RISK ASSESSMENT COVERING PAGE - ABOUT THE PROCESS

It is important that policy decisions and action within Great Britain are underpinned by evidence. At the same time it is not always possible to have complete scientific certainty before taking action. To determine the evidence base and manage uncertainty a process of risk analysis is used.

Risk analysis comprises three component parts: risk assessment (determining the severity and likelihood of a hazard occurring); risk management (the practicalities of reducing the risk); and risk communication (interpreting the results of the analysis and explaining them clearly). This tool relates to risk assessment only. The Non-native Species Secretariat manages the risk analysis process on behalf of the GB Programme Board for Non-native Species. During this process risk assessments are:

- Commissioned using a consistent template to ensure the full range of issues is addressed and maintain comparable quality of risk and confidence scoring supported by appropriate evidence.
- Drafted by an independent expert in the species and peer reviewed by a different expert.
- Approved by the NNRAP (an independent risk analysis panel) only when they are satisfied the assessment is fit-for-purpose.
- Approved by the GB Programme Board for Non-native Species.
- Placed on the GB Non-native Species Secretariat (NNSS) website for a three month period of public comment.
- Finalised by the risk assessor to the satisfaction of the NNRAP and GB Programme Board if necessary.

Common misconceptions about risk assessments

The risk assessments:

- Consider only the risks (i.e. the chance and severity of a hazard occurring) posed by a species. They do not consider the practicalities, impacts or other issues relating to the management of the species. They also only consider only the negative impacts of the species, they do not consider any positive effects. They therefore cannot on their own be used to determine what, if any, management response should be undertaken.
- Are advisory and therefore part of the suite of information on which policy decisions are based.
- Are not final and absolute. They are an assessment based on the evidence available at that time. Substantive new scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

Period for comment

Once placed on the NNSS website, risk assessments are open for stakeholders to provide comment on the scientific evidence which underpins them for three months. Relevant comments are collated by the NNSS and sent to the risk assessor for them to consider and, if necessary, amend the risk assessment. Where significant comments are received the NNRAP will determine whether the final risk assessment suitably takes into account the comments provided.

To find out more: published risk assessments and more information can be found at https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=22

GB NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Name of organism: ***Callosciurus erythraeus***
Author: Maria Vittoria Mazzamuto, Lucas Wauters, Adriano Martinoli, Sandro Bertolino
Risk Assessment Area: European Union (28 Countries)

Draft: 05/12/2014

EU CHAPPEAU	
QUESTION	**RESPONSE**
1. In how many EU member states has this species been recorded? List them.	France, The Netherlands, Belgium, Italy
2. In how many EU member states has this species currently established populations? List them.	France, The Netherlands, Belgium, Italy
3. In how many EU member states has this species shown signs of invasiveness? List them.	France, The Netherlands, Belgium, Italy
4. In which EU Biogeographic areas could this species establish?	Continental area, probably Mediterranean area
5. In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them.	The species is established in Italy, France, Belgium, The Netherland. It probably also adapt to climatic condition present in Austria, Croatia, Czech Republic, Germany, Hungary, Luxembourg, Malta, Poland, Romania, Slovakia, Slovenia, Spain,.
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, mainly for the possibility to reduce population size or even 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** **[chose one entry, delete all others]**	**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?	*Callosciurus erythraeus* Pallas, 1779. EN: Pallas's squirrel (red-bellied tree squirrel); FR: ecureuil à ventre rouge (ecureuil de Pallas, ecureuil de Formose); IT: scoiattolo di Pallas; DE: Pallas-hörnchen	Yes, this species can be adequately distinguished from other entities of the same rank
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	A Risk Assessment has been conducted in Belgium and The Netherlands and the result was that the species has high potential of establishment and dispersal in those countries.
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?		South East Asia
6. What is the global distribution of the organism (excluding Europe)?		The species is native to the north-eastern part of South Asia: it is widely distributed in central and southern China (Smith & Xie 2008), and mainland Southeast Asia (Duckworth et al. 2008a). The countries concerned are: Bangladesh, north-eastern India (Molur et al. 2005), Myanmar, northern Thailand, Laos, southern and northern Vietnam, eastern Cambodia, Peninsular Malaysia and Taiwan (Moore & Tate 1965, Wilson & Reeder 2005, Duckworth et al. 2008a, Bertolino & Lurz 2013).

