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: *Cydalima perspectalis* (Walker, 1859)

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

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This risk assessment has been peer-reviewed by three 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.

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Photo credit: Tim Haye

[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 likely**	**high**	The organism is already present in the risk assessment area and in most EU countries.
Summarise Establishment[4]	**very likely**	**high**	The organism is already established in the risk assessment area and most EU countries. Of particular importance is its probable absence in Mallorca where the rare *Buxus balearica* occurs. It is not clear whether the moth has reached the *B. balearica* stands in Andalucía and Sardinia.
Summarise Spread[5]	**rapidly**	**high**	The spread in Europe as contaminant on host plants and by natural dispersal has been very fast. In 12 years it invaded most of the suitable areas in Europe. Probably it has not yet reached some native stands of *Buxus* spp. in Southern France and Spain.
Summarise Impact[6]	**massive**	**high**	While the economic impact of the invasion of *C. perspectalis* in Europe can be considered as minor currently, the ecological impact on biodiversity and, potentially, various ecosystem services is major to massive. Natural stands of *Buxus sempervirens* in Southern and Western Europe are quickly disappearing, potentially leading to the local extinction of a high number of species closely linked to the plant.
Conclusion of the risk assessment[7]	**high**	**high**	*Cydalima perspectalis* is already present in most of its potential range, which covers most natural stands of

[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

[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

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

			native *Buxus* spp. in Europe. If no area-wide management method is implemented to lower populations in natural stands, e.g. through the introduction of a specific natural enemy from Asia, or if no resilience of *Buxus* stands is observed in the next few years, the risk is high that whole ecosystems will disappear, including many species that live exclusively in these ecosystems.

Distribution Summary:

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

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

Member States

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

Slovakia	Yes	Yes	Yes	-
Slovenia	Yes	Yes	Yes	-
Spain	Yes	Yes	Yes	Yes
Sweden	Yes	Yes[&]	Yes	-
United Kingdom	Yes	Yes	Yes	-

*Countries where damage on wild box stands has been observed

[&]Countries where there is no published reference specifically mentioning that established populations occur. However, the high number of records in various regions of the country (GBIF 2019) strongly suggests that the moth is firmly established.

Biogeographical regions of the risk assessment area

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

*Regions where damage on wild box stands has been observed

ANNEXES

ANNEX VI Map of predicted distribution and relative abundance (Ecoclimatic Index) of *Cydalima perspectalis* in Europe.

ANNEX VII Map of occurrence of natural stands of *Buxus sempervirens* and *B. balearica* in Europe.

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: *Cydalima perspectalis* (Walker, 1859) Class: Insecta Order: Lepidoptera Family: Crambidae Genus: *Cydalima* Lederer, 1863 Synonyms: The species was previously placed in various genera, most commonly *Diaphania* and *Glyphodes*. Mally and Nuss (2010) most recently placed it in the genus *Cydalima*. *Diaphania perspectalis* (Walker, 1859) *Glyphodes perspectalis* (Walker, 1859) *Palpita perspectalis* (Walker, 1859) Common names: Box tree moth, box tree caterpillar, pyrale du buis (F), Buchsbaumzünsler (D) No sub-species, varieties or breeds are known.
A2. Provide information on the existence of other species that look very similar [that may be detected in the risk assessment area, either in the wild, in confinement or associated with a pathway of introduction]	According to Mally and Nuss (2010), there is no risk to confuse this species with any other Crambidae. Furthermore, in the EU there is no similarly looking caterpillar on *Buxus* spp.
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)	Yes, FERA did a rapid risk assessment for UK in 2010 (FERA 2010). The conclusion was that there was no need for a full pest risk analysis since it was already present in the UK and already too widespread in Europe. They also added that, if the moth is not controlled, impacts are likely to be seen in *Buxus* plants across Europe. However, this RA did not specifically consider the risk for wild box trees in Southern

	Europe, which were not yet affected at that time.
A4. Where is the organism native?	*Cydalima perspectalis* is supposedly native to India, China, Korea, Japan and the Russian Far East (Mally and Nuss 2010). According to Nacambo et al. (2014), the presence of the moth in India refers to an old reference only (Hampson 1896) and its presence is uncertain. It could be also non-native in regions where *Buxus* spp. do not occur naturally, such as Northern China and Russian Far East (Nacambo et al. 2014). Most records in the literature refer to ornamental *Buxus* spp. in urban areas (Mally and Nuss 2010; Wan et al. 2014). Its confirmed distribution in Asia covers a wide variety of climates from the humid continental climate of North-Eastern China and Russian Far East to the humid subtropical climate of Southern China and Southern Japan (Mally and Nuss 2010). In its native range in Japan, *Euonymus japonicus* and *Ilex purpurea* are also mentioned as host plants (van der Straten and Muus, 2010). However, there are no reports of these plant genera being affected in Europe and laboratory tests suggest that *Buxus* spp. are the only plants where it can complete a full cycle (CABI 2019; M. Kenis unpublished data).
A5. What is the global non-native distribution of the organism outside the risk assessment area?	Outside the risk assessment area, it is distributed in most European non-EU countries (see below) as well as Turkey (Hizal 2012), Georgia (Matsiakh et al. 2018), Iran (Farahani et al. 2016; Zamani et al. 2017) and Western Russia (Tuniyev 2016). It has been reported in Pakistan by Sial et al. (2017) but it cannot be ruled out that it is native in this country. It has also been recently recorded in Canada (CABI 2019) *Cydalima perspectalis* is present in non-EU countries in Central Europe such as Switzerland and Liechtenstein as well as in Southern Europe such as Bosnia-Herzegovina, Albania, Macedonia, Montenegro and Serbia (Raineri et al. 2017; CABI 2019; M. Kenis unpublished data).
A6. In which biogeographic region(s) or marine subregion(s) in the risk assessment area has the species been recorded and where is it established?	*Cydalima perspectalis* is recorded and established in the following terrestrial biogeographic regions in the risk assessment area: Atlantic, Black Sea, Continental, Mediterranean, Pannonian and Steppic (CABI 2019; GBIF 2019). It is also present at lower altitudes in the Alpine region (GBIF 2019); there is no published record of the presence of *C. perspectalis* in the Boreal region.
A7. In which biogeographic region(s) or marine subregion(s) in the risk assessment area could the species establish in the future under current climate and under foreseeable climate change?	*Cydalima perspectalis* is already present in most of its potential range in the risk assessment area (Nacambo et al. 2014; Raineri et al. 2017). With climate change, it should be able to establish at higher altitudes in the Alpine region and in warmer areas of the Boreal region, although no model has been used yet to predict its distribution under climate change scenarios. Of particular importance is its apparent absence in most Mediterranean Islands, including the Balearic Islands (Mallorca) where the rare *Buxus balearica* occurs. For details on the assumptions made in relation to climate change see

