Annex 8. Risk Assessment for *Sciurus carolinensis* (Grey Squirrel)

EUROPE NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME
Name of organism: *Sciurus carolinensis*
Author: Sandro Bertolino, Adriano Martinoli, Lucas Wauters; reviewed by John Gurnell and Peter Lurz (Great Britain)
Risk Assessment Area: European Union (28 Countries)
Draft: Draft 1 (*30/06/2014*)

EU CHAPPEAU	
QUESTION	**RESPONSE**
1. In how many EU member states has this species been recorded? List them.	Great Britain, Ireland, Italy
2. In how many EU member states has this species currently established populations? List them.	Great Britain, Ireland, Italy
3. In how many EU member states has this species shown signs of invasiveness? List them.	Great Britain, Ireland, Italy
4. In which EU Biogeographic areas could this species establish?	The suitability was evaluated with a comparison of the biogeographical regions with the European projections of the grey squirrel's climatic niche (Di Febbraro et al. 2013, see map below). High climatic suitability (0.6-1.0): Atlantic, Black Sea, Continental (Western Part), Macaronesia (Azores), Mediterranean (excluding part of Spain) Medium climatic suitability (0.4-0.6): Alpine (Eastern Alps), Continental (Eastern Part), Pannonian, Macaronesia (Canary Islands) Low climatic suitability (<0.4): Alpine (Western Alps), Anatolian, Arctic, Boreal
5. In how many EU Member States could this species establish in the	Based on simulation of the grey squirrel's climatic niche in Maxent suitability is:

future [given current climate] (including those where it is already established)? List them.	High (suitability > 0.6) in United Kingdom, Ireland, Portugal, Spain, France, Italy, Netherlands, Belgium, Luxembourg, Germany, Austria, Czech Republic, Slovenia, Croatia, Denmark, Bulgaria, Hungary, Romania, Greece, Cyprus. Lower (suitability < 0.6) in Sweden, Finland, Lithuania, Latvia, Estonia, Slovakia, Poland, Malta,
6. In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)?	The species could become invasive in most of Europe, if established (see question 5), mainly for the possibility to replace the native red squirrel that is the only native tree squirrel present in Europe. The confidence of this prediction is higher in parts of Europe where mixed broadleaves forests are dominant and lower for areas where conifers are dominant.

SECTION A – Organism Information and Screening		
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?	*Sciurus carolinensis* Gmelin, 1788. EN: grey squirrel; FR: Écureuil gris; IT: Scoiattolo grigio; D: Grauhörnchen	Yes, this species can be adequately distinguished from other entities of the same genus.
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)	NA	

3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No	No risk assessment has been carried out for the whole of Europe. A Risk Assessment has been conducted in Belgium and the result was that the species has high potential of establishment and dispersal in that country. For these reasons the species was included in the Black list (Score 11) and in the Alert list (AO) for its potential high environmental hazard. In Italy, the Grey squirrel Pest Risk Assessment has been produced following three different European procedures. With the Belgian system (Invasive Species Environmental Impact Assessment) the final list score was: A2 (black list). Using the Quickscan Risk Assessment method, according to a report for the Commission for Invasive exotic species (COIE) of the Netherlands Ministery of Agriculture, Nature and Food quality, the final evaluation was that this organism could present a risk to the Risk Assessment area (Italy). With the UK non-native organism risk assessment scheme version 3.3 the final evaluation was: risk of entry: 4 (very likely), risk of establishment: 4 (very likely), risk of spread: 2 (intermediate), impacts 3 (major).
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	No	They only consider single countries.
5. Where is the organism native?		North America

6. What is the global distribution of the organism (excluding Europe)?		The species is native to North America where it is distributed from the Gulf of Mexico, the Eastern United States to the southern part of Quebec and Ontario (Koprowski 1994). Grey squirrels have been introduced to many localities of North America (USA and Canada), Australia (2 areas extinct, 1 area eradicated), and South Africa (Long 2003; Wood et al. 2007; Bertolino 2009; Peacock 2009).
7. What is the distribution of the organism in Europe?		Expanding grey squirrel populations are present in Great Britain, Ireland and Italy (O'Teangana et al. 2000; Gurnell et al. 2008b; Martinoli et al. 2010)
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	Grey squirrels have been introduced and established population in many localities of North America (USA and Canada), South Africa (Long 2003; Bertolino 2009) and Europe (UK, Ireland, Italy). Already reported in the IUCN list of 100 worst invasive species (Lowe et al. 2000). The grey squirrel is impacting biodiversity and commercial forestry in Great Britain through bark stripping (Kenward & Parish 1986; Kenward et al. 1992; Mayle et al. 2003; Gurnell et al. 2008). Bark stripping increases the risk of fungal infections and invertebrate damage, which can reduce timber yield (Mayle 2010). Tree species, age and time of year influence the risk of squirrel damage (Mayle et al. 2008). Beech (*Fagus sylvatica*) and sycamore (*Acer pseudoplatanus*) are at the greatest risk of damage but any thin-barked tree species between 10 and 40 years old is at risk e.g.