		Pallas's squirrels have been introduced to five localities of Argentina (Guichón et al. 2005, Benitez et al. 2010, Bertolino & Lurz 2013) and in at least 13 areas in Japan (1 area eradicated) (Abe et al. 2005, Ikeda et al. 2011), and to Hong Kong (2 known populations) (Ho 1994, Chung & Corlett 2006).
7. What is the distribution of the organism in Europe?		Southern France (Gurnell & Wauters 1998; Duff & Lawson 2004; Chapuis et al. 2011), a small area in south-east of The Netherlands close to Belgium border (Dijkstra et al. 2009) and north of Italy (Bertolino & Lurz 2013). In Belgium one of the two populations of the species has been eradicated (Stuyck et al. 2009) while a limited number of animals occur near Bree-Bocholt close to Dutch border and near the Dutch population (Schockert 2012).
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	The most evident damage caused by Pallas's squirrels is bark stripping, especially where and when food availability is weak (Guo et al. 2011): it can be really important as reported in France (Jouanin 1986), Argentina (Guichón & Doncaster, 2008) and Japan (Tamura & Ohara 2005). Bark stripping increases the risk of fungal infections and invertebrate damage, which can reduce timber yield (Mayle 2010). Another impact of *C. erythraeus* may be linked to the use of leaves, branches and bark to build its nests. Some potential problems of predation on native fauna have been mentioned in Argentina and Japan where predation on eggs was observed (Pereira et al. 2003; Guichón et al. 2005, 2009; Azuma 1998) but further studies are required. Unpublished data from North Italy suggest that interspecific competition with the native red squirrel occurs

		resulting in reduced density or even disappearance of the native species (Mazzamuto unpubl. data)
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 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 *Callosciurus* spp. (*C. erythraeus and C. finlaysonii* the introduced species considered) to successfully establish a viable population is 73% and a likelihood ratio of 90% is achieved with >4 animals (Bertolino 2009). The number of yearly litters is from 1 to 3 if the mast production (food supply) is high, with an average of 1.4 weaned offspring (Tamura et al. 1989; Dijkstra, com. pers.). Few studies of dispersal distances are available for this squirrel species, but it is usually considered that the maximum dispersal distance is about 5 km (Lin & Yo 1981, Guichón & Doncaster 2008). The species lives in deciduous, mixed and coniferous woodland habitats (Chapuis et al. 2011, Dijkstra & Dekker 2008, Dijkstra et al. 2009) feeding on tree seeds and a variety of other foods (tree flowers, buds, mushrooms, berries, occasionally insects and bird eggs; they may sometimes feed on cereals). The species is also

		found in suburban areas where it benefits from supplemental feeding (Bertolino & Lurz 2013).
13. Does the organism occur outside effective containment in Europe?	Yes	
14. Is the organism widely distributed in Europe?	Yes	Pallas's squirrel populations are present in France (Chapuis & Menigaux 2010), The Netherlands (Dijkstra 2010), Italy (Martinoli et al. 2010), and Belgium (Schockert 2012).
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 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 12 (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 EU or sufficiently similar for the organism to survive and thrive?	Yes	If they initially originate from tropical and subtropical broadleaf forests, due to their flexibility, they were also able to colonize warm temperate environments (Setoguchi 1990; Sheng et al. 1999) as well as subalpine broadleaf and coniferous forests until 3000 m of altitude (Smith & Xie 2008), but it seems they were not able to

