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]

Name of organism: ***Solenopsis geminata*** **(Fabricius 1804).**

S. geminata worker (major), credits : Alex Wild

Author(s) of the assessment:
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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 two 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:
10/18/2018

[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. geminata* to Europe is the unintentional translocation 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. Queen ants are also likely to arrive as hitchhikers, but only aircraft will allow a transfer fast enough for survival. Finally, queens may enter the risk assessment area through the ant market on the internet. This pathway should be considered in the future if the online market of ants is not sufficiently regulated.
Summarise Establishment[4]	very unlikely unlikely moderately likely **likely** very likely	low **medium** high	Based on a global species distribution model, *S. geminata* could become established in all countries around the Mediterranean Sea, with both the Southern Atlantic Coast from Southern France to Spain and the Adriatic coast of Italy being particularly suitable. Less than 2% of Europe is and will be suitable under climate change in the future to 2080. Predictions on the geographic extent of potential establishment indicate a slight increase in suitable

[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

			areas. 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. geminata* will probably spread moderately rapidly. Although *S. geminata* can spread unaided over several 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. It is likely that if established, the ant will have a patchy distribution in Southern Europe, with moderate densities and extent in open and sunny disturbed habitats.
Summarise Impact[6]	minimal minor **moderate** major massive	low **medium** high	The species has a moderate to major environmental, economic and social impact elsewhere in the world. Similar impacts may occur in Southern Europe. However, the transferability of this impact to Europe is hindered by uncertain data on habitat/climatic suitability that may limit the geographic area that is most favourable to the insect. In other words, if only limited zones in the Mediterranean and Atlantic biogeographical regions will be favourable for the ant, impacts will be largely restricted to these zones.

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

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

Conclusion of the risk assessment[7]	low **moderate** high	low **medium** high	*Solenopsis geminata* is not one of the most damaging invasive ants on earth but probably one of the most successful at invading and colonising new areas. There is no doubt that it can enter Europe through a variety of pathways, but its establishment and impact would be constrained by climate, habitat suitability and competition from other already established invasive ant species. It might have environmental, economic and social impact in some areas of Southern Europe, but the extent of its potential distribution remains unclear.

[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	-	-	-	-
Belgium	-	-	-	-
Bulgaria	-	-	-	-
Croatia	-	-	YES	-
Cyprus	YES	-	-	-
Czech Republic	-	-	-	-
Denmark	-	-	-	-
Estonia	-	-	-	-
Finland	-	-	-	-
France	-	-	YES	-
Germany	-	-	-	-
Greece	YES	-	YES	-
Hungary	-	-	-	-
Ireland	-	-	YES	-
Italy	YES	-	YES	-
Latvia	-	-	-	-
Lithuania	-	-	-	-
Luxembourg	-	-	-	-
Malta	-	-	-	-
Netherlands	YES	-	-	-
Poland	-	-	-	-
Portugal	-	-	YES	-
Romania	-	-	-	-

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

*Countries with suitability index >0.5 in 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	-	YES	-
Black Sea		-	-	-
Boreal		-	-	-
Continental		-	YES	-
Mediterranean	YES	-	YES	-
Pannonian		-	-	-
Steppic		-	-	-

Marine regions and sub-regions 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 geminata* (Fabricius, 1804) Class: Insecta Order: Hymenoptera Family: Formicidae Genus: *Solenopsis* Westwood, 1840 There is one subspecies: *Solenopsis geminata micans* Stitz, 1912 (Bolton 2019) *S. geminata* is a highly polymorphic species, with a wide range of worker size and shape within the colony (head width = 0.55 – 2.30 mm). It shows considerable variation in coloration. *Solenopsis geminata* can occur in a "red form" that is more abundant in open areas and in a "black form" that prefers forested areas (Longino 2005). The environmental or genetic determinants of these forms are unknown. As a result of this variability, combined with some poor taxonomic work, *S. geminata* has been described repeatedly under many different names, now designated as junior synonyms (Wetterer 2011). Synonyms: *Solenopsis geminata rufa* (Jerdon, 1851) and 21 other junior synonyms. Original name: *Atta geminata* Fabricius (1804). A comprehensive and regularly updated list can be found at www.antcat.org. Common name: Tropical Fire ant (TFA)
A2. Provide information on the existence of other species that look very similar [that may be detected in the risk assessment area, either	The genus *Solenopsis* contains 196 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