		oak (*Quercus* spp.), sweet chestnut (*Castanea sativa*), larch (*Larix* spp.) and Norway spruce (*Picea abies*) (Mayle, 2004; Mayle & Broome 2013). Bark stripping has influenced woodland management practices in England, where a shift away from trees susceptible to squirrel damage has been observed (Mayle, 2005), with an influence on the flora and fauna associated with specific woodland types. Grey squirrels predate eggs and fledgling of birds; at present there is little evidence of any national population declines in woodland bird species as a result of this predation, but further research is needed to exclude impacts for specific species and habitats (Amar et al., 2006; Newson et al., 2010).
9. Describe any known socio-economic benefits of the organism in the risk assessment area.	None known	
Stage 2. Screening Questions		
10. Has this risk assessment been requested by the a Programme Board? (If uncertain check with the Non-native Species Secretariat)	NA	
11. What is the reason for performing the risk assessment?	Identification of invasive alien species of EU concern	

12. Does the organism have intrinsic attributes that indicate that it could be invasive, i.e. threaten species, habitats or ecosystems?		Tree squirrels are highly adaptive and opportunistic species and viable populations could establish from few founders. The likelihood ratio for a couple of *Sciurus* spp. (*S. aberti*, *S. aureogaster*, *S. carolinensis*, *S. niger* the introduced species considered) to successfully establish a viable population is 57% and a likelihood ratio of 90% is achieved with >14 animals (Bertolino 2009). Females can have 2 litters/year with 2-5 weaned young; varying percentage of adult females reproduce in a given season, depending on food quality and quantity. Dispersal capacity is high, juveniles can move easily between 1 and 3 (5) km from the natal site (Koprowski 1994; Wauters et al. 1997; Lurz et al. 2001). The species lives in deciduous, mixed and coniferous woodland habitats feeding on tree seeds and a variety of other foods (tree flowers, buds, mushrooms, berries, occasionally insects and bird eggs/young; they may sometimes feed on cereals (e.g. maize). The species is commonly found in suburban areas where it benefits from supplemental feeding (Bonnington et al.2013, 2014).
13. Does the organism occur outside effective containment in Europe?	Yes	

14. Is the organism widely distributed in Europe?	Yes	Grey squirrel populations are present in Great Britain (see map in Gurnell et al. 2008b), Ireland (O'Teangana et al. 2000) and Italy (Martinoli et al. 2010)
15. Does at least one species (for herbivores, predators and parasites) or suitable habitat vital for the survival, development and multiplication of the organism occur in Europe, in the open, in protected conditions or both?	Yes	The species is found in deciduous and mixed forest, farmland with small scattered woodland cover and in urban parks (open); it is also present in zoological gardens and as a pet in private houses and parks (protected conditions).
16. Does the organism require another species for critical stages in its life cycle such as growth (e.g. root symbionts), reproduction (e.g. pollinators; egg incubators), spread (e.g. seed dispersers) and transmission, (e.g. vectors)?	No	
17. Is the other critical species identified in question 15 (or a similar species that may provide a similar function) present in Europe or likely to be introduced? If in doubt, then a separate assessment of the probability of introduction of this species may be needed.	NA	
18. Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of Europe or sufficiently similar for the organism to survive and thrive?	Yes	Climatic conditions in most of Europe are considered suitable for grey squirrels (Di Febbraro et al. 2013). The species is found in eco-temperate climatic zones (Gurnell 1987; Bertolino 2008); in the natural range from north to south, there are very large changes in weather (Koprowski 1994) indicating adaptability to different climatic condition. The adaptability of the species is also confirmed by a shift in its climatic niche in Europe (Di Febbraro et al. 2013).

19. Could the organism establish under protected conditions (e.g. glasshouses, aquaculture facilities, terraria, zoological gardens) in Europe?	Yes	The species is present in zoological gardens and private collections; therefore, there are risks for accidental or voluntary releases.
20. Has the organism entered and established viable (reproducing) populations in new areas outside its original range, either as a direct or indirect result of man's activities?	Yes	The species has been introduced to many localities of North America, Australia (extinct or eradicated), South Africa, Great Britain, Ireland and Italy (Long 2003; Bertolino2009). In Europe, the grey squirrel was introduced to Great Britain on more than 30 occasions from 1876 until 1929 (Middleton1932; Shorten 1954; Gurnell 1987) and to Ireland in 1913 (O'Teangana et al. 2000). At least 20 separate introductions took place in Italy (Bertolino 2009; Martinoli et al.2010). Presently, the range of introduced grey squirrel populations covers most of England and Wales, part of Scotland, the eastern part of Ireland, as well as many areas in Northwestern Italy and a location in central Italy (Wauters et al.1997; O'Teangana et al. 2000; Bertolino 2008; Gurnell et al. 2008b; Martinoli et al. 2010)
21. Can the organism spread rapidly by natural means or by human assistance?	Yes	High natural dispersal capacity (Koprowski 1994; Wauters et al. 1997; Lurz et al. 2001; Bertolino et al. 2008). Humans can further promote the spread of the species with translocation from one area to another (Shorten 1954; Martinoli et al. 2010; Signorile et al. 2014a,b)
22. Could the organism as such, or acting as a vector, cause economic, environmental or social harm in Europe?	Yes	The grey squirrel is replacing the native red squirrel (*Sciurus vulgaris*) in Great Britain (Gurnell & Pepper 1993; Gurnell et al. 2008a,b), Ireland (O'Teangana et al. 2000) and Italy (Martinoli et al.