		colonize the northern deciduous forests with harsh winter conditions (i.e. large snow precipitations and a mean temperature of coldest months lower than -4°C) (Setoguchi 1990, Bertolino 2009). Frost sensitivity of the Pallas's squirrel is likely to reduce its establishment capacity but the Dutch climate fully matches with the species requirements (Dijkstra & Dekker 2008).
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.
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 Japan (from years 1930s), Argentina (from 1970) and Hong Kong (1972) establishing viable populations. In Europe, Pallas's squirrel was introduced in Southern France at the end of the 1960s, while in The Netherlands (3 populations), Italy (1 population) and Belgium (two populations, one eradicated) the populations reported are quite recent (from 1998 onwards) (Bertolino & Lurz 2013).
21. Can the organism spread rapidly by natural means or by human assistance?	Yes	Good natural dispersal capacity (Lin & Yo 1981; Guichón & Doncaster 2008). Humans can further promote the spread of the species with translocation from one area to another (Shorten 1954; Guichón et al. 2005; Martinoli et al. 2010).
22. Could the organism as such, or acting as a vector, cause economic, environmental or social harm in Europe?	Yes	In its native area *C. erythraeus* is considered as a tropical crop pest (Hill 2008). It causes damages in fruit trees and crop plantations, eating and spoiling the fruits which are eaten as well as the green parts of coveted plants and significant economic impacts in the native range have been pointed out in many publications (especially on conifer plantations; Lin & Yo 1981; Kuo 1982; Tsui et al. 1982).

		In the new recipient areas, the most evident damage caused by this species is also bark stripping (especially where and when food availability is weak, Guo et al. 2011) with substantial economic loss of profit in tree plantations (Jouanin 1992, Stuyck et al. 2009); damage can be really important as reported in France (Chapuis & Menigaux 2010), Argentina (Guichón et al. 2009) and Japan (Tamura & Ohara 2005). In Argentina the consumption of cereals in storage silos is also reported (Guichón et al. 2009, Bertolino & Lurz 2013). However most of the data are qualitative and don't enable us to assess the quantitative losses caused by the Pallas's squirrel (Bertolino & Lurz 2013). Another impact of C. erythraeus may be linked to the use of leaves, branches and bark to build its nests. The species is also considered as a pest because of damages caused in gardens and plantations (bark stripping of trees and shrubs, fruit consumption especially in olive and citrus plantations and in orchards) and damages to infrastructures like telephonic cables, sprinkler systems, etc. In Argentina, such problems of deterioration of lighting, television and telephonic cables have also been reported (Dijkstra et al. 2009; Guichón et al. 2005, 2009; Chapuis & Menigaux 2010). Thus, nowadays, in France part of the citizens call it "Korean rat" (Chapuis et al. 2011). Competition with native species like the red squirrel (*Sciurus vulgaris*) is also considered a strong potential impact (Chapuis et al. 2011; Mazzamuto unpub. data) and transmission of pathogens could likely cause a risk but, currently, it is not documented enough.

SECTION B – Detailed assessment

PROBABILITY OF ENTRY

Important instructions:

- Entry is the introduction of an organism into Europe. Not to be confused with spread, the movement of an organism within Europe.
- 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 [chose one entry, delete all others]	CONFIDENCE [chose one entry, delete all others]	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 four 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. 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)?	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.

(If intentional, only answer questions 1.4, 1.9, 1.10, 1.11)			
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 November 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 Pallas's squirrels on Danish and Swedish websites; there were several advertisements for people wanting 'squirrels' in German and Swedish 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). The species is often released in urban parks, suburban gardens, parkland, etc., which could provide suitable habitats with supplemental feeding from humans (Bertolino et al. 2004; Bonnington et al. 2014a,b), and from here spread to forested habitats (deciduous, mixed and coniferous woodland) (Miyamoto et al. 2004; Guichón et al. 2005).
1.10. Estimate the overall likelihood of entry into Europe based on this pathway?	likely	high	The species is already present in Italy, France, Belgium and The Netherlands 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). In Italy a Decree signed on 24th December 2013 forbids trading, raising and keeping of Pallas's squirrel and two

			other squirrel species (*Sciurus niger*, *Sciurus carolinensis*). In The Netherlands there is the prohibition of trading and keeping the same three species since July 2012. In Belgium with the Royal Decree of 16th July 2009 *C. erythraeus* has not been included in the short positive list of mammal species that may be held by private people. This, however, does not stop the movements of animals within Europe where the species is already sold in some countries (UNEP-WCMC 2010).