	annex VI: projection of climatic suitability (Nacambo et al. 2014).
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.	Established in the following Member States, by year of first observation: Germany (2006), Netherlands (2007), Austria, France, Slovenia, United Kingdom (2008), Belgium, Italy (2010), Hungary, Czech Republic, Romania (2011), Croatia, Poland (2012), Greece, Slovakia, Spain (2013), Bulgaria (2014), Luxemburg (2015), Portugal, Sweden (2016). See references in Bella (2013) and CABI (2019), except for Luxemburg (Hellers and Christian 2016), Poland (Kudła and Dawidowicz 2016), Portugal (Corley et al. 2018) and Sweden (Bengtsson 2017). In some countries such as Malta, Denmark, Finland or Sweden, there is no published reference mentioning that established populations occur. However, the high number of records in various regions of the country (GBIF 2019) strongly suggests that the moth is firmly established. For a comprehensive chronology of the spread of *C. perspectalis* in European countries see Raineri et al. (2017), CABI (2019) and Bras et al. (2019).
A9. In which EU member states could the species establish in the future under current climate and under foreseeable climate change?	No records were yet found from Cyprus, Estonia, Ireland (but a moth has been caught in Northern Ireland), Latvia and Lithuania. The moth can probably establish in all these member states under current climatic conditions, except for Finland, where the distribution is likely to be restricted to the warmest regions and more likely under foreseeable climate change. In several countries listed under A8, the moth is not yet known from the whole territory. In Sweden and UK, it is likely that the northern regions are not yet suitable for its establishment Nacambo et al. 2014). In others (e.g. Spain and Portugal), it is only a matter of time before the whole country will be invaded.
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. In the Caucasus, most particularly Georgia, it severely affects native stands of *Buxus sempervirens* (Tuniyev 2016; Matsiakh et al. 2018; Mitchell et al. 2018).
A11. In which biogeographic region(s) or marine subregion(s) in the risk assessment area has the species shown signs of invasiveness?	*Cydalima perspectalis* is damaging ornamental and wild *Buxus* spp. in most areas where it has become established. However, in Northern Europe, where it cannot complete two generations, damage is much less severe (M. Kenis, unpublished data). It is established in the following biogeographic regions in the EU: Atlantic, Black Sea, Continental, Mediterranean and Pannonian (CABI 2019). Its only host plants, *Buxus* spp. occur naturally mainly in the Mediterranean and Continental regions of the EU (Di Domenico et al. 2012; Kenis et al. 2013). It is therefore in these regions that the species is likely to be most invasive.
A12. In which EU member states has the species shown signs of invasiveness?	Serious damage on ornamental and wild box trees has occurred in most countries where it has become established, as listed in A8. Di Domenico et al. (2012) (see Annex VII) and Kenis et al. (2013) provide maps of the occurrence of *Buxus sempervirens* and *B. balearica*, its only two potential wild hosts in

	Europe. EU countries where there have been notifications of *C. perspectalis* damaging wild stands of *Buxus sempervirens* include Belgium, France, Germany, Italy, and Spain (John and Schumacher 2013; Kenis et al. 2013; Raineri et al. 2017; Mitchell et al. 2018). The rare stands of *B. balearica* in Southern Spain and Mallorca have not yet been found infested. In Sardinia, the moth has been observed on cultivated *Buxus* spp. but it is not known whether it has reached the rare B. *balearica* stands (Prof Ignazio Floris, personal communication).
A13. Describe any known socio-economic benefits of the organism.	There is no known socio-economic benefit for this species.

SECTION B – Detailed assessment

Important instructions:

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

PROBABILITY OF INTRODUCTION and ENTRY

Important instructions:

- Introduction is the movement of the species into the risk assessment area.
- Entry is the release/escape/arrival in the environment, i.e. occurrence in the wild. Not to be confused with spread, the movement of an organism within the risk assessment area.
- For organisms which are already present in the risk assessment area, only complete this section for current active or if relevant potential future pathways. This section need not be completed for organisms which have entered in the past and have no current pathway of introduction and entry.