		2010; Bertolino et al. 2014), through resource competion (Wauters et al. 2002a,b; Gurnell et al. 2004); in Great Britain and Ireland the replacement is also disease-mediated, as the species act as a reservoir host to a squirrel poxvirus that causes high mortality in red squirrels (Sainsbury et al. 2000; Tompkins et al. 2002; Rushton et al. 2006). The species is impacting biodiversity and commercial forestry in Great Britain through bark stripping (Mayle et al. 2003; Gurnell et al. 2008; Mayle & Broome 2013). Bark stripping has influenced woodland management practices in England, where a shift away from trees susceptible to squirrel damage has been observed (Mayle, 2005) with an influence on the flora and fauna associated with specific woodland types. Squirrels predate eggs and fledgling of birds; further studies are required on whether they contribute to the decline of particular woodland bird species (Amar et al., 2006; Newson et al., 2010). Economic impact of bark stripping damage in Great Britain. Total costs for grey squirrel management in UK forests (damage + control) is estimated at GBP 6,097,320 (Williams et al. 2010) - GBP 10 million (Anon. 2006; Mayle & Broome 2013) annually. Damage done by grey squirrels to property (damage to furniture, ornaments, cables) is estimated to be GBP 5,128,274; while the cost of removing squirrels in buildings and other infrastructure is estimated in GBP 1,914,555 (total

		damage + control GBP 7,042,829) (Williams et al. 2010). Projected annual costs for grey squirrel management in Irish (Ireland and Northern Ireland) forests is € 856,141; the cost to the agricultural sectors is € 4,580,818 and for building protection is € 988,978 (Kelly et al. 2013). In Italy limited damage to maize crops and poplar plantations are recorded (Currado 1993; Currado et al. 1997; Signorile and Evans 2007), but costs are not estimated. The species is also reported to be a garden pest by digging up bulbs and eating fruits and the bark of ornamental plants, and can damage properties, chewing timber, wires and stored goods. Social conflict expected on eradication programmes that will be inacceptable for extreme animal-rights groups (Bertolino et al. 2003; Anon. 2013); however, on this aspect see the position paper of the Eurogroup for Animals (July 2013, EU Strategy on Invasive Alien Species), a leading voice for animal welfare at European Union level, which recognise that in some cases it may be more humane and have less negative impact on animal welfare to utilise a rapid lethal method than longer term controls impacting larger number of animals.

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: 36. Entry is the introduction of an organism into Europe. Not to be confused with spread, the movement of an organism within Europe. 37. For organisms which are already present in Europe, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms which have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.1. How many active pathways are relevant to the potential entry of this organism? (If there are no active pathways or potential future pathways respond N/A and move to the Establishment section)	few	very high	The species is already present in the Risk Assessment area with viable and spreading populations in three countries. The pathway for new introduction is escapes from pet owners, deliberate release from pet owners, deliberate introductions.
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. For each pathway answer questions 1.3 to 1.10 (copy and paste additional rows at the end of this section as necessary).	[Pet-trade]		The primary pathway for entry involves their escape or deliberate release from captivity (see as an example of squirrel's pathway the video on YouTube regarding an illegal release of a chipmunk, *Tamias* sp. (http://www.youtube.com/watch?v=p_Ee4Bvk-eU). The origin of the pathway is considered to be the keeping of the animals in captivity but also deliberate introductions in parks and woods. Likelihood of association is considered to remain high as long as the species continues to be kept in captivity and sold by pet shops (Bertolino 2009). Natural populations could be the source of animals for an illegal trade of the species (Signorile et al. 2014b).
Pathway name:	[Pet-Trade]		

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	very high	The species is intentionally imported and traded in many European countries (UNEP-WCMC 2010). The animals may then be released or escape.
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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	moderately likely	medium	Trade statistics are not available. An internet survey conducted in May 2010, in order to investigate whether the species appears to be traded within the EU, and whether there appears to be demand for this species as a pet, found adverts for the sale of grey squirrels on Austrian, Danish, French, Great Britain, Italian, and Spanish websites; there were several advertisements for people wanting 'squirrels' in French, British, Italian, and Spanish websites (UNEP-WCMC 2010).
1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	very likely	high	Natural populations can establish from few founders and grow quickly (Shorten 1954; Bertolino 2009; Wood et al. 2007;Signorile et al. 2014a). The species is often released in urban parks, suburban gardens, parkland, etc., which could provide suitable habitats with supplemental feeding from humans (Bonnington etb al. 2013, 2014), and from here spread to forested habitats (deciduous, mixed and coniferous woodland) (Bertolino et al. 2014).
1.10. Estimate the overall likelihood of entry into Europe based on this pathway?	likely	high	The species is already present in three countries and is traded in many others.
End of pathway assessment, repeat as necessary.			

1.11. Estimate the overall likelihood of entry into Europe based on all pathways (comment on the key issues that lead to this conclusion).	likely	high	The principal pathway for entry is escape or release from captivity. The origin of the pathway is considered to be the keeping of the animals in captivity but also deliberate introductions in parks and woods. Likelihood of association is considered to remain high as long as the species continues to be kept in captivity and sold by pet shops (Bertolino 2009). Natural populations could be the source of animals for an illegal trade of the species (Signorile et al. 2014b). The importation of the grey squirrel was suspended in the European Union in year 2012 by including it in a list of species whose introduction in Europe is suspended on the basis of the evidence that they constitute an ecological threat to biodiversity. This list is an implementation of the CITES Regulation and is directly applicable in all Member States. This, however, does not stop the movements of animals within Europe where the species is already bred and sold in many countries (UNEP-WCMC 2010). In Italy the limitation is now even more stringent. A Decree signed on 24th December 2013 by the Ministers of the Environment, Agriculture and Economic Development and published on 2nd February 2014 forbids trading, raising and keeping of grey squirrels and two other squirrel species (*Sciurus niger*, *Callosciurus erythraeus*). In UK, under the Wildlife and Countryside Act (1981) it is illegal to release non-indigenous animals into the wild, so any grey squirrels caught should be killed.