PROBABILITY OF ESTABLISHMENT

Important instructions:

- 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.

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 France, Belgium, The Netherlands and Italy (Bertolino & Lurz 2013). If they initially originate from tropical and subtropical climate, due to their flexibility, they are also able to colonize warm temperate environments (Chapuis et al. 2011; Bertolino & Lurz 2013). Dutch cold climate also fully matches with the species requirements (Dijkstra & Dekker 2008). For these reasons climatic conditions in most of Europe is considered suitable for Pallas's squirrels.
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	The species lives in deciduous, mixed and coniferous woodland habitats so all the temperate forests and woodlands in Europe have many tree species that provide food resources to the species; (sub)urban park populations occur both in Europe and in the native Asian range.
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 and sometimes on cereals. The species is also 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 Europe?	NA		
1.17. How likely is it that establishment will occur despite competition from existing species in Europe?	likely	high	There are some data indicating competition with the native red squirrel, but outcome seems in favour of the alien species (Chapuis et al. 2001; Mazzamuto unpub. data)
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 were the species has been introduced in Europe.
1.19. How likely is the organism to establish despite existing management practices in Europe?	likely	high	In Belgium the species is not included in the short positive list of mammal species that may be held by private people and in The Netherlands and Italy there is the prohibition of trading and keeping the species. However, the species is still sold in other countries so a general wildlife management strategy in continental Europe is absolutely needed because all countries don't invest the same energy to prevent introductions of exotic species on their territory (Genovesi & Shine 2004). Just one population in Belgium has been eradicated while

			in The Netherlands, France and Italy eradication is still in progress. 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?	moderately likely	medium	The dispersal potential of the species seems to be very limited, but it is also clear that established populations in Europe and South America originated from few animals (Wood et al. 2007, Bertolino 2009), thus proving the adaptability of *Callosciurus erythraeus* to new habitats, even if the colonization is slow and thus moderate (Dijkstra et al. 2009). Tree squirrels are generally considered as particularly adaptable because of their relatively high reproductive potential, wide food habits, and plasticity to anthropogenic habitats (Palmer et al. 2007, UNEP-WCMC 2010). Thus, prompt actions are recommended in any case of suspected invasiveness leading to possible impacts (Stuyck et al. 2009; Schockert 2012).
1.22. How likely are the biological characteristics of the organism to facilitate its establishment?	very likely	high	The number of yearly litters is from 1 to 3 if the mast production (food supply) is high, with an average of 1.4 weaned offspring (Tamura et al. 1989; Dijkstra, com. pers.). The species has wide food habits and adaptability to new habitats (Bertolino & Lurz 2013).
1.23. How likely is the capacity to spread of the organism to facilitate its establishment?	likely	high	The dispersal capacity of juveniles away from their natal home range is considered to be lower than 5 km/year (Lin & Yo 1981, Guichón & Doncaster 2008). Bridgeman et al. (2012) consider *C. erythraeus* as able to cross some habitat gaps if

			the distance without connectivity is smaller than 100 m.
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?	likely	high	Pallas's squirrels have proven to be very successful invaders able to start new populations and spread even from few founders (Bertolino 2009; Schockert 2012).
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	25 out of 29 (86.2%) introductions outside the native range in Asia, South America, Europe were successful (Bertolino & Lurz 2013). The species already established in North (Belgium, The Netherlands) and South (France, 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 EU but is established because of continual release, is an example of a transient species.	unlikely	medium	If the species does not establish 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 (Belgium, The Netherlands) and South (France, Italy) Europe. Climatic conditions in most of Europe are considered suitable for Pallas's squirrels (Chapuis et al. 2011; Bertolino & Lurz 2013; Dijkstra & Dekker 2008). If they initially originate from tropical and subtropical broadleaf forests, they were also able to colonize warm temperate environments (Setoguchi 1990, Sheng et al. 1999) as well as subalpine broadleaf and coniferous forests until 3000 m of altitude (Smith & Xie 2008) indicating 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. Callosciurus erythraeus proven to be a very successful invader able to start new populations world-wide even from few founders (Bertolino 2009; Schockert 2012). Humans could help the spreading translocating them to new areas.