QUESTION	RESPONSE [chose one entry, delete all others]	CONFIDENCE [chose one entry, delete all others]	COMMENT
1.1. How many active pathways are relevant to the potential introduction of this organism? (If there are no active pathways or potential future	**very few**	**high**	

[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

pathways respond N/A and move to the Establishment section)			
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.	**Contaminant on plants, Unaided**		Entry pathways in the risk assessment area mainly consist in: a) Contaminant on plant: Import of live *Buxus* plants or plant parts into the EU b) Unaided: Adult flight from neighbouring countries.
Pathway name:	Contaminant on plants (Import of live *Buxus* plants or plant parts into the EU).		
1.3a. Is introduction along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)? (if intentional, only answer questions 1.4, 1.9, 1.10, 1.11 – delete other rows)	**unintentional**	**high**	
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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.	**moderately likely**	**medium**	*Cydalima perspectalis* has already been introduced into the EU from Asia (Kenis et al. 2013; Bras et al. 2019) and into other parts of the world (e.g. into Russia from Italy) via this pathway (van der Straten and Muus 2010; Gninenko et al. 2014). However, while millions of box tree plants were imported from Asia up to 2010 (EPPO 2012), the volume of trade has most probably decreased nowadays because of the low amount of *Buxus* spp. sold in Europe after the introduction of *C. perspectalis* and another invasive species, the fungus *Calonectria pseudonaviculata* (Mitchell et al. 2018). Furthermore, since the invasion of *C. perspectalis*, traded box plants are usually treated with systemic insecticides (M. Kenis personal observation). Thus, the frequency of entries

			(propagule pressure) and the likelihood of large numbers of individuals are lower than they used to be, albeit difficult to quantify.
1.5a. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	**very likely**	**high**	The insect is very resistant to different climatic conditions. Overwintering small larvae are the stage most likely transported and can survive several months in diapause or quiescence (Nacambo et al. 2014). The organism can theoretically multiply along the pathway if the plants are stored during a sufficiently long time in a nursery during transport.
1.6a. How likely is the organism to survive existing management practices during passage along the pathway?	**unlikely**	**medium**	Box trees that are imported into Europe are supposed to be free of pests and treated against the moth and other insects with insecticides. It was already so at the time the species was introduced accidentally into Europe and other regions. However, management practices in Europe have increased since the outbreak of *C. perspectalis*, i.e. plants are usually treated with systemic insecticides before being sold.
1.7a. How likely is the organism to enter the risk assessment area undetected?	**likely**	**high**	The green translucent egg masses and young larvae are difficult to detect on plants.
1.8a. How likely is the organism to arrive during the months of the year most appropriate for establishment?	**very likely**	**high**	Since *C. perspectalis* travels on its plant, it will most likely arrive in an appropriate situation for establishment. If the infested plant arrives in winter, it will likely transport young overwintering larvae that will delay their development until temperatures are more favourable.
1.9a. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	**very likely**	**high**	Emerging adults from imported plants will be able to find other trees since box trees are frequently planted as ornamentals. However, natural *Buxus* spp. are not that common in the wild and usually far from ornamental *Buxus* plants. Thus, it may take some years before the moth reaches natural stands, even though adult moths are able to spread up to 7 km per year (Leuthardt et al. 2010)..

1.10a. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	**moderately likely**	**medium**	The chance of new introductions from Asia is lower than in the past because the volume of traded *Buxus* trees has decreased recently due to the decrease in demand for box trees.
Pathway name:	Unaided (Natural dispersal across borders of invasive alien species that have been introduced through pathways 1 to 5)		
1.3b. Is introduction along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)? (if intentional, only answer questions 1.4, 1.9, 1.10, 1.11 – delete other rows)	**unintentional**	**high**	
1.4b. How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.	**likely**	**high**	Adults are good flyers and, when swarming in large numbers during outbreaks, they can spread up to seven kilometres per year by themselves (Leuthardt et al. 2010).
1.5b. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	**very likely**	**high**	*Buxus* spp. are commonly planted in parks and gardens and, thus, adults that would enter not yet colonized areas within the risk assessment area through natural dispersal would likely find trees for survival. The moth can naturally reproduce during its natural dispersal as long as host plants are found.
1.6b. How likely is the organism to survive existing management practices during passage along the pathway?			N/a
1.7b. How likely is the organism to enter the risk assessment area undetected?	**likely**	**medium**	By nature, natural flights are largely undetected. However, adults are highly attracted to light sources as well as well as to pheromone traps, which can be used to monitor entries in new areas (Santi et al 2015).
1.8b. How likely is the organism to arrive during the	**very likely**	**high**	Adults entering through natural flight will enter the risk

months of the year most appropriate for establishment?			assessment area during an appropriate season.
1.9b. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	**very likely**	**high**	*Buxus* spp. are commonly planted in parks and gardens and, thus, adults that would enter not yet colonized areas within the risk assessment area through natural dispersal would likely find trees for ovipositing. However, natural *Buxus* spp. are not that common in the wild and usually far from ornamental *Buxus* plants and, thus, it may take some time before the moth reaches natural stands.
1.10b. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	**very likely**	**high**	There are only few areas in the risk assessment area where the moth is not yet established and where the climate is suitable.
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 likely**	**high**	The likelihood of entry to not yet colonized areas in the risk assessment area by natural dispersal from neighbouring countries is very high.
1.12. Estimate the overall likelihood of entry into the risk assessment area based on all pathways in foreseeable climate change conditions?	**very likely**	**high**	Although no studies including projected climate change scenarios have yet been carried out for this species, the areas not yet invaded in the risk assessment area because of climatic unsuitability (the largest parts of Fennoscandia) are more likely to be invaded in the future under foreseeable climate change according to studies on diapause termination, thermal requirements and phenology (Nacambo et al. 2014).

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 likely**	**high**	The species is already established in most EU countries. Nacambo et al. (2014) provided a CLIMEX model for the moth and a risk map in Europe. Some areas that are climatically suitable are not yet fully invaded, in particular areas in Spain, Portugal and Southern Italy (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 likely**	**high**	The species is already established in most EU countries.
1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in the risk assessment area?	**widespread**	**high**	*Cydalima perspectalis* is restricted to *Buxus* spp. in Europe (Leuthardt and Baur 2013; Matošević et al. 2017). Ornamental *Buxus* plants are widely planted in the EU. Natural *B. sempervirens* populations are more scattered and abundant only in Southern France and Northern Spain (Di Domenico et al. 2012; Annex VII). In the EU, *B. balearica* is a rare species only present in the Balearic Islands (Mallorca), Andalusia and at one site in Sardinia.
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?	**very likely**	**high**	In Europe, the organism is restricted to its host plant on which it feeds. Eggs and larvae are transported together with the plants and establishment is therefore very likely.