in the wild, in confinement or associated with a pathway of introduction]	considered invasive, *Solenopsis invicta*, *Solenopsis geminata*, *Solenopsis richteri* and *Solenopsis papuana*. Fire ants are a group of related species (*Solenopsis geminata* group) that has its centre of diversity in southern South America (Trager 1991). (Reference?) Smaller *S. geminata* workers ("minor") are often not distinguishable from minor workers of other fire ant species, but larger workers with wide head ("major") have a distinct head morphology. A key for separation of the taxa in the *S. geminata* species-group was provided by Trager (1991). Seven species of the genus Solenopsis are present in Europe (taxon under revision), they all belong to the sub-genus Diplorhoptrum (Lebas et al. 2016). Workers are all tiny, from 1.5 to 2.2mm and light yellow. They have a very distinct behaviour from *S. geminata*. They never forage on the soil surface except during nuptial flights. They are relatively easy to distinguish from *S. geminata*.
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, which concludes that, although they are regularly found during import inspections in the Netherlands, it is unlikely that they can establish outdoors in the country (Noordijk 2010). This is particularly true for *Solenopsis geminata* which is more thermophilic than *S. invicta* and *S. richteri*. However, establishment in permanently heated buildings is possible, 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). These conclusions are similar to those in the present risk assessment for the North Atlantic biogeographical region. Another RA has been carried out for New Zealand, which classified *S. geminata* as having a *high risk* of entry but a *low risk* of establishment and spread (Harris 2005). However, RA made for different regions are not easily comparable.
A4. Where is the organism native?	The exact limitation of the native range of *Solenopsis geminata* in New World remains unclear (Gotzek et al. 2015). It is disputed, in part because the species is continuously distributed from the South-eastern United States to the south of South America (www.antmaps.org; Guénard et al. 2017). Trager (1991) considers *S. geminata* native to the south-eastern coastal plain of Florida to Texas south through Central America to northern South America, including the coastal areas of north-eastern Brazil, west through the Guianas to the Orinoco Basin, the

	western Amazon Basin and coastal areas of Peru. Wetterer (2011) wrote: "*S. geminata* is originally from the New World tropics and subtropics. However, the extent of the native range of *S. geminata* in the New World remains unclear. *Solenopsis geminata* is almost certainly native to South America, Central America and Mexico, and most authors consider *S. geminata* as native to the South-eastern US." In fact, *S. geminata* in US might be a mix of native and exotic populations (Wetterer 2011).
A5. What is the global non-native distribution of the organism outside the risk assessment area?	*Solenopsis geminata* has been extraordinarily successful in spreading into five continents and has colonized many tropical islands on all the oceans (for the most current distribution map see www.antmaps.org). South and Central American countries: It has been reported from all South and Central American countries North America: The species has in the Southern US from California to Virginia. West Indies: It has spread in every island group in the West Indies Asia and Australasian region: Australia, New Caledonia, Papua New Guinea, Solomon Islands, Indonesia, Philippines, Malaysia, Gambodia, Vietnam, Sumatra, Java, Taiwan, Sri Lanka, India, Pakistan, Thailand, Bangladesh, Hong Kong, China, Turkey. However, a number of these records were possible misidentifications (e.g. of *Solenopsis xyloni*, *Solenopsis gayi*, *Solenopsis saevissima*) (Wetterer 2011). Arabian Peninsula: Arab Emirates, Oman. African continent:

	The documented range of *S. geminata* in Africa is much more limited and many records appear to be a different species (Kouakou et al. 2017). Its presence was confirmed only in Côte d'Ivoire (West Africa) Reports of presence of *S. geminata* in Africa are based on information dating back to 1958. Due to the lack of scientific knowledge of the species in Africa, African populations were not considered in the recently published global invasion history reconstruction of the species (Gotzek et al. 2015). We thus decided to not consider potential misidentification in this risk assessment..
A6. In which biogeographic region(s) or marine sub-region(s) in the risk assessment area has the species been recorded and where is it established?	<u>Recorded:</u> Mediterranean and Atlantic biogeographic regions. <u>Established:</u> The species currently is not established in the risk assessment area, neither in the wild nor indoors. One population was established in a building in the Netherlands (Atlantic Biogeographic Region) and was eradicated (Noordijk 2010).
A7. In which biogeographic region(s) or marine sub-region(s) in the risk assessment area could the species establish in the future under current climate and under foreseeable climate change?	<u>Current climate (suitability index above 0.5 in Bertelsmeier et al. (2015), see annexe 1):</u> Atlantic, Continental and Mediterranean <u>Future climate (suitability index above 0.5 in Bertelsmeier et al. (2015), see annexe 1):</u> Atlantic, Continental and Mediterranean. To consider a range of possible future climates, <u>Bertelsmeier et al. (2015)</u> 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. geminata* 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 Atlantic (North of Spain and Portugal, South West coast of France and South East of Ireland), Continental (North of Italy) and Mediterranean (Spain, France, Italy, Croatia, Cyprus, Greece and Malta) Biogeographic Regions. According to the applied models, overlap between species' current and future potential distributions is 98.1 % (Bertelsmeier et al. 2015).

	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 SDM.
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.	Recorded in the following Member States: The species was recorded in Italy before 1861 (Mayr 1861 as *D. drewseni*), in England in 1932 (Donisthorpe 1943), in Greece in 1982 and 1988 (Collingwood 1993), in Cyprus before 1997 (Collingwood et al. 1997) and Netherlands in 1992 (Boer and Vierbergen 2008) (see Wetterer 2011). <u>Established:</u> The species currently is not established in the risk assessment area. Workers have been found occasionally during import inspections, and in at least one occasion in the Netherlands, a nest has been found in an apartment building (Noordijk 2010). It was eradicated using chloredecone.
A9. In which EU member states could the species establish in the future under current climate and under foreseeable climate change?	<u>Current climate</u> (suitability index above 0.5 in Bertelsmeier et al. (2015) (see ; annex VI): Croatia, Cyprus, France, Greece, Ireland, Italy, Malta, Portugal, Slovenia and Spain. <u>Future climate</u> (suitability index above 0.5 in Bertelsmeier et al. (2015) (see ; annex VI): same countries as above mentioned According to the only available species distribution model (Bertelsmeier et al. 2015), *S. geminata* will not become established widely in Europe under both current and future climatic conditions until 2080. It will have the capacity to establish in Southern Europe: Croatia, Cyprus, France, Greece, Italy, Slovenia and Spain. However even in Southern Europe climatic suitability is currently low and will likely be so in the future except for the northern part of Italy.

