Risk assessment template developed under the "Study on Invasive Alien Species – Development of risk assessments to tackle priority species and enhance prevention" Contract No 07.0202/2017/763379/ETU/ENV.D.2[1]

S. richetri worker, credits : Alex Wild

Name of organism: *Solenopsis richteri,* Forel, 1909.

Author(s) of the assessment:
Olivier Blight, Dr, Institut Méditerranéen de Biodiversité et d'Ecologie, Avignon University, France

Risk Assessment Area:
The risk assessment area is the territory of the European Union, excluding the outermost regions.

Peer review 1: Wolfgang Rabitsch, Environment Agency Austria, Vienna, Austria
Peer review 2: Jørgen Eilenberg, University of Copenhagen, Denmark
Peer review 3: Richard Shaw, CABI, UK
Peer review 4: Marc Kenis, CABI, Switzerland

This risk assessment has been peer-reviewed by four independent experts and discussed during a joint expert workshop. Details on the review and how comments were addressed are available in the final report of the study.

Date of completion:
First draft: 10/18/2018
Second draft following comments from the Scientific Forum: 11/02/2020

[1] This template is based on the Great Britain non-native species risk assessment scheme (GBNNRA).

Contents

RISK SUMMARIES

	RESPONSE	CONFIDENCE[2]	COMMENT
Summarise Entry[3]	very unlikely unlikely **moderately likely** likely very likely	low **medium** high	The most important pathway of introduction for *S. richteri* in Europe is the entry of nests as contaminant of nursery material (including soil) and as stowaway/hitchhiker in container/bulk or other commodities (e.g. vehicles, machinery, packaging material). However, the propagule pressure of nests is largely unknown. Polygyne colonies in South America are mobile and disperse by budding, promoting the chances of queens with workers being transported from this region. Queen ants are also likely to arrive as hitchhikers, but only aircraft will allow the fast transfer that will allow a successful establishment. The entry of *S. richteri* in the EU is scored moderately likely because it has never been intercepted at the Netherlands border (nor has it in Australia, Hawaii or New Zealand and only once in the USA). Moreover, *S. richteri* has a restricted North American distribution. It is more widespread in southern Brazil, Uruguay, and northern Argentina. This assessment of moderately likely risk of entry should be reconsidered in the future if its distribution expands beyond the Americas.
Summarise Establishment[4]	very unlikely unlikely	low **medium** high	Once it enters, *S. richteri* is likely to find suitable habitat for nesting in close proximity to sites of arrival. However, there is only limited experimental data on

[2] In a scale of low / medium / high, see Annex III

[3] In a scale of very unlikely / unlikely / moderately likely / likely / very likely, see Annex I

[4] In a scale of very unlikely / unlikely / moderately likely / likely / very likely, see Annex I

	moderately likely likely **likely** very likely		climate tolerances of *S. richteri*. The climate assessment is based principally on consideration of the large body of experimental data relating to *S. invicta*, and on climate estimates from known sites of establishment of *S. richteri*. Species distribution model available for *S. richteri* indicates a total area below 2% of the EU suitable for its establishment. The climate of the Atlantic region is considered suitable for establishment. *S. richteri* is unlikely to encounter natural enemies but would encounter competition from other dominant ants. Its ability to establish at sites dominated by *Linepithema humile* or *Tapinoma magnum* is unknown. It is likely that if established, the ant will have a patchy distribution, with moderate to high densities and extent in open disturbed habitats. This assessment is based on one species distribution model. The use of additional models may improve the prediction and confidence level of this assessment.
Summarise Spread[5]	very slowly slowly **moderately** rapidly very rapidly	low **medium** high	In all potentially infested biogeographical regions, *S. richteri* will probably spread moderately compared to other insects. Suitable habitat and climate occur in the EU. A range of low vegetation cover habitats are favoured, including urban areas, agricultural land and grasslands; forest is unlikely to be colonised. Colony development is relatively slow, and sub-optimal temperatures are likely to restrict foraging and colony

[5] In a scale of very slowly / slowly / moderately / rapidly / very rapidly

			development and extend the period from colony founding to the production of reproductives. Although *S. richteri* can spread by natural means over few kilometres per year, its spread will occur mainly through human-assisted transport, in particular with soil and infested items, but its distribution will be constrained by climate, habitat suitability and competition from other dominant ants.
Summarise Impact[6]	minimal minor **moderate** major massive	**low** medium high	There is currently limited published information on the impacts of *S. richteri* in invaded areas in the USA, which constrains the impact assessment. However, considering its similarity to *S. invicta*, it is likely that the species locally has a moderate to major environmental, economic and social impacts in invaded areas. It has significant medical consequences, even at low ant densities, due to human reactions to the venom. Moreover, the presence of colonies in urban areas can impact negatively outdoor activities and resulting in initiation of pest control. It has some detrimental impacts in agriculture (e.g., stinging domestic stock) and horticulture (e.g., stinging pickers, mounds interfering with equipment) wherever the ant established. Finally, it is likely that *S. richteri* has a negative impact on biodiversity. *Solenopsis richteri* may impact plant/insect interactions by reducing the abundance and richness of local ants and more broadly ground active insects. They may also imperil lizards and birds similar to the impact of *S. invicta*. The transferability to Europe is hindered by uncertain data on habitat/climatic suitability that may limit the

[6] In a scale of minimal / minor / moderate / major / massive, see Annex II

			geographic area that is most favourable to the insect. In other words, if only limited zones in the Atlantic and Continental biogeographical regions will be favourable for the ant, impacts will be largely restricted to these zones.
Conclusion of the risk assessment[7]	low **moderate** high	**low** medium high	*Solenopsis richteri* is not one of the most successful invasive ants on earth but there is no doubt that it can enter Europe through a variety of pathways. However, its limited native and introduced distribution reduces the likelihood of it being accidently transported to Europe. Its establishment and impact will be constrained by climatic, habitat suitability and competition from other dominant ant species. It might become an environmental, economic and social pest in some areas of West Europe, but the extent of its potential distribution remains unclear. This assessment of moderate risk should be reconsidered if its distribution expands beyond the Americas.

[7] In a scale of low / moderate / high

Distribution Summary:

The columns refer to the answers to Questions A6 to A12 under Section A.
The answers in the tables below indicate the following:

Yes recorded, established or invasive
– not recorded, established or invasive
? Unknown; data deficient

Member States

	Recorded	Established (currently)	Established (future)*	Invasive (currently)
Austria	-	-	YES	-
Belgium	-	-	-	-
Bulgaria	-	-	-	-
Croatia	-	-		-
Cyprus	-	-	-	-
Czech Republic	-	-	YES	-
Denmark	-	-	-	-
Estonia	-	-	-	-
Finland	-	-	-	-
France	-	-	YES	-
Germany	-	-	YES	-
Greece	-	-		-
Hungary	-	-	-	-
Ireland	-	-	YES	-
Italy	-	-	YES	-
Latvia	-	-	-	-
Lithuania	-	-	-	-
Luxembourg	-	-	-	-
Malta	-	-	-	-
Netherlands	-	-	-	-
Poland	-	-	YES	-
Portugal	-	-	YES	-
Romania	-	-	-	-

Slovakia	-	-	-	-
Slovenia	-	-	YES	-
Spain	-	-	YES	-
Sweden	-	-	-	-
United Kingdom	-	-	YES	-

*Countries with suitability index >0.5 in current climate or foreseeable climate change in Bertelsmeier et al. (2015)

Biogeographical regions of the risk assessment area

	Recorded	Established (currently)	Established (future)	Invasive (currently)
Alpine	-	-	-	-
Atlantic	-	-	YES	-
Black Sea	-	-	-	-
Boreal	-	-	-	-
Continental	-	-	YES	-
Mediterranean	-	-	YES	-
Pannonian	-	-	-	-
Steppic	-	-	-	-

Marine regions and subregions of the risk assessment area

	Recorded	Established (currently)	Established (future)	Invasive (currently)
Baltic Sea				
Black Sea				
North-east Atlantic Ocean				
Bay of Biscay and the Iberian Coast				
Celtic Sea				
Greater North Sea				
Mediterranean Sea				
Adriatic Sea				
Aegean-Levantine Sea				
Ionian Sea and the Central Mediterranean Sea				
Western Mediterranean Sea				

SECTION A – Organism Information and Screening	
Organism Information	**RESPONSE**
A1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	Scientific name: *Solenopsis richteri* Forel 1909. Class: Insecta Order: Hymenoptera Family: Formicidae Genus: *Solenopsis* Westwood, 1840 *Solenopsis richteri* can be recognized by their large mounds, polymorphic castes (varying sizes of workers), and 10-segmented antennae ending in a 2-segmented club. However, because *S. richteri* hybridizes with *S. invicta*, it can be a challenge to differentiate them from the hybrid, which may have characters of both species. The most reliable methods for identification of this group is a cuticular hydrocarbon test or a genetic analysis. Recently, however, immunoassays have been suggested as a means for discrimination between *S. invicta*, *S richteri* and hybrids (Valles et al 2018). Original name: *Solenopsis pylades* var. *richteri* Forel 1909 Synonyms: *Solenopsis saevissima* var. *oblongiceps* Santschi 1936, *Solenopsis pylades* var. *tricuspis* Forel, 1912, *Solenopsis saevissima* st. *richteri* Forel 1909, *Solenopsis saevissima* var. *tricuspis* Forel, 1912. A comprehensive and regularly updated list can be found at www.antweb.org . Common name: Black Imported Fire Ant (BIFA) Due to the limited distribution of *S. richteri* in the USA, there is much more information available on the biology and ecology of *S. invicta*. Where there was a shortage of information on *S. richteri* this is supplemented with information on *S. invicta* in this pest risk assessment, but this is made clear each time.
A2. Provide information on the existence of other species that look very similar [that may be detected in the risk assessment area, either in the	The genus *Solenopsis* contains about 200 species, among which 18 to 20 are “true fire ants”, which all look very similar and have the potential of becoming invasive (Trager 1991), four of them are considered invasive, *Solenopsis invicta*, *Solenopsis geminata*, *Solenopsis richteri* and *Solenopsis papuana*.

wild, in confinement or associated with a pathway of introduction]	Fire ants are a group of related species that has its centre of diversity in southern South America. Identification of fire ants to species is difficult and usually involves evaluating the morphology of a series of major workers rather than just one specimen. No varieties or breeds of *S. richteri* are known, but hybridization between *Solenopsis* species is regularly observed, particularly between *S. invicta* and *S. richteri*. Hybrid fire ants occupy about 130 000 km^2 in North America, a considerably larger area than remains of *S. richteri* (~30 000 km) in North America (Tschinkel 2006). A regularly updated distribution map can be found at www.antweb.org. The two taxa are still considered separate because they are seen as distantly related within the *S. saevissima* complex by genetic (Ross and Trager 1990) and morphological characterization (Trager 1991). The hybrid taxon is excluded from this assessment. A key for separation of the taxa in the *Solenopsis* species-group was provided by Trager (1991).
A3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment and its validity in relation to the risk assessment area)	A risk assessment has been made for fire ants (*Solenopsis* spp.) in the Netherlands, but focused rather on *S. invicta* and *S. geminata* than on *S. richteri*. The RA concludes that, although they are regularly found during import inspections in the Netherlands, it is unlikely that they could establish outdoors in the country. However, establishment in permanently heated buildings is possible (e.g. *Solenopsis geminata*), and can cause nuisance to humans through their sting and the destruction of equipment such as electrical installations (including air conditioner units, computers, etc.) (Noordijk 2010). *S. richteri* has not been intercepted at the Netherlands border unlike *S. invicta* and *S. geminata*. Another RA relevant for Europe has been carried out for New Zealand, which classified *S. richteri* as having a *low risk* of entry and a *moderate* to *high risk* of establishment and spread (Harris et al. 2005). However, RA made for different regions are not easily comparable.
A4. Where is the organism native?	*Solenopsis richteri* is native to South America, from south-eastern Brazil (Rio Negro, Paraná) west into Misiones province (Trager 1991). The southern part of the range is limited by the Atlantic Ocean on the east and extends west to Mendoza Province and as far south as Uruguay (Lofgren et al. 1975), and Buenos Aires Province in Argentina (Briano and Williams 2002).
A5. What is the global non-native distribution of the organism outside the risk assessment area?	*Solenopsis richteri* has established outside its native range only in the southern USA. Its current distribution, restricted by the presence of *S. invicta* with which it does not co-exist, is an area of about 30,000 km^2 in north-western Alabama, north eastern Mississippi, and southern Tennessee (www.antweb.org). Between S. *richteri* and *S. invicta* is a band of territory occupied by a hybrid between the two species (Trager 1991). *S. richteri* is thought to be more tolerant to cold temperatures and has the capacity to spread to areas marginally suitable for *S. invicta* in the USA (Korzukhin et al. 2001).