1.17. How likely is it that establishment will occur despite competition from existing species in the risk assessment area?	**very likely**	**high**	There is no other significant defoliator on *Buxus* spp. in Europe. However in some regions, *Buxus* spp. are also severely affected by box blight (caused by *Calonectria pseudonaviculata* (=*Cylindrocladium buxicola)* and *C. henricotiae*) two invasive fungi, and other indigenous fungi, which may also severely damage *Buxus* plants, including in wild stands (Lehtijärvi et al. 2014; Gehesquière et al. 2016).
1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area?	**very likely**	**high**	Parasitism by indigenous parasitoids is very low (Wan et al. 2014). It is commonly attacked by generalist predators such as wasps and birds (M. Kenis, unpublished data) but so far predation has not affected moth's populations. Furthermore, some generalist predators may not prey on the larvae because they contain toxic alkaloids (Leuthardt et al. 2013)
1.19. How likely is the organism to establish despite existing management practices in the risk assessment area?	**very likely**	**high**	Management practices are in place for ornamental trees, e.g. using pesticides or biological control products, with local success, but without preventing establishment. There are no management practices already in place for natural *Buxus* stands.
1.20. How likely are existing management practices in the risk assessment area to facilitate establishment?	**very unlikely**	**high**	Cutting/uprooting and careless disposal of trees or parts of trees favours the spread of the species because cut trees may carry larvae or pupae (CABI 2019).
1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the risk assessment area?	**likely**	**high**	Most larvae are killed by pesticides or biological control products such as *Bacillus thuringiensis*. There are yet no indications of resistance or avoidance behaviour. However, the high reproduction rate (see 1.22) and the already wide distribution in the risk assessment area make it likely to survive local or regional eradication

			attempts.
1.22. How likely are the biological characteristics of the organism to facilitate its establishment in the risk assessment area?	**very likely**	**high**	Its biological characteristics have facilitated its establishment: -High fecundity, i.e. 199-488 eggs/female depending on the generation (Cheng 2005, in Wan et al. 2014) -Two generations per year in Central Europe, at least three in southern Europe (Nacambo et al. 2014) -Good flight capacities (several km per year), allowing the adult to find suitable trees for oviposition (Leuthardt et al. 2010) -Diapausing larvae can survive low temperatures in winter (at least -25°C, M. Kenis, unpublished data)
1.23. How likely is the adaptability of the organism to facilitate its establishment?	**very likely**	**high**	The species is already established in most EU countries.
1.24. How likely is it that the organism could establish despite low genetic diversity in the founder population?	**very likely**	**high**	The species is already established in most EU countries. The high and geographically structured genetic diversity observed in Europe suggests multiple introduction events (Bras et al. 2019).
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 likely**	**high**	The species is already established in most EU countries.
1.26. If the organism does not establish, then how likely is it that casual populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is present because of continual release, is an example of a transient species.		low medium high	N/a. The species is already established in most EU countries.
1.27. Estimate the overall likelihood of establishment in relevant biogeographical regions in current conditions	**very likely**	**high**	*Cydalima perspectalis* is established in the following terrestrial biogeographic regions in the

(mention any key issues in the comment box).			EU: Atlantic, Black Sea, Continental, Mediterranean, Pannonian and Steppic (CABI 2019; GBIF 2019). It is also present at lower altitudes in the Alpine region;; it is still probably absent from the Boreal region. Only some areas in Southern Europe (Spain, Portugal, Greece, Southern Italy and Cyprus) are still to be invaded (Nacambo et al. 2014; Annex VI).
1.28. Estimate the overall likelihood of establishment in relevant biogeographical regions in foreseeable climate change conditions	**very likely**	**high**	In foreseeable climate change conditions, the warmest areas of the Boreal Region may be invaded, as well as cool regions from the Alpine, Atlantic and Continental regions that are presently too cold for the moth to survive or to complete a generation. More important, with temperature increases, the moth will develop two generations per year in areas where it cannot presently complete two generations. This will most certainly cause higher damage in Northern Europe and at higher elevations (Nacambo et al. 2014).

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.)	**moderate**	**high**	Adult moths are good flyers and are able to spread up to 7 km per year (Leuthardt et al. 2010).
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.	**major**	**high**	The moth has spread, and is still spreading in Europe via the plant trade. The trade of *Buxus* spp. is not regulated within the EU. There is no data on the trade of *Buxus* spp. in the EU. Individual persons and gardeners also transport *Buxus* spp. at shorter distances, including for the disposal of cut infested trees. According to Roques et al. (2016) the invasion radius between 2 and 3 years after the first record for the box moth was 155 km $year^{-1}$, which largely exceeds their potential flight capabilities. In fact, this insect has colonized the major part of the European continent just 10 years following their first record (Bras et al. 2019).
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	**Contaminant on plants, Unaided**		Spread pathways in the EU mainly consist in : a) Unaided: adult flight b) Contaminant: movements of live *Buxus* plants or plant parts in the EU.

