Mongolia; Montenegro; Morocco; Myanmar; Nepal; Netherlands; Pakistan; Palestinian Territory, Occupied; Poland; Portugal; Romania; Russian Federation; San Marino; Serbia (Serbia); Slovakia; Slovenia; Spain; Sri Lanka; Switzerland; Syrian Arab Republic; Taiwan, Province of China; Tajikistan; Thailand; Tunisia; Turkey; Turkmenistan; Ukraine; Uzbekistan; and Vietnam (Figure 1; Oliver and Leus, 2008). Oliver and Leus (2008) detail the species as reintroduced to Sweden and the United Kingdom (Figure 1), where they have escaped from farms (Wilson, 2005; Truvé and Lemel, 2003). They are regionally extinct in Denmark; Egypt; Libya; and Norway (Oliver and Leus, 2008). Although, wild boar has long been thought as one of Ireland's 'native' animal species, no bones of wild boar have been identified in the fossil records, to date, from the island of Ireland before humans first arrived about 9,600 years ago (Carden, 2012). They are first recorded in Ireland during the Mesolithic period (Woodman *et al*., 1997) and evidence strongly indicates that early human settlers of this period introduced wild boar onto the island (Carden, 2012). From this time onwards they may have been present in Ireland until the twelfth century (Murray and McCormick, 2011). But we do not know the exact timing of the establishment or re-introduction(s) of wild boar or even domesticated pig populations onto the island (Carden, 2012). The history and uncovering a definitive answer as to whether the species is native is complicated by difficulties associated with differentiating between wild boar and domesticated pig (domesticated pigs are descendants of wild boar) in the archaeological records (Rowley-Conwy *et al*., 2011). Today, there are no free-living descendents of the early populations of wild boar on the island of Ireland occurring in the wild (Carden, 2012)

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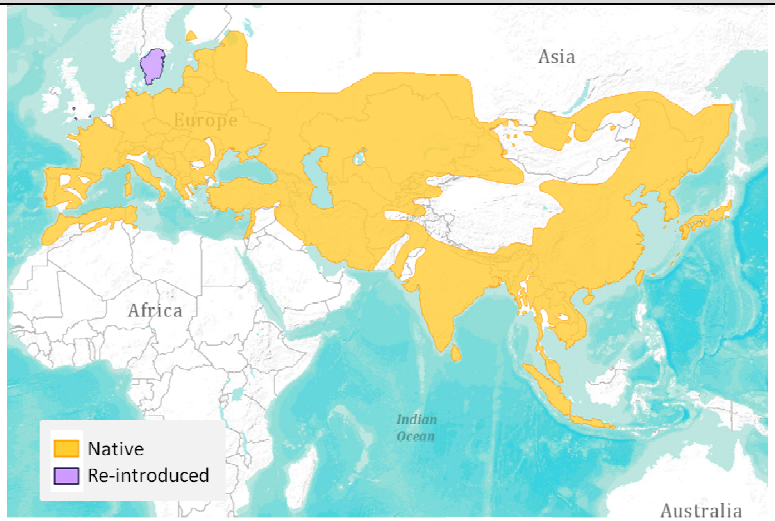
			As is the case in Britain in relation to wild boar, much of the debate in Ireland has centred on possible restoration of this assumed native species (Frantz *et al*., 2012; McDevitt *et al*., 2013). If native status is assumed, it is therefore clear that if wild boar are to remain in the wild in Ireland, or if a re-introduction programme is to be considered, then these animals should be genetically pure wild boar (Frantz *et al*., 2012; Oliver and Leus, 2008). Frantz *et al*. (2012) found that the 'wild boar' in the Forest of Dean, in western England, were a genetic mixture of wild boar and domestic pig and did not fit the criterion of being a restored naive species. Similarly McDevitt *et al*.'s (2013), examination of the genetic purity of 15 of the recorded 'wild boar' in Ireland, found that only three individuals could be classified as hybrids, with all other individuals genetically classified as domestic pig (refer to Question 9). Within the context of Ireland, genetically pure wild boar may be considered as an early introduction via anthropogenic mediated actions during the Mesolithic archaeological period. Other early introductions from the Neolithic period (deliberate and/or accidental) of other mammals such as red deer, pygmy shrew and the badger have been considered and some are still currently thought of as a 'native' species, even given recent research which indicates otherwise or do not provide concrete proof of native status (Frantz *et al*., 2014; Carden *et al*., 2012; McDevitt *et al*.2011). Recent and continuing research and discussions between governmental bodies and NGOs has contributed to the ongoing controversial debate as to whether wild boar (genetically pure) should be classified as an invasive species within Ireland. Further research and discussions are obviously required with regards to this classification and separation between genetically pure wild boar and non-genetically pure wild boar and feral and domestic pig hybrids.

