Risk assessment template developed under the "Study on Invasive Alien Species – Development of risk assessments to tackle priority species and enhance prevention"
Contract No 07.0202/2018/788519/ETU/ENV.D.2[1]

Name of organism: ***Phytolacca americana*** **L.**

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) and the United Kingdom.

Peer review 1: *Johan van Valkenburg, National Plant Protection Organization, Netherlands*
Peer review 2: *Giuseppe Brundu, University of Sassari, Sardinia, Italy.*

Date of completion: 17 September 2019

Date of revision: 19 August 2020

Positive opinion by the Scientific Forum given at the meeting of 17 November 2020

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[1] This template is based on the Great Britain non-native species risk assessment scheme (GBNNRA). A number of amendments have been introduced to ensure compliance with Regulation (EU) 1143/2014 on IAS and relevant legislation, including the Delegated Regulation (EU) 2018/968 of 30 April 2018, supplementing Regulation (EU) No 1143/2014 of the European Parliament and of the Council with regard to risk assessments in relation to invasive alien species (see https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32018R0968).

Contents

SECTION A – Organism Information and Screening

A1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?

including the following elements:

- the taxonomic family, order and class to which the species belongs;
- the scientific name and author of the species, as well as a list of the most common synonym names;
- names used in commerce (if any)
- a list of the most common subspecies, lower taxa, varieties, breeds or hybrids

As a general rule, one risk assessment should be developed for a single species. However, there may be cases where it may be justified to develop one risk assessment covering more than one species (e.g. species belonging to the same genus with comparable or identical features and impact). It shall be clearly stated if the risk assessment covers more than one species, or if it excludes or only includes certain subspecies, lower taxa, hybrids, varieties or breeds (and if so, which subspecies, lower taxa, hybrids, varieties or breeds). Any such choice must be properly justified.

Response: It should be noted that the Flora of North America (http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=220010427) detail that the "The infraspecific taxonomy of *Phytolacca americana* has been disputed since J. K. Small (1905) recognized *P. rigida* [*Phytolacca americana* var. *rigida* (Small) Caulkins & R.E. Wyatt, Bull. Torrey Bot. Club 117(4): 366 1990. basyonym: *Phytolacca rigida* Small, Bull. New York Bot. Gard. 3(11): 422–423 1905] as distinct from *P. americana* on the basis of its "permanently erect panicles" [sic] and "pedicels...much shorter than the diameter of the berries." J. W. Hardin (1964b) separated *P. rigida* from *P. americana* by the length of the raceme (2-12 cm in *P. rigida*, 5-30 cm in *P. americana*) and the thickness and diameter of the xylem center of the peduncle (70% greater thickness in *P. rigida*, 17% greater diameter in *P. americana*), but he found no discontinuities in any feature. J. W. Nowicke (1968) and J. D. Sauer (1952), among others, treated *P. rigida* as a synonym of *P. americana*. Most recently, D. B. Caulkins and R. Wyatt (1990) recognized *P. rigida* as a variety of *P. americana*."

Taxonomy:
Scientific name: *Phytolacca americana* L., Sp. Pl.: 441 (1753)

For this risk assessment (RA), *P. americana* s.l. (in the broad sense) is considered especially in view of a lack of distinguishing character states and such a distinction not being made in Europe.

Kingdom: Plantae;
Phylum: Magnoliophyta;
Class: Angiospermae;
Order: Caryophyllales;
Family: Phytolaccaceae
Genus: *Phytolacca*

Synonyms:
Phytolacca americana var. *americana* L. (autonym)
Phytolacca decandra L., Sp. Pl. ed. 2: 631 (1762)

Note: Other checklist databases detail other synonyms for *P. americana* such as *Phytolacca vulgaris* Bubani, *Phytolacca vulgaris* Crantz (Bock *et al*., 2018).

English common names: American cancer, American nightshade, American pokeweed, American spinach, bears grape, cancer root, garget, inkberry, pigeonberry, poke, pokeberry, pokeroot, pokeweed, red-ink plant, stoke berry, Virginia poke.