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.			
Pathway name:	**Unaided (Natural dispersal by adult flight)**		
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)?	**unintentional**	**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 likely**	**high**	Adult moths are good flyers, able to spread several km per year (Leuthardt et al. 2010) and due to their abundance it is very likely that sufficient numbers of individuals spread to originate viable populations. One generation is sufficient to establish a viable population.
2.5a. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	**very likely**	**high**	*Buxus* spp. are commonly planted in parks and gardens and, thus, adults that would enter not yet colonized areas within the risk assessment area through natural dispersal would likely find trees for survival.
2.6a. How likely is the organism to survive existing management practices during spread?			N/a
2.7a. How likely is the organism to spread in the risk assessment area undetected?	**likely**	**medium**	Adult flights are nocturnal and largely undetected when invading a new area in low numbers. However, adults are highly attracted to light sources as well as well as to pheromones (Martin et al. 2015; Santi et al. 2015), which can be used to monitor the spread of the organism in new areas
2.8a. How likely is the organism to be able to transfer to a suitable habitat or host during spread?	**very likely**	**high**	*Buxus* spp. are commonly planted in parks and gardens in the EU and, thus, adults that would move through natural flight would very likely find trees for

			ovipositing.
2.9a. Estimate the overall potential rate of spread within the Union based on this pathway? If possible, provide quantitative data.	**moderately**	**high**	The species has already spread to large parts within the risk assessment area. Further spread by natural dispersal is likely. Adult moths are good flyers and are able to spread several up to 7 km per year (Leuthardt et al. 2010).
Pathway name:	Contaminant on plants (Movement of live *Buxus* plants or plant material)		
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)?	**unintentional**	**high**	Spreading by plant trade continues within EU.
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 likely**	**high**	Eggs, larvae and pupae can be very abundant on traded and non-traded *Buxus* plants or plant materials, although traded plants are now usually protected with insecticides.
2.5b. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	**very likely**	**high**	When carried on their host plants, the insect can develop until adult emergence. The insect is very resistant to different climatic conditions. Overwintering small larvae are the most likely transported stage in winter and can survive several months in diapause or quiescence (Nacambo et al. 2014).
2.6b. How likely is the organism to survive existing management practices during spread?	**moderately likely**	**medium**	Marketed box trees are usually, but not always, treated against the moth with systemic insecticides. Trees and branches carried by people can be infested.
2.7b. How likely is the organism to spread in the risk assessment area undetected?	**very likely**	**high**	Eggs and young larvae are difficult to detect on plants.
2.8b. How likely is the organism to be able to transfer to a suitable habitat or host during spread?	**very likely**	**high**	When *C. perspectalis* travels on its live host plant, it will arrive in an appropriate situation for establishment. Emerging adults will be able to find other trees since box trees are frequently planted as ornamental plants. However, natural *Buxus* spp. are not that common in the wild and usually far from ornamental *Buxus* plants. Thus, it may take some time

			before the moth reaches natural stands.
2.9b. Estimate the overall potential rate of spread within the Union based on this pathway? If possible, provide quantitative data.	**rapidly**	**high**	Live plants' movement is the most suitable long distance pathway in Europe and the most likely cause of the fast spread of the moth to most European countries in just about 10 years (Matošević et al. 2017). The movement of *Buxus* spp. plants is free within Europe. Traded plants are now commonly treated with insecticides but there are exceptions and private people are also carrying plants. Cut branches for celebrations and decoration and cut or uprooted trees brought to composting places can also contribute to the spread. The spread of the moth reached an invasion radius of 155 km year-1. 2-3 years after its introduction (Roques et al. 2016).
End of pathway assessment			
2.10. Within the risk assessment area, how difficult would it be to contain the organism in relation to these pathways of spread?	**very difficult**	**high**	Adult flights cannot be contained and the trade of *Buxus* spp. is not regulated within the EU.
2.11. Estimate the overall potential 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). If possible, provide quantitative data.	**rapidly**	**high**	Based on the spread pattern of the moth since its arrival in Europe, we can estimate that the few areas in the Mediterranean Region that are climatically suitable and not yet invaded will be reached within the next 5 years, with the possible exception of islands.
2.12. Estimate the overall potential rate of spread in relevant biogeographical regions in foreseeable climate change conditions. If possible, provide quantitative data.	**moderately**	**medium**	In foreseeable climate change conditions, the warmest areas of the Boreal Region may be invaded, as well as cool regions from the Alpine, Atlantic and Continental regions that are presently too cold for the moth to survive or to complete a generation. More important, with temperature increases, the moth will develop two generations per year in areas where it cannot presently complete two generations. This will most certainly cause higher damage in Northern Europe and at higher elevations (Nacambo et al. 2014).

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?	**massive**	**high**	Total defoliation kills box trees very rapidly. In the Caucasus, the moth is eradicating native *Buxus sempervirens* from large areas, an important component of natural forest ecosystems (Tuniyev 2016; Matsiakh et al. 2018; Mitchell et al. 2018). This probably has cascading effects on species that live exclusively or mainly in this ecosystem. Mitchell et al. (2018) found a total of 132 fungi, 12 chromista (algae), 98 invertebrate and 44 lichens using *Buxus* species in the Caucasus and Europe. Of these, 43 fungi, 3 chromista and 18 invertebrate species have only been recorded on *Buxus* species. This suggests that all these potentially monophagous species are at risk if *Buxus* spp. were disappearing from the region. The impact has been scored "massive" in the context of box tree distribution and the intrinsically linked biodiversity, which will disappear in the absence of box trees.
2.14. How important is the current known impact of the	**massive**	**high**	In the risk assessment area, damage on native *Buxus*