Stage 1 - Organism Information

The aim of this section is to gather basic information about the organism.

N	QUESTION	RESPONSE	COMMENT
			 **Figure 1.** Native and re-introduced range of wild boar (*Sus scrofa*; modified from Oliver and Leus, 2008).
8	What is the current global distribution of the organism (excluding Ireland)? (map optional)		Wild boar are one of the most widely distributed mammals in the world; present on all continents except Antarctica (Barrios-Garcia and Ballari, 2012). Including the species native range (refer to Question 7), they have a current introduced range in Antigua and Barbuda; Argentina; Australia; Brazil; Colombia; Cuba; Dominican Republic; Ecuador (Galápagos); Fiji; Haiti; Jamaica; New Zealand; Papua New Guinea; South Africa; Sudan; United States (Arizona, Florida, Georgia (not Georgia Eurasia where it is native), Hawaiian Is., Kentucky, Mississippi, New Mexico, North Carolina, Tennessee, Texas, Virginia, West Virginia); Virgin Islands, U.S. (Oliver and Leus, 2008).
9	What is the current distribution of the organism in Ireland? (map optional)		'Wild boar' were first officially recorded in the wild in Ireland in April 2009 (ISI, 2014; McDevitt et al., 2013). There are currently 27 verified recorded sightings of the animal on the island comprising of approximately 76 individuals, 9 of the records have been recorded in county Wexford (Figure 2; National Biodiversity Data Centre, 2014a). McDevitt et al. (2013) examined the genetic purity of 15 of the animals recorded between 2009

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			and 2012 using 14 microsatellites and mitochondrial DNA (mtDNA). These were compared to European wild boar, domestic pig breeds, and a hybrid population of 'wild boar' from England (McDevitt *et al*., 2013). Microsatellite analysis revealed that almost all the Irish individuals belonged to the domestic pig genetic cluster, with only three individuals being classified as hybrids (McDevitt *et al*., 2013). All but two individuals carried Asian mtDNA haplotypes, indicating a domestic pig origin (McDevitt *et al*., 2013). It is clear from this study that the individuals currently found in Ireland are not pure wild boars (McDevitt *et al*., 2013). The species has been designated as an invasive species in Ireland (refer to Question 10), which is seen as controversial by some because of uncertainties about the historic status of the species in Ireland (McDevitt *et al*., 2013). Regardless of whether the species was at one time native to Ireland or an early introduction, the current population found on the island are not genetically pure wild boar and are majority are best described as feral (domestic) pigs and a few may be hybrids. Restoration of a wild species formerly present on a landmass must be of genetically pure lineages, in accordance with the IUCN guidelines.

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			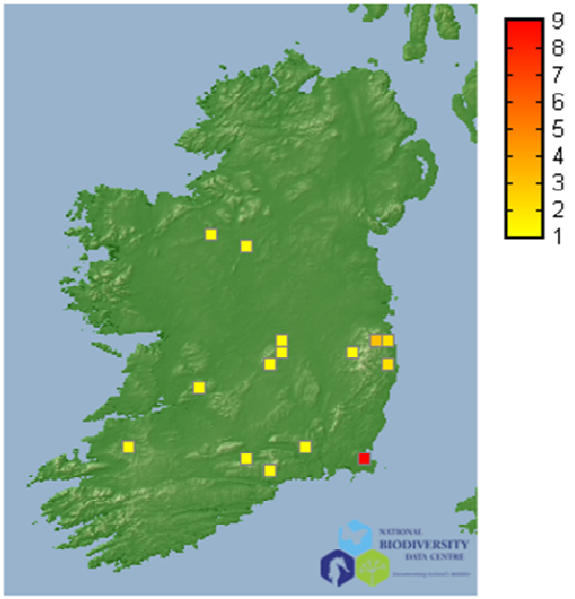 **Figure 2.** Map showing most of the verified records for *Sus scrofa* (wild boar/feral pigs/hybrids) per 10km^2 in Ireland. Colour scale bar slows density of records per 10km (National Biodiversity Data Centre, 2014a).
10	Is the organism known to be invasive anywhere in the world?	YES	The World Conservation Union's Invasive Species Specialist Group lists feral pigs as among "100 of the world's worst invasive alien species" and recognises them as potentially major drivers of extinction and ecosystem change (CABI, 2014; GISD, 2010; ISI, 2014). Because of concerns about further releases, disease transmission and unspecified ecological risks, non-genetically pure wild boar have been classified as an invasive species in Ireland (ISI, 2014; McDevitt *et al.*, 2013; National Biodiversity Data Centre, 2014b).