PROBABILITY OF ESTABLISHMENT

Important instructions:

38. For organisms which are already well established in Europe, only complete questions 1.15 and 1.21 then move onto the spread section. If uncertain, check with the Non-native Species Secretariat. For Europe mainland, grey squirrel is established only in Italy, while other populations are on islands (Great Britain, Ireland); therefore all questions were completed

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.12. How likely is it that the organism will be able to establish in Europe based on the similarity between climatic conditions in Europe and the organism's current distribution?	very likely	very high	The species already established in Great Britain, Ireland and Italy (Bertolino 2009); only Italy is part of mainland Europe. According to statistical prediction models that simulate the possible expansion of the grey squirrel from Italy, in the medium term the grey squirrel will be able to colonize the Alps, the Apennines and the bordering countries of France and Switzerland in next decades (Lurz et al. 2001; Tattoni et al. 2006; Bertolino et al. 2008). These studies support the presence of suitable habitats in these areas. A recent study also supports the hypothesis of a shift in the grey squirrel's climatic niche in the area of introductions. Climatic conditions in most of Europe were considered suitable for grey squirrels (Di Febbraro et al. 2013).

1.13. How likely is it that the organism will be able to establish in Europe based on the similarity between other abiotic conditions in Europe and the organism's current distribution?	very likely	very high	Temperate forests and woodlands in Europe have many tree species that are similar (same genus) than in the native area of grey squirrels and thus produce food resources similar in quantity and quality; (sub)urban park populations occur both in Europe and N. America. Climatic conditions in most of Europe are considered suitable for grey squirrels (Di Febbraro et al. 2013).
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 Europe? Subnote: gardens are not considered protected conditions	very likely	very high	The species is already keeps in wildlife parks, zoological gardens, private collections and pet shops.
1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Europe?	widespread	very high	The species lives in deciduous, mixed and coniferous woodland habitats, feeding on nuts, seeds, tree flowers, buds, mushrooms, berries, caterpillars, rarely on insects and bird eggs/young and sometimes on cereals (maize). The species is also regularly found in parks and towns. Therefore no single species is "vital" for its survival, development and multiplication. Suitable habitats are present and widely distributed in the Risk Assessment Area.
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 GB?	NA		

1.17. How likely is it that establishment will occur despite competition from existing species in Europe?	very likely	very high	Outcome of competition with the only native tree squirrel species (red squirrel, *Sciurus vulgaris*) is in favour of the alien species (Gurnell & Pepper 1993; Kenward & Holm 1993; Wauters et al. 2001, 2002a, b; Gurnell et al. 2004)
1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in Europe?	very likely	high	A range of potential predators exist in Europe, these include raptors, red fox (*Vulpes vulpes*), stone and pine marten (*Martes* spp.), feral and domestic cats, and potentially owls. This suite of predators has not prevented the establishment, nor the spread of the animals. Feral/domestic cats may have an impact in some urban areas (Bertolino & Genovesi 2005). Pine marten (*Martes martes*) seems to have an impact in some parts of Ireland (Sheehy et al. 2014).

1.19. How likely is the organism to establish despite existing management practices in Europe?	likely	high	A national bounty scheme in the Great Britain between 1953 and 1958 did not reduce numbers or geographic range of the grey squirrel, or damage to trees, and was stopped (Shorten 1957; Thompson & Peace 1962; Sheail 1999). Subsequent control actions in Great Britain, Ireland and Italy show that high removal rates are necessary to obtain success and that numbers return quickly to pre-control levels once killing is stopped (Lawton & Rochford 2007). The management of the grey squirrel in Italy aims to stop the spread of the species to other countries. Though successful, these management actions would stop the spread of established populations, but not the risk for Europe. The main pathway of entry is the pet trade and the risk of new introductions in other European countries continues to be present.
1.20. How likely are management practices in Europe to facilitate establishment?	NA		
1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in Europe?	likely	medium	So far no eradication campaigns have been started, but control actions in the Great Britain, Ireland and Italy show that high removal rates are necessary to obtain success and that numbers return quickly to pre-control levels once killing is stopped (Lawton & Rochford 2007). Once established, grey squirrels are difficult if not impossible (with large populations) to eradicate though some success can be achieved at a local level with a high control effort (Schuchert et al. 2014)

1.22. How likely are the biological characteristics of the organism to facilitate its establishment?	very likely	very high	Can have 2 litters/year with 2-5 weaned young; varying percentage of adult females reproduce in a given season (Gurnell 1987; Koprowki 1994). The animals are attractive to humans that feed populations in urban parks or nearby. This could help small populations to overcome the first phase when extinction is possible.
1.23. How likely is the capacity to spread of the organism to facilitate its establishment?	very likely	very high	Dispersal capacity high, juveniles can move easily between 1 and 3 (5) km from the natal site (Koprowski 1994; Wauters et al. 1997; Lurz et al. 2001)
1.24. How likely is the adaptability of the organism to facilitate its establishment?	very likely	very high	The species could adapt to urban, suburban and more natural area, occurring in a variety of woodland habitat types
1.25. How likely is it that the organism could establish despite low genetic diversity in the founder population?	very likely	very high	Grey squirrels have proven to be very successful invaders able to start new populations and spread even from few founders with low genetic diversity (Wood et al., 2007; Bertolino 2009; Signorile et al. 2014 a,b).
1.26. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Europe? (If possible, specify the instances in the comments box.)	very likely	very high	59 out of 74 (79.7%) introductions outside the native range in US, Canada, Europe, Australia, South Africa, were successful (Bertolino 2009). The species already established in North (Great Britain and Ireland) and South (Italy) Europe, showing its ability to adapt to European habitats