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)?			*sempervirens* stands that have been attacked since at least three years appear similar to those observed in the Caucasus, although the exact magnitude and long term effects on these stands still need to be confirmed. The natural stands that were first attacked in 2009 around Basel in Switzerland, Germany and France took about 8 years to decline by over 95% (John and Schumacher 2013; M. Kenis personal observation). However in this region the moth develops two generations per year while, in the in the Eastern Black Sea region, where at least three generations per year are observed (as in Southern Europe), the decline was much faster (Tuniyev 2016; Matsiakh et al. 2018). In their literature survey, Mitchell et al. (2018) found a total of 132 fungi, 12 chromista (algae), 98 invertebrate and 44 lichens using *Buxus* species in the Caucasus and Europe. Of these, 43 fungi, 3 chromista and 18 invertebrate species have only been recorded on *Buxus* species and are at risk if *Buxus* spp. were disappearing.
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?	**massive**	**high**	If no area-wide management method is implemented to lower populations in natural stands, e.g. through the introduction of a specific natural enemy from Asia (Wan et al. 2014), or if no resilience of *Buxus* stands are observed in the next few years, the risk is high that whole ecosystems will disappear, including many species that live exclusively in these ecosystems (Kenis et al. 2013; Mitchell et al. 2018).
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?	**major**	**high**	Several natural *Buxus* spp. stands are important components of protected sites in Europe. In Germany, the only sizeable *B. sempervirens* stand, which has now disappeared at more than 95%, was situated in the protected Natura 2000 reserve "Wälder bei Wyhlen". The moth has damaged *B. sempervirens* stands in Natura 2000 sites in Italy (Raineri et al. 2017) and France (M. Kenis unpublished data) and is also present

			in the only Natura 2000 site hosting wild *B. sempervirens* in Belgium (T. Adriaens, pers. Comm.). In the EU Habitats Directive, *B. sempervirens* is listed as a characteristic species in five Annex 1 habitat types, including two that are priority habitat types: *Taxus baccata* woods of the British Isles and Mediterranean *Taxus baccata* woods (Mitchell et al. 2018).
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?	**major**	**high**	*Buxus balearica* is considered as "Near Threatened" in Spain, "Vulnerable" in Andalusia and it also occurs in the Balearic Islands. There is a single population in Sardinia (Di Domenico et al. 2012). We are not aware of *C. perspectalis* having reached *B. balearica* stands yet but field tests and observations in botanical gardens have shown that it is a suitable host for the moth (Brua 2014; Mitchell et al 2018). Native *Buxus sempervirens* stands are still abundant at European scale but some countries or regions have placed the species in red lists, e.g. Luxemburg has classified it as "vulnerable" (Colling 2005) and the Alsace region in France as "Endangered" (Vangendt et al. 2014).
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?	**major**	**medium**	The observed impacts of *C. perspectalis* on ecosystem services are caused the diminishing and/or disappearance of *Buxus* vegetation. In the Eastern Black Sea region, impacts on provisioning and regulating services have not yet been quantified but are likely (see 2.20). Mitchell et al. (2018) review the cultural services of *Buxus* trees in the Black Sea region, where wood and leaves are associated with different folklore and sacred rites since a very long time and are still important nowadays. In this region, the disappearance of one of the most important woody plants motivated international Actions, including from the FAO and the EU Office of the Special Representative for the South Caucasus and the crisis in

			Georgia (Mitchell et al. 2018). Box wood is also a very hard and highly valuable wood that is used for very specific purposes. For example it provides good sound projection because it is free from the grain produced by the growth rings. This makes it suitable for crafting high quality musical instruments such as the classical oboe and the violin (Savill 2013).
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)?	**major**	**medium**	In the risk assessment area, impacts on provisioning and regulating services have not yet been quantified but are likely (see 2.20). In their review, Mitchell et al. (2018) also include cultural services of *Buxus* trees in the EU. While the cultural significance of the plant is probably less important than in other regions such as in the Eastern Black Sea region, *B. sempervirens* is nevertheless considered a plant of religious significance, in particular on Palm Sunday (Decocq et al. 2004). *Buxus sempervirens* is also a key component of many castles and historic gardens, which have to spray regularly to avoid the loss of these important cultural heritages. Box wood is also a very hard and highly valuable wood that is used for very specific purposes. For example it provides good sound projection because it is free from the grain produced by the growth rings. This makes it suitable for crafting high quality musical instruments such as the classical oboe and the violin (Savill 2013).
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?	**major**	**low**	The ecological disappearance of native *Buxus* spp. stands is likely to have consequences on provisioning and regulating services. However, these consequences will depend on how the gaps within the forests are going to be filled by co-occurring species. A replacement by species that differ in structure or traits could affect various forest function (e.g. leaf litter decomposition rates and nutrient cycling), forest structure (e.g. taller trees establishing) and the forest

			community (e.g. changes in biodiversity) (Mitchell et al. 2018). So far, ecosystem processes and functions related to *Buxus* stands have been rather poorly studied in the EU. *Buxus sempervirens* is known to influence woodland succession by differentially influencing establishment and survival of tree species such as in the Pyrenees, where it favours *Fagus sylvatica* over *Abies alba* (Dolezal et al. 2004). *Buxus* spp. are also able to grow on steep crumbly slopes where they probably play an important role in sediment trapping (Duvigneaud 1969; Savill 2013). *Buxus sempervirens* traps 2.8 times more sediment than *Juniperus communis* and 1.5 times more sediment than *Pinus nigra*, but less sediment than *Lavandula angustifolia* (Burylo et al. 2012).
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	**moderate**	**high**	Economic costs of the invasion of *C. perspectalis* in other parts of its current area of distribution have not been calculated. In the Eastern Black Sea regions, non-EU European countries and in invaded ranges in East Asia (e.g, Northern China), most costs are probably borne by municipalities and private gardeners who have to spray or use other management methods to control the species or, when infestations are too heavy, replace their ornamental box trees by other plants. In the Eastern Black Sea Region, efforts to reduce the impact on the highly valuable natural *Buxus* stand (e.g. spraying, development of resistant cultivars, biological control programmes) have non-negligible costs although this has never been quantified.
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)?	**minor**	**high**	Economic costs of the invasion of *C. perspectalis* and related diminishing and/or disappearance of *Buxus* vegetation in the risk assessment area have not been calculated. When management costs are excluded, costs