Stage 2 - Detailed assessment: Section A - Entry

This section evaluates the probability of entry of an organism into Ireland. For organisms which are already present, only complete the entry section for currently active pathways of entry and potential future pathways. The entry section need not be completed for pathways which have allowed an organism to enter in the past but are no longer active.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.01	How many active/future pathways are relevant to the potential entry of this organism (n/a, very few, few, moderate number, many or very many)?	FEW	HIGH	There are very few active pathways relevant to the entry of wild boar.
1.02	List significant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.	1. Deliberate introduction	HIGH	It is implausible that the species would enter Ireland naturally. Therefore, the only relevant active pathway to the potential entry of the species is one of deliberate introduction. Wild boar are one of the oldest recorded intentional mammal introductions by humans, as early explorers released them for bush meat throughout the world (Long 2003). However, more recent introductions are most likely motivated by commercial farming and hunting (Long, 2003; Wilson, 2005). Deliberate introduction of the species is likely to result in illegal intentional release into the wild and/or unintentional escapees from captive collections.

Pathway 1 – Deliberate introduction/translocation/release

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)?	INTENTIONAL	VERY HIGH	As there is no natural pathway for this species to enter Ireland or Northern Ireland, any entry has to be intentional i.e. introduced by man. It is likely that introductions would be for farming and hunting.
1.04	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?	MODERATELY LIKELY	LOW	There is no reliable data that exists to allow a reasonable assessment to be made of the number of animals that may, or may not, be brought into Ireland.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	LIKELY	HIGH	It is likely that this species can enter Ireland without the knowledge of the competent authorities. This is substantiated by the records of animals recorded in Ireland that indicate successful introductions have taken place without the knowledge of the competent authorities.

Pathway 1 – Deliberate introduction/translocation/release				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.06	How likely is the organism to survive during passage along the pathway?	LIKELY	MEDIUM	Likely for the species nutrimental and housing requirements to be catered for by the importer, especially when the likely enterprise is farming or hunting.
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	MODERATELY LIKELY	LOW	Establishment success in a new area would be initially dependent on the introduction of one sexually mature animal of each sex or a pregnant sow, subsequently giving birth to a litter of mixed sexed piglets to a suitable habitat during the breeding season. Inbreeding depression may be a factor, but persons unknown releasing such animals would not necessarily be aware of this. In temperate regions breeding is confined to the spring (Masterson, 2007). It is moderately likely for the species to arrive during this period.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	LIKELY	HIGH	The typically favoured wild habitat are moist forests and shrublands but are highly adapted to a variety of environments including agricultural areas, coastland, range/grasslands, riparian zones, ruderal/disturbed areas, urban areas and wetlands (Goulding et a., 2008; ISI, 2014). The only unsuitable habitat is that where snow fall is significant, which affects mobility and forage availability i.e. increase natural mortality. The species is likely to be introduced to and or encounter such suitable habitat within the Irish landscape (CORINE, 2006; Fossitt, 2000).
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	LIKELY	HIGH	The likelihood is high following confirmed records of the species in Ireland (National Biodiversity Data Centre, 2014a). There are Internet advertisements for the sale of wild boar in Ireland, see, for example, http://www.donedeal.ie/find/all/for-sale/Ireland/WILD%20BOAR. As no licences for the introduction of the species have been granted, these animals have been illegally imported into the country (ISI, 2011).
1.10	Do other pathways need to be considered?	NO	MEDIUM	

Overall likelihood				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.11	Estimate the overall likelihood of entry into Ireland based on all pathways (comment on the key issues that lead to this conclusion).	VERY LIKELY	HIGH	The likelihood of entry into Ireland is high as introductions have already taken place.

Stage 2 - Detailed assessment: Section B – Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.01	Is the organism well established in Ireland (if there is any uncertainty answer 'unsure')	UNSURE	MEDIUM	A paper by McDevitt *et al*. (2013) sheds light on the genetic make-up of 15 pigs recorded in the wild in Ireland. Of the pigs studied none are pure wild boars and are instead feral pigs and hybrids, with only a few confirmed individuals of the latter. With 15 known recordings of feral pigs/hybrids and a further 12 recordings of unknown *Sus* sp. in the wild it would not currently be considered correct to describe this wild *Sus* population as well established.
2.02	How likely is it that the organism will be able to establish in Ireland based on the similarity between local climatic conditions and the organism's current global distribution?	VERY LIKELY	VERY HIGH	Wild boar are one of the most widely distributed mammals in the world; present on all continents except Antarctica (Barrios-Garcia and Ballari, 2012). In its domesticated form as the common domestic pig, it has been taken to and established almost everywhere that humans live (CABI, 2014). They occur from temperate climates to the tropics and their activity patterns are tied to the temperature regimes of the various climates in which they are found (Masterson, 2007).The species, therefore, acclimatises readily to climatic conditions ranging from temperate, subtropical to tropical. This range includes climatic conditions comparable with Ireland; a temperate oceanic climate which is mild, moist and changeable (Keane and Collins, 2004). They may be limited by maximum winter snowfall and severe temperature changes, as deep snow decreases their ability to travel and find food, with low temperatures causing discomfort (CABI, 2014). Conversely, they are prone to sunstroke in unusually warm temperatures, and have developed the technique of wallowing in mud or water to maintain a comfortable temperature in hotter climates, this practice also protects against sunburn and insect bites (CABI, 2014; refer to Question 2.12 for further details regarding adaptability). In dry and hot climates, they will only become established if water supplies are adequate to allow survival (Gingerich, 1994). Establishment of the species in Ireland is unlikely to be limited by climate conditions as described above; a country where there is abundant rainfall and a lack of temperature extremes (Keane and Collins, 2004).