A6. In which biogeographical region(s) or marine subregion(s) in the risk assessment area has the species been recorded and where is it established?	Recorded: Not yet recorded or established in the risk assessment area Established: Not yet recorded or established in the risk assessment area
A7. In which biogeographical region(s) or marine subregion(s) in the risk assessment area could the species establish in the future under current climate and under foreseeable climate change?	Current climate (suitability index above 0.5 in Bertelsmeier et al. (2015), see annex VI: Atlantic, Continental and Mediterranean biogeographical regions Future climate (suitability index above 0.5 in Bertelsmeier et al. (2015), see annex VI): Atlantic, Continental, Mediterranean and Alpine biogeographical regions. To consider a range of possible future climates, Bertelsmeier et al. (2015) used downscaled climate data from three GCMs: the CCCMA-GCM2 model; the CSIRO MK2 model; and the HCCPR-HADCM3 model (GIEC 2007). Similarly, they used the two extreme SRES: the optimistic B2a; and pessimistic A2a scenario. According to the only available species distribution model (Bertelsmeier et al. 2015), *S. richteri* will not establish widely in Europe under both current and future climatic conditions until 2080. However, it will have the capacity to do so in Southern Europe in the Atlantic, the Continental and the Mediterranean biogeographical regions. It is also predicted that the Alpine biogeographical region will be suitable, but with a low habitat suitability index, in 2080. For details on the assumptions made in relation to climate change see Annex VI: projection of climatic suitability. A number of underlying assumptions and inherent uncertainties are associated with the niche modelling approach and the actual distribution is contingent on many factors. This species distribution model is only based on climate data developed at a coarse scale. It does not include information on biotic interactions or other abiotic factors having an influence at a regional or global scale. The choice of the 0.5 threshold is arbitrary. There is uncertainty about the potential and future geographic distribution of the species. Confidence will be increased with other species distribution model.
A8. In which EU member states has the species been recorded and in which EU member states has it established? List them with an indication of the timeline of observations.	Not yet recorded or established in the risk assessment area
A9. In which EU member states could the species establish in the future under current climate and under foreseeable climate change?	According to the only available species distribution model (Bertelsmeier et al. 2015), *S. richteri* is not predicted to establish widely in Europe under both current and future climatic conditions until 2080 (Annex VI). The range of habitat suitability is expected to increase in the future (2080) but areas scored with the highest suitability index will decrease. The bioclimatic variables used were derived from monthly temperature and rainfall values from 1960 to 1990, and represent annual trends (e.g., mean annual

	temperature, annual precipitation), seasonality (e.g., annual range in temperature and precipitation) and extreme or limiting environmental factors (e.g., temperatures of the coldest and warmest month, and precipitations of the wet and dry quarters) which are known to influence species distributions. To consider a range of possible future climates, they used downscaled climate data from three GCMs: the CCCMA-GCM2 model; the CSIRO MK2 model; and the HCCPR-HADCM3 model (GIEC 2007). Similarly, they used the two extreme SRES: the optimistic B2a; and pessimistic A2a scenario. Current climate (suitability index above 0.5 in Bertelsmeier et al. (2015): France, Germany, Ireland, Slovenia, United Kingdom. Future climate (suitability index above 0.5 in Bertelsmeier et al. 2015): Austria, France, Ireland, Italy, Slovenia, United Kingdom. This species distribution model is only based on climate data developed at a coarse scale. It does not include information on biotic interactions or other abiotic factors having an influence at a regional or global scale. The choice of the 0.5 threshold is arbitrary. There is uncertainty about the potential and future geographic distribution of the species. Confidence will be increased with other species distribution model.
A10. Is the organism known to be invasive (i.e. to threaten or adversely impact upon biodiversity and related ecosystem services) anywhere outside the risk assessment area?	Yes. It is considered to be invasive. It has ecological and economic impacts albeit its impacts are restricted to the USA. However some authors do not consider this species as invasive but rather as having the capacity to become invasive (e.g. Peterson and Nakazawa 2008).
A11. In which biogeographical region(s) or marine subregion(s) in the risk assessment area has the species shown signs of invasiveness?	None.
A12. In which EU member states has the species shown signs of invasiveness?	None.
A13. Describe any known socio-economic benefits of the organism.	At present there are no socio-economic benefits in areas where it is invasive. The species is not present in the RA area.

SECTION B – Detailed assessment

Important instructions:

- In the case of lack of information the assessors are requested to use a standardized answer: "No information has been found."
- The classification of pathways developed by the Convention of Biological Diversity shall be used For detailed explanations of the CBD pathway classification scheme consult the IUCN/CEH guidance document[8] and the provided key to pathways[9].
- With regard to the scoring of the likelihood of events or the magnitude of impacts see Annexes I and II.
- With regard to the confidence levels, see Annex III.

PROBABILITY OF INTRODUCTION and ENTRY

Important instructions:

- Introduction is the movement of the species into the risk assessment area.
- Entry is the release/escape/arrival in the environment, i.e. occurrence in the wild. Not to be confused with spread, the movement of an organism within the risk assessment area.
- For organisms which are already present in the risk assessment area, only complete this section for current active or if relevant potential future pathways. This section need not be completed for organisms which have entered in the past and have no current pathway of introduction and 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 introduction of this organism? (If there are no active pathways or potential future pathways respond N/A and move to the Establishment section)	none very few few moderate number **many** very many	low medium **high**	Ants can be dispersed through many different pathways (Suarez et al. 2005).

[8] https://circabc.europa.eu/sd/a/738e82a8-f0a6-47c6-8f3b-aeddb535b83b/TSSR-2016-010%20CBD%20categories%20on%20pathways%20Final.pdf
[9] https://circabc.europa.eu/sd/a/0aeba7f1-c8c2-45a1-9ba3-bcb91a9f039d/TSSR-2016-010%20CBD%20pathways%20key%20full%20only.pdf

1.2. List relevant pathways through which the organism could be introduced. Where possible give detail about the specific origins and end points of the pathways as well as a description of any associated commodities. For each pathway answer questions 1.3 to 1.10 (copy and paste additional rows at the end of this section as necessary). Please attribute unique identifiers to each question if you consider more than one pathway, e.g. 1.3a, 1.4a, etc. and then 1.3b, 1.4b etc. for the next pathway.	a) Transport-Stowaway (Hitchhikers in or on airplane) b) Transport-Contaminant (nursery material and other matters from horticultural trade) c) Transport-Stowaway (nests transported in container/bulk, including sea freight, airfreight, train, etc.)		*Solenopsis richteri* is termed a "tramp" ant, it can hitchhike with many commodities through many pathways. However, only the entry of queen ants and nests present a risk of establishment. In the case of an independent colony foundation, the queen has to find a suitable place quickly after the nuptial flight. These restrictions reduce the number of active pathways as the risk of predation is very high. *S. richteri* has only invaded the USA, so data of potential pathways of introduction are lacking. It has not been intercepted in New Zealand, nor in Australia, Hawaii or the Netherlands. Harris et al. (2005) provides a very detailed analysis of these potential pathways of introduction of *S. richteri* in New Zealand, which is also relevant for Europe.
Pathway name:	a) Transport-Stowaway (Hitchhikers in or on airplane)		
1.3a. Is introduction along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)? (if intentional, only answer questions 1.4, 1.9, 1.10, 1.11 – delete other rows)	intentional **unintentional**	low medium **high**	This concerns only newly-mated queens that are transported few hours after mating.
1.4a. 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?	very unlikely **unlikely** moderately likely likely very likely	**low** medium high	No *S. richteri* queens have been intercepted at ports or airports in New Zealand nor in Australia (Harris 2005; Lester 2013).

Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.			Although few data are available on ant interceptions at ports and airports, the proportion of queens in interception database is very low which suggests a relatively low number of newly-mated queens travelling along this pathway.
1.5a. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	very unlikely **unlikely** moderately likely likely very likely	**low** medium high	Queen ants are able to survive several tens of days using their own reserves before the first workers emerge when they are hidden in their nest with humidity. However, their chance of survival and of establishing a nest decreases in nature after few hours if they are not settled in a nest. Considering that ships from the nearest infested areas take more than a week to reach the EU, newly-mated queens might only arrive successfully in airplanes. However, it cannot be ruled out that newly-mated queens establish a nest on a ship if they find suitable conditions (see Qu. 1.5a). Multiplication and the establishment of a small nest during an intercontinental flight however is highly unlikely.
1.6a. How likely is the organism to survive existing management practices during passage along the pathway?	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	N/A. There are no management practices against hitchhiking ants or ant queens in or on airplanes in place.
1.7a. How likely is the organism to enter the risk assessment area undetected?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Solitary queens or even several queens or small nests are not easy to detect in cargo planes and thus their detection rates will be low.
1.8a. How likely is the organism to arrive during the months of the year most appropriate for establishment?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Nuptial flights of *S. richteri* occur at air temperature as low as 21°C (Lofgren et al. 1975). In *S. invicta* flights can occur all year in subtropical areas but predominantly occur in late summer (May through August in North America/USA) when climate conditions are most

			suitable and soil temperatures optimal (Lofgren et al. 1975). In Europe a relatively narrow window of suitable conditions is likely for nuptial flights. However, commodities with which ants can enter Europe are imported throughout the year.
1.9a. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Many airports are surrounded by suitable habitats including irrigated/watered gardens and parks. Indeed, this species simply requires soil as a substrate in which to establish a nest and has been found to occur in diverse open areas of pastures, cultivated fields, and lawns (Taber 2000).
1.10a. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	very unlikely unlikely **moderately likely** likely very likely	low **medium** high	The likelihood is scored moderately likely because the number of queen ants travelling through this pathway is expected to be relatively low and the duration of the transportation would be unlikely to favour the survival of the queen. Harris et al. (2005) scored the likelihood of introduction of a *S. richteri* queen ant by aircraft as "low".
Pathway name:	*b)* Transport-Contaminant (nursery material and other matters from the horticultural trade)		
1.3b. 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 **unintentional**	low medium **high**	This concerns both fully developed nests (with active workers-the maximum size of a fully developed colony of *S. invicta* may reach more than 200,000 workers (Tschinkel 2006).) and newly-founded nests (before workers are developed and start foraging) transported in nursery material by the horticultural trade. Newly-founded nests can also be formed by queens transported in ships before the nursery material arrives at destination. A free volume of 10ml should be sufficient for an incipient colony composed by a queen and a dozen of workers.

1.4b. 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. Also comment on the volume of movement along this pathway.	very unlikely unlikely **moderately likely** likely very likely	low **medium** high	There are no data on *S. richteri* nests arriving through the horticultural trade in Europe, nor in the USA, in New Zealand and in Australia. Ants are not listed as quarantine pests in the EU and, therefore, records rarely appear in the national and international lists of intercepted pests. However, millions of plants arrive with soil or in pots (with substrates) from infested areas (southern US, Mexico, Caribbean islands and China) every year in Europe and, although the soil/substrate is supposed to be sterile, infestation by ants can occur just before or during transport. Flower pots are one of the preferred habitats for *S. invicta* in invaded regions, in particular because of their humidity and because they are usually in contact with the ground. Other horticultural material such as mulch, hay and other plant material can harbour ant nests. Both polygynous and monogynous nests occur in *S. richteri*. Polygynous colonies are particularly large since they include many queens and may contain thousands of workers. The maximum size of a fully developed colony of *S. invicta* may reach more than 200,000 workers (Tschinkel 2006). In *S. richteri* (and other members of the *S. saevissima* species group) specific amino acid substitutions in a gene are associated with the expression of monogyny or polygyny (Ross et al. 2003). Approximately half the *S. richteri* colonies examined in San Eladio, Argentina were polygyne with up to 180 queens (Calcaterra et al. 1999). Only monogyne colonies have been found in the USA (Vogt et al. 2004), which suggests that either only the monogyne form has been introduced, or, if the polygyne form did establish, it has subsequently disappeared.