*i.e. excluding costs of management			of damage and/or loss are probably minor. Some horticulturist specialised in Box tree production may be affected but, in general, the horticultural sector is probably not much affected by the loss of the *Buxus* spp. market since *Buxus* spp. are replaced by other species. Should management not be applied, there would be a risk for the historic gardens whose interest is partly based on topiary to lose tourists, but all of them protect their topiaries by spraying.
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	**minor**	**high**	Economic costs excluding management are likely to increase in the future if spread continues, but probably will remain minor.
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)?	**moderate**	**medium**	In invaded areas in the risk assessment area, most costs are due to the use of pesticides, biological control products or other management methods to protect ornamental trees, including replacement by other plants and are probably borne by municipalities and private gardeners. However, there are no quantitative data on these costs available at EU or member state level.
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?	**moderate**	**medium**	Since the organism has already reached most of the ornamental box trees in the risk assessment area, and ornamental box trees are disappearing from parks and gardens, economic costs will probably remain moderate.
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**	**high**	In addition to impacts on cultural services (2.18 and 2.19), there are no other relevant impacts described.
2.27. How important is social, human health or other impact (not directly included in any earlier categories)	**minimal**	**high**	There is no indication that other relevant impacts will increase in the future.

caused by the organism in the future for the risk assessment area.			
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)?	**minimal**	**high**	*Cydalima perspectalis* is not known as food, host, symbiont or vector of other damaging organisms. It cannot be ruled out that it interacts with the numerous fungi that affect *Buxus* spp, including the invasive *Calonectria pseudonaviculata*, agent of box blight, but this has never been shown.
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)			N/a
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?	**major** massive	**low**	So far, parasitism by native parasitoids or pathogens is minimal in the risk assessment area (Wan et al. 2014; Belokobylskij and Gninenko 2016). Generalist predators such as wasps and birds are often observed praying on *C. perspectalis* larvae (Tuniyev 2016; M. Kenis, unpublished data), but their impact is unclear and they presently do not prevent total defoliation.

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ANNEX I Scoring of Likelihoods of Events

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

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

ANNEX II Scoring of Magnitude of Impacts

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

Score	**Biodiversity and ecosystem impact**	**Ecosystem Services impact**	**Economic impact (Monetary loss and response costs per year)**	**Social and human health impact**
	Question 2.18-22	*Question 2.23-25*	*Question 2.26-30*	*Question 2.31-32*
Minimal	Local, short-term population loss, no significant ecosystem effect	No services affected[10]	Up to 10,000 Euro	No social disruption. Local, mild, short-term reversible effects to individuals.
Minor	Some ecosystem impact, reversible changes, localised	Local and temporary, reversible effects to one or few services	10,000-100,000 Euro	Significant concern expressed at local level. Mild short-term reversible effects to identifiable groups, localised.
Moderate	Measureable long-term damage to populations and ecosystem, but little spread, no extinction	Measureable, temporary, local and reversible effects on one or several services	100,000-1,000,000 Euro	Temporary changes to normal activities at local level. Minor irreversible effects and/or larger numbers covered by reversible effects, localised.
Major	Long-term irreversible ecosystem change, spreading beyond local area	Local and irreversible or widespread and reversible effects on one / several services	1,000,000-10,000,000 Euro	Some permanent change of activity locally, concern expressed over wider area. Significant irreversible effects locally or reversible effects over large area.
Massive	Widespread, long-term population loss or extinction, affecting several species with serious ecosystem effects	Widespread and irreversible effects on one / several services	Above 10,000,000 Euro	Long-term social change, significant loss of employment, migration from affected area. Widespread, severe, long-term, irreversible health effects.

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

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.*

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

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

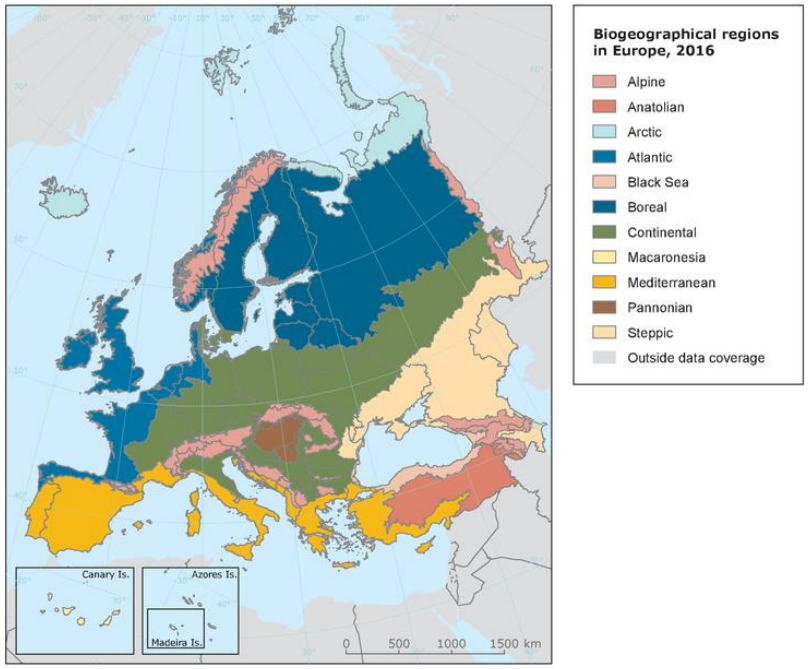
			composition etc.) that make it attractive for recreation, wild life watching etc.
		Intellectual and representative interactions with natural environment	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge; Characteristics of living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