Other languages: Albanian çapezë; Bulgarian американски лаконос, лаконос; Croatian američki kermes; Czech líčidlo americké; Danish asiatisk kermesbær; Dutc karmozijnbes, westerse karmozijnbes h; laque, French: phytolacca américain, phytolaque américaine, phytolaque d'Amérique, phytolaque à dix étamines, raisin d'Amérique; amerikanische Kermesbeere, Scharlachbeere, Schminkbeere German; Greek αγριοσταφίδα ή μαυροστάφυλο ; Hebrew fitolakah amerikanit; Hungarian amerikai alkörmös; Italian cremesina uva-turca, erba carmesina, fitolacca, uva d'America, uva da colorare; Polish szkarłatka amerykańska; Portuguese baga-noiva; erva-dos-cachos-de-índia, erva-dos-cancros, gaia-moça, tintureira, uva-da-américa, uva-dos-tintureiros, vermelhão, caruru-de-cacho, fruto-de-pombo, uva-de-tinta; Romanian cîrmîz; Russian лаконос американский; Serbian америчка винобоја, гроздасти кермес; Slovakian líčidlo americké;; Slovenian navadna barvilnica; Spanish carmesín de oblea, espinacas de América, fitolaca, grana encarnada, granilla, hierba carmín, tintilla, uvas de América, uvas de Indiasombú; Swedish amerikanskt kermesbär; Turkish şekerciboyası Ukrainian лаконос американський

See also Euro+Med (2006).

Description of the species: *Phytolacca americana* is a polycarpic perennial herb (Armesto *et al.*, 1983) with a large white taproot which can reach 12 – 15 cm in diameter at ground level (Balogh & Juhász, 2008). The Flora of North America detail: 3 (-7) m in height. Leaves: petiole 1-6 cm; blade lanceolate to ovate, to 35 × 18 cm, base rounded to cordate, apex acuminate. Racemes open, proximal most pedicels sometimes bearing 2-few flowers, erect to drooping, 6-30 cm; peduncle to 15 cm; pedicel 3-13 mm. Flowers: sepals 5, white or greenish white to pinkish or purplish, ovate to suborbiculate, equal to subequal, 2.5-3.3 mm; stamens (9-)10(-12) in 1 whorl; carpels 6-12, connate at least in proximal $^1/2$; ovary 6-12-loculed. Berries purple-black, 6-11 mm diam. Seeds black, lenticular, 3 mm, shiny. 2*n* = 36. Seeds can weigh 6.1 – 7.5 g/1000 seeds (Balogh & Juhász, 2008).

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 environment, in confinement or associated with a pathway of introduction]

Include both native and non-native species that could be confused with the species being assessed, including the following elements:

- other alien species with similar invasive characteristics, to be avoided as substitute species (in this case preparing a risk assessment for more than one species together may be considered);
- other alien species without similar invasive characteristics, potential substitute species;
- native species, potential misidentification and mis-targeting

Response:

The Manual of the Alien Plants of Belgium (2020) states: '*Phytolacca acinosa* (an emerging invasive species in the EU) is often confused with *P. americana* in Belgium. In fact many records of the latter doubtlessly belong to *Phytolacca acinosa*, by far the commonest representative of the genus in Belgium. *Phytolacca acinosa* always is a much smaller plant (rarely exceeding 100 cm) with an erect inflorescence and broader leaves. Moreover, at least in Belgium, it starts flowering much earlier: *Phytolacca acinosa* starts flowering from May onwards whereas *Phytolacca americana* does not flower before July'.

Verloove (2019) detail that *P. acinosa* is an increasingly locally naturalised garden escape in Belgium. The species was first recorded in 1960 on a talus slope of the Albertkanaal in Kanne. From 1990 it has been recorded as an urban weed in many cities: Antwerpen, Brugge, Brussel, Gent, Izegem, Kortrijk, Leuven, Liège, Menen, Tielt, Tongeren occurring in gardens or parks in cemeteries or in urban wasteland. *P. acinosa* also occurs in Hungary and Croatia as a non-native species (respectively Balogh and Juhasz, 2008; Borak and Šoštarić, 2016). In Slovenia, *P. acinosa* has been recorded in 70 locations (LIFE Artemis Project, 2020). It is also present in Denmark (Hartvig, 2015). *P. polyandra* is locally naturalised in the British Isles (Clement & Foster 1994). *P. esculenta* is recorded as a casual alien plant in France (Tison & de Foucault, 2014).

In the horticultural trade within the risk assessment area plants traded as *Phytolacca rivinoides* and *Phytolacca latbenia* can be confused with. *P. americana* especially the morphological similarity and the colour of the inflorescence. In addition, *Phytolacca acinosa* Roxb., and *Phytolacca polyandra* Batalin can be confused with *P. americana.*

Phytolacca americana may also be confused with the native species *Atropa belladonna* in the forest cuttings.