	There are no other published predictions of the current and future potential of *S. geminata* establishment in Europe.
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 amongst the most widely distributed invasive species on earth. It has colonized almost all continents and has ecological and economic impacts albeit its impacts are often considered lower than other invasive ants (Holway et al. 2002).
A11. In which biogeographic region(s) or marine sub-region(s) in the risk assessment area has the species shown signs of invasiveness?	None. There was one established population in a building in the Netherlands, but it was eradicated using chloredecone.
A12. In which EU member states has the species shown signs of invasiveness?	None. There was one established population in a building in the Netherlands, but it was eradicated using chloredecone.
A13. Describe any known socio-economic benefits of the organism.	In some cases, *S. geminata* has been reported to provide benefits to crops by preying on pests (Way et al. 2002; Litsinger et al. 2007; Jacquot et al. 2017). 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?	none very few few	low medium **high**	*S. geminata* has been intercepted from a variety of commodities (ornamental plants and fruits) and origins (South America, US) at US ports and

[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

(If there are no active pathways or potential future pathways respond N/A and move to the Establishment section)	moderate number **many** very many		airports since 1910 (Blight et al. unpublished data). *S. geminata* intercepted in the Netherlands originated mainly from Thailand (Noordijk 2010).
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 geminata* 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 limit the number of active pathways as the risk of predation is very high. Harris (2005) provided a very detailed analysis of potential pathways of introduction of *S. geminata* in New Zealand, which is also highly relevant for Europe. Noordijk (2010) provides a brief assessment of pathways for the Netherlands as well as interception data. Queens may enter the risk assessment area through the ant market on the internet. This pathway should be considered in the future if the online sale of ants is not sufficiently regulated.
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)?	intentional **unintentional**	low medium **high**	This concerns only new mated queens.

(if intentional, only answer questions 1.4, 1.9, 1.10, 1.11 – delete other rows)			
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? Sub-note: 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	Although many individuals may travel this pathway, new colonies are established by solitary fertile queens following a mating flight. Colonies consist of workers and queens but only the queens can reproduce. Queens seek moist areas within a few kilometres of the parent colony. Once a suitable site is found the female sheds her wings and digs a small burrow into the soil and seals it. Although few data is 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. Few *S. geminata* queens have been intercepted at ports or airports in New Zealand (six queens or nests over 55 separate interceptions from 1964 to 2002, Harris 2005), as well as in the Nertherlands (at least one was introduced but not intercepted, over 20 records from 1984 to 2010, Noordijk 2010).
1.5a. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Sub-note: 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. However, likelihood of survival will decrease with increasing travel duration, but is possible. Multiplication and the establishment of a small nest during such 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**	Detection rates for solitary queens or even several queens or small nests are low; in general, ants are not easy to detect in cargo airplanes and detection rate thus 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**	During warm months winged individuals are found in large numbers in mature colonies. Reproduction of ant queens can occur over several months and commodities with which ants can enter Europe occur throughout the year. Nuptial flights occur from spring to fall (McInnes and Tschinkel 1995). Among the 21 records between 1984 and 2010 in the Netherlands no *S. geminata* queen has been intercepted (Noordijk 2010). However, one established nest has been recorded in a building suggesting the entry of at least one queen. They were intercepted throughout the year from January to December (Noordijk 2010).
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 in the Mediterranean region 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 degraded habitats particularly in warm opened habitat. *Solenopsis geminata* is most abundant in open and disturbed sunny areas. It is common in agricultural areas and around human

			settlements. In the lowlands it is found not only in the open but may also penetrate into forest understory, albeit at lower density (see section A1 above about red and black forms).
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.
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) 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.
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? Sub-note: 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 very limited data on ant nests arriving through the horticultural trade in Europe. At least some nests have reached Europe (the Netherlands), New Zealand, Australia and US. *Solenopsis geminata* was imported in the Netherlands with potted plants from Honduras, Costa Rica, Suriname, Thailand and Taiwan (Noordijk 2010). 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. geminata* 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. Monogyne and polygyne nests occur. Polygynous nests are mainly found in the introduced range of *S. geminate* and may originate via a founder event from a local monogyne population (Ross et al. 2003). The number of workers in a polygynous nest can vary enormously, from 4 000 to hundreds of thousands (Taber 2000). Way et al. (1998) estimated up to 100 000 *S. geminata* workers in a large nest and at least 500 000 in 100 metres of rice field edge. Ant nests might get onto the pathway in large numbers as contaminant of horticultural materials contains soil.
1.5b. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Sub-note: In your comment consider whether the organism could multiply along the pathway.	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	The likelihood of nest survival along this pathway is high. In the case they do not find food resources they can eat their eggs and larvae. Moreover, some ant species (e.g. *Temnothorax rugatulus*) can survive for several months without food resources (Rueppell and Kirkman 2005).