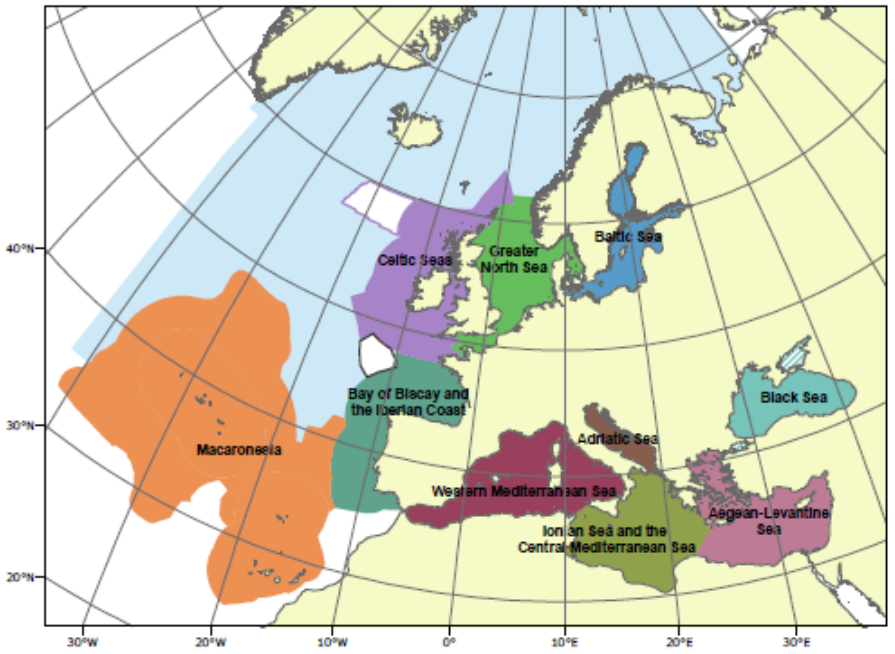
ANNEX V EU Biogeographic Regions and MSFD Subregions

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

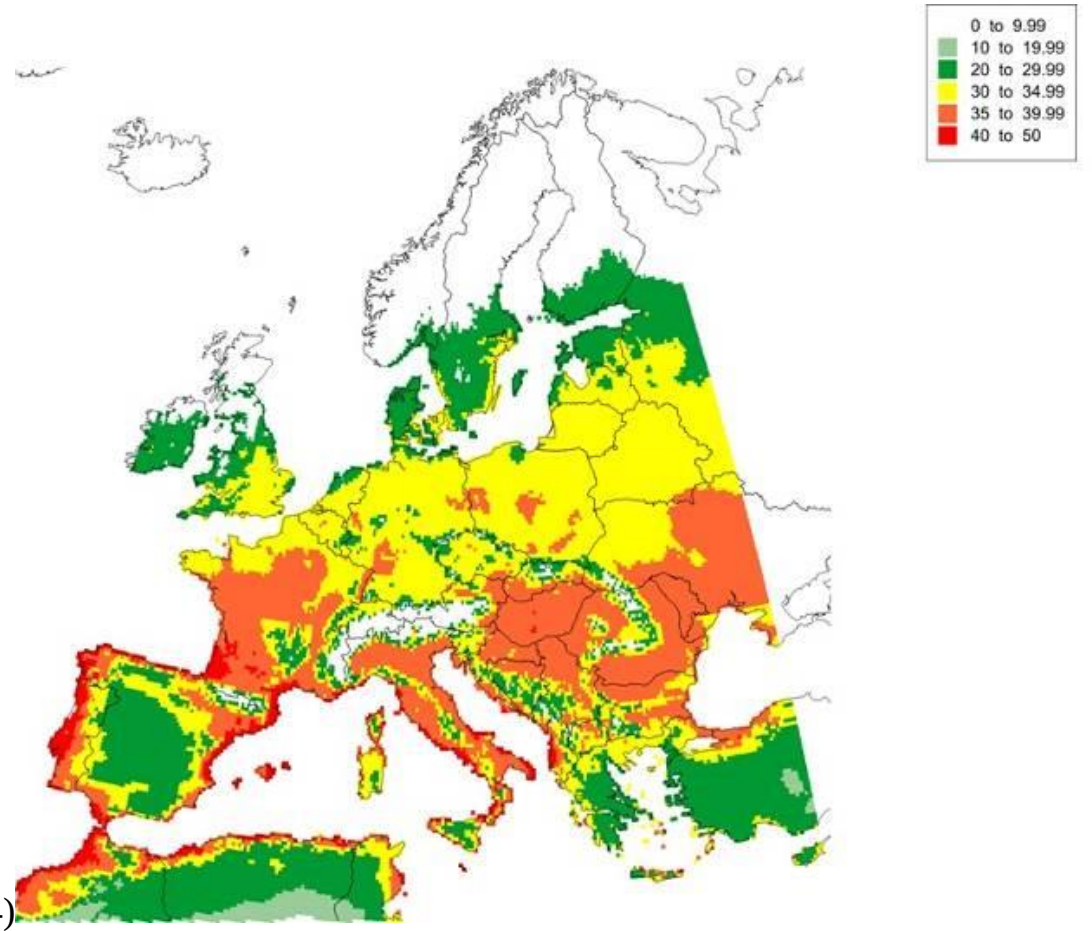
and

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





ANNEX VI. Map of predicted distribution and relative abundance (Ecoclimatic Index) of *Cydalima perspectalis* in Europe. EI values of 30 or more are considered as vary favourable whereas areas with EI less than 10 are not considered favourable for the species. From Nacambo et al. (2014)



ANNEX VII. Map of occurrence of natural stands of *Buxus sempervirens* (green) and *B. balearica* (red) in Europe. From Di Domenico et al. (2012). With courtesy from F. Di Domenico