Stage 2 - Detailed assessment: Section B – Establishment

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.03	How likely is it that the organism will be able to establish in Ireland based on the similarity between other local abiotic conditions and the organism's current global distribution?	LIKELY	HIGH	The wide native distribution of wild boar, in Eurasia and North Africa, suggests they are pre-adapted to a wide range of environmental conditions when (re)introduced to new ranges (Baskin and Danell, 2003).
2.04	How likely is the organism to encounter habitats necessary for the survival, development and multiplication of the organism in Ireland?	LIKELY	HIGH	If introduced to Ireland, introductions are likely to take place in habitats suitable for survival, development and multiplication of the organism. The typically favoured wild habitat are moist forests and shrublands but are adapted to a variety of environments including agricultural areas, coastland, range/grasslands, riparian zones, ruderal/disturbed areas, urban areas and wetlands (Goulding *et al*., 2008; ISI, 2014). The species is also likely to encounter such suitable habitats within the Irish landscape (CORINE, 2006; Fossitt, 2000).
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?	VERY LIKELY	MEDIUM	They may compete with farm livestock by consuming or damaging pasture (CABI, 2014). They may also compete with wild deer on wild resources within woodlands/forests.
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Ireland?	VERY LIKELY	HIGH	Non-human predation of wild boar is limited in its native and introduced range because of low predator abundances, natural predator population declines, or intentional removal of predators by humans (Tolleson *et al*., 1995). Goulding *et al*. (2008), describes the species as almost immune to predation, except for humans and wolves (extinct in Ireland). Dogs may act as predators also; with known pack instinct and a capacity to kill, for example, sheep/lambs.
2.07	How likely is it that establishment will occur despite existing management practices?	LIKELY	MEDIUM	In Ireland wild boar is a regulated species (European Communities (Birds and Natural Habitats) Regulations 2011, SI 477/2011). In November 2011, a Policy Position Statement (PPS) was prepared by Invasive Species Ireland on behalf of the Invasive Species Ireland Steering Group (ISI, 2014). This statement summarises the policy position surrounding the importing, keeping, releasing and the escape of wild boar and their hybrids in Ireland and Northern Ireland. A *Sus scrofa* Invasive Species Action Plan was also published in November 2011. Both of these documents specifically address practical management guidelines for the control or eradication of the animal. At present there are no known

Stage 2 - Detailed assessment: Section B – Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				management practices geared towards this species. From the National Invasive Species Database (NBDC, 2014a) we know that 59 animals have been removed from the wild either by live capture or shooting.
2.08	How likely is it that management practices in Ireland will facilitate the establishment of the organism?	LIKELY	MEDIUM	Expansion of agriculture has promoted the establishment and spread of wild boar populations in nearly every region where they have been introduced (Barrios-Garcia and Ballari, 2012). The recent expansion in feral pig distribution in Australia has been attributed to the increase in suitable habitats, in particular, an increase in water availability from farm dams and development of forest industries (Spencer and Hampton, 2005). Similar patterns may occur within Ireland in relation to increased forestry cover and intensification of agriculture if populations established.
2.09	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Ireland?	LIKELY	MEDIUM	Once populations are established, wild pigs have proven to be extremely difficult to control, and close to impossible to eradicate (Ditchoff *et al.*, 2012).
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	VERY LIKELY	MEDIUM	Part of the success and impact of wild boar introductions is related to the biology of the species (Barrios-Garcia and Ballari, 2012). The species is fecund and reproduce vigorously (Taylor *et al.*, 1998). Also, wild boar have a highly variable diet, feeding opportunistically on many plants and animals, which can vary greatly by geographic location and season (Baubet *et al.*, 2004).
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?	VERY LIKELY	MEDIUM	*Sus scrofa* is a fast runner and a good swimmer. It seldom wanders beyond an area of 26 km² if food is abundant, but may extend its range to up to 130 km² when forage is poor (CABI, 2014). In Australia, feral pigs have been recorded moving 20 km in 48 h when exposed to food shortage (Auld and Tisdell 1986).
2.12	How likely is it that the organism's adaptability will facilitate its establishment?	VERY LIKELY	MEDIUM	The wide native distribution of wild boar in Eurasia and North Africa, suggests they are pre-adapted to a wide range of environmental conditions (Baskin and Danell, 2003). In their introduced range they can adapt to a variety of environments, from Mediterranean oak woodland forests to the semi-arid rangelands of Eastern Australia, from the flood plains, billabongs and grassland savannas of tropical north-western