			Ant nests might get into this pathway in large numbers as contaminants of horticultural materials including soil. The likelihood of reinvasion after eradication is identical to the likelihood of introduction in the first place. NB: The number of ports of origin are limited compared to other invasive ants that are widely distributed across the world.
1.5b. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	Ant queens are able to survive several tens of days using their own reserves before the first workers emerge. Once sealed in a newly-founded nest, a *S. invicta* queen is able to survive 13 to 95 days, i.e. much longer than before nest establishment (Markin et al. 1972). Likelihood of survival nevertheless will decrease with increasing travel duration. Multiplication of a small nest during intercontinental translocation however is highly unlikely.
1.6b How likely is the organism to survive existing management practices during passage along the pathway?	very unlikely unlikely moderately likely **likely** very likely	**low** medium high	Horticulture plants and soils/substrates are usually chemically treated-fumigation using Methyl Bromide or Phosphine is the usual method used for disinfestations of consignments (FAO 2014)-before shipment but can be infested after treatment either before departure or during transport. Hara et al. (2001) provided an efficient strategy using water drenches for potted nursery plants against *Wasmannia auropunctata*, an invasive ant.
1.7b. How likely is the organism to enter the risk assessment area undetected?	very unlikely unlikely moderately likely **likely** very likely	low **medium** high	Fully developed nests are quite visible. Newly-founded nests with few queen(s) and workers in the soil/substrate can easily arrive undetected.

1.8b. How likely is the organism to arrive during the months of the year most appropriate for establishment?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	The horticultural trade is active throughout the year.
1.9b. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Potted plants and plant materials are likely to be transported outdoors in gardens, which may be, or adjoin, a suitable habitat. It is expected that suburban and urban habitats are most at risk at the beginning of an invasion
1.10b. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	very unlikely unlikely **moderately likely** likely very likely	low medium **high**	We consider this pathway as the most likely pathway of entry of *S. richteri* into Europe. Noordijk (2010) also consider the horticultural trade as the most likely pathway for introduction of *Solenopsis* species in the Netherlands.
Pathway name:	c) Transport-Stowaway (nests transported in container/bulk, including sea freight, airfreight, train, etc.)		
1.3c. 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 **unintentional**	low medium **high**	This section includes travelling nests that are not directly associated with the horticultural trade. Virtually any article of commerce can host hitchhiking nests of all sizes and ages, including newly-founded and fully developed nests. There are very many articles of commerce and container types that are grouped together here. This includes, e.g. sea containers but also vehicles (incl. used car parts), machinery, building material, packaging materials, bark, aquaculture material and used electric equipment.
1.4c. 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?	very unlikely unlikely **moderately likely** likely very likely	low **medium** high	There are no data on *S. richteri* nests arriving in Europe. Sea containers and all articles of commerce cited above were scored by Harris et al. (2005) as presenting a high likelihood of introduction for nests of *Solenopsis* species.

Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.			Ants are not listed as quarantine pests in the EU and, therefore, records rarely appear in the national and international lists of intercepted pests. Polygynous nests include many queens and may contain thousands of workers. The maximum size of a fully developed colony of *S. invicta* may reach more than 200,000 workers (Tschinkel 2006). Ant nests might get onto the pathway in large numbers as stowaway in containers or other bulk freight, including soil. The likelihood of reinvasion after eradication is identical to the likelihood of introduction in the first place.
1.5c. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	Ant queens are able to survive several tens of days using their own reserves before the first workers emerge. Once sealed in a newly-founded nest, a *S. invicta* queen is able to survive 13 to 95 days on her own reserves, i.e. much longer than before nest establishment (Markin et al. 1972). This is sufficient to survive longer trips to Europe from any origin. Likelihood of survival nevertheless will decrease with increasing travel duration.
1.6c How likely is the organism to survive existing management practices during passage along the pathway?	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	In most of the commodities in this pathway, there are no management practices in place.
1.7c. How likely is the organism to enter the risk assessment area undetected?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Many of these commodities are not carefully inspected. While established nests are usually obvious, newly-founded nests are often inconspicuous. Newly-founded nests with few queen(s) and workers could easily arrive undetected.
1.8c. How likely is the organism to arrive during the months of the year most appropriate for establishment?	very unlikely unlikely moderately likely	low medium **high**	Commodities that can carry *S. richteri* are introduced to the risk assessment area throughout the year.

	likely very likely		
1.9c. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Several of the potential commodities and items in which nests can hide can be transported to suitable habitats since the ant particularly likes open and disturbed habitats, which are found everywhere, specifically in urban and semi-urban areas.
1.10c. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	very unlikely unlikely **moderately likely** likely very likely	low **medium** high	Given the high numbers and types of containers, commodities and items that can be associated with *S. richteri*, entry along pathway can be considered as being moderately likely.
End of pathway assessment, repeat as necessary			
1.11. Estimate the overall likelihood of entry into the risk assessment area based on all pathways and specify if different in relevant biogeographical regions in current conditions (comment on the key issues that lead to this conclusion).	very unlikely unlikely **moderately likely** likely very likely	low **medium** high	The species has never been recorded/intercepted in Europe. Its distribution in the native range (South America) and the introduced range (a limited part of the USA) decreases the likelihood of it being accidently introduced into Europe. It is moderately likely that this will happen in the future, specifically with contaminated soil in the horticultural trade and/or as stowaway with container/bulk imports in sea or air freights. This scoring should be reconsidered in the case of an expansion of the introduced range of *S. richteri*.
1.12. Estimate the overall likelihood of entry into the risk assessment area based on all pathways in foreseeable climate change conditions?	very unlikely unlikely **moderately likely** likely very likely	low **medium** high	Climate change is not changing the risk of introduction or likelihood of entry based on the mentioned active pathways except, for example, if shipments of horticultural plants from invaded areas increase.

PROBABILITY OF ESTABLISHMENT

Important instructions:

- For organisms which are already established in parts of the risk assessment area, answer the questions with regard to those areas, where the species is not yet established. If the species is established in all Member States, continue with Question 1.16.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.13. How likely is it that the organism will be able to establish in the risk assessment area based on the similarity between climatic conditions within it and the organism's current distribution?	very unlikely unlikely moderately likely **likely** very likely	**Low** medium high	Only one climatic model has been developed for *S. richteri* at a global scale (Bertelsmeier et al. 2015) (Annex VI). Using a climate matching model (Maxent) based on present distributions, they showed that less than 2% of the European continent is presently suitable for *S. richteri*, but predicted a potential distribution mainly in France, Ireland, United Kingdom, and Germany (Annex VI). A climatic model developed specifically for France confirms the suitability of these biogeographical regions (Atlantic and Continental) for *S. richteri* (Bertelsmeier and Courchamp 2014). However, Europe is less suitable than the introduced range of *S. richteri* in the USA (Bertelsmeier et al. 2015). Although *S. richteri* seems to be more tolerant to cold temperatures than *S. invicta*, various climatic models developed for *S. invicta* can be used to assess the likelihood of establishment of *S. richteri* in Europe (Morrison et al. 2004; Sutherst and Maywald 2005). However, they do not all agree in their conclusions on the suitability of Europe. Morrison et al. (2004) used the model of Korzukhin et al. (2001) to map suitable areas for the

			reproduction of *S. invicta* worldwide. The model used a dynamic, ecophysiological model of colony growth, superposing temperature and precipitation requirements to predict the potential global range distribution of the ant. The model showed that large parts of the Mediterranean region fall in the area suitable for *S. invicta* establishment. Sutherst and Maywald (2005) used the CLIMEX climate modeling software to assess the potential geographic range of *S. invicta* based on an ecoclimatic index (EI) that represents the overall suitability of the given geographical location. EI values of 0<10 indicate marginal habitats, 10<20 will support substantial populations, and >20 are highly favourable. A value of zero indicates that the species is unable to persist at that location. For Europe, the analysis showed that climate per se will not constrain the ant from colonizing countries bordering the Mediterranean and western France. Irrigation would allow it to establish in arid zones and increase colony growth in Mediterranean climates (Supplementary material, Fig. S2, but see Fig S3). However, EI for Europe was substantially lower (0<10) than for the regions where the ant is highly invasive (e.g. in North America with an EI up to 39 and Oceania with an EI up to 44 in Australia), suggesting that, in Europe, establishment and population growth may be less straightforward, except in irrigated lands and in habitats in direct contact with permanent water bodies. Indeed, the model shows much higher EIs when irrigation is added.

1.14. How likely is it that the organism will be able to establish in the risk assessment area based on the similarity between other abiotic conditions within it and the organism's current distribution?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Other abiotic conditions should not be a constraint for the establishment of *S. richteri* in Europe, maybe except for high-altitude environments. The ant prefers disturbed soils, which are found everywhere, especially in urban and semi-urban habitats (Harris et al. 2005).
1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in the risk assessment area?	very isolated isolated moderately widespread **widespread** ubiquitous	low medium **high**	*Solenopsis richteri* prefers open and disturbed habitats, which are found everywhere in Europe. In Argentina, near the southern extent of its natural range, foraging did not occur during the colder months, and in summer workers were seen when air temperature ranged from 19 to 36°C (Palomo et al. 2003). In regions with unsuitable climates, it may survive under artificial warm conditions indoors, in buildings or greenhouses as well as in gardens and parks in cities. *Solenopsis* species have shown temporary indoor colony establishments including at least once in the Netherlands (*i.e. S. geminata*) (Noordijk 2010). However, indoor colonies can normally be eradicated easily.
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 the risk assessment area?	**NA** very unlikely unlikely moderately likely likely very likely	low medium **high**	*Solenopsis richteri* does not require another species for establishment.
1.17. How likely is it that establishment will occur despite competition from existing species in the risk assessment area?	very unlikely unlikely **moderately likely** likely very likely	low **medium** high	Within its native range *S. richteri* can attain high densities and be dominant in disturbed habitats. *Solenopsis richteri* monopolized space and food in grassland habitat in Argentina that was susceptible to flooding (Folgarait et al. 2004). It can reach high mound densities (707 nests/ha) which is comparable to those seen for *S. invicta* in the USA (Folgarait et al. 2004).

			There is probably intense competition with other dominant species in some locations. However, *S. richteri* seems to be less competitive than *S. invicta* which has drastically reduced its distribution in the USA (Tschinkel 2006). In several suitable areas in Europe, it will have to face competition from at least two invasive species already established, the Argentine ant *Linepithema humile* and *Tapinoma magnum*. These species are highly competitive (Blight et al. 2010; Blight et al. 2014) and confrontations will be asymmetric as they both already form colonies of many hundred thousands of individuals. Successful colony founding by *S. richteri* within established populations of either species would seem unlikely. The Argentine ant was superior to the highly competitive *S. invicta* during asymmetrical confrontation tests (numerical advantage for the Argentine ant) under laboratory confrontations (Kabashima et al 2007). The Argentine ant is largely distributed along the Mediterranean coast from Portugal to Italy through Spain and France. It has been also recorded in Malta and Greece. Nonetheless, where these competitive species are not present the establishment may easily occur.
1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area?	very unlikely unlikely moderately likely **likely** very likely	low **medium** high	Only few *Solenopsis* spp. are native to Europe, and no specific natural enemies of *Solenopsis* spp. occur in Europe. Thus, establishment in Europe is only likely to be hindered by other ant species and possibly generalist predators that may prey on individual queens.

1.19. How likely is the organism to establish despite existing management practices in the risk assessment area?	very unlikely unlikely moderately likely **likely** very likely	low **medium** high	No specific management practices are in place against invasive ants in the wild in Europe. Eradication of single nests is straightforward in buildings (e.g. Noordijk 2010) but much less so outdoors. However, some eradication programmes of *S. invicta* have succeeded, e.g. in Australia (Hoffmann et al. 2016; Wylie et al. 2016)
1.20. How likely are existing management practices in the risk assessment area to facilitate establishment?	very unlikely **unlikely** moderately likely likely very likely	low **medium** high	There are no specific management practices against invasive ants in the risk assessment area. But based on what is done locally to control ants, i.e. chemical treatments, it is unlikely that management practices, if set up, facilitate establishment.
1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the risk assessment area?	very unlikely unlikely moderately likely **likely** very likely	low **medium** high	The eradication of invasive ants outdoors is difficult, especially when populations reach high densities of nests and individuals (Hoffmann et al. 2016). However incipient ant colonies can be successfully eradicated (Hoffmann et al. 2016).
1.22. How likely are the biological characteristics of the organism to facilitate its establishment in the risk assessment area?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	*Solenopsis richteri* has monogynous and polygynous populations. The polygynous form can establish more easily because the higher number of queens increases reproduction potential, especially in the critical early stages of establishment. The number of workers in a polygynous nest can vary enormously, from thousands to hundreds of thousands (Taber 2000). However only monogynous colonies have been observed so far in the introduced range of *S. richteri*. It is unknown if establishment of the polygyne form outside its native range would see similar increases in densities and impacts as *S. invicta* in the USA, but they can achieve high densities in ideal conditions within their native range (Calcaterra et al. 1999).