			However, likelihood of survival is high but 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 before shipment but can be infested after treatment either before departure or during transport.
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 adjoin a suitable habitat. It is expected that suburban and urban habitats are most at risk at the beginning of an invasion. *Solenopsis geminata* is most abundant in open and disturbed sunny areas. It is common in agricultural areas and around human settlements. In the lowlands it is found not only in the open but may also penetrate into forest understory, albeit at lower density (see section A1 above about red and black forms).

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. geminata* into Europe. Noordijk (2010) also considers the horticultural trade as the most likely pathway for introduction 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. Many articles 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 electrical 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? Sub-note: 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 very limited data on ant nests arriving in Europe. Sea containers and all articles of commerce cited above were scored by Harris (2005) as presenting a high likelihood of introduction for nests of *S. geminata*. The number of workers in a polygynous nest can vary enormously, from 4000 to hundreds of thousands (Taber 2000). Way et al. (1998) estimated up to 100 000 *S. geminata* workers in a

			large nest and at least 500 000 in 100 metres of rice field edge. Ant nests might get onto the pathway in large numbers as stowaway in containers or other bulk freight, including soil. The movement of large numbers of workers increases colony survival. However, it is of less concern compared to mated queens as workers do not reproduce. 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)? Sub-note: In your comment consider whether the organism could multiply along the pathway.	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	The likelihood of nest survival along this pathway is high. In the case they do not find food resources they can eat their eggs and larvae. Moreover, some ant species (e.g. *Temnothorax rugatulus*) can survive for several months without food resources (Rueppell and Kirkman 2005). However, likelihood of survival is high but nevertheless will decrease with increasing travel duration. Multiplication of a small nest during intercontinental translocation however is highly unlikely.
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 **likely** very likely	low medium **high**	Commodities that can carry *S. geminata* are introduced to the risk assessment area throughout the year.
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 disturbed soils, which are found everywhere, specifically in urban and semi-urban habitats. *Solenopsis geminata* is most abundant in open and disturbed sunny areas. It is common in agricultural areas and around human settlements. In the lowlands it is found not only in the open but may also penetrate into forest understory, albeit at lower density (see section A1 above about red and black forms).
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. geminata*, this pathway can be considered as having a high likelihood of entry, as determined by Harris (2005) and Noordijk (2010). Sixteen of the 46 interceptions of *S. geminata* in Australia were in containers including empty ones (Source: Department of Agriculture, Fisheries and Forestry, Canberra).

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 been already recorded/intercepted in Europe (Noordijk 2010) and it is likely that this will happen again, specifically with contaminated soil in the horticultural trade and/or as stowaway with container/bulk imports in sea or air freights. *Solenopsis geminata* was imported at least 21 times between 1984 and 2010 in the Netherlands with potted plants from Honduras, Costa Rica, Suriname, Thailand and Taiwan (Noordijk 2010). Although it concerns one country in Europe, these data highly suggest the regular entry of the species into Europe through different points of origin.
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.

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	Bertelsmeier et al. (2015), using a climate matching model (Maxent) based on present distributions, mapped suitable areas globally for 15 of the worst invasive ant species (incl. *S. geminata*). They showed that less than 2% of the European continent is presently suitable for *S. geminata* (Annex VI).
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 on the establishment of *S. geminata* in Europe, except for high-altitude environments. The ant particularly likes open disturbed soils, which are found everywhere, specifically in urban and semi-urban habitats (Perfecto and Vander Meer 2011).
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 geminata* prefers open disturbed habitats, which are found everywhere in Europe. However, as a tropical species it needs hot temperatures to complete its life cycle (Cokendolpher and Francke 1985; Braulick et al. 1988), which may limit its distribution to the Mediterranean region, at

			least in natural areas. There is no experimental data on cold climate tolerances of *S. geminata*. However, preferred temperatures for brood development are reported to be above 22°C.
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 geminata* 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	*Solenopsis geminata* is an ecologically dominant ant in disturbed ecosystems and open habitat within its native range (Morrison 2000). There is probably intense competition with other dominant species in some habitats. In La Réunion island, Jacquot et al (2009) found *S. geminata* to numerically dominate ant communities in agricultural systems. However, *S. geminata* does not appear to be highly competitive compared to other invasive ant species. It has been replaced by *S. invicta* in many places in US (Tschinkel 1988a). In several suitable areas it will have to face the competition with two invasive species, 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. 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. Moreover, these species have a more temperate distribution and may have a competitive advantage over *S. geminata* in the risk assessment area.
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 specialist natural enemies of *Solenopsis* spp. are known to occur in Europe. Moreover, native *Solenopsis* species belong to the sub-genus Diplorhoptrum, they have a very distinct ecology. Unlike *S. geminata*, they never forage on the soil surface. The nest is never open to the soil surface. 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 have succeeded at a local scale