A3. Does a relevant earlier risk assessment exist? Give details of any previous risk assessment, including the final scores and its validity in relation to the risk assessment area.

Response: In Belgium, the species was evaluated in 2010 using the impact assessment protocol ISEIA http://ias.biodiversity.be/species/show/111. The species was scored 9, which means moderate impact. In Germany, the species was risk assessed and the species was included in the Grey List which means the species is classified as potentially invasive (Nehring et al., 2013).

Phytolacca americana was also assessed with the use of a modified version of the Australian Weed Risk Assessment System (AWRAS) in Italy and in Portugal (respectively Crosti et al., 2010 and Morais et al., 2017). AWRAS classifies species as "accept" (species that are not likely to become invasive), "reject" (species that have a high risk of becoming invasive) or "evaluate further". Both assessments classified the species as "reject".

A4. Where is the organism native?

including the following elements:

- an indication of the continent or part of a continent, climatic zone and habitat where the species is naturally occurring
- if applicable, indicate whether the species could naturally spread into the risk assessment area

Response: *Phytolacca americana* is native to North America (including southeastern Canada, eastern the US and the northeast of Mexico) (Sauer, 1952; Rzedowski and Rzedowski, 2000). Its native range includes a little of southeastern Canada and almost the entire eastern half of the USA (Sauer, 1952). The species has however, spread westwards into other States and USDA (2019) detail the species present in: Alabama, Arkansas, Arizona, California, Connecticut, District of Columbia, Deleware, Florida, Georgia, Iowa, Illinois, Indiana, Kansas, Kentucky, Louisiana, Massachusetts, Maryland, Maine, Michigan, Minnesota, Missouri, North Carolina, Nebraska, New Hampshire, New Jersey, New York, Ohii, Oklahoma, Pennsylvania, Rhode island, South Carolina, Tennessee, Texas, Virginia, Vermont, Wisconsin, and West Virginia (USDA, 2019; US NPGS, 2019). In Canada, the species is present in the Provinces: Brunswick, Ontario and Quebec. The spread of the species in North America is regarded as being greatly influenced by humans over the last few centuries (Sauer, 1952).

It is not possible for *P. americana* to naturally spread into the risk assessment area from its native range.

The species is native within a number of Kőppen-Geiger climate zones including, the main zones of Hot-summer humid continental climate (Dfa), Warm-summer humid continental climate (Dfb), humid subtropical climate (Cfa), Hot-summer Mediterranean climate (Csa).

Regarding the habitat preference of the species in its native range, it is often abundant in open, disturbed habitats, as well as in forest edges and light gaps (Sauer 1952, cited by Armesto et al (1983)). Balogh & Juhasz (2008) describe in more details that *"In its native range Ph. americana primarily grows as a pioneer plant of disturbed and open surfaces of damp soiled forests (for example around badger's burrows), on the fringe of forests and on riverbanks. Of the antropogeneous habitats it can be found on cuttings, waysides, fields and fallows. They prefer the eutrophic, flimsy, damp soils. It occurs rarely on sites where the temperature goes under –15 °C permanently in the winter, propagation is favourable if the average temperature is around 20 °C in July. In its native range it occurs at 1400 m of elevation."*

A5. What is the global non-native distribution of the organism outside the risk assessment area?

Response: *Phytolacca americana* has been introduced into many regions of the world. In Asia it is common from Turkey to Iran, and present in India, China, Taiwan, Japan, and Indonesia (on Sumatra it was found on 1500 m a.s.l.) (Balogh and Juhasz, 2008). The species is cultivated in China and recorded in the following provinces (Anhui, Fujian, Guangdong, Guizhou, Hebei, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Shandong, Sichuan, Taiwan, Yunnan, Zhejiang) (Flora of China, 2019). It has also been reported as invasive in China where it can become out of control in urban garden environments (Li *et al.*, 2016). The species is widely recorded in South Korea and considered an invasive alien species (Kim *et al.*, 2008). In Japan, the species is reportedly present throughout the country and it is estimated that the species was originally introduced into the country around 1970 (NIES, 2019). In Israel the species was first recorded in 1898 (Dufour-Dror 2012). In Turkey, the species is present around the Black Sea region from Samsun to Sarp/Artvin where invaded habitats included forests, river banks, waste land, coastal regions, urban and along the edges of agricultural areas (Akyol *et al.*, 2015).