			Few data are available on the biology of *S. richteri*. Inseminated females (queens) of *Solenopsis invicta* lay up to 200 eggs per hour (Tschinkel 1988). Within one year, the colony can grow to several thousands of workers, within three years it can reach up to 230,000 workers (Tschinkel 1988). The peculiar, almost unique, reproductive caste system of these eusocial insects can facilitate establishment. For the Argentine ant, it was shown that as few as 10 workers and a queen are sufficient for a colony to grow quickly (Hee et al. 2000; Luque et al. 2013).
1.23. How likely is the adaptability of the organism to facilitate its establishment?	very unlikely unlikely **moderately likely** likely very likely	low **medium** high	*Solenopsis richteri* is one of the less successful invasive ants (established and invasive only in the USA) which might, among other explanations, suggest a moderate adaptability to new environments. Despite *S. richteri* being a generalist, opportunistic species, it requires open places, especially those that are related to humans. Also, it has a restricted flight period. Nuptial flights have been recorded only during the warmest seasons of the year. However, *S. invicta* which is closely related to *S. richteri* has demonstrated a high adaptability to new environments (Tschinkel 2006).
1.24. How likely is it that the organism could establish despite low genetic diversity in the founder population?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Most invasive ants, which are among the most invasive insects worldwide, establish following the entry of single nests or queens (Holway et al. 2002; Vonshak et al. 2010). Therefore, low genetic diversity does not seem to be a barrier to establishment.

1.25. Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in the risk assessment area? (If possible, specify the instances in the comments box.)	very unlikely unlikely **moderately likely** likely very likely	low **medium** high	*Solenopsis richteri* has been introduced (according to interception records, Lester 2005, Harris et al. 2005, Blight et al. unpublished data) and became established only in Southern US. However, it shares several biological and ecological features with closely-related species such as *S. geminata* and *S. invicta* that are two of the most widely distributed invasive ants. Should the climate of Southern Europe be suitable and habitats available for the species, the history of invasion suggests that it is moderately likely to establish in Europe.
1.26. If the organism does not establish, then how likely is it that casual populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is present because of continual release, is an example of a transient species.	very unlikely unlikely **moderately likely** likely very likely	low medium **high**	As shown with interception data from countries such as the Netherlands (Noordijk 2010), US (Suarez et al. 2005; Bertelsmeier et al. 2018), New Zealand (Harris et al. 2005), *Solenopsis* spp. are regularly intercepted at ports and airports. However, in most cases, these are sterile workers that cannot establish in the wild. Ants are not listed as quarantine pests in the EU and, therefore, interception data are not good indicators of their frequency of entry because they do not have to be mentioned in the national and international lists of intercepted pests. It has to be assumed that there is a considerable number of unreported cases even for *S. richteri* which is absent from almost all interceptions data bases.
1.27. Estimate the overall likelihood of establishment in relevant biogeographical regions in current conditions (mention any key issues in the comment box).	very unlikely unlikely moderately likely **likely** very likely	low **medium** high	In the Atlantic and continental biogeographical regions, establishment under current conditions is likely, at least in France, Germany, Ireland, Slovenia, United Kingdom (Bertelsmeier et al. 2015) (Annex VI).

			The absence of other, more regional, models predicting *S. richteri*'s possible distribution in Europe limits our conclusions.
1.28. Estimate the overall likelihood of establishment in relevant biogeographical regions in foreseeable climate change conditions	very unlikely unlikely moderately likely **likely** very likely	low **medium** high	Bertelsmeier et al. (2015) predict an expansion of the potential range of *S. richteri* but the proportion of regions scored with a high suitability index (over 0.7) decreases. Under foreseeable climate change, *S. richteri* may establish in the Atlantic, Mediterranean, Continental and Alpine biogeographical regions. To consider a range of possible future climates, they used downscaled climate data from three GCMs: the CCCMA-GCM2 model; the CSIRO MK2 model; and the HCCPR-HADCM3 model (GIEC 2007). Similarly, they used the two extreme SRES: the optimistic B2a; and pessimistic A2a scenario. The absence of other, more regional, models predicting *S. richteri*'s possible distribution in Europe limits our conclusions.

PROBABILITY OF SPREAD

Important notes:

- Spread is defined as the expansion of the geographical distribution of an alien species within the risk assessment area.
- Repeated releases at separate locations do not represent spread and should be considered in the probability of introduction and entry section. In other words, intentional anthropogenic "spread" via release or escape should be dealt within the introduction and entry section.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
2.1. How important is the expected spread of this organism within the risk assessment area by natural means? (Please list and comment on each of the mechanisms for natural spread.)	minimal minor **moderate** major massive	low medium **high**	Due to the limited distribution of *S. richteri* in the USA, there is much more information available on the biology and ecology of *S. invicta*. Where there was a shortage of information on *S. richteri* this is supplemented with information on *S. invicta*, a related species, in this pest risk assessment. New colonies are founded by winged females, capable of flying long distances. This allows new sites of infestation to be established a long distance from the source infestation (Holway et al. 2002).Nuptial flights will result in rapid spread outwards from a site of establishment. For example, most queens of *S. invicta* do not fly far from the colony of origin but some may fly up to 12 kilometres (Tschinkel 2006). Nuptial flights occur during the warmest seasons of the year. Polygynous colonies can also spread by "budding", i.e. alates mate in the nest and queens disperse only short distances and take workers with them to start a new colony (Tschinkel 2006). Such a strategy does not allow a rapid spread but increases survival rates of queens and colonies. Even if there is no specific data on *S. richteri*, these generalities probably apply to it.

			When *S. invicta* colonies reach about 10% of their maximum size they begin producing reproductives (Tschinkel 1988). Under ideal conditions, this can occur within 6 months of founding (Vinson & Greenberg 1986). At suboptimal temperatures this may take longer to achieve, as development rates are strongly temperature dependent (Porter 1988). Colonies budded from polygyne colonies will likely produce reproductives sooner than independently founded nests (Tschinkel 1988). Sometimes, an entire colony of *S. invicta* can disperse by rafting/floating on water, e.g. after flooding of its habitat (e.g. Adams et al. 2011). The question is scored "moderate" because it is likely to spread more slowly by natural means than by human assistance.
2.2. How important is the expected spread of this organism within the risk assessment area by human assistance? (Please list and comment on each of the mechanisms for human-assisted spread) and provide a description of the associated commodities.	minimal minor moderate **major** massive	low medium **high**	Human assisted pathways of spread are the agricultural and horticultural trade of plants, plant materials, and soil/substrate as well as other movements of commodities (Harris et al. 2005; Ward 2006; King et al. 2009). Invasive ants are commonly transported with horticultural plants (commercial or private). This pathway is probably the main mechanism for human-assisted spread of invasive ants. Building construction or agricultural activities can also contribute to their spread, especially when soil is excavated and moved to different places. Finally, ants can be accidently transported by individuals. For example, invasive ants

			are known to enter into vehicles, probably because of the heat produce by the engine.
2.2a. List and describe relevant pathways of spread. Where possible give detail about the specific origins and end points of the pathways. For each pathway answer questions 2.3 to 2.9 (copy and paste additional rows at the end of this section as necessary). Please attribute unique identifiers to each question if you consider more than one pathway, e.g. 2.3a, 2.4a, etc. and then 2.3b, 2.4b etc. for the next pathway.	a) Transport-Contaminant (Contaminant nursery material) b) Transport-Stowaway (Container/bulk, including road transport, sea freight, airfreight, train, etc.) c) Unaided (Natural dispersal)		Due to the limited distribution of *S. richteri* in the USA, there is much more information available on the biology and ecology of *S. invicta*. Where there was a shortage of information on *S. richteri* this is supplemented with information on *S. invicta* in this pest risk assessment.
Pathway name:	a) Transport-Contaminant (Contaminant nursery material)		
2.3a. Is spread along this pathway intentional (e.g. the organism is released at distant localities) or unintentional (the organism is a contaminant of imported goods)?	intentional **unintentional**	low medium **high**	
2.4a. How likely is it that a number of individuals sufficient to originate a viable population will spread along this pathway from the point(s) of origin over the course of one year?	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	Within Europe, movements of potted plants are unrestricted and frequent. Soil/substrate in potted plants is a favourite media for nesting (see entry section above). Thus, newly founded nests or parts of fully developed nests could easily be moved. Other horticultural material such as mulch, hay and other plant material can harbour ant nests. Polygynous nests include many queens and may contain thousands of workers. Ant nests might get onto the pathway in large numbers as contaminant of horticultural materials including soil.

			The likelihood of reinvasion after eradication is identical to the likelihood of introduction in the first place.
2.5a. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	very unlikely unlikely moderately likely **likely** very likely	low **medium** high	No data specific to *S. richteri* was available but considering the relatedness between *S. richteri* and *S. invicta*, we based our evaluation on this later. Once sealed in a newly-founded nest, a queen of *S. invicta* is able to survive 13 to 95 days on her own reserves, i.e. much longer than before nest establishment (Markin et al. 1972; Porter 1988). Likelihood of survival is high, nevertheless will decrease with increasing travel duration. Multiplication (i.e. production of sexuals and reproduction) of a colony during spread within the EU cannot be ruled out, but is rather unlikely.
2.6a. How likely is the organism to survive existing management practices during spread?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Horticultural plants and products and soils/substrates are usually not treated before translocation within the EU.
2.7a. How likely is the organism to spread in the risk assessment area undetected?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Fully developed nests are quite visible. In contrast, newly-founded nests with few queen(s) and workers can easily travel undetected in soil or other horticultural products.
2.8a. How likely is the organism to be able to transfer to a suitable habitat or host during spread?	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	Potted plants and plant materials are often planted or stored in or close to highly suitable habitats, such as gardens, parks, road sides, etc. It is expected that spread facilitates occurrences in urban, suburban and agricultural habitats.
2.9a. Estimate the overall potential for rate of spread within the Union based on this pathway (when possible provide quantitative data)?	very slowly slowly **moderately** rapidly	low **medium** high	We consider this pathway as the most likely pathway of spread of *S. richteri* within Europe. A similar conclusion has been made for New Zealand (Harris et al. 2005).

	very rapidly		The rate of spread will depend on the internal volume of trade within Europe.
Pathway name:	b) Transport-Stowaway (Container/bulk, including road transport, sea freight, airfreight, train, etc.)		
2.3b. Is spread along this pathway intentional (e.g. the organism is released at distant localities) or unintentional (the organism is a contaminant of imported goods)?	intentional **unintentional**	low medium **high**	Virtually any article of commerce can host hitchhiking ants with nests of all sizes and ages, including newly-founded and fully developed nests. A free volume of 10ml should be sufficient for an incipient colony composed by a queen and a dozen of workers. There are very many transported items (e.g. vehicles (incl. used car parts), machinery, building material, agricultural equipment packaging materials, bark, used electric equipment, non-agricultural soil, sand, gravel) that are suitable to carry nests and are grouped here together.
2.4b. How likely is it that a number of individuals sufficient to originate a viable population will spread along this pathway from the point(s) of origin over the course of one year?	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	There are very limited data on ant nests translocated within the EU. Ant nests might be established in transported items in large numbers as stowaways. The likelihood of reinvasion after eradication is identical to the likelihood of introduction in the first place.
2.5b. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Once sealed in a newly-founded nest, a queen of *S. invicta* is able to survive 13 to 95 days on her own reserves, i.e. much longer than before nest establishment (Markin et al. 1972; Porter 1988). Likelihood of survival is high, nevertheless will decrease with increasing travel duration. Post introduction distances and hence transport periods are likely to be relatively short. Multiplication of a colony during spread within the EU cannot be ruled out, but is rather unlikely.