			(Hoffmann et al. 2016), such as in Australia (Hoffmann and O'Connor 2004).
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 have been no management practices applied in the risk assessment area but conventional management practices to date should not facilitate establishment (Hoffmann et al. 2016).
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 *S. geminata* outdoors is difficult, especially when populations reach high densities of nests and individuals. Only killing of the queens will eradicate the population, which requires the use of delayed toxin to reach that queens that are protected inside the nest. Incipient 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 geminata* has single queen (monogynous) and multi-queen (polygynous) populations. Polygynous forms are mainly found in the introduced range of *S. geminata*. As queens found nests individually, a single mated queen would be enough to found a population if it arrived in good condition. The polygynous form can more easily establish 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 4000 to hundreds of thousands (Taber 2000). Way et al. (1998)

			estimated up to 100 000 *S. geminata* workers in a large nest and at least 500 000 in 100 metres of rice field edge. Few data are available on the biology of *S. geminata*. The queen lay around 10 to 15 eggs each day for up to 10 days after which she will stop laying eggs until the workers are mature (source: iss.org). On an indicative basis, inseminated females (queens) of *Solenopsis invicta* lay up to 200 eggs per hour (Tschinkel 1988b). Within one year, the colony of *S. invicta* can grow to several thousands of workers, within three years it can reach up to 230,000 workers (Tschinkel 1988b). The division of labour, i.e. the existence of reproductive caste, enabled ants to become ecologically dominant invertebrates in terrestrial habitats, with a high success rate of reproduction and dispersal. For the Argentine ant, *Linepithema humile*, 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 geminata* is probably one of the most widespread invasive ant, highlighting its capacity to adaptation when introduced to new environments (see www.antmaps.org). However, several factors can constrain establishment of this species. Despite *S.*

			geminata being a generalist, opportunistic species, it requires open, sunny places, and favours those that are associated with humans. Also, in contrast to the invasive *S. invicta*, it has a restricted flight period. Nuptial flights have been recorded only during the warmest seasons. Similarly, foraging and brood development are restricted by cold temperatures. Foraging was not recorded below 15°C (Wuellner and Saunders 2003). In Australia, *S. geminata* is assigned to the hot climate specialist functional group (Andersen and Reichel 1994).
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). In the case of *S. geminata*, it may increase its success of establishment as low genetic diversity is associated with the polygynous form of colonies (Ross et al. 2003). 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 geminata* may be the most widely distributed invasive ant (Wetterer 2011) which highlight its capacity to establish outside its native range. However, considering climatic requirements and potential competition with other dominant ants, *S. geminata* 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? Sub-note: 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 (Bertelsmeier et al. 2018), New Zealand (Harris 2005), *S. geminata* and related *Solenopsis* spp. are regularly intercepted at ports of entry. 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.
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 Mediterranean biogeographical region, establishment under current conditions is likely at least in the most open and hot habitats. Also, both the southern Atlantic (Southern France, Northeast of Spain and North of Portugal) in the Mediterranean region and parts of the Continental (Northeast of Italy and Slovenia) region are considered to be potentially susceptible (Bertelsmeier et al. 2015). However, all these predicted suitable areas are restricted and cover a very limited area in the risk assessment area. The absence of other, more regional, models predicting *S. geminata*'s possible distribution in Europe limits our conclusions.

			The question is also scored "moderately likely" because considering the great invasion success of *S. geminata* throughout the world for 150 years, the absence of established populations in Europe so far suggests that abiotic and/or biotic filters may constrain its establishment under current climatic conditions.
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	Under foreseeable climate change, *S. geminata* may establish in the Atlantic, Mediterranean and Continental biogeographic regions (according to Bertelsmeier et al. 2015, Annex VI). The overall area suitable for *S. geminata* will not significantly increase in the future. However, some of the current suitable areas such as in Italy and Slovenia are predicted to be more suitable. 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. The absence of other, more regional, models predicting *S. geminata*'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**	New colonies are founded by winged females, capable of flying long distances. This allows new colonisations a long distance from the source population (Holway et al. 2002). Nuptial flights will result in rapid spread outwards from a site of establishment. Newly mated queens of *S. geminata* seek moist areas, normally within 2 km of the mother colony. Polygynous colonies can also spread by "budding", i.e. queens disperse only short distances over land and take workers with her to start a new colony. However, this type of colony foundation has not been observed in *S. geminata* (McInnes and Tschinkel 1995). 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.
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)		
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. 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)? Sub-note: 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 that independently found new colonies are able to survive several weeks on their own reserves (Hölldobler and Wilson 1990). Likelihood of survival is high, nevertheless will decrease with increasing travel duration. Colonies of the ant *Temnothorax rugatulus* can survive for several months without food resources (Rueppell and Kirkman 2005). Multiplication of a colony (production of sexuals and reproduction) 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 not systematically treated before translocation within the EU (directive 2000/29/CE) (see management annex for treatments before introduction into Europe).