PROBABILITY OF SPREAD

Important notes:

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

QUESTION	RESPONSE	CONFIDENCE	COMMENT
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.)	major	high	Active saturation dispersal, mainly of immature individuals, which will colonize new areas of suitable habitat. Quantitative studies are not reported for Europe but the mean areal expansion rate observed in Japan and Argentina varies between 6 and 22 km²/year and is known to increase after the establishment phase.
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	Human assistance may amplify the potential of expansion of *C. erythraeus* by translocation. The main pathway of Pallas's Introductions in Europe has been connected to private citizens and animal traders who keep animals in captivity, with consequent risk of escape or release them into public estates and parks (Schockert 2012).
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).
2.4. Based on the answers to questions on the potential for	[Most of Europe]	high	See answers to questions 4 and 5 of EU CHAPPEAU

establishment and spread in Europe, define the area endangered by the organism.			
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?	0-10	high	
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	medium	Eradication programs are ongoing for all the colonies present in Italy, France, Belgium and Netherlands. If these management actions will not be effective a limited expansion is expected in next years.
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	high	In 10 years the outcome of the eradication programs ongoing in the four countries will be clear
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	Depending on the results of the eradication programs
2.9. Estimate the overall potential for future spread for this organism in Europe (using the comment box to indicate any key issues).	moderately	medium	Few studies of dispersal distances are available for this squirrel species, but it is usually considered that the maximum dispersal distance is about 5 km (Lin & Yo 1981, Guichón & Doncaster 2008). In case of new introduction in other countries, the likelihood of establishment is high and the spread could be from slowly to moderate, depending on the habitat.

PROBABILITY OF IMPACT

Important instructions:

- 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.
- 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).
- 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 EUROPE 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 excluding Europe, including the cost of any current management?	major	high	In its native area *C. erythraeus* is considered as a tropical crop pest (Hill 2008). It causes damages in fruit trees and crop plantations, eating and spoiling the fruits which are eaten as well as the green parts of coveted plants and significant economic impacts in the native range have been pointed out in many publications (especially on conifer plantations; Lin & Yo 1981; Kuo 1982; Tsui et al. 1982). In the new recipient areas, the most evident damage caused by this species is also bark stripping (especially where and when food availability is weak, Guo et al. 2011) with substantial economic loss of profit in tree plantations; damage can be really important, though not quantified, as reported Argentina (Guichón et al. 2009) and Japan (Tamura & Ohara 2005). In Argentina the consumption of cereals in storage silos is also reported (Guichón et al. 2009, Bertolino & Lurz 2013). However most of the data are qualitative and don't enable us to assess the quantitative losses caused by the Pallas's squirrel (Bertolino & Lurz 2013). The species is also considered as a pest because of

			damages caused in gardens and plantations (bark stripping of trees and shrubs, fruit consumption especially in olive and citrus plantations and in orchards) and damages to infrastructures like telephonic cables, sprinkler systems, etc. In Argentina, such problems of deterioration of lighting, television and telephonic cables have also been reported (Guichón et al. 2005, 2009).
2.11. How great is the economic cost of the organism currently in Europe excluding management costs (include any past costs in your response)?	moderate	medium	In Europe the most evident damage caused by this species is bark stripping, with substantial economic loss of profit in tree plantations (Jouanin 1992, Stuyck et al. 2009); damage can be really important as reported in France (Chapuis & Menigaux 2010), though not quantified. However most of the data are qualitative and don't enable us to assess the quantitative losses caused by the Pallas's squirrel (Bertolino & Lurz 2013). The species is also considered as a pest because of damages caused in gardens and plantations (bark stripping of trees and shrubs, fruit consumption especially in olive and citrus plantations and in orchards) and damages to infrastructures like telephonic cables, sprinkler systems, etc. (Dijkstra et al. 2009; Chapuis & Menigaux 2010).
2.12. How great is the economic cost of the organism likely to be in the future in Europe excluding management costs?	moderate	low	If the species is not eradicated or if it establish in other areas, damage reported in point 2.11 should be probably moderate, but is some are they could be major. Since available data are limited there is a high incertitude in these predictions.
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	Eradication programs are ongoing in four countries, manly by means of live trapping and euthanasia or keeping animals in captivity. Cost evaluation of these management actions are not yet available, but considering previous eradication programs on other species they should be high.