2.6b. How likely is the organism to survive existing management practices during spread?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Most potential commodities that can carry ants or nests are not managed.
2.7b. How likely is the organism to spread in the risk assessment area undetected?	very unlikely unlikely moderately likely **likely** very likely	low medium **high**	Fully developed nests are quite visible. In contrast, newly-founded nests with few queen(s) and workers can easily travel undetected in most potential transported items.
2.8b. How likely is the organism to be able to transfer to a suitable habitat or host during spread?	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	Several of the potential commodities and items in which nests can hide can be transported to suitable outdoor habitats since the ant prefers disturbed soils, which are found everywhere and are often close to storage facilities where commodities may be shipped, specifically in urban, semi-urban and agricultural habitats.
2.9b. Estimate the overall potential for rate of spread within the Union based on this pathway (when possible provide quantitative data)?	very slowly slowly **moderately** rapidly very rapidly	low **medium** high	Given the high numbers and types of commodities and items that can be associated with *S. richteri*, this species has the potential to spread rapidly in the RA area through this pathway. The rate of spread will depend on the internal volume of trade within Europe. Accidental transportation by humans has resulted in rates of spread of 10.50 km/yr in the case of *S. invicta* into uninvaded areas of the USA (Ross and Trager 1990).
Pathway name:	c) Unaided (Natural dispersal)		
2.3c. Is spread along this pathway intentional (e.g. the organism is released at distant localities) or unintentional (the organism is a contaminant of imported goods)?	intentional **unintentional**	low medium **high**	
2.4c. How likely is it that a number of individuals sufficient to originate a viable population will spread	very unlikely unlikely	low **medium**	Spread by nuptial flights occur only during the warmest months of the year in *S. richteri*, and likely

along this pathway from the point(s) of origin over the course of one year?	**moderately likely** likely very likely	high	will be restricted to few weeks in the risk assessment area; it will include small numbers of alates, while budding usually includes a larger number of queens and workers. After mating, queens fly 3-5 m above the ground. It is possible that reproductives from monogyne colonies form mating swarms fly much higher, as is reported for *S. invicta* (Markin et al. 1971), and therefore could experience enhanced wind-assisted dispersal. The likelihood of reinvasion after eradication is identical to the likelihood of introduction in the first place.
2.5c. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	Rates of survival of mated queens are relatively low after the nuptial flight (Hölldobler and Wilson 1990). However, this is compensated by the production of hundreds of females per nest giving a very likely score. Dispersion by budding increases queen survival but reduces dispersion distances.
2.6c. How likely is the organism to survive existing management practices during spread?	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	Management practices during unaided spread are not currently in place.
2.7c. How likely is the organism to spread in the risk assessment area undetected?	very unlikely unlikely **moderately likely** likely very likely	low medium **high**	Low ant densities (e.g. single queens, small newly-founded nests) often remain undetected for longer periods. However, spread will mainly occur from well-established nests, which would be more noticeable and spread should be detected earlier. The fact that *S. richteri* has a painful sting and is highly likely to be found in close association with urban areas should aid early detection of its presence, even if its initial establishment may go unnoticed.

2.8c. How likely is the organism to be able to transfer to a suitable habitat or host during spread?	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	Queens of *S. invicta* can fly up to 16 km in extreme cases and will very likely find suitable habitats (e.g. open and disturbed habitat).
2.9c. Estimate the overall potential for rate of spread within the Union based on this pathway (when possible provide quantitative data)?	very slowly slowly **moderately** rapidly very rapidly	low **medium** high	*Solenopsis richteri* should be able to spread unaided to all suitable habitats within its suitable climatic range. Alate females of *S. invicta* can fly up to 16 km and colonies can also be occasionally transported by water flood. This rate of spread decreases in polygynous colonies that reproduce by budding (below 300m per year, Hölldobler& Wilson 1990). For polygyne *S. invicta*, the invasion front moved 10.40 m/yr in central Texas via budding (Porter 1988). There are a number of intrinsic and extrinsic factors that influence spread including availability of disturbed habitats and morphology of the queens (Tschinkel 2006; King and Tschinkel 2008).
End of pathway assessment, repeat as necessary.			
2.10. Within the risk assessment area, how difficult would it be to contain the organism in relation to these pathways of spread?	very easy easy with some difficulty difficult **very difficult**	low medium **high**	It will probably be very difficult to physically contain the species. Its spread will be constrained by climate, habitat suitability and competition from other dominant ants. If *S. richteri* becomes established in a European region, quarantine measures could be put in place to restrict the risk of long-distance spread, e.g. through nursery stock, as in USA for *S. invicta* (USDA 2015).
2.11. Estimate the overall potential for rate of spread in relevant biogeographical regions under current conditions for this organism in the risk assessment area (using the comment box to indicate any key issues).	very slowly slowly **moderately** rapidly very rapidly	low **medium** high	Based on its restricted distribution in North America and the lower ecoclimatic suitability in Europe (Bertelsmeier et al. 2015), we can estimate that it will spread to all potentially infested biogeographical regions, but possibly slower than in North America.

			Habitat suitability is predicted to be lower in Europe even in relevant biogeographical regions, than in the introduced range of *S. richteri*. Its spread will occur mainly through human transport but its distribution will be indirectly constrained by climate, habitat suitability and competition from other dominant ants (invasive and native). The rate of spread will depend on the internal volume of trade within Europe.
2.12. Estimate the overall potential for rate of spread in relevant biogeographical regions in foreseeable climate change conditions	very slowly slowly **moderately** rapidly very rapidly	low **medium** high	Climate change will not increase the potential or rapidity of spread directly, but may facilitate population growth with subsequently increasing potential for spread. Despite climate change may widen the distribution range of this species, future suitable areas are predicted to have low suitability index (Bertelsmeier et al. 2015).

MAGNITUDE OF IMPACT

Important instructions:

- Questions 2.13-2.17 relate to biodiversity and ecosystem impacts, 2.18-2.20 to impacts on ecosystem services, 2.21-2.25 to economic impact, 2.26-2.27 to social and human health impact, and 2.28-2.30 to other impacts. These impacts can be interlinked, for example a disease may cause impacts on biodiversity and/or ecosystem functioning that leads to impacts on ecosystem services and finally economic impacts. In such cases the assessor should try to note the different impacts where most appropriate, cross-referencing between questions when needed.
- Each set of questions starts with the impact elsewhere in the world, then considers impacts in the risk assessment area (=EU excluding outermost regions) separating known impacts to date (i.e. past and current impacts) from potential future impacts (including foreseeable climate change).
- Only negative impacts are considered in this section (socio-economic benefits are considered in Qu. A.7)

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
Biodiversity and ecosystem impacts			
2.13. How important is impact of the organism on biodiversity at all levels of organisation caused by the organism in its non-native range excluding the risk assessment area?	minimal minor **moderate** major massive	**low** medium high	There is no research on impacts of *S. richteri*, principally due to its limited distribution and displacement by *S. invicta* in the USA. Therefore, the following information refer to *S. invicta*, a related species. That is the reason why the confidence level is scored "low". Even if S. invicta seems to displace S. richteri in the US, this species had successfully spread in several areas which demonstrates its compacity to compete with native species. Wang et al. (2013) provided an extensive review of studies on the environmental impact of *S. invicta* since its invasion in China. -<u>Impact on fauna</u>: In southern North America, *S. invicta* threatens several arthropods, molluscs, reptiles, birds, amphibians and mammals by direct predation,

			competition or stinging (see review by Wojcik et al. (2001), Holway et al. (2002), Allen et al. (2004) and more recent studies such as Allen et al. (2017)). In particular, it has been shown to displace or reduce populations of native and invasive ants (including the Argentine ant) (McGlynn 1999; Holway et al. 2002; King and Tschinkel 2008). It also attacks beneficial insects such as parasitoids and predators (Eubanks et al. 2002; Ness 2003). It must be noted, however, that data on direct effects on long term population declines of animals are largely lacking, even for impact on native ants. *Solenopsis invicta* mainly occupies niches in highly disturbed habitats and, in such situations, it is difficult to distinguish between the effects of disturbance and the effects of *S. invicta* on other ants (King and Tschinkel 2006). -<u>Impact on plants</u>: the impact on wild plants has been less studied than that on animals or cultivated plants. However, the flora can also be affected through various mechanisms, such as changes in soil properties (Lafleur et al. 2005), predation or tending of plant pests, direct seed predation and competition with native ant dispersers (Ness and Bronstein 2004). However, *S. invicta* may also facilitate seed dispersal (Stuble et al. 2010). -<u>Alteration of ecosystem functions</u>: Nest building and foraging activities of *S. invicta*, affect physical and chemical soil properties and strongly enhances plant growth through the increase of $NH4^{+}$ (Lafleur et al. 2005). It also affects mutualistic interactions between plants and insects by reducing numbers of plant mutualists that protect the plant or disperse plant seeds (Ness and Bronstein 2004).

			It is likely that impact on ecosystem functions may be locally major and similar to that observed in presently invaded areas elsewhere.
2.14. How important is the current known impact of the organism on biodiversity at all levels of organisation (e.g. decline in native species, changes in native species communities, hybridisation) in the risk assessment area (include any past impact in your response)?	minimal minor moderate major massive	low medium high	N/A. Because the species is not present in Europe, there is no current impact on biodiversity and related ecosystem services.
2.15. How important is the potential future impact of the organism on biodiversity at all levels of organisation likely to be in the risk assessment area?	minimal minor **moderate** major massive	**low** medium high	It is likely that, if *S. richteri* establish and spread in the Atlantic and Continental biogeographical regions (Annex VI), the impact on native biodiversity, in particular on arthropods, and small vertebrates would be major and similar to the impacts of *S. invicta*. The magnitude of the impacts will depend on the densities *S. richteri* achieves. Establishment in areas of suboptimal climate will limit dense populations and reduce impacts.
2.16. How important is decline in conservation value with regard to European and national nature conservation legislation caused by the organism currently in the risk assessment area?	minimal minor moderate major massive	low medium high	N/A. Because the species is not present in Europe, there is no current impact on the conservation value of native species or habitats
2.17. How important is decline in conservation value with regard to European and national nature conservation legislation caused by the organism likely to be in the future in the risk assessment area?	minimal **minor** moderate major massive	**low** medium high	Although *S. richteri* can inhabit a wide range of habitats, in the USA it particularly dominates highly disturbed habitats, such as roadsides, agricultural areas including irrigated soils, gardens, etc. Therefore, many natural habitats of high conservation value may not be threatened by the ant. However, some natural habitats in the Atlantic biogeographical region may well be suitable. Some of them could be N2000 habitat, such as natural grasslands (code 61) and semi-natural dry grasslands and scrubland facies (code 62).
Ecosystem Services impacts			

2.18 How important is the impact of the organism on provisioning, regulating, and cultural services in its non-native range excluding the risk assessment area?	minimal minor **moderate** major massive	**low** medium high	There is no research on impacts of *S. richteri*, principally due to its limited distribution and displacement by *S. invicta* in the USA. <u>Provisioning-Nutrition</u>: *S. invicta* damages cultivated field crops by feeding on the seeds, seedlings and developing fruit (Adams et al. 1983). It also negatively affects cattle farming (Teal et al. 1999). <u>Regulating-Seed dispersal</u>: *S. invita* may interfere with seed dispersal of native ant species and directly predate (and therefore reduce) amount of seeds (Ness and Bronstein 2004). However, *S. invicta* may also facilitate seed dispersal (Stuble et al. 2010). <u>Regulating-Pest and disease Control</u>: *S. invicta* may interfere with beneficial insects that exert biocontrol activities in modified habitats. <u>Cultural-Physical use of landscapes</u>: *S. invicta* is a social nuisance in infested areas. Public areas such as parks and recreational areas may become unsafe for children and people have modified their behaviour to avoid the nuisance (Wylie and Janssen-May 2017).
2.19. How important is the impact of the organism on provisioning, regulating, and cultural services currently in the different biogeographical regions or marine sub-regions where the species has established in the risk assessment area (include any past impact in your response)?	minimal minor moderate major massive	low medium high	N/A. Because the species is not present in Europe, there is no current impact on ecosystem services.
2.20. How important is the impact of the organism on provisioning, regulating, and cultural services likely to be in the different biogeographical regions or marine sub-regions where the species can establish in the risk assessment area in the future?	minimal minor **moderate** major massive	**low** medium high	It is likely that, if *S. richteri* finds suitable habitats and climates for its development in the Atlantic and continental regions, the impact on ecosystem services may be locally major and similar to the impacts of *S. invicta*. But its extent is very difficult to estimate

			considering the uncertainty related to habitat/climatic suitability. The magnitude of the impacts will depend on the densities *S. richteri* achieves. Establishment in areas of suboptimal climate will limit dense populations and reduce impacts.
Economic impacts			
2.21. How great is the overall economic cost caused by the organism within its current area of distribution (excluding the risk assessment area), including both costs of / loss due to damage and the cost of current management	minimal minor **moderate** major massive	**low** medium high	There is no research on impacts of *S. richteri*, principally due to its displacement by *S. invicta* in the USA, and the subsequent problems the latter pest has caused. Various estimates of economic costs due to *S. invicta* in USA have been published, which range from half a billion to several billion dollars per year (Pimentel et al. 2000; Morrison et al. 2004). Some more specific accounts exist for regions and impact categories. For example, as cited in CABI (2018): "In 1998, the average household cost for imported fire ant problems per Texas household in urban areas was US $150.79, with US $9.40 spent on medical care. The total annual metroplex (Austin, Dallas, Ft. Worth, Houston and San Antonio) expenditures for medical care costs was 9% or US $47.1 million of the US $526 million total expenditure cost due to *S. invicta* (Lard et al. 2002)". In Australia, the likely impact of *S. invicta* on various economic sectors is estimated at between A$8.5 and A$45 billion (Wylie and Janssen-May 2017). Other regions have made estimations for potential economic costs in case of *S. invicta* invasion. For Hawaii, it was estimated that the impact on various economic sectors would be around US $211 million per year (Gutrich et al. 2007). Economic costs in invaded areas are mainly related to three impact categories:

			-Impact on agriculture: *S. invicta* can directly damage crops such as corn, sorghum, okra, potatoes and sunflowers by feeding on the seeds, seedlings and developing fruit (Stewart and Vinson 1991; CABI 2018). The impact may also be indirect through the tending of homopteran pests (aphids, scale insects, etc.), which they protect against natural enemies to collect honeydew. However, it must be noted that *S. invicta* also preys on plant pests and may provide benefits to crops. The ant also affects livestock by stinging particularly very young, old or confined animals. The ants move to moist areas of the body (eyes, genitals), the yolk of hatching birds and wounds, and begin stinging when disturbed. The stings result in injury such as blindness, and swelling or can even lead to death (CABI 2018). Finally, the ant can also affect the agriculture sector by stinging workers in the field and affecting agricultural equipment (see below). -Health impacts: *S. invicta* can sting people and may cause an allergic reaction that requires medical care and, sometimes, causes anaphylaxis. See social impact below for a description of the medical issue in south-eastern USA. -Impacts on infrastructure and equipment: Ants and their mounds damage roads and electrical equipment. Also domestic electrical equipment may be damaged such as computers, swimming pool pumps, cars or washing machines. Colonies move into buildings or vehicles seeking favourable nesting sites, particularly during flooding and very hot, dry conditions. Fire ant foraging

			and nesting activities can result in the failure of many types of mechanical (such as hay harvesting machinery and sprinkler systems) and electrical equipment (including air conditioner units and traffic box switching mechanisms) (Wylie and Janssen-May 2017; CABI 2018).
2.22. How great is the economic cost of / loss due to damage* of the organism currently in the risk assessment area (include any past costs in your response)? *i.e. excluding costs of management	minimal minor moderate major massive	low medium high	N/A. Because the species is not present in Europe, there is no current cost of damage.
2.23. How great is the economic cost of / loss due to damage* of the organism likely to be in the future in the risk assessment area? *i.e. excluding costs of management	minimal minor **moderate** major massive	**low** medium high	It is likely that, if *S. richteri* finds suitable habitats and climates for its development in the Atlantic and continental regions, the impact may be locally major and similar to the impacts of *S. invicta*. But its extent is very difficult to estimate considering the uncertainty related to habitat/climatic suitability. The magnitude of the impacts will depend on the densities *S. richteri* achieves. Establishment in areas of suboptimal climate will limit dense populations and reduce impacts. In the risk assessment for the Netherlands, Noordijk (2010) also mentions potential 'indirect' effects caused by probable import restrictions if fire ants become established indoors in the Netherlands. Many countries, including the countries in the Mediterranean region, are susceptible to fire ant establishments. These countries will have strict regulations on imports of certain goods from infested countries. If the Netherlands harbours fire ants, this will have serious consequences on plant (material) export trade in Europe and worldwide.
2.24. How great are the economic costs / losses associated with managing this organism currently in the risk assessment area (include any past costs in your response)?	minimal minor moderate	low medium high	N/A. Because the species is not present in Europe, there is no current cost of damage.

	major massive		
2.25. How great are the economic costs / losses associated with managing this organism likely to be in the future in the risk assessment area?	minimal minor **moderate** major massive	**low** medium high	It is likely that, if *S. richteri* finds suitable habitats and climates for its development in the Atlantic and continental regions, the economic costs associated with its management may be locally major and similar to the economic costs of *S. invicta*. But its extent is very difficult to estimate considering the uncertainty related to habitat/climatic suitability. The magnitude of the impacts will depend on the densities *S. richteri* achieves. Establishment in areas of suboptimal climate will limit dense populations and reduce impacts.
Social and human health impacts			
2.26. How important is social, human health or other impact (not directly included in any earlier categories) caused by the organism for the risk assessment area and for third countries, if relevant (e.g. with similar eco-climatic conditions).	minimal minor moderate **major** massive	**low** medium high	*Solenopsis richteri* is a social nuisance in infested areas much like *S. invicta*. Colonies are common around urban areas and are considered an urban pest. Ants also enter buildings and can destroy various domestic equipment. This ant has a painful sting that may cause injury to humans and domestic animals. The sting may produce an immediate, intense pain followed by red swelling. *Solenopsis invicta* significantly affects human health. In south-eastern USA, an estimated 14 million people are stung annually (CABI 2018). A survey in Texas showed that 79% of inhabitants have been stung by the ant in the year of the survey (Drees 2000). While, for most people, the effect of stings is relatively minor, albeit painful, some people are hypersensitive to a protein contained in the venom and, for them, a sting can lead to an anaphylactic shock. Anaphylaxis occurs in 0.6 to 6% of persons who are stung and can be lethal. Several deaths are reported each year in south-eastern USA (DeShazo et al. 1999). A survey in South Carolina showed that 0.94% of the people seek medical attention for *S. invicta* stings

			and 0.02% are treated for anaphylaxis (Caldwell et al. 1999).
2.27. How important is social, human health or other impact (not directly included in any earlier categories) caused by the organism in the future for the risk assessment area.	minimal minor moderate **major** massive	**low** medium high	It is likely that, if *S. richteri* finds suitable habitats and climates for its development in the Atlantic and continental regions, the impact on social and human health may be locally major and similar to the impacts of *S. invicta*. But its extent is very difficult to estimate considering the uncertainty related to habitat/climatic suitability. The magnitude of the impacts will depend on the densities *S. richteri* achieves. Establishment in areas of suboptimal climate will limit dense populations and reduce impacts.
Other impacts			
2.28. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	**NA** minimal minor moderate major massive	low medium high	*Solenopsis richteri* is not known for being used as food or feed, being a host or vector of other damaging organisms.
2.29. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	**NA** minimal minor moderate major massive	low medium high	No other impacts were found.
2.30. 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 the risk assessment area?	minimal minor **moderate** major massive	low **medium** high	There are no specific natural enemies of *Solenopsis* spp. in Europe. Thus, only generalist natural enemies of ants may affect the ant and these are highly unlikely to regulate (control) populations.

REFERENCES

Adams BJ, Hooper-Bùi LM, Strecker RM, O'Brien DM. 2011. Raft formation by the red imported fire ant, Solenopsis invicta. J. Insect Sci. 11:171. doi:10.1673/031.011.17101.

Adams CT, Banks WA, Lofgren CS, Smittle BJ, Harlan DP. 1983. Impact of the red imported fire ant, Solenopsis invicta (Hymenoptera: Formicidae), on the growth and yield of soybeans. J. Econ. Entomol. 76:1129–1132.

Allen CR, Birge HE, Slater J, Wiggers E. 2017. The invasive ant, Solenopsis invicta, reduces herpetofauna richness and abundance. Biol. Invasions 19:713–722. doi:10.1007/s10530-016-1343-7.

Allen CR, Epperson DM, Garmestani AS. 2004. Red imported fire ant impacts on wildlife: a decade of research. Am. Midl. Nat. 152:88–103. doi:10.1674/0003-0031(2004)152[0088:RIFAIO]2.0.CO;2.

Bertelsmeier C, Courchamp F. 2014. Future ant invasions in France. Environ. Conserv. 41:217–228. doi:10.1017/S0376892913000556.

Bertelsmeier C, Liebhold AM, Brockerhoff EG, Ward D, Keller L, States U, Zealand N. 2018. Recurrent bridgehead effects accelerate global alien ant spread. Proc. Natl. Acad. Sci. USA:1–6. doi:10.1073/pnas.1801990115.

Bertelsmeier C, Luque GM, Hoffmann BD, Courchamp F. 2015. Worldwide ant invasions under climate change. Biodivers. Conserv. 24:117–128. doi:10.1007/s10531-014-0794-3.

Blight O, Orgeas J, Torre F, Provost E. 2014. Competitive dominance in the organisation of Mediterranean ant communities. Ecol. Entomol. 39. doi:10.1111/een.12137.

Blight O, Provost E, Renucci M, Tirard A, Orgeas J. 2010. A native ant armed to limit the spread of the Argentine ant. Biol. Invasions 12:3785–3793.

Briano J a., Williams DF. 2002. Natural occurrence and laboratory studies of the fire ant pathogen Vairimorpha invictae (Microsporida: Burenellidae) in Argentina. Environ. Entomol. 31:887–894. doi:10.1603/0046-225X-31.5.887.

CABI 2018. *Solenopsis invicta* [original text updated by D Gunawardana]. In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/iscCalcaterra LA, Briano JA, Williams DF. 1999. Field studies of the parasitic ant Solenopsis daguerrei (Hymenoptera: Formicidae) on fire ants in Argentina. Environ. Entomol. 28:88–95. doi:10.1093/ee/28.1.88.

Caldwell ST, Schuman SH, Simpson Jr. WM. 1999. Fire ants: a continuing community health threat in South Carolina. J. South Carolina Med. Assoc. 95:231–235.

DeShazo RD, Williams DF, Moak ES. 1999. Fire ant attacks on residents in health care facilities: A report of two cases. Ann. Intern. Med. 131:424–429. doi:10.7326/0003-4819-131-6-199909210-00005.

Drees BM (2000) The Scripps Howard Texas Poll: Fire Ants in Texas. Fire Ant Trails, 3(5), Texas Cooperative Extension, College Station,Texas, USA. http://fireant.tamu.edu/materials/newsletters/fatrails3.005.htm#scripps.

Eubanks MD, Blackwell SA, Parrish CJ, Delamar ZD, Hull-Sanders H. 2002. Intraguild predation of beneficial arthropods by red imported fire ants in cotton. Environ. Entomol. 31:1168–1174. doi:10.1603/0046-225X-31.6.1168.

Folgarait PJ, Adamo PD, Gilbert LE. 2004. A Grassland Ant Community in Argentina : The Case of Solenopsis richteri and Camponotus punctulatus (Hymenoptera : Formicidae) Attaining High Densities in Their Native Ranges. Ann. Entomol. Soc. Am. 97:450–457. doi:10.1603/0013-

8746(2004)097[0450:AGACIA]2.0.CO;2.
GIEC 2007. Climate Change 2007: Synthesis Report. An Assessment of the Intergovernmental Panel on Climate Change.
Gutrich JJ, VanGelder E, Loope L. 2007. Potential economic impact of introduction and spread of the red imported fire ant, Solenopsis invicta, in Hawaii. Environ. Sci. Policy 10:685–696. doi:10.1016/j.envsci.2007.03.007.
Hara AH, Cabral SK, Niino-Duponte RY, Jacobsen CM, Onuma K. 2011. Bait insecticides and hot water drenches against the little fire ant, Wasmannia auropunctata (Hymenoptera: Formicidae), infesting containerized nursery plants. Florida entomologist 94(3), 517-526.
Harris RJ, Abbott K, Barton K, Berry J, Don W, Gunawardana D, Lester P, Rees J, Stanley M, Sutherlaland A, Toft R. 2005. Invasive ant pest risk assessment project for Biodiversity New Zealand. Series of unpublished Landcare research contract reports to Biosecurity New Zealand. BAH/35/2004-1.
Hee JJ, Holway D a., Suarez A V., Case TJ. 2000. Role of propagule size in the success of incipient colonies of the invasive Argentine ant. Conserv. Biol. 14:559–563. doi:10.1046/j.1523-1739.2000.99040.x.
Hoffmann BD, Luque GM, Bellard C, Holmes ND, Donlan CJ. 2016. Improving invasive ant eradication as a conservation tool: A review. Biol. Conserv. 198:37–49. doi:10.1016/j.biocon.2016.03.036.
Hölldobler B, Wilson EO. 1990. The Ants.
Holway DA, Lach L, Suarez A V., Tsutsui ND, Case TJ. 2002. The causes and consequences of ant invasions. Annu. Rev. Ecol. Syst. 33:181–233. doi:10.1146/annurev.ecolsys.33.010802.150444.
Kabashima JN, Greenberg L, Rust MK, Paine TD (2007) Aggressive interactions between *Solenopsis invicta* and *Linepithema humile* (Hymenoptera: Formicidae) under laboratory conditions. Journal of Economic Entomology, 100:148-154.
King JR, Tschinkel WR. 2006. Experimental evidence that the introduced fire ant, Solenopsis invicta, does not competitively suppress co-occurring ants in a disturbed habitat. J. Anim. Ecol. 75:1370–1378. doi:10.1111/j.1365-2656.2006.01161.x.
King JR, Tschinkel WR. 2008. Experimental evidence that human impacts drive fire ant invasions and ecological change. Proc. Natl. Acad. Sci. U. S. A. 105:20339–20343. doi:10.1073/pnas.0809423105.
Korzukhin MD, Porter SD, Thompson LC, Wiley S. 2001. Modeling temperature-dependent range limits for the fire ant Solenopsis invicta (Hymenoptera: Formicidae) in the United States. Environ. Entomol. 30:645–655. doi:doi: 10.1603/0046-225X-30.4.645.
Lafleur B, Hooper-Bùi LM, Mumma EP, Geaghan JP. 2005. Soil fertility and plant growth in soils from pine forests and plantations: Effect of invasive red imported fire ants Solenopsis invicta (Buren). Pedobiologia (Jena). 49:415–423. doi:10.1016/j.pedobi.2005.05.002.
Lard CF, Hall C, Salin V. 2002. Economic assessments of red imported fire ant on Texas' urban and agricultural sectors. Southwest. Entomol. 25, Suppl.:123–137.
Lester P. 2005. Determinants for the successful establishment of exotic ants in New Zealand. Diversity and Distributions 11:279-288.
Lofgren CS, Banks WA, Glancey BM. 1975. Biology and control of imported fire snts. Annu. Rev. Entomol. 20:1–30.
Luque GM, Giraud T, Courchamp F. 2013. Allee effects in ants. J. Anim. Ecol. 82:956–965. doi:10.1111/1365-2656.12091.
Markin GP, Collins HL, Dillier JH. 1972. Colony founding by queens of the red imported fire ant, Solenopsis invicta. Ann. Entomol. Soc. Am. 65:1053–8.
Markin GP, Dillier JH, Hill SO, Blum MS, Hermann HR. 1971. Nuptial flight and flight ranges of the imported fire ant Solenopsis saevissima richteri (Hymenoptera: Formicidae). J. Georg. Entomol. Soc. 6:145–156.
McGlynn TP. 1999. The Worldwide Transfer of Ants: Geographic Distribution and Ecological Invasion. J. Biogeogr. 26:535–548.