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.	unlikely	medium	If the species does not establish, as in an urban park in Rome in the 1980s (Bertolino & Genovesi 2005), and in some areas in Great Britain (Shorten 1954) and in Australia (Long 2003), then it is probable that the introduced animals will disappear. However, the risk of new introductions will continue to remain.
1.28. Estimate the overall likelihood of establishment (mention any key issues in the comment box).	likely	high	The species already established in North (Great Britain and Ireland) and South (Italy) Europe. Climatic conditions in most of Europe are considered suitable for grey squirrels (Di Febbraro et al. 2013). The species is found in eco-temperate climatic zones (Bertolino 2008, 2009); in the natural range from north to south (Koprowski 1994), there are very large changes in weather to indicate a certain adaptability of the species. The species could adapt to urban, suburban and more natural area, occurring in a variety of woodland habitat types. Grey squirrels have proven to be very successful invaders able to start new populations world-wide even from few founders with low genetic diversity (Wood et al., 2007; Bertolino 2009; Signorile et al. 2014 a,b). Humans could help the spreading feeding the animals or translocating them to new areas. It must be underlined that both Ireland and Great Britain are islands and the main risk to the rest of Europe comes from pet trade and range expansion form Italy. Grey squirrels in Italy should therefore be a priority in terms of action.

PROBABILITY OF SPREAD			
Important notes: 39. Spread is defined as the expansion of the geographical distribution of a pest within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How important is the expected spread of this organism in Europe by natural means? (Please list and comment on the mechanisms for natural spread.)	high	high	Active saturation dispersal, mainly of immature individuals, which will colonize new areas of suitable habitat. Information on the spread of the species are reported by Okubo et al. (1989) for England, by O'Teangana et al. (2000) for Ireland and Bertolino et al. (2014) for Italy.
2.2. How important is the expected spread of this organism in Europe by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	major	high	Squirrels are often released in or near urban areas such as parks, where they could benefit from supplementary feeding by humans. This could increase survival and help to overcome first periods with very low density. All 32 introductions in UK and Ireland were human mediated; at least 11 were translocations from other populations already established. (Shorten 1954). The same probably happened in north Italy (Martinoli et al. 2010) and was documented for central Italy (Signorile et al. 2014b).

2.3. Within Europe, how difficult would it be to contain the organism?	difficult	medium	Likelihood is that it could be 'contained' where it doesn't spread over large areas, partly because of seasonally high trappability, and partly because of easy recognition of the species in new areas. However, practical difficulties likely to arise because of diverse landownership patterns likely to be encountered in typical release/escape areas and because of potential public opposition to control/eradication (Barr et al. 2002; Rushton et al. 2002; Anon. 2013).
2.4. Based on the answers to questions on the potential for establishment and spread in Europe, define the area endangered by the organism.	[Most of Europe]	high	See bioclimatic model for the species in Di Febbraro et al. (2013) and questions 4 and 5 of EU CHAPPEAU
2.5. What proportion (%) of the area/habitat suitable for establishment (i.e. those parts of Europe were the species could establish), if any, has already been colonised by the organism?	10-33	high	See distribution maps in Bertolino (2008) and bioclimatic model for the species in Di Febbraro et al. (2013).
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	high	Expansion of the colonies in North and Central Italy, Ireland and Scotland.

2.7. What other timeframe (in years) would be appropriate to estimate any significant further spread of the organism in Europe? (Please comment on why this timeframe is chosen.)	10	medium	In 2010 Italian authorities started a LIFE funded project (LIFE09 NAT/IT/00095 EC-SQUARE), with the aim to control the grey squirrel across different regions on Northern Italy. A second LIFE project (LIFE13 BIO/IT/000204 U-SAVEREDS) is due to start in October 2014 with the aim to eradicate the grey squirrel from central Italy (Umbria). These LIFE projects will end in 2015 and 2018 and in this timeframe information on the possibility to eradicate or control the species in Italy will become available.
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?	0-10	medium	If control actions fails, the species would invade further areas in north and central Italy in this timeframe.

2.9. Estimate the overall potential for future spread for this organism in Europe (using the comment box to indicate any key issues).	rapidly	medium	Based on the results of a spatially explicit population dynamic model it is believed that in 20-40 years from 1996 the species can colonize the western Alps in the provinces of Cuneo and Turin and in about 30 years reach France (i.e. by 2026). The populations in Lombardy would take 20-40 years to colonize the area along the Ticino river and Lake Maggiore and the first grey squirrels could easily reach Switzerland in the decade 2030-2040 (Lurz et al. 2001; Tattoni et al. 2006; Bertolino et al. 2008). These prediction, however, are based on modeling the spread of only three populations (Bertolino et al. 2008), while now there more than 20 populations are known for Italy (Martinoli et al. 2010) and do not assume further jumps via human-mediated translocations. In case of new introduction in other countries, the likelihood of establishment is high and the spread could be from moderate to rapid, depending on the habitat.

PROBABILITY OF IMPACT
Important instructions: 40. When assessing potential future impacts, climate change should not be taken into account. This is done in later questions at the end of the assessment. 41. Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section). 42. Note questions 2.10-2.14 relate to economic impact and 2.15-2.21 to environmental impact. Each set of questions starts with the impact elsewhere in the world, then considers impacts in GB separating known impacts to date (i.e. past and current impacts) from potential future impacts. Key words are in bold for emphasis.