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 the distribution of these media will facilitate 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 very rapidly	low medium **high**	We consider this pathway as the most likely pathway of spread of *S. geminata* within Europe. A similar conclusion has been made for New Zealand (Harris 2005). 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:	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 within 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. Polygynous nests include many queens and may contain thousands of workers. Ant nests might get onto transported items in large numbers as stowaways. For the Argentine ant, *Linepithema humile*, 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).
2.5b. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Sub-note: 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 that independently found new colonies are able to survive several months on their own reserves (Hölldobler and Wilson 1990). Their likelihood of survival is high, but 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	low medium **high**	Fully developed nests are quite visible. In contrast, newly-founded nests with few queen(s) and

	likely very likely		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 particularly likes disturbed soils, which are found everywhere, 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. geminata*, 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 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	Spread by nuptial flights occur only during the warmest months of the year (McInnes and Tschinkel 1995), and will likely 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. However, it is yet to be observed in *S. geminata* polygynous colonies. 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)? Sub-note: 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 individual mated queens are relatively low after the nuptial flight (Hölldobler and Wilson 1990). However, this low life expectancy is compensated by the production of tens of females per nest. Dispersion by budding increases queen survival, however it remains to be observed in *S. geminata* polygynous colonies.
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**	There are no management practices 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. geminata* has a painful sting, and is highly likely to be found in close association with urban areas and people should aid early detection of its presence, even if its initial establishment 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**	Queen ants can fly up to 2 km (Tschinkel 2006), and will likely find suitable habitats (e.g. sunny open 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 geminata* will spread unaided to all suitable habitats within its suitable climatic range. Alate females (queens) can fly up to 2 km during nuptial flights in monogynous colonies (Tschinkel 2006). In general, 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). However, budding has not yet been observed in *S. geminata*. 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 invasive species. If *S. geminata* become 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*.

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 observations in introduced areas at its bioclimatic limits (e.g. US) where *S. geminata* has been replaced by *S. invicta* and the low climatic suitability in Europe, we can estimate that it will spread unaided to all potentially infested biogeographical regions, but slower than in tropical and sub-tropical regions. 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 significantly increase the potential or speed of spread directly, as it is not expected to significantly widen the distribution range (98% of overlap between species' current and future potential distributions) (Bertelsmeier et al. 2015). However, it may facilitate population growth with subsequently increasing potential for spread.

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	*Solenopsis geminata* is one of the most widespread invasive ant species but it is not considered as one of the worst. Indeed, the environmental impacts of *S. geminata* seem to be less pronounced than those of other invasive ants (Holway et al. 2002). Environmental impacts caused by the ant in the invaded ranged excluding the European Union are multiple: -<u>Impact on fauna</u>: In disturbed ecosystems at low latitudes in the New World (and other areas to which they have been introduced), *Solenopsis geminata* is often at the top

			end of dominance hierarchies (Morrison 1996). However, in Central America, *S. geminata* is a pioneer species colonising quickly after disturbance and initially dominant, but it is gradually replaced by other species after about 3 weeks (Perfecto 1991). In New Caledonia, *S. geminata* co-occurs with several other native and introduced species in open habitats (Blight et al. in prep) and has not been described as a numerically dominant species (Berman et al. 2013). In La Réunion island, no impact on the fauna has been attributed to *S. geminata* (Jacquot et al. 2017). In French Polynesia, *S. geminata* mostly occurs in open and sunny disturbed habitats, and co-occurs with other introduced species (Ramage 2014 ; pers. obs.). Foraging ants also prey on vertebrates. They have been reported to attack and consume young birds in their nest or those that have fallen from their nest (Plentovich et al. 2009); and sting young tortoises and land iguanas on the Galapagos (Williams and Whelan 1991). However, no studies that quantified impacts of *S. geminata* on vertebrate populations were found. The paucity of reports of effects of *S. geminata* compared to *S. invicta* suggests that attributes other than its stinging ability may explain the difference in the magnitude of their respective impacts. <u>-Impact on plants</u>:

			The impact on wild plants has been less studied than that on animals or cultivated plants. *Solenopsis geminata* interferes with seed dispersal of myrmecochorous plants by reducing dispersal distances, feeding on seeds, and leaving them exposed on the soil surface (Holway et al. 2002; Ness and Bronstein 2004). -Alteration of ecosystem functions: As with other invasive ant, *S. geminata* is attracted to plants by their carbohydrate-rich resources or by honeydew-producing herbivores. It has also been reported that *S. geminata* preys on Asian corn borer, *Ostrinia furnacalis* eggs and larvae, which might reduce pest infestation (Litsinger et al. 2007). It 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).
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. geminata* establish and spread in the Mediterranean biogeographical region, the impact on native biodiversity, in particular on arthropods, and small vertebrates may be moderate to locally major and similar to that it is observed in presently invaded areas elsewhere.