In the Oceania region, the species is non-native in Australia, where it is found in New South Wales and Queensland (Hewson, 1984). It is also present in New Zealand (Webb *et al.*, 1988).

In Africa, *P. americana* is an invasive non-native species in South Africa (Invasive species South Africa, 2019), where it is listed as a NEMBA Category 1b species (i.e. "invasive species that may not be owned, imported into South Africa, grown, moved, sold, given as a gift or dumped in a waterway"). It is recorded as being problematic in Mpumalanga (Invasive species South Africa, 2019). Q bank (2019) also list the species as present in Cape Verde, Democratic People's Republic of Congo, Liberia, Mauritius, Reunion and Swaziland. Interestingly, the species is listed on the A1 list since 2001 for East Africa (EPPO, 2019).

Q bank (2019) lists central and South American countries where *P. americana* is present including: Costa Rica. Bolivia, Ecuador and Uruguay. There are some reports that the species is present in the Galapagos Islands (Charles Darwin Foundation, 2019).

The species is present in Switzerland where it is listed on the Observation list of Invasive Alien Plants since 2013 (EPPO, 2019). The species is reported to have been introduced into Switzerland in the 1700s as an ornamental plant (FOEN, 2006). It is mostly distributed south of the Alps, but some occurrences are recorded in northern Switzerland. It is reportedly a ruderal species growing in waste ground, disturbed habitats, open woods, pastures and along roadsides and railways (FOEN, 2006).

The species is present in Serbia where it has been recorded in woodland habitats in Vojvodina (Krtivojević *et al.*, 2012). It has been recorded in Ukraine (Balogh and Juhasz, 2008). The species is recorded as being non-native in Albania (Balogh and Juhasz, 2008). Maslo (2016) details *P. americana is* present in Bosnia and Herzegovina where it was first recorded in 1908.

The species is recorded as naturalised in Georgia with 107 recorded occurrences (Slodowicz *et al.*, 2018).

The species occurs as a non-native species in Macaronesia (Invasoras, 2019). It is present in the Azores archipelago (all islands) and the Madeira archipelago (Madeira island) (Invasoras, 2019).

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? The information needs be given separately for recorded and established occurrences.

A6a. Recorded: List regions

A6b. Established: List regions

Freshwater / terrestrial biogeographic regions:

- Alpine, Atlantic, Black Sea, Boreal, Continental, Mediterranean, Pannonian, Steppic

Marine regions:

- Baltic Sea, North-east Atlantic Ocean, Mediterranean Sea, Black Sea

Marine subregions:

- Greater North Sea, incl. the Kattegat and the English Channel, Celtic Seas, Bay of Biscay and the Iberian Coast, Western Mediterranean Sea, Adriatic Sea, Ionian Sea, Central Mediterranean Sea, Aegean-Levantine Sea.

Comment on the sources of information on which the response is based and discuss any uncertainty in the response.

For delimitation of EU biogeographical regions please refer to https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2 (see also Annex V).

For delimitation of EU marine regions and subregions consider the Marine Strategy Framework Directive areas; please refer to https://www.eea.europa.eu/data-and-maps/data/msfd-regions-and-subregions/technical-document/pdf (see also Annex V).

Response (6a):

terrestrial biogeographic regions:

- Alpine, Atlantic, Black Sea, Continental, Mediterranean, Pannonian, Steppic (based on GBIF data, 2019; Euro+Med, 2011).

Response (6b):

terrestrial biogeographic regions:

- Alpine, Atlantic, Black Sea, Continental, Mediterranean, Pannonian, Steppic (based on Euro+Med, 2011).

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? The information needs be given separately for current climate and under foreseeable climate change conditions.

A7a. Current climate: List regions

A7b. Future climate: List regions

With regard to EU biogeographic and marine (sub)regions, see above.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5)
- what aspects of climate change are most likely to affect the risk assessment (e.g. increase in average winter temperature, increase in drought periods)

The assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

Response (7a): Alpine, Atlantic, Black Sea, Continental, Mediterranean, Pannonian, Steppic (see Figure 8, species modelling Annex VII).

Response (7b): Alpine, Atlantic, Black Sea, Boreal, Continental, Mediterranean, Pannonian, Steppic. With climate change there is the potential that areas of the boreal biogeographical regions may become suitable for the establishment of the species. Areas of the Mediterranean may become more limited for the establishment of the species (see Figure 8, species modelling Annex VII).