Stage 2 - Detailed assessment: Section B – Establishment

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				Australia to the grey beech forests of the Smoky Mountains in America, and from the wetland and lowland evergreen monsoon forests of Australia to the fresh water marshes and brackish water marshes of South Carolina (Wolf and Conover, 2003). They rarely found at altitudes over 1650m, but are known to be found at altitudes as high as 3000 m in New Guinea (Hide 2003).
2.13	How likely is it that the organism could establish despite low genetic diversity in the founder population?	LIKELY	LOW	Wild and domesticated forms of *S. scrofa* can interbreed and produce fertile hybrids. Hybrids may be morphologically similar to wild boar (Lui, 2000). Hybrids can successfully breed with wild domestic forms or with other hybrids (Lui, 2000; Grossi *et al*., 2006) Domestic pigs can also establish feral populations in the wild i.e. feral pigs. Animals descended from wild boar, domestic pigs, or a combination of the two, are present in many parts of the world (CABI, 2014).
2.14	Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in Ireland? If possible, specify the instances of invasion elsewhere in the justification box	LIKELY	HIGH	Ireland has a suitable climate and the necessary habitat to facilitate establishment of the species.
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?	MODERATELY LIKELY	MEDIUM	If not eradicated it is possible that transient populations would continue to occur.
2.16	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	LIKELY	HIGH	Establishment is likely in Ireland particularly due to the high adaptability of the species.

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.01	What area (given in % or 10km squares) in Ireland could the organism establish (0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%)?	68% - 90%	MEDIUM	The species is likely to be introduced to and/or encounter suitable habitat within the Irish landscape (CORINE, 2006; Fossitt, 2000). The typically favoured wild habitat are moist forests and shrublands. This favoured habitat constitutes about 10% of the Irish land cover (broad leaved forest – 0.41%, coniferous forest – 3.23%, mixed forest – 0.42% and transitional woodland – 5.89%) (CORINE, 2006). But they are adapted to a variety of environments including agricultural areas, coastland, range/grasslands, riparian zones, ruderal/disturbed areas, urban areas and wetlands (Goulding et a., 2008; ISI, 2014) and therefore have the potential to spread to 67%-90% of the Irish land cover.
3.02	How important is the expected spread of this organism in Ireland by natural means (minimal, minor, moderate, major or massive)?	MODERATE	MEDIUM	Refer to Question 2.11
3.03	How important is the expected spread of this organism in Ireland by human assistance (minimal, minor, moderate, major or massive)?	MAJOR	MEDIUM	The range of the species has been greatly expanded by human agency (Oliver and Leus, 2008). Refer to Question 1.02.
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MAJOR	MEDIUM	Containment of the species in the wild would present major difficulties, mainly because of their ability to establish in a wide range of habitats. Once populations are established, *S. scrofa* have proven to be extremely difficult to control, and close to impossible to eradicate (Ditchoff *et al.*, 2012).
3.05	What proportion (%) of the area in Ireland suitable for establishment, if any, has already been colonised by the organism?	0% -10%	MEDIUM	Wild boar have be recorded in 15 of the c.1081 10km squares that constitute the island of Ireland (National Biodiversity Data Centre, 2014a)
3.06	What proportion of the area in Ireland 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	The large majority of Ireland has suitable habitat for this species. However, with 27 verified recorded sightings of the species since 2009, comprising of approximately 76 individuals, most of which are dead animals, it would not be expected for the animal to establish in a land area over 0%-10% within the next five years.