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.10. How great is the economic loss caused by the organism within its existing geographic range, including the cost of any current management?	major	high	Total costs for grey squirrel management in UK forests (damage + control) is estimated at GBP 6,097,320 (Williams et al. 2010) - GBP 10 million (Anon. 2006; Mayle & Broome 2013) annually. Damage done by grey squirrels in properties (damage to furniture, ornaments, cables) is estimated to be GBP 5,128,274; while the cost of removing squirrels in buildings and other properties is estimated in GBP 1,914,555 (total damage + control GBP 7,042,829) (Williams et al. 2010). Projected annual costs of grey squirrel to the Irish (Ireland and Northern Ireland) agricultural sectors is GBP 3,635,570 (€ 4,580,818) (Kelly et al. 2013). In Italy limited damage to maize crops and poplar plantations are recorded (Currado 1998; Signorile and Evans 2007). In Italy two LIFE projects for the control of grey squirrels in north (2010-2015) and central Italy (2014-2018) cost: € 1,930,00 and € 1,433,241 respectively.

2.11. How great is the economic cost of the organism currently in Europe excluding management costs (include any past costs in your response)?	NA		Grey squirrels damage to the timber industry through bark stripping in Great Britain is estimated at GBP 684,802 per annum; damage to buildings and other infrastructures is estimated at GBP 5,128,000 (Williams et al. 2010). Mayle and Broome (2013) give a different estimate, with economic estimates of timber revenue loss, "In 2000 the cost of grey squirrel damage to the British timber industry, based on tree loss, reduction in timber quality and reduced yield (as described above), was estimated to be up to £10 million at the end of the then current rotation for standing crops of sycamore, beech and oak (Broome A and Johnson A, unpublished)." Annual impact to forestry in Ireland (Ireland and Northern Ireland combined) from grey squirrel is estimated at GBP 3,635,570 (€ 4,580,818); damage to buildings and other infrastructures is estimated at GBP 571,487 (€720,074)
2.12. How great is the economic cost of the organism likely to be in the future in Europe excluding management costs?	massive	high	Damage in Great Britain and Ireland is expected to remain at the levels now estimated because eradication is not possible and control is not able to reduce damage. Future damage is expected in hazelnut orchards in Piedmont (Currado et al. 1987, Currado 1993). Similar cost are expected if the species will be introduced in other countries without a rapid removal of the animals.

2.13. How great are the economic costs associated with managing this organism currently in Europe (include any past costs in your response)?	major	medium	The cost of control depends on the method used (In UK poison in grey squirrel-only areas, trapping or shooting elsewhere), the trapping intensity, personnel etc. (Huxley 2003). Two reports evaluated the cost of grey squirrel management in Great Britain (Williams et al. 2010) and Ireland, extrapolating nationwide local estimates. In Great Britain, an average price of GBP 15 per hectare is estimate as control cost to protect forestry, with an estimation of GBP 5,412,518 per annum for the whole country. Grey squirrels can do serious damage inside lofts and a total cost of GBP 1,914,555 is estimate for removing squirrels from buildings. The annual cost of grey squirrel control as part of the red squirrel protection is estimated to GBP 611,600. The average cost of controlling grey squirrels in Northern Ireland would be GBP 2,841,300 per year and €19,579,576 per year for Ireland. In Italy two LIFE projects for the control of grey squirrels in north (2010-2015) and central Italy (2014-2018) cost: € 1,930,00 and € 1,433,241 respectively.

2.14. How great are the economic costs associated with managing this organism likely to be in the future in Europe?	major	high	The cost for the control of grey squirrels in Great Britain and Ireland are expected to remain at the levels now estimated because eradication is not possible and thus control should be continued to reduce damage. In Italy future cost for managing the species will depends on the results of the two LIFE project but will continue because the eradication of the specie in the country is possible for most of the populations, but will require a long term strategy. Similar cost are expected if the species will be introduced in other countries without a rapid removal of the animals.
2.15. How important is environmental harm caused by the organism within its existing geographic range excluding Europe?	moderate	medium	No damage is known from South Africa. In North America the grey squirrel could have an impact on the native American red squirrel (Tamiasciurus hudsonicus) *but information is still scant*. In Vancouver Island (Canada), introduced grey squirrels pose a threat to sensitive Garry Oak ecosystems. They frequently bite out the tips of the cached acorns of some oaks, including Garry oaks, and may negatively affect oak regeneration. Grey squirrels can damage and kill trees, especially young oaks, by stripping the bark. Squirrels may also eat native lily bulbs such as camas (*Camassia* spp.) in Garry oak ecosystems (http://www.goert.ca/documents/InvFS_sciucaro.pdf).