2.14. How great are the economic costs associated with managing this organism likely to be in the future in Europe?	moderate	low	Eradication programs are ongoing and therefore costs associated will still be present. If the species is not banned from Europe, the possibility of new introductions is high and therefore further management actions will be needed.
2.15. How important is environmental harm caused by the organism within its existing geographic range excluding Europe?	major	high	In its native area *C. erythraeus* is considered as a tropical crop pest (Hill 2008). It causes damages in fruit trees and crop plantations, especially in oil palm, papaya and cocoa trees, eating and spoiling the fruits which are eaten as well as the green parts of coveted plants. In Japan and Argentina the most evident damage caused by this species is bark stripping (especially where and when food availability is weak (Guo et al. 2011)) with substantial economic loss of profit in tree plantations (Tamura & Ohara 2005; Guichón et al. 2009). In Argentina the consumption of cereals in storage silos, damages to infrastructures like telephonic and television cables, sprinkler systems have also been reported (Guichón et al. 2005, 2009). In Japan the Pallas's squirrel could have an impact on the native squirrel species, *Sciurus lis*, that is locally declining (Ministry of the Environment, Japan, 2002; Hori et al. 2006).
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 activity of bark stripping typical of the species increases the risk of fungal infections and invertebrate damage with an influence on the flora and fauna associated with specific woodland types. Another impact may be linked to the use of leaves, branches and bark to build its nests. There are some potential problems of predation on bird eggs (Pereira et al. 2003; Guichón et al. 2005, 2009; Azuma 1998) but further studies are required on whether they contribute to the decline of particular woodland bird species in Europe.

			Competition with native species like *Sciurus vulgaris* is also considered a strong potential impact (Chapuis et al. 2011; Mazzamuto unpubl. data) and transmission of pathogens could likely cause a risk but, currently, it is not documented enough.
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 Pallas's 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, could probably affect the native red squirrel.
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 could influence woodland management practices, with a shift away from trees susceptible to squirrel damage (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	low	Bark stripping could influence woodland management practices (Mayle, 2005); its impact, however, will depend on the results of the eradication programs. In case of introductions of the species 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 Pallas's 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 Pallas's squirrel in other parts of France, Belgium, Netherlands and 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,	NA		

environmental or social effects more serious?			
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)?	minimal	low	Transmission of pathogens could likely be a risk but, currently, it is not documented enough.
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 cause of mortality in Pallas's squirrel populations (Tamura et al. 1989; Chapuis 2011; Schockert 2012). Parasites and pathogens present in Belgium, France, Netherlands and Italy do not limit the species (Dozières et al. 2010).
2.27. Indicate any parts of Europe where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	Depends on eradication outcomes and/or new introductions]	medium	Italy, France, Belgium, The Netherlands if eradication projects will not be effective. In other countries in the Continental and Mediterranean biogeographic areas if the species will be introduced.