Morrison LW, Porter SD, Daniels E, Korzukhin MD. 2004. Potential global expansion of the invasive fire ant, Solenopsis invicta. Biol. Invasions 6:183–191.

Ness JH. 2003. Contrasting exotic Solenopsis invicta and native forelius pruinosus ants as mutualists with Catalpa bignonioides, a native plant. Ecol. Entomol. 28:247–251. doi:10.1046/j.1365-2311.2003.00500.x.

Ness JH, Bronstein JL. 2004. The effects of invasive ants on prospective ant mutualists. Biol. Invasions 6:445–461. doi:10.1023/B:BINV.0000041556.88920.dd.

Noordijk J. 2010. A risk analysis for fire ants in the Netherlands. Leiden, Stichting European Invertebrate Survey, 37 pp.

Palomo G, Martinetto P, Perez C, Iribarne O. 2003. Ant predation on intertidal polychaetes in a SW atlantic estuary. Mar. Ecol. Prog. Ser. 253:165–173. doi:10.3354/meps253165.

Peterson AT, Nakazawa Y. 2008. Environmental data sets matter in ecological niche modelling : an example with Solenopsis invicta and Solenopsis richteri. :135–144. doi:10.1111/j.1466-8238.2007.00347.x.

Pimentel D, Lach L, Zuniga R, Morrison D. 2000. Environmental and Economic Costs of Nonindigenous Species in the United States. Bioscience 50:53. doi:10.1641/0006-3568(2000)050[0053:EAECON]2.3.CO;2.

Porter SD. 1988. Impact of temperature on colony growth and developmental rates of the ant, Solenopsis invicta. J. Insect Physiol. 34:1127–1133. doi:10.1016/0022-1910(88)90215-6.

Ross KG, Krieger MJB, DeWayne Shoemaker D. 2003. Alternative Genetic Foundations for a Key Social Polymorphism in Fire Ants. Genetics 165:1853–1867.

Ross KG, Trager JC. 1990. Systematics and population genetics of fire ants (Solenopsis saevissima complex) from Argentina. Evolution (N. Y). 44:2113–2134. doi:10.2307/2409620.

Stewart JW and Vinson SB. 1991. Red imported fire ant damage to commercial cucumber and sunflower plants. Southwestern Entomologist Scientific Note, 16, 168-170.

Stuble KL, Kirkman LK, Carroll CR. 2010. Are red imported fire ants facilitators of native seed dispersal? Biol. Invasions 12:1661–1669. doi:10.1007/s10530-009-9579-0.

Suarez A V, Holway D a, Ward PS. 2005. The role of opportunity in the unintentional introduction of nonnative ants. Proc. Natl. Acad. Sci. U. S. A. 102:17032–17035. doi:10.1073/pnas.0506119102.

Sutherst RW, Maywald G. 2005. A Climate Model of the Red Imported Fire Ant, Solenopsis invicta Buren (Hymenoptera : Formicidae): Implications for Invasion of New Regions , Particularly Oceania A Climate Model of the Red Imported Fire Ant , Solenopsis invicta Buren (Hymenoptera : F. Popul. Ecol. 34:317–335.

Taber SW. 2000. Fire Ants. College Station, Texas: Texas A&M University Press.

Teal S., Segarra E., Barr C., Drees B. 1999. The cost of red imported fire ant infestation: The case of the Texas cattle industry. Texas Journal of Agriculture and Natural Resources 12: 88-97.

Trager JC. 1991. A revision of the fire ants, *Solenopsis geminata* group (Hymenoptera: Formicidae: Myrmicinae). J. New York Entomol. Soc. 99:141–198.

Tschinkel WR. 1988. Colony growth and the ontogeny of worker polymorphism in the fire ant, Solenopsis invicta. Behav. Ecol. Sociobiol. 22:103–115. doi:10.1007/BF00303545.

Tschinkel WR. 2006. The fire ants. Harvard University Press, Cambridge.

Valles, SM, Strong, CA Callcott, A-MA 2018. Multiplex lateral flow immunoassay to discriminate *Solenopsis invicta, Solenopsis richter*i, and *Solenopsis*

invicta x *richteri* hybrides. Insectes Sociaux 65: 493-501.
Vinson, S.B., Greenberg, L., 1986. The biology, physiology, and ecology of imported fire ants. In: Vinson, S.B. (Ed.), Economic Impact and Control of Social Insects. Praeger Scientific, New York, pp. 193–226.
Vogt JT, Streett DA, Boykin D. 2004. Seasonal characteristics of black imported fire ant (Hymenoptera: Formicidae) mounds in northern Mississippi pastures. Sociobiology 43:513–522. doi:www.csuchico.edu/biol/Sociobiology/sociobiologyindex.html.
Vonshak M, Dayan T, Ionescu-Hirsh A, Freidberg A, Hefetz A. 2010. The little fire ant Wasmannia auropunctata: A new invasive species in the Middle East and its impact on the local arthropod fauna. Biol. Invasions 12:1825–1837. doi:10.1007/s10530-009-9593-2.
Wang L, Lu Y, Xu Y, Zeng L. 2013. The current status of research on Solenopsis invicta Buren (Hymenoptera: Formicidae) in mainland China. Asian Myrmecol. 5:125–137.
Wojcik DP, Allen CR, Brenner RJ, Forys EA, Jouvenaz DP. 2001. Red imported fire ants : impact on biodiversity.
Wylie FR, Janssen-May S. 2017. Red Imported Fire Ant in Australia: What if we lose the war? Ecol. Manag. Restor. 18:32–44. doi:10.1111/emr.12238.
Wylie R, Jennings C, McNaught MK, Oakey J, Harris EJ. 2016. Eradication of two incursions of the Red Imported Fire Ant in Queensland, Australia. Ecol. Manag. Restor. 17:22–32. doi:10.1111/emr.12197.

ANNEXES

ANNEX I Scoring of Likelihoods of Events

(taken from UK Non-native Organism Risk Assessment Scheme User Manual, Version 3.3, 28.02.2005)

Score	Description	Frequency
Very unlikely	This sort of event is theoretically possible, but is never known to have occurred and is not expected to occur	1 in 10,000 years
Unlikely	This sort of event has not occurred anywhere in living memory	1 in 1,000 years
Possible	This sort of event has occurred somewhere at least once in recent years, but not locally	1 in 100 years
Likely	This sort of event has happened on several occasions elsewhere, or on at least one occasion locally in recent years	1 in 10 years
Very likely	This sort of event happens continually and would be expected to occur	Once a year

ANNEX II Scoring of Magnitude of Impacts

(modified from UK Non-native Organism Risk Assessment Scheme User Manual, Version 3.3, 28.02.2005)

Score	Biodiversity and ecosystem impact	Ecosystem Services impact	Economic impact (Monetary loss and response costs per year)	Social and human health impact
	Question 2.18-22	*Question 2.23-25*	*Question 2.26-30*	*Question 2.31-32*

Minimal	Local, short-term population loss, no significant ecosystem effect	No services affected[10]	Up to 10,000 Euro	No social disruption. Local, mild, short-term reversible effects to individuals.
Minor	Some ecosystem impact, reversible changes, localised	Local and temporary, reversible effects to one or few services	10,000-100,000 Euro	Significant concern expressed at local level. Mild short-term reversible effects to identifiable groups, localised.
Moderate	Measureable long-term damage to populations and ecosystem, but little spread, no extinction	Measureable, temporary, local and reversible effects on one or several services	100,000-1,000,000 Euro	Temporary changes to normal activities at local level. Minor irreversible effects and/or larger numbers covered by reversible effects, localised.
Major	Long-term irreversible ecosystem change, spreading beyond local area	Local and irreversible or widespread and reversible effects on one / several services	1,000,000-10,000,000 Euro	Some permanent change of activity locally, concern expressed over wider area. Significant irreversible effects locally or reversible effects over large area.
Massive	Widespread, long-term population loss or extinction, affecting several species with serious ecosystem effects	Widespread and irreversible effects on one / several services	Above 10,000,000 Euro	Long-term social change, significant loss of employment, migration from affected area. Widespread, severe, long-term, irreversible health effects.

ANNEX III Scoring of Confidence Levels

(modified from Bacher et al. 2017)

Confidence level	Description
Low	There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence *and/or* Impacts are recorded at a spatial scale which is unlikely to be relevant to the assessment area *and/or* Evidence is poor and

[10] Not to be confused with „no impact“.

	difficult to interpret, e.g. because it is strongly ambiguous *and/or* The information sources are considered to be of low quality or contain information that is unreliable.
Medium	There is some direct observational evidence to support the assessment, but some information is inferred *and/or* Impacts are recorded at a small spatial scale, but rescaling of the data to relevant scales of the assessment area is considered reliable, or to embrace little uncertainty *and/or* The interpretation of the data is to some extent ambiguous or contradictory.
High	There is direct relevant observational evidence to support the assessment (including causality) *and* Impacts are recorded at a comparable scale *and/or* There are reliable/good quality data sources on impacts of the taxa *and* The interpretation of data/information is straightforward *and/or* Data/information are not controversial or contradictory.

ANNEX IV Ecosystem services classification (CICES V5.1, simplified) and examples

For the purposes of this risk assessment, please feel free to use what seems as the most appropriate category / level / combination of impact (Section – Division – Group), reflecting information available.