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.07	What other timeframe would be appropriate to estimate any significant further spread of the organism (10, 20, 40, 80 or 160 years)? Please comment on why this timeframe is chosen.	10 years	LOW	This time frame was chosen as it is the smallest time period available. We would recommend a shorter timeframe to monitor the species in order to assess whether records of this species increase across the island from where they have been reported previously, or based on new locations, which may suggest a breeding population. If an increase in records indicated a breeding population then appropriate management would be required. The longer a population is left to breed the more expensive the eventual management response will be.
3.08	In this timeframe, what proportion of the area (including any currently occupied areas) is likely to have been invaded by this organism?	0% - 10%	LOW	Current records of this species in Ireland are from just 15 of Ireland's approximately 1018 hectads (10km^2). As it is not expected that the species is well established in Ireland the area to have been invaded by *S. scrofa* in 10 years may be relatively low at 0% - 10%. However, current records are based on reported sightings and not on any systematic island-wide surveillance and monitoring and therefore, at present, we don't know how much of this habitat is invaded by this species.
3.09	Based on the answers to questions on the potential for establishment and spread in Ireland, define the area endangered by the organism. Be as specific as possible. If available, provide a map showing the area most likely to be endangered.	-	MEDIUM	Forestry, scrubland and habitats in the vicinity of agriculture land is most endangered to invasion.
3.10	Estimate the overall potential for future spread for this organism in (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues.	MODERATLEY	MEDIUM	The species is likely to be introduced to and/or encounter suitable habitat within the Irish landscape. Its favoured habitat of forest and scrubland, which constitutes about 10% of the Irish land cover, is most endangered to invasion.

Stage 2 - Detailed assessment: Section D - Impact
This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.01	How great is the economic loss caused by the organism within its global distribution (excluding Ireland), including the cost of any current management?	MAJOR	MEDIUM	They are considered a major threat to stock as a potential carrier of exotic diseases and of major concern is their role as a reservoir host of foot-and-mouth disease (CABI, 2014). Other notifiable diseases associated with wild boar include: African Swine Fever (ASF), Aujeszky's Disease, Classical Swine Fever (CSF), Rabies, Swine Vesicular Disease (SVD) (ISI, 2011) Landowners and farmers regularly report damage and loss due to *S. scrofa* activity. Food crops like corn, oats, wheat and soybeans are attacked, as are young trees planted in silviculture operations (CABI, 2014). Damage to fences and water sources, and competition with stock for feed by consuming or damaging pasture may occur (CABI, 2014). Home gardens often suffer damage. In 1998 in California, it was estimated that the economic loss resulting from pig rooting was $1.73 million (Masterson, 2007). In terms of negative impacts (damage) caused by wild boar in their native distribution range, within Europe, the following studies have shown damage to agricultural crops to varying degrees which in some countries are considered of significant economic damage in some countries: Austria (Reimoser and Reimoser 2010), Baltic countries (Andersone-Lilley et al. 2010), Belgium (Casaer and Licoppe 2010), Croatia (Kusak and Krapinec 2010), France (Maillard et al. 2010), Germany (Wotschikowsky 2010), Greece (Papaioannou 2010), Italy (Apollonio et al. 2010), Netherlands (van Wieren and Groot Bruinderink 2010), Poland (Wawrzyniak et al. 2010), Portugal (Vingada et al. 2010), Romania (Micu et al. 2010), Slovakia (Findo and Skuban 2010), Slovenia (Adamic and Jerina 2010), Spain (Carranza 2010) and Switzerland (Imesch-Bebié et al. 2010). In terms of the afforested European landscape, where it has been specifically recorded as damage by wild boar to trees, it has occurred at relatively low levels within Romania (Micu et al. 2010). However, it must be stated that few European countries distinguish deer from wild boar negative impacts on trees, rather such impacts and damage are mostly recorded as ungulate damage.

Stage 2 - Detailed assessment: Section D - Impact

This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.02	How great has the economic cost of the organism been in Ireland from the time of introduction to the present? Exclude any costs associated with managing the organism from your answer.	MINIMAL	MEDIUM	It is too early to assess the economic impact of the species in Ireland (McDevitt *et al*., 2013).
4.03	How great is the economic cost of the organism likely to be in the future in Ireland? Exclude any costs associated with managing the organism from your answer.	MAJOR	MEDIUM	The Irish economy is heavily dependent on the agricultural sector and wild boar populations are known to significantly impact upon agricultural enterprises.
4.04	How great have the economic costs of managing this organism been in Ireland from the time of introduction to the present?	MINIMAL	HIGH	There is currently no management of this species in place in Ireland to estimate economic costs from.
4.05	How great is the economic cost of managing this organism likely to be in the future in Ireland?	MODERATE	MEDIUM	The economic cost of managing wild boar depends on whether or not breeding populations establish in Ireland and whether these populations spread. At present this information is unknown for Ireland and therefore it is difficult to make an assessment.
4.06	How important is environmental harm caused by the organism within its global distribution?	MAJOR	HIGH	To feed on belowground plant parts, fungi and invertebrates, wild boar over turn extensive areas of soil vegetation (Cushman *et al*., 2004). This not only directly affects above and belowground components of the communities but also indirectly affects other organisms by physically changing habitat characteristics and modifying resource availability (Crooks, 2002). Because the rooting behaviour has marked ecosystem-level effects, wild boar are considered ecosystem engineers (Crooks, 2002). Wild boar rooting directly alters soil structure and processes and could be comparable to the effect of tillage treatment in agroecosystems (Barrios-Garcia and Ballari, 2012). In general, the absence of studies and idiosyncratic results of the few studies available prevent general agreement on wild boar effects on soil properties (Barrios-Garcia and Ballari, 2012). The most obvious direct effect of rooting by wild boar is the reduction in plant cover. In the introduced range, the extent of rooting varies