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	very likely	high	The species is already present in the Risk Assessment area in Italy, France, Belgium and The Netherlands with viable populations (Bertolino & Lurz 2013). The primary pathway for entry involves their escape or deliberate 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. The species is still intentionally imported and traded in many European countries (UNEP-WCMC 2010) and is already keeps in wildlife parks, zoological gardens, private collections and pet shops.
Summarise Establishment	very likely	high	The species already established in France, Belgium, The Netherlands and Italy (Bertolino & Lurz 2013). If they initially originate from tropical and subtropical climate, due to their flexibility, they are also able to colonize warm temperate environments (Chapuis et al. 2011; Bertolino & Lurz 2013). Dutch cold climate also fully matches with the species requirements (Dijkstra & Dekker 2008). For these reasons climatic conditions in most of Europe is considered suitable for Pallas's squirrels. The species lives in deciduous, mixed and coniferous woodland habitats so all the temperate forests and woodlands in Europe have many tree species that provide food resources to the species; (sub)urban park populations occur both in Europe and in the native Asian range.
Summarise Spread	moderately	medium	Eradication programs are ongoing for all the colonies present in Italy, France, Belgium and Netherlands. If these management actions will not be effective an

			expansion is expected in next years. In case of new introduction in other countries, the likelihood of establishment is high and the spread could be from slowly to moderate, depending on the habitat. Active saturation dispersal, mainly of immature individuals, which will colonize new areas of suitable habitat. Quantitative studies are not reported for Europe but the mean areal expansion rate observed in Japan and Argentina varies between 6 and 22 km²/year and is known to increase after the establishment phase. Human assistance may amplify the potential of expansion of *C. erythraeus* by translocation
Summarise Impact	major	medium	The magnitude of present and future impacts will depends on the results of ongoing management activities and the possible establishment of new populations The most evident damage caused by Pallas's squirrels is bark stripping, especially where and when food availability is weak (Guo et al. 2011): it can be really important as reported in France (Jouanin 1986), Argentina (Guichón & Doncaster, 2008) and Japan (Tamura & Ohara 2005). Bark stripping increases the risk of fungal infections and invertebrate damage, which can reduce timber yield (Mayle 2010). Another impact of *C. erythraeus* may be linked to the use of leaves, branches and bark to build its nests. Some potential problems of predation on native fauna have been mentioned in Argentina and Japan where predation on eggs was observed (Pereira et al. 2003; Guichón et al. 2005, 2009; Azuma 1998) but further studies are required. Unpublished data from North Italy suggest that interspecific competition with the native red squirrel occurs resulting in reduced density or even disappearance of the native species (Mazzamuto unpubl. data).

Conclusion of the risk assessment	high	medium	A large number of scientific publications demonstrate the invasiveness of *Callosciurus erythraeus* in terms of establishment probabilities and damage to forestry and plantations. Data on the possible impacts on native species (e.g. predation or competition) are scanty though preliminary results of ongoing research suggest that interspecific competition with the native red squirrel occurs resulting in reduced density or even disappearance of the native species (Mazzamuto unpubl. data).

Additional questions are on the following page ...

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	*Callosciurus erythraues* initially originate from tropical and subtropical broadleaf forests, due to their flexibility, they were also able to colonize warm temperate environments (Setoguchi 1990; Sheng et al. 1999) as well as subalpine broadleaf and coniferous forests until 3000 m of altitude (Smith & Xie 2008), but it seems they were not able to colonize the northern deciduous forests with harsh winter conditions (i.e. large snow precipitations and a mean temperature of coldest months lower than -4°C) (Setoguchi 1990, Bertolino 2009). Frost sensitivity of the Pallas's squirrel is likely to reduce its establishment capacity but the Dutch climate fully matches with the species requirements (Dijkstra & Dekker 2008). Considering that warmer and drier conditions seem to favour the spread of the species, the present climate change may further benefit the species in colonising new areas.
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 impact to native fauna should be further investigated]	medium	Confidence in the risk assessment is high for establishment, spread and damage to forestry and plantations. Data on the possible impacts on native species are scanty though preliminary results suggest a possible competition with the native red squirrel; there

			are also occasional reports of bird eggs predation. The impacts on native species should be further investigated to better evaluate the level of invasiveness of the species. The outcomes of the ongoing eradication programs should be published to better evaluate costs and effectiveness of these management actions.

Please provide a reference list on the following page ...

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