It should however be noted that the SDM may over represent the potential establishment of the species in the natural environment within the RA area as the data taken from GBIF to perform the models would also include localities where the species has been planted.

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. The information needs be given separately for recorded and established occurrences.

A8a. Recorded: List Member States

A8b. Established: List Member States

Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom

The description of the invasion history of the species shall include information on countries invaded and an indication of the timeline of the first observations, establishment and spread.

Response (8a): Recorded: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, France, Germany, Greece, Hungary, Italy, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, United Kingdom (Euro+Med, 2011; and references below)

Response (8b): Established: Austria, Bulgaria, Croatia, Cyprus, Czech Republic, France, Germany, Greece, Hungary, Italy, Malta, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain (Euro+Med, 2011; and references below)

Further information on occurrence in EU Member States (where available):

Phytolacca americana was first recorded in Europe in the 17th century where its cultivation begun around the Mediterranean Sea (South Europe and North Africa), due to planting of the species as a dye-plant since 1650 (Balogh and Juhasz, 2008). From 1770 it started to spread out from Bordeaux (France). In Europe, the species has been introduced into Austria, Belgium (not established, Verloove, 2019), Bulgaria (Petrova *et al.*, 2013), Cyprus, Croatia (Boršić et al., 2008: Nikolić et al., 2014; Nikolić, 2020), Czech Republic, France (Le Neindre, 2002; Chabrol *et al.*, 2007), including Corsica (Jeanmonod *et al.*, 2011), Germany (Nehring et al., 2013), Greece (Arianoutsou *et al.*, 2010) including Crete, Hungary (Botta-Dukát and Mihály, 2006), Italy (Galasso *et al.*, 2008; Celesti-Grapow *et al.*, 2009) including Sardinia and Sicilia, Malta (M. Filipovic, pers. comm.2020), Netherlands (J. van Valkenburg, pers comm. 2019), Poland (Chmura 2016), Portugal (Invasive Plants in Portugal, 2019), Romania, Slovenia, Slovakia, Switzerland, Spain, UK (Stace, 2019). In Belgium, there are increasing observations of the species, along with other *Phytolacca* species (e.g. *P. acinosa*) (Adriaens *et al*, 2019). *P. americana* has been recorded in 1173 locations in Slovenia (https://www.invazivke.si/, 19.11.2020). In Germany, the species was first introduced for horticulture between 1630-1651 (Nehring et al., 2013).

Borbás mentioned in 1879 that it started to escape around gardens and hedges in Budapest (Hungary). Domokos (1937) writes about it as a frequent plant in the Mecsekalja and along the Lower Danube already in the first half of the 20th century. Recent distribution in Hungary is South Transdanubia (mostly Belső-Somogy, West-Baranya), Duna-Tisza Interfluve (Budapest–Csévharaszt, to the south from Kecskemét) and Hajdúság (Téglás– Hajdúhadház). Balogh & Juhasz (2008) detail that recently its presence has been noticed in South-Mezőföld, but its smaller or bigger stands can be found in many other areas (for example eastern Vas County, Bakonyalja, Balaton-uplands, Gerecse, Külső-Somogy, Zselic).

A9. In which EU Member States could the species establish in the future under current climate and under foreseeable climate change? The information needs be given separately for current climate and under foreseeable climate change conditions.

A9a. Current climate: List Member States

A9b. Future climate: List Member States

With regard to EU Member States, see above.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5)
- what aspects of climate change are most likely to affect the risk assessment (e.g. increase in average winter temperature, increase in drought periods)

The assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

Response (9a): At present *P. americana* is established in Austria, Bulgaria, Croatia, Cyprus, Czech Republic, France, Germany, Greece, Hungary, Italy, Malta, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain.It is envisaged that further establishment would be seen in these countries and other countries where the biogeographical regions are the same. Additional countries to the aforementioned would be Belgium, Estonia, Finland, Latvia, Lithuania and Luxembourg.

Response (9b): Under a climate change scenario of (RCP 4.5, over the next 30/50 years), countries in northern Europe may be suitable for the establishment of *P. americana* due to the increased temperature and the length of the growing season. Both increased summer and winter temperatures would benefit the species. Increased precipitation and CO2 levels as a result of climate change may also favor the species. These countries would include Denmark, Lithuania, Latvia, Estonia, Finland, Sweden and the UK. See Annex VII for more details.