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. geminata* can inhabit a wide range of open habitats, in invaded regions it particularly dominates highly disturbed habitats, such as newly deforested areas, road sides, agricultural areas including irrigated soils, gardens, etc. Therefore, many natural habitats of high conservation value may not be threatened by the ant. However, some open natural habitats in the Mediterranean biogeographical region may well be suitable. Some of them could be N2000 habitat, such as sea dunes of the Mediterranean coast (code 22), sub-Mediterranean ant temperate scrub (code 51), or 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	<u>Provisioning-Nutrition</u>: Foragers tend honeydew-producing homoptera, especially mealybugs, and including root feeding species. Homopteran tending may increase pest populations and reduce crop seed set and yields (Behera et al. 2001, cited in Harris 2005). Experimental removal of *S. geminata* from plots in an agroecosystem reduced aphid populations significantly (Risch and Carroll 1982). <u>Regulating-Seed dispersal</u>: *S. geminata* may interfere with seed dispersal of native ant species

			and directly predate, and therefore reduce the amount of seeds. However, it can, in some specific cases, contribute to disperse native plant species (Le Yannou-Cateine 2017). Regulating-Pest and disease Control: Ants can be used as control agents in sustainable agriculture (Offenberg 2015). In some cases, *S. geminata* has been reported to provide benefits to crops by preying on pests (Way et al. 2002; Litsinger et al. 2007; Jacquot et al. 2017). In Martinique banana plantations, *S. geminata* has been suggested as a biocontrol agent against the banana weevil *Cosmopolites sordidus* (Mollot et al. 2012). Predation on weevil eggs increased from 8% to 70% when the density of *S. geminata* increased approximately fivefold via the addition of a cover crop in the plantation. However, *S. geminata* may also interfere with beneficial insects that exert biocontrol activities in modified habitats (Trible and Carroll 2014). Cultural-Physical use of landscapes: *Solenopsis geminata* is a social nuisance in infested areas. *S. geminata* colonies are common around urban areas and are considered urban pests in many countries (e.g., India (Lakshmikantha et al. 1996), USA (Smith 1965), and Hawaii (Reimer et al. 1990) cited in Harris 2005). *Solenopsis geminata* is also a nuisance in agricultural fields in La Réunion and in French Polynesia (Ramage, pers. comm.).

			In addition to stinging, foragers are attracted to electric fields (MacKay et al. 1992) and their chewing can cause damage to PVC coatings of electrical wiring potentially causing electrical shorts and resultant fires. They also build mounds in lawns, steal seeds from seedbeds, and enter buildings and feed on a range of household foods (Lee 2002, cited in Harris 2005).
2.19. How important is the impact of the organism on provisioning, regulating, and cultural services currently in the different biogeographic 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 biogeographic 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. geminata* finds suitable habitats and climates for its development in the Mediterranean biogeographical region, the impact on ecosystem services may be moderate to locally major and similar to that observed in presently invaded areas. But its extent is very difficult to estimate considering the uncertainty related to habitat/climatic suitability.
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	*S. geminata* is considered to be an economically important pest ant in some introduced areas however, data on the overall estimate of economic losses are unavailable. Losses in agricultural crops can be significant where this species is abundant. Foragers have been recorded feeding on the seeds and seedlings of sorghum, tomato, citrus, avocados, coffee, cocoa,

			corn, and tobacco (Risch and Carroll 1982; Lakshmikantha et al. 1996). These losses can be significant (e.g., 11% of potato and tomato crops had gnawed tubers and girdling of stems (Lakshmikantha et al. 1996). Economic benefits can also be provided by this species; it has been documented to be a major predator of many other arthropod pests, may also be a valuable predator of weed seeds in some instances. It has for example reduced 98% of the population of the pest weevil *Sitophilus sp.* in corn crops (Risch and Carroll 1982) (see Q 2.18). <u>Health impacts</u>: *S. geminata* can sting people and may cause an allergic reaction that requires medical care and, sometimes, causes anaphylaxis. This ant has a painful sting that may cause injury to humans and domestic animals (Potiwat et al. 2018). However, the venom is chemically different to that of *S. invicta* (Cabreraa et al. 2004) and considered less potent (Taber 2000), and foragers behave less aggressively. This makes *S. geminata* less medically important compared to *S. invicta*. 0033677124092 -<u>Impacts on infrastructure and equipment</u>: Ants and their mounds damage roads and electrical equipment. Colonies move into buildings or vehicles seeking favourable nesting sites and as a result, domestic electrical equipment may be damaged such as computers, swimming pool pumps, cars or washing machines.

			S. geminata activities can result in the failure of many types of mechanical (such as hay harvesting machinery and sprinkler systems) and electrical equipment (Harris 2005).
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. geminata* finds suitable habitats and climates for its development in the Mediterranean region, the economic cost may be moderate to locally major and similar to that observed in presently invaded areas. But its extent is very difficult to estimate considering the uncertainty related to climatic suitability and biotic interactions.
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 major massive	low medium high	N/A. Because the species is not present in Europe, there is no current cost of damage.
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. geminata* establish and spread in the Mediterranean and South Atlantic regions, the management costs may be locally moderate to major, and similar to that observed in presently invaded areas elsewhere. However, its extent is very difficult to estimate considering the uncertainty related to habitat/climatic suitability.
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 geminata* is a social nuisance in infested areas. Colonies are common around urban areas and are considered an urban pest in many countries (e.g. India, USA, and Hawaii (Harris 2005)). Ants also enter buildings, destroying various domestic equipment. This ant has a painful sting that may cause injury to humans and domestic animals (Potiwat et al. 2018). The sting may produce an immediate, intense pain followed by red swelling. However, the venom is chemically different to that of *S. invicta* (Cabreraa et al. 2004) and considered less potent (Taber 2000), and foragers behave less aggressively, which makes *S. geminata* less medically important. *S. geminata* has been recently described as a potential vector of foodborne pathogens such as coliforms, *Bacillus spp*. or *Escherichia coli* (Simothy et al 2018). It may act as disease vectors and contaminate food, water and food-contact surfaces of kitchens resulting in foodborne illnesses.
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. geminata* establish and spread in the Mediterranean region, the social impact, including health impact, may be locally moderate to major, and similar to that observed in presently invaded areas elsewhere.
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 geminata* is not known for being used as food or feed. It has been observed carrying pathogens however up to date no transmission to humans or incidence of food contaminations have been recorded. The score should be upgraded if evidence of transmission is made.
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.