Stage 2 - Detailed assessment: Section D - Impact
This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				depending on the season, but this activity can reduce as much as 80% of understory cover (Singer *et al.*, 1984). Although wild boar are omnivorous, plant matter comprises the majority of their diet (Cuevas *et al.*, 2010). The consequences of this activity vary with plant community, but generally rooting decreases species diversity and regeneration and alters species composition (Siemann *et al.*, 2009), which could lead to local extinction of species (Singer *et al.*, 1984). One of the main concerns about rooting is the fact that soil disturbance by wild boar is associated with increased abundance of exotic plant taxa (Barrios-Garcia and Ballari, 2012). Conversely, Studies from Britain and Sweden have shown that rooting activities of wild boar have a positive impact on the species diversity of the ground flora of forests, particularly small seeded species like orchids and trees like pine and birch (Welander, 1995; Sims, 2006). Wild boar has also been shown to effectively control bracken, which is considered to be an "invasive native" in some habitats (http://www.treesforlife.org.uk/forest/missing/guisachan200805.html).
4.07	How important has the impact of the organism on biodiversity* been in Ireland from the time of introduction to the present? *e.g. decline in native species, changes in community structure, hybridisation	MINIMAL	MEDIUM	There has been no research conducted to date assessing the species impact on Ireland's biodiversity. Therefore, no assessment can be made at present.
4.08	How important is the impact of the organism on biodiversity likely to be in the future in Ireland?	MAJOR	HIGH	Refer to Question 4.06
4.09	How important has alteration of ecosystem function* caused by the organism been in Ireland from the time of introduction to the present? *e.g. habitat change, nutrient cycling, trophic interactions	MINIMAL	MEDIUM	There has been no research conducted to date assessing the species impact on the ecosystem functioning within Ireland. Therefore, an assessment cannot be made at present.

Stage 2 - Detailed assessment: Section D - Impact

This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.10	How important is alteration of ecosystem function caused by the organism likely to be in Ireland in the future?	MAJOR	HIGH	Refer to Question 4.06
4.11	How important has decline in conservation status* caused by the organism been in Ireland from the time of introduction to the present? *e.g. sites of nature conservation value, WFD classification, etc.	MINIMAL	MEDIUM	There has been no research conducted to date assessing the species impact on Ireland's biodiversity. Therefore, we can't make an assessment at present.
4.12	How important is decline in conservation status caused by the organism likely to be in the future in Ireland?	MODERATE	LOW	It is difficult to provide an answer to this, since *S. scrofa* has both positive and negative impacts, depending on densities (CABI 2014). *S. scrofa* (at low densities) may have a positive role within an ecosystem and may promote biodiversity levels. But at higher densities or at densities that are unsuitable with regards to the landuse management objectives, *S. scrofa* may have significant negative impacts within the habitats where they occur, including negative impacts on agriculture crops. It may also siginificantly impact on priority ground flora of woodlands and forests that do not occur in Great Britain but may be found within Ireland. Within Europe, invertebrate taxa such as earthworms and snails and vertebrate taxa such as ground nesting birds' eggs may be at risk from predation by *S. scrofa* (Massei and Genov 2004). Negative and positive impacts by wild boar have been recorded in protected conservation habitats within the Baltic countries (Anderson-Lilley et al. 2010), however for the most part there is no information available from the majority of the European countries regards impacts by wild boar on protected conservation habitats, probably in part due to the lack of national monitoring system or central database for such observations, or indeed perhaps there is very little negative/positive impacts or none that are observed by the human eye. Any observable impact to humans is highly subjective and many indirect multifaceted effects within an ecosystem go unobserved without study.