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?

Response: In the USA, in Pennsylvania, which is outside of its native range, *P. americana* is reported as a frequent weed (i.e. invasive in cultivated areas) in corn and soybean crops (Patches *et al.*, 2017; Steckel, 2006)). The species is also reported as a common pasture weed in the USA (Kiningham, nd). Sellers *et al* (2006) highlights that the species can be poisonous to animals and can impact on hogs, sheep, cattle, horses and poultry.

It has also been reported as invasive in China where it can become out of control in urban garden environments (Li *et al.*, 2016) In China, in natural reserves in Jiangsu, *P. americana* threatens the survival of native plants such as *Emilia sonchifolia* and *Taraxacum mongolicum* (Dong et al., 2011). The species is widely recorded in South Korea where it can invade coastal dune systems and has been designated as a harmful species because of its adverse effects on the ecosystem (Min 2014).

P. americana is an invasive non-native species in South Africa (Invasive species South Africa, 2019), where it is listed as a NEMBA Category 1b[2] species. It is recorded as being problematic in Mpumalanga where it spreads into natural habitats (Invasive species South Africa, 2019).

A11. In which biogeographic region(s) or marine subregion(s) in the risk assessment area has the species shown signs of invasiveness? Indicate the area endangered by the organism as detailed as possible.

Freshwater / terrestrial biogeographic regions:

- Alpine, Atlantic, Black Sea, Boreal, Continental, Mediterranean, Pannonian, Steppic

Marine regions:

- Baltic Sea, North-east Atlantic Ocean, Mediterranean Sea, Black Sea

Marine subregions:

Greater North Sea, incl. the Kattegat and the English Channel, Celtic Seas, Bay of Biscay and the Iberian Coast, Western Mediterranean Sea, Adriatic Sea, Ionian Sea, Central Mediterranean Sea, Aegean-Levantine Sea

Response: Alpine, Atlantic, Continental, Mediterranean, Pannonian.

The endangered area includes areas of forests, river banks, waste land, coastal regions, urban habitats and along the edges of agricultural areas within the aforementioned biogeographical regions

A12. In which EU Member States has the species shown signs of invasiveness? Indicate the area endangered by the organism as detailed as possible.

Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom

Response: Croatia (Boršić et al., 2008: Nikolić et al., 2014), France (Dumas, 2011a), Germany (Schirmel, 2019), Hungary (Balogh and Juhasz, 2008), Italy (Acta plantarum, 2019), Poland (Chmura, 2016), Portugal (Invasoras, 2019), Romania (Szatmari, 2012), Spain (Sanz-Eloraza *et al*., 2001; Dana *et al*., 2001), Slovenia (Kus Veenvliet *et al* 2017).

The endangered area includes areas of forests, river banks, waste land, coastal regions, urban habitats and along the edges of agricultural areas within the aforementioned countries.

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[2] **Category 1b**: Invasive species requiring compulsory control as part of an invasive species control programme. Remove and destroy. These plants are deemed to have such a high invasive potential that infestations can qualify to be placed under a government sponsored invasive species management programme.

A13. Describe any known socio-economic benefits of the organism.

including the following elements:

- Description of known uses for the species, including a list and description of known uses in the Union and third countries, if relevant.
- Description of social and economic benefits deriving from those uses, including a description of the environmental, social and economic relevance of each of those uses and an indication of associated beneficiaries, quantitatively and/or qualitatively depending on what information is available.

If the information available is not sufficient to provide a description of those benefits for the entire risk assessment area, qualitative data or different case studies from across the Union or third countries shall be used, if available.

Response: *Phytolacca americana* has numerous medicinal uses, these include achy muscles and joints (rheumatism); swelling of the nose, throat, and chest; tonsillitis; hoarse throat (laryngitis); swelling of lymph glands (adenitis); swollen and tender breasts (mastitis); mumps; skin infections including scabies, tinea, sycosis, ringworm, and acne; fluid retention (edema), skin cancers, menstrual cramps (dysmenorrhea), and syphilis. See Paly *et al*., (1994), Patra et al 2014 for examples of chemical compounds.

Research is undertaken on the properties of natural compounds produced by *Phytolacca americana* e.g. Cho *et al*. (2003), Getiya *et al.* (2011).

The leaves of *P. americana* can be eaten – though they must be cooked, and apparently, it is used like spinach. The root is also reported as edible, though it is the most toxic part of the plant.