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ANNEXE

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.

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

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 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.*
	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.*

[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.

		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*

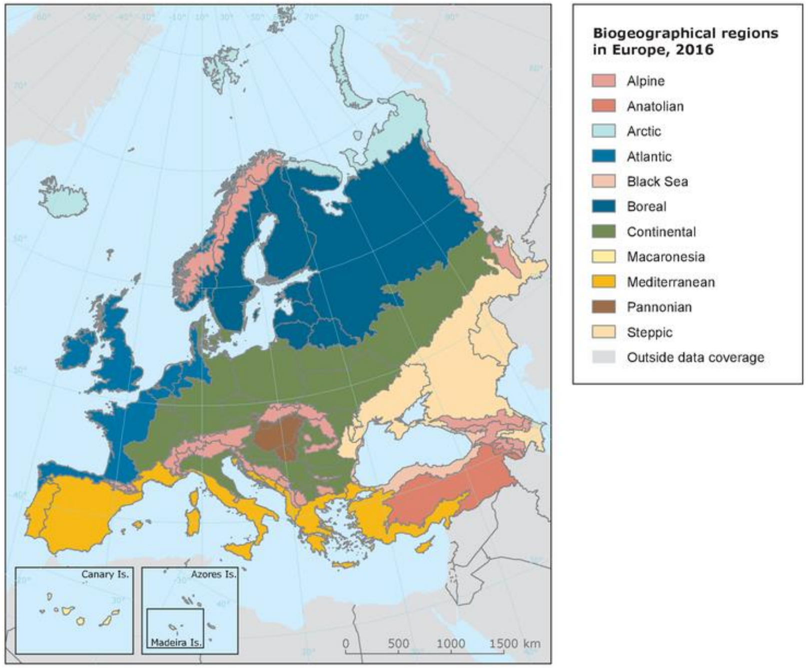
	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	**Spiritual, symbolic** and other interactions with natural environment	Elements of living systems that have symbolic meaning; Elements of living systems that have sacred or religious 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.*

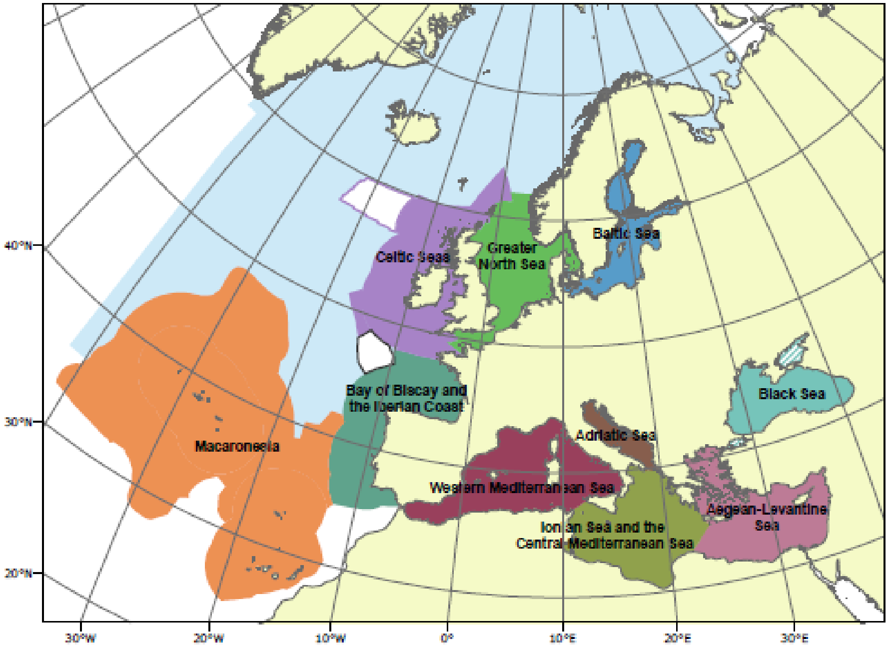
ANNEX V EU Biogeographic Regions and MSFD Subregions

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 (2080) climatic conditions (Bertelsmeier et al 2015). 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. 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 the species can persist because for invasive species in novel environments niche shifts can occur leading to differences with the native shift.