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 Europe (include any past impact in your response)?	major	high	The grey squirrel threatens the native red squirrel with extinction due to resource competition (Wauters et al. 2001, 2002a, b; Gurnell et al. 2004). In Great Britain the competitive exclusion is also mediated by a squirrel poxvirus (Sainsbury et al. 2000; Rushton et al. 2006). Since the introduction of the alien species, red squirrels have gone extinct in large parts of Great Britain and in most of the area now occupied by the alien species in Piedmont, N. Italy (Gurnell et al. 2008 a,b; Bertolino et al. 2014) Bark stripping has influenced woodland management practices in England, where a shift away from trees susceptible to squirrel damage has been observed (Mayle, 2005), with an influence on the flora and fauna associated with specific woodland types. Squirrels predate eggs and fledgling of birds; further studies are required on whether they contribute to the decline of particular woodland bird species (Amar et al., 2006; Newson et al., 2010).
2.17. How important is the impact of the organism on biodiversity likely to be in the future in Europe?	major	high	If uncontrolled, the spread of the grey squirrel from Italy to France and Switzerland, and in the long term to other European countries, or the direct introduction of the species to other countries, will affect the survival of the native red squirrel. The potential impact on other species such as woodland birds or glirids is unknown but possible

2.18. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism currently in Europe (include any past impact in your response)?	moderate	medium	Bark stripping has influenced woodland management practices in England, where a shift away from trees susceptible to squirrel damage has been observed (Mayle, 2005), with an influence on the flora and fauna associated with specific woodland types.
2.19. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism likely to be in Europe in the future?	moderate/ major	medium	Bark stripping has influenced woodland management practices in England, but not in Italy. This is probably related to different woodland management practices in the two countries, with more natural forests in Italy (Kenward & Parish 1986; Kenward et al. 1992; Currado 1998). This habitat change is likely to continue in the future in Britain, while in case of introductions of the grey squirrel in other countries woodland damage and alteration will depends on local management practices.
2.20. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism currently in Europe?	moderate	high	Though not included in the Habitat Directive, the extinction of the red squirrel with its replacement by the grey squirrel decreases the conservation status of many areas.
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 Europe?	moderate	high	A decrease in the conservation status of many areas is expected if the red squirrel will be replaced by the grey squirrel in other parts of Scotland, Ireland, Italy and possibly in new areas of introduction.
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?	NA		

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?	minimal	low	Not known
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	Vector for squirrel poxvirus which causes a lethal disease in native red squirrels (Tompkins et al. 2002) Spill-over of gastro-intestinal nematode, *Strongyloides robustus* to native red squirrels occurs in Italy (Romeo et al. 2013, 2014), this may lead to parasite-mediated competition
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)	minimal	low	Not known
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 Europe?	major	medium	Predation is only rarely a major cause of mortality in grey squirrel populations (Koprowski 1994; Gurnell 1996). However, pine marten seems to have an impact in some parts of Ireland (Sheehy et al. 2014). Parasites and pathogens present in UK, Ireland and Italy do not limit the species.
2.27. Indicate any parts of Europe where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	[Most of the countries (see map)]	high	The European projection of the grey squirrel's climatic niche calculated in Maxent using records from native and invasive range predicted many highly suitable areas in a large extent of Europe (see attached map from Di Febbraro et al. 2013) including most of the European countries.

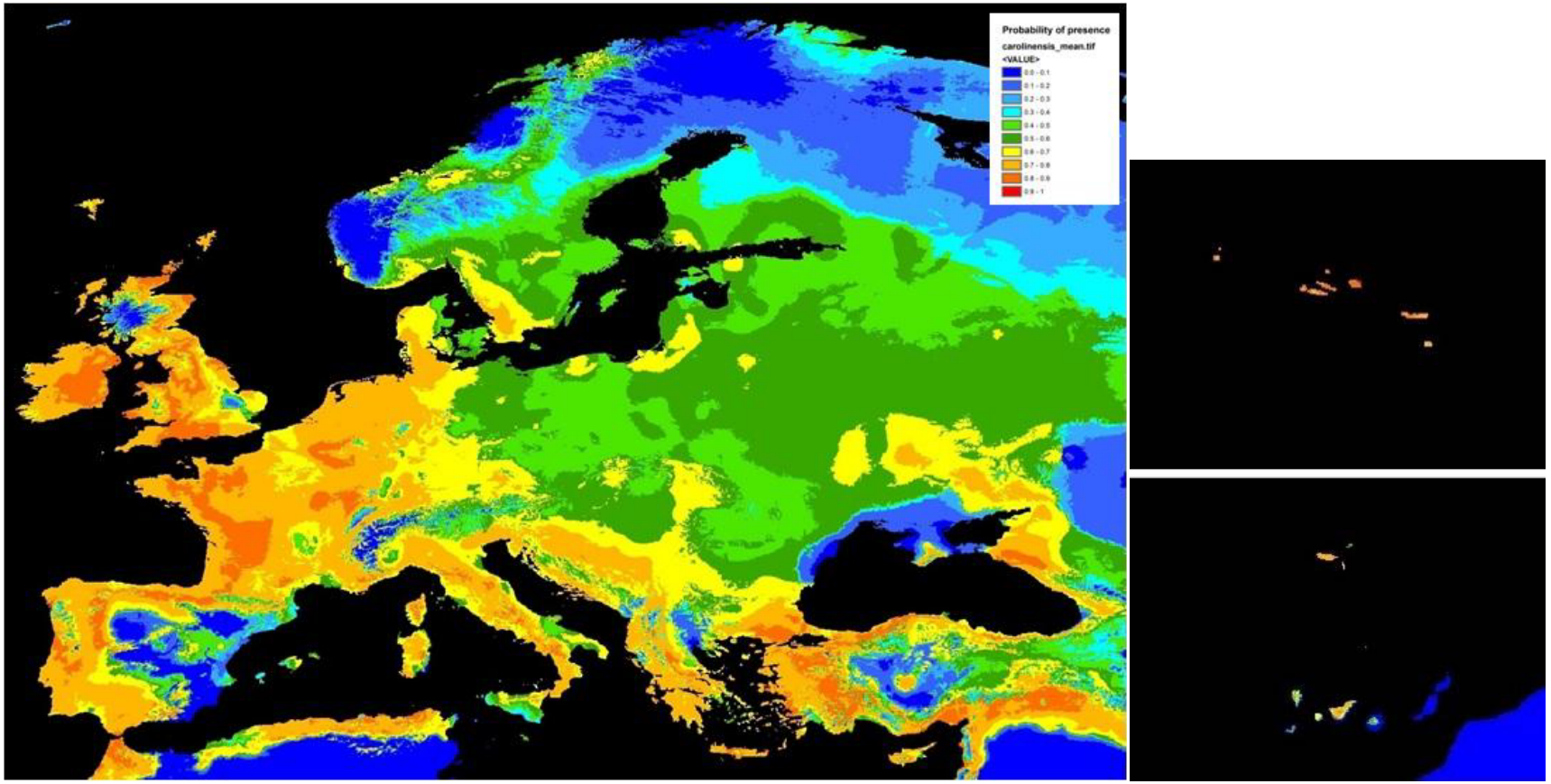
RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	likely	high	The grey squirrel is already present in Great Britain, Ireland and Italy. Both Ireland and Great Britain are islands and the main risk to the rest of Europe comes from pet trade and range expansion form Italy. Here the species is present in the northern part of the country close to the French and Swiss border and will spread in these countries (Bertolino et al. 20008) in a near future without an effective control in Italy. Management actions are ongoing in Italy despite a strong opposition from some animal right groups; considering the spread of the populations, control need to be continued for many years. The species is still traded in many European countries with the risk of new releases (UNEP-WCMC 2010).