A dye can be obtained from the fruit, which can be used as ink and a dye for clothes (Balogh & Juhasz (2008). The ink can be used as body paint which American native Indians used. There are reports that the dye has been used as a food coloring and as a wine coloring agent.

It is reported that the roots are rich in saponins, which can be used as a substitute for soap.

Such an array of uses may be the reason why the species has expanded from its native range in the USA to cover most of the United States (Sauer, 1952).

Balogh & Juhasz (2008) detail that *P. americana* can also be used for the coloration of foods such as preserved fruit and sweets.

RHS reports the species being available in the horticulture industry in 16 nurseries in UK, see: https://www.rhs.org.uk/Plants/12895/i-Phytolacca-americana-i/Details. The species is widely sold in the EU as a horticulture plant and this is historically the main entry pathway for the species. In Germany, the species is marketed as being attractive for ‘bees, bumblebees and other insects. (e.g. : https://www.pflanzen-fuer-dich.de/de-de/artikel/3176/phytolacca-americana).

In addition, Min et al. 2006 find that *P. americana* hyper-accumulate metal and may be used for phytoremidiation

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.”
- 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.
- Highlight the selected response score and confidence level in **bold** but keep the other scores in normal text (so that the selected score is evident in the final document).

1 PROBABILITY OF INTRODUCTION

Important instructions:

- **Introduction** is the movement of the species into the risk assessment area (it may be either in captive conditions and/or in the environment, depending on the relevant pathways).
- **Entry** is the release/escape/arrival in the environment, i.e. occurrence in the wild and is treated in the next section (N.B. introduction and entry may coincide for species entering through pathways such as “corridor” or “unaided)”.
- The classification of pathways developed by the Convention of Biological Diversity (CBD) should be used. For detailed explanations of the CBD pathway classification scheme consult the IUCN/CEH guidance document[3] and the provided key to pathways[4].
- For organisms which are already present in the risk assessment area, only complete this section for current active pathways and, if relevant, potential future pathways.

Qu. 1.1. List relevant pathways through which the organism could be introduced. Where possible give details about the specific origins and end points of the pathways as well as a description of any associated commodities.

For each pathway answer questions 1.2 to 1.7 (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. 1.2a, 1.3a, etc. and then 1.2b, 1.3b etc. for the next pathway.

In this context a pathway is the route or mechanism of introduction of the species.

The description of commodities with which the introduction of the species is generally associated shall include a list and description of commodities with an indication of associated risks (e.g. the volume of trade; the likelihood of a commodity being contaminated or acting as vector).

If there are no active pathways or potential future pathways this should be stated explicitly here, and there is no need to answer the questions 1.2-1.9

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[3] https://circabc.europa.eu/sd/a/738e82a8-f0a6-47c6-8f3b-aeddb535b83b/TSSR-2016-010%20CBD%20categories%20on%20pathways%20Final.pdf

[4] https://circabc.europa.eu/sd/a/0aeba7f1-c8c2-45a1-9ba3-bcb91a9f039d/TSSR-2016-010%20CBD%20pathways%20key%20full%20only.pdf

Introduction pathways considered in this section are:

1) **Horticulture**
2) **Transport – Contaminant (transport of habitat material (soil, vegetation))**
3) **Transport – stowaway (machinery/equipment)**
4) **Pathway name: unaided**
5) **People and their luggage/equipment (in particular tourism)**

Pathway name: **(1) Horticulture**

Qu. 1.2a. 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)?

RESPONSE	**intentional** unintentional	**CONFIDENCE**	Low medium **high**

Response: Introduction via this pathway is deliberate, and planting of the species would be the end result of the movement of the species. *Phytolacca americana* is grown as a garden ornamental species within the RA area. The species is traded within the RA area. The species is on sale on eBay and Amazon and suppliers can send seeds from Russia, USA, and Mexico. It is likely that the species is sold throughout the RA area as an ornamental species.

Qu. 1.3a. How likely is it that large numbers of the organism will be introduced through this pathway from the point(s) of origin over the course of one year?

including the following elements:

- 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.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in introduction whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	low **medium** high

Response: *Phytolacca americana* is available through the horticultural trade both within the RA area and outside. The species is available via internet suppliers (e.g. Amazon.com and ebay.com) but it remains unclear if the species can be sent to buyers within the EU from outside.