Section	Division	Group	Examples (i.e. relevant CICES "classes")
Provisioning	**Biomass**	**Cultivated *terrestrial* plants**	Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes; Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials); Cultivated plants (including fungi, algae) grown as a source of energy *Example: negative impacts of non-native organisms to crops, orchards, timber etc.*
		Cultivated *aquatic* plants	Plants cultivated by in- situ aquaculture grown for nutritional purposes; Fibres and other materials from in-situ aquaculture for direct use or processing (excluding genetic materials); Plants cultivated by in- situ aquaculture grown as an energy source. *Example: negative impacts of non-native organisms to aquatic plants cultivated for nutrition, gardening etc. purposes.*
		Reared animals	Animals reared for nutritional purposes; Fibres and other materials from reared animals for direct use or processing (excluding genetic materials); Animals reared to provide energy (including mechanical) *Example: negative impacts of non-native organisms to livestock*
		Reared *aquatic* animals	Animals reared by in-situ aquaculture for nutritional purposes; Fibres and other materials from animals grown by in-situ aquaculture for direct use or processing (excluding genetic materials); Animals reared by in-situ aquaculture as an energy source *Example: negative impacts of non-native organisms to fish farming*
		Wild plants (terrestrial and aquatic)	Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition; Fibres and other materials from wild plants for direct use or processing (excluding genetic materials); Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy *Example: reduction in the availability of wild plants (e.g. wild berries, ornamentals) due to non-native organisms (competition, spread of disease etc.)*
		Wild animals (terrestrial and aquatic)	Wild animals (terrestrial and aquatic) used for nutritional purposes; Fibres and other materials from wild animals for direct use or processing (excluding genetic materials); Wild animals (terrestrial and aquatic) used as a source of energy

			Example: reduction in the availability of wild animals (e.g. fish stocks, game) due to non-native organisms (competition, predations, spread of disease etc.)
	Genetic material from all biota	**Genetic material** from plants, algae or fungi	Seeds, spores and other plant materials collected for maintaining or establishing a population; Higher and lower plants (whole organisms) used to breed new strains or varieties; Individual genes extracted from higher and lower plants for the design and construction of new biological entities *Example: negative impacts of non-native organisms due to interbreeding*
		Genetic material from animals	Animal material collected for the purposes of maintaining or establishing a population; Wild animals (whole organisms) used to breed new strains or varieties; Individual genes extracted from organisms for the design and construction of new biological entities *Example: negative impacts of non-native organisms due to interbreeding*
	Water[11]	**Surface water** used for nutrition, materials or energy	Surface water for drinking; Surface water used as a material (non-drinking purposes); Freshwater surface water, coastal and marine water used as an energy source *Example: loss of access to surface water due to spread of non-native organisms*
		Ground water for used for nutrition, materials or energy	Ground (and subsurface) water for drinking; Ground water (and subsurface) used as a material (non-drinking purposes); Ground water (and subsurface) used as an energy source *Example: reduced availability of ground water due to spread of non-native organisms and associated increase of ground water consumption by vegetation.*
Regulation & Maintenance	**Transformation** of biochemical or physical inputs to ecosystems	**Mediation of wastes or toxic substances** of anthropogenic origin by living processes	Bio-remediation by micro-organisms, algae, plants, and animals; Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals *Example: changes caused by non-native organisms to ecosystem functioning and ability to filtrate etc. waste or toxics*
		Mediation of nuisances of anthropogenic origin	Smell reduction; noise attenuation; visual screening (e.g. by means of green infrastructure) *Example: changes caused by non-native organisms to ecosystem structure, leading to reduced ability to mediate nuisances.*

[11] Note: in the CICES classification provisioning of water is considered as an abiotic service whereas the rest of ecosystem services listed here are considered biotic.

	Regulation of physical, chemical, biological conditions	**Baseline flows and extreme event** regulation	Control of erosion rates; Buffering and attenuation of mass movement; Hydrological cycle and water flow regulation (Including flood control, and coastal protection); Wind protection; Fire protection *Example: changes caused by non-native organisms to ecosystem functioning or structure leading to, for example, destabilisation of soil, increased risk or intensity of wild fires etc.*
		Lifecycle maintenance, habitat and gene pool protection	Pollination (or 'gamete' dispersal in a marine context); Seed dispersal; Maintaining nursery populations and habitats (Including gene pool protection) *Example: changes caused by non-native organisms to the abundance and/or distribution of wild pollinators; changes to the availability / quality of nursery habitats for fisheries*
		Pest and disease control	Pest control; Disease control *Example: changes caused by non-native organisms to the abundance and/or distribution of pests*
		Soil quality regulation	Weathering processes and their effect on soil quality; Decomposition and fixing processes and their effect on soil quality *Example: changes caused by non-native organisms to vegetation structure and/or soil fauna leading to reduced soil quality*
		Water conditions	Regulation of the chemical condition of freshwaters by living processes; Regulation of the chemical condition of salt waters by living processes *Example: changes caused by non-native organisms to buffer strips along water courses that remove nutrients in runoff and/or fish communities that regulate the resilience and resistance of water bodies to eutrophication*
		Atmospheric composition and conditions	Regulation of chemical composition of atmosphere and oceans; Regulation of temperature and humidity, including ventilation and transpiration *Example: changes caused by non-native organisms to ecosystems' ability to sequester carbon and/or evaporative cooling (e.g. by urban trees)*
Cultural	**Direct, in-situ and outdoor interactions** with living systems that depend on presence in the environmental setting	**Physical and experiential** interactions with natural environment	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions; Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions

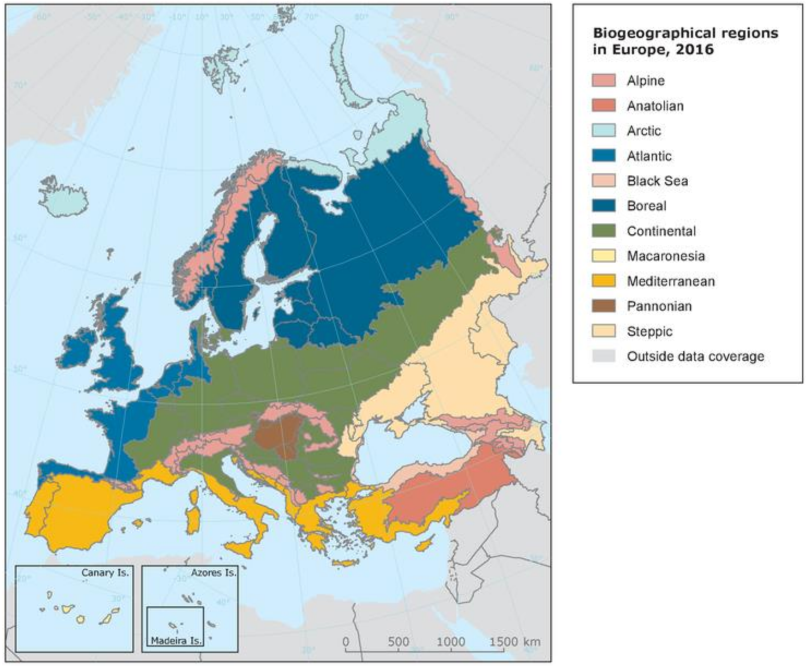
			Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that make it attractive for recreation, wild life watching etc.
		Intellectual and representative interactions with natural environment	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge; Characteristics of living systems that enable education and training; Characteristics of living systems that are resonant in terms of culture or heritage; Characteristics of living systems that enable aesthetic experiences *Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that have cultural importance*
	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	**Spiritual, symbolic** and other interactions with natural environment	Elements of living systems that have symbolic meaning; Elements of living systems that have sacred or religious meaning; Elements of living systems used for entertainment or representation *Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that have sacred or religious meaning*
		Other biotic characteristics that have a **non-use value**	Characteristics or features of living systems that have an existence value; Characteristics or features of living systems that have an option or bequest value *Example: changes caused by non-native organisms to ecosystems designated as wilderness areas, habitats of endangered species etc.*

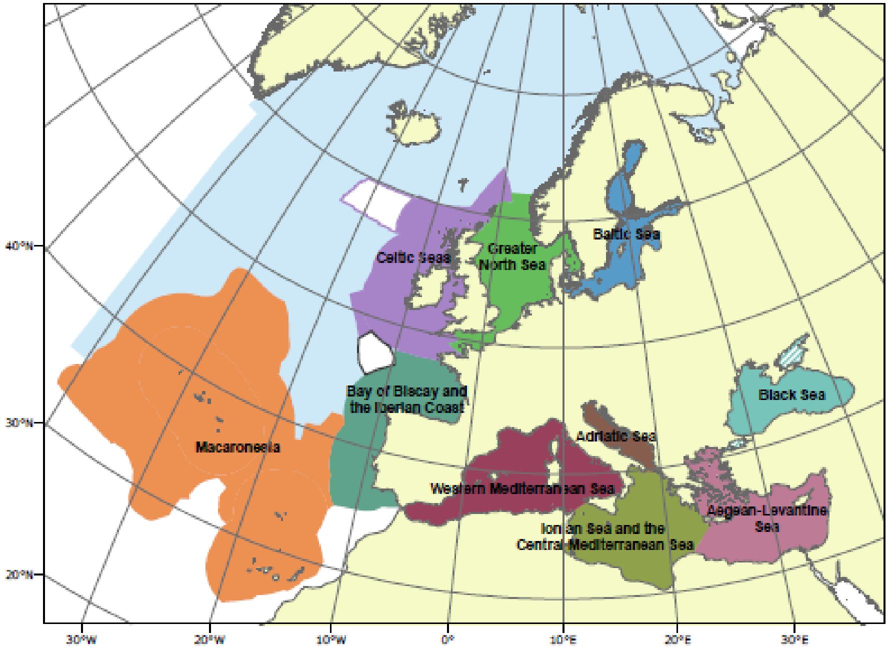
ANNEX V EU Biogeographical Regions and MSFD Subregions

See https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2 ,
http://ec.europa.eu/environment/nature/natura2000/biogeog_regions/

and

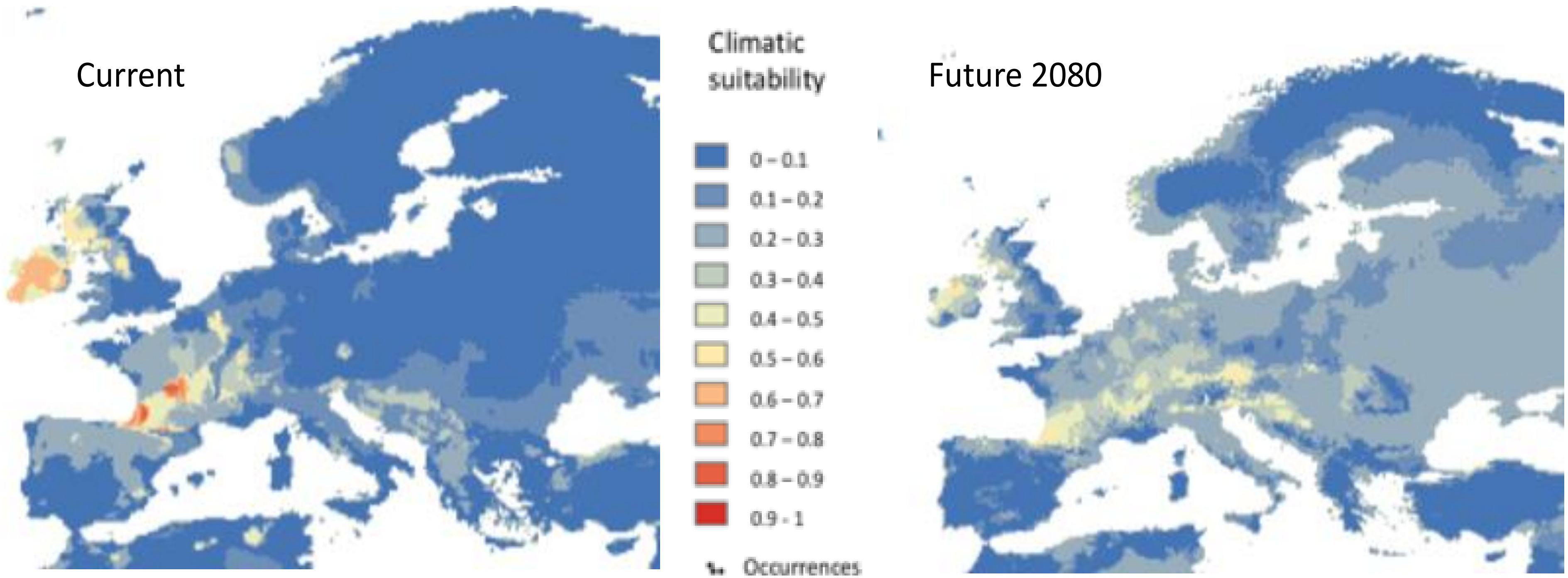
https://www.eea.europa.eu/data-and-maps/data/msfd-regions-and-subregions-1/technical-document/pdf





Annex VI Species distribution models under current and future climatic conditions

(Bertelsmeier et al 2015).
To consider a range of possible future climates, Bertelsmeier et al. (2015) used downscaled climate data from three Global Climate Models (GCMs): the CCCMA-GCM2 model; the CSIRO MK2 model; and the HCCPR-HADCM3 model (GIEC 2007). Similarly, they used the two extreme SRES: the optimistic B2a; and pessimistic A2a scenario. The bioclimatic variables used were derived from monthly temperature and rainfall values from 1960 to 1990, and represent annual trends (e.g., mean annual temperature, annual precipitation), seasonality (e.g., annual range in temperature and precipitation) and extreme or limiting environmental factors (e.g., temperatures of the coldest and warmest month, and precipitations of the wet and dry quarters) which are known to influence species distributions. They predicted an expansion of the potential range of *S. richteri* but the proportion of regions scored with a high suitability index (over 0.7) decreases. This method is based on the assumption that the species' niche remains unchanged when extrapolations are made in space (new potential distribution) and time (future climate scenarios). Occurrence points from both the invaded and native ranges were included to the full set of climatic conditions under which each species can persist because for invasive species in novel environments niche shifts can occur leading to differences with the native shift.


Current
Climatic suitability
0 – 0.1
0.1 – 0.2
0.2 – 0.3
0.3 – 0.4
0.4 – 0.5
0.5 – 0.6
0.6 – 0.7
0.7 – 0.8
0.8 – 0.9
0.9 - 1
Occurrences
Future 2080