Stage 2 - Detailed assessment: Section D - Impact

This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.13	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within its global distribution?	MODERATE	MEDIUM	*Sus scrofa* carries parasitic infections transmissible to humans through eating undercooked pork and through contact, including trichinosis, cysticercosis, brucellosis and toxoplasmosis (Masterson, 2007). They have also been implicated in an outbreak of human *Escherichia coli* infection in California (Masterson, 2007). Both domesticated and wild pigs can be quite aggressive, at least when threatened.
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within Ireland?	MINIMAL	MEDIUM	At present there is no measure of the level of social or human health harm caused by wild boar in Ireland. However, the impact is likely to be moderate due to the many potential diseases carried by the animal that can infect man or livestock.
4.15	How important is it that genetic traits of the organism could be carried to other organisms / species, modifying their genetic nature and making their economic, environmental or social effects more serious?	MODERATE	MEDIUM	Wild boar (*Sus scrofa*) and domestic pigs (*Sus domesticus*) can mate and produce fertile hybrids. Hybrids can successfully breed with wild boar and domestic pigs or with other hybrids (Lui, 2000; Grossi *et al.*, 2006) Animals with introgressed genes, i.e. descended from wild boar, domestic pigs, or a combination of the two, are present in many parts of the world (CABI, 2014).
4.16	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	MEDIUM	Refer to Question 4.01
4.17	How important might other impacts not already covered by previous questions be resulting from introduction of the organism? Specify in the justification box.	N/A	MEDIUM	We are not aware of any other impacts the introduction of this species would have.
4.18	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 Ireland?	MAJOR	MEDIUM	Refer to Question 2.06

Stage 2 - Detailed assessment: Section D - Impact

This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.19	Indicate any parts of where economic, environmental and social impacts are particularly likely to occur. Provide as much detail as possible, where possible include a map showing vulnerable areas.	-	MEDIUM	Environmental impacts where *S. scrofa* occur at high localised densities may potentially be greatest within broad leaved woodlands and to certain agricultural crops, where such crops (e.g. maize) are located within their home ranges. To assess the risk arising from such impacts will require a further assessment (see also 4.07). Economic impacts arising from road traffic collisions will be greatest where roads and broad leaved woodlands and certain favoured agricultural crops are located. To assess the risk arising from road use in these locations will require a further assessment.
4.20	Estimate the overall potential impact of this organism in Ireland. Use the justification box to indicate any key issues.	MAJOR	MEDIUM	Wild boar may cause extensive damage to agriculture and natural habitats, threaten native species, and carry diseases which can affect domestic animals or humans (Barrios-Garcia and Ballari, 2012). Potential disease transmission to other wild ungulates, for example those that effect hooved species such as wild deer (foot and mouth disease, for example).

Stage 2 - Detailed assessment: Section E - Conclusion

This section requires the assessor to provide a score for the overall risk posed by an organism, taking into account previous answers to entry, establishment, spread and impact questions.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
5.01	Estimate the overall risk of this organism in Ireland. Noting answers given in 1.11, 2.16, 3.10 & 4.20	MAJOR	MEDIUM	It is important to note that this risk assessment of non-genetically pure wild boar (*Sus scrofa*) also encompasses feral pigs (*Sus domesticus*) and hybrids as relative literature of the *Sus* sp. in the wild are recorded as one group in terms of records, behaviour, origins and risks (CABI, 2014; Ferdia Marnell, per. comm., 6th February 2014). The likelihood of entry into Ireland is high as introductions have already taken place. Establishment is likely in Ireland particularly due to the high adaptability of the species. The species is likely to be introduced to and/or encounter suitable habitat within the Irish landscape. Its favoured habitat of forest and scrubland, which constitutes about 10% of the Irish land cover, is most endangered to invasion. *Sus scrofa* at high densities may cause damage to agriculture and natural habitats, threaten native species. Of most concern is the potential for the species to carry diseases which can affect domestic (and wild) animals or humans (Barrios-Garcia and Ballari, 2012).

Stage 2 - Detailed assessment: Section F – Additional questions

This section is used to gather information about the potential effects of climate change on the risk posed by an organism. It is also an opportunity for the risk assessor to highlight high priority research that could help improve the risk assessment.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
6.01	What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	-	HIGH	As the species is already acclimatised to climatic conditions ranging from temperate to subtropical and tropical, climate change would be expected to have very little bearing over the risk assessment.
6.02	What is the likely timeframe for such changes (5, 10, 15, 20, 50 or 100 years)?	N/A	MEDIUM	See justification in Q 6.01
6.03	What aspects of the risk assessment are most likely to change as a result of climate change	-	MEDIUM	See justification in Q 6.01
6.04	If there is any research that would significantly strengthen confidence in the risk assessment, please note this here. If more than one research area is provided, please list in order of priority.	-	MEDIUM	Modelling of the species potential rate of spread and likely distribution and an assessment of potential suitable habitat and population dynamics in Ireland would significantly strengthen the confidence in this risk assessment. Such research is currently being conducted (Ruth Carden, per. comm., 11th March 2014).

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