Summarise Establishment	likely	high	The spread from Italy to other countries is likely as well as the possibility of human-mediated releases in other European countries. In such a situation, the successful establishment of new populations is highly likely. The climatic conditions in most of Europe are considered suitable for the establishment of grey squirrel populations (Di Febbraro et al. 2013). Temperate forests and woodlands in Europe have many tree species that are similar (same genus) than in the native area of grey squirrels and thus produce food resources similar in quantity and quality. The grey squirrel is a highly adaptive and opportunistic species and viable populations could establish from few founders. Animals are often released in urban parks, suburban gardens, parkland, which could provide suitable habitats with high food availability and supplementary feeding by humans that could help to overcome first periods with very low density; from here spread to forested habitats (deciduous, mixed and coniferous woodland) is likely considering the dispersal ability of the species (Koprowski 1994; Wauters et al. 1997; Lurz et al. 2001; Bertolino et al. 2014). Humans can further promote the spread of the species with translocation from one area to another (Shorten 1954; Martinoli et al. 2010; Signorile et al. 2014)

Summarise Spread	I moderately II rapidly	medium	I. Typical saturation dispersal of small-sized mammals; SEPD models show typical logistic growth with slow population growth and spread in the early phase after introduction, followed by rapid increase of population size and distribution range (Lurz et al. 2001; Tattoni et al. 2006; Bertolino et al. 2008). The species already spread over large areas in Great Britain, Ireland and Italy. II. Further spread of species via releases (accidental and deliberate introductions and translocations)
Summarise Impact	major	very high	Extinction of the native red squirrel (Gurnel & Pepper 1993; Gurnell et al. 2004; Bertolino et al. 2014); economic impacts to commercial forestry, damage to recreational trees and an influence on forestry tree species composition with a shift away from trees susceptible to squirrel damage and an impact on the flora and fauna associated with specific woodland types (Mayle 2005; Mayle & Broome 2013).
Conclusion of the risk assessment	high	high	A large number of scientific publications demonstrate the invasiveness of the grey squirrel, its economic impact (in Great Britain and Ireland) and mechanisms by which it replaces the native red squirrel, causing wide-scale extinction of the latter.

ADDITIONAL QUESTIONS - CLIMATE CHANGE			
3.1. What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	[Climate directly]	high	Squirrel populations will increase due to increased seeding of oak and warmer winters. Considering that warmer and drier conditions seem to favour the spread of the grey squirrel, the present climate change may further benefit the species in colonising new areas (Di Febbraro et al. 2013).
3.2. What is the likely timeframe for such changes?	50 - 100 years	medium	
3.3. What aspects of the risk assessment are most likely to change as a result of climate change?	[Increase suitability of some habitats]	medium	

ADDITIONAL QUESTIONS – RESEARCH			
4.1. If there is any research that would significantly strengthen confidence in the risk assessment please summarise this here.	[The species invasiveness is demonstrated by many papers]	high	Confidence in the risk assessment is high. A large number of scientific publications demonstrate the invasiveness of the grey squirrel, its economic impact (in Great Britain and Ireland) and mechanisms by which it replaces the native red squirrel, causing wide-scale extinction of the latter. The species is already established in large areas of Great Britain, Ireland and Italy. The European projections of the grey squirrel's climatic niche evaluated in Maxent show a high suitability for the species of most of Europe. Recent, parasitological studies (Romeo et al. 2013; 2014) highlighted the introduction to Italy of the Nearctic nematode *Strongyloides robustus* by grey squirrels and its subsequent spillover to the native species. The impact of this novel parasite on red squirrels (and potentially other rodents) is still unknown, but it deserves further attention, since it may potentially exacerbate the competition between the two sciurid species



European projections of grey squirrel's climatic niche calculated in Maxent using records from native and invasive range (Great Britain, Ireland, Italy). Maps taken from the results presented in Di Febbraro et al. (2013).

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