Examples of suppliers on Amazon:
https://www.amazon.com/Pokeberry-Phytolacca-americana-Heirloom-Collector/dp/B01NBP3U2G
https://www.amazon.com/Pokeweed-Phytolacca-Americana-Bare-Plants/dp/B07YLRN3JS
https://www.amazon.de/Plant-World-Seeds-Phytolacca-Americana/dp/B00YL48OL8/ref=sr_1_44?adgrpid=74804538441&dchild=1&gclid=EAIaIQobChMI8IS2oL7W6QIVTM-yCh2OMAhtEAMYASAAEgIML_D_BwE&hvadid=352663555374&hvdev=c&hvlocphy=9068494&hvnetw=g&hvqmt=b&hvrand=4597339880119585550&hvtargid=kwd-303673593781&hydadcr=21902_1838669&keywords=phytolacca+americana&qid=1590666579&sr=8-44

By definition, both seeds and whole plants could enter the RA area via plants for planting.

As entry via this pathway is deliberate, and planting of the species would be the end result of the movement of the species low numbers of propagules could result in the entry of the species.

A medium confidence is given which reflects the known introduction of the species but there are still gaps in the knowledge, i.e. if the species is continually introduced into the RA area for horticulture.

Qu. 1.4a. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response: The pathway 'Horticulture' is the deliberate movement of plant material into the risk assessment area and as such plant material would be maintained and moved to ensure survival. No management practices would be carried out along this pathway.

It is unlikely that the species will reproduce or increase along the pathway. Both seed and live plants could be moved along this pathway.

Qu. 1.5a. How likely is the organism to survive existing management practices during transport and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely likely	**CONFIDENCE**	Low medium **high**

	very likely		

Response: No management practices would be carried out along this pathway.

Qu. 1.6a. How likely is the organism to be introduced into the risk assessment area undetected?

RESPONSE	very unlikely **unlikely** moderately likely likely very likely	**CONFIDENCE**	low medium **high**

Response: It is unlikely that the organism will enter the risk assessment area undetected via the pathway 'Horticulture (escape from confinement)' is the deliberate movement of plant material into the risk assessment area. Any plant material imported into the EU should be accompanied with a Phytosanitary Certificate. Therefore, a high confidence is given.

Qu. 1.7a. Estimate the overall likelihood of introduction into the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low **medium** high

Response: *Phytolacca americana* is available through the horticultural trade both within the PRA area and outside. The species is available via internet suppliers (e.g. Amazon.com and ebay.com) but it remains unclear if the species can be sent to buyers within the EU from outside, hence a medium confidence score. Therefore, based on the latter, a medium rating of uncertainty has been given.

(2) Pathway name: **Transport – Contaminant (transport of habitat material (soil, vegetation))**

Qu. 1.2b. 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)?

RESPONSE	**unintentional** intentional	**CONFIDENCE**	low medium **high**

Response: Entry via this pathway is unintentional movement of the species via the contamination of habitat material (soil and vegetation).

Qu. 1.3b. How likely is it that large numbers of the organism will be introduced through this pathway from the point(s) of origin over the course of one year?

including the following elements:

- 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.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in introduction whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response: The transport of topsoil and or other contaminated material with seed of the species can facilitate entry into the RA area. However, the pathway is mainly closed within the RA as there are prohibitions of the movement of soil into the EU from many countries. The lack of data associated with this pathway is reflected by a low confidence.

Qu. 1.4b. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low **medium** high

Response: The pathway Transport – Contaminant (transport of habitat material (soil, vegetation) is the unintentional movement of plant material into the risk assessment area. As the seed would be moved with soil it is likely that they would survive during passage.

It is unlikely that the plant will multiply along the pathway

Seeds would be the most likely plant parts for transport, rather than whole plant parts. Seeds can remain dormant within a seed bank for a number of years. Therefore, habitat material collected from the natural environment may potentially contain viable seeds. For example, Michigan State University (2020) report seeds can remain viable in the seedbank for up to 50 years and Sellers et al (2019) detail 40 years). However, the aforementioned figures are likely to be the extreme. Hyatt and Casper (2000) showed in a forest gap in the USA, 46 % of *P. americana* seeds were viable in the soil for at least a year.

Seed viability under controlled (artificial) conditions may be significantly lower compared to the seedbank. USDA Forest Service (1970) showed that after 5 months of storage under different conditions, germination was 8 % (at room temperature), 0 % at 42 °F (5 °C) (in air), 54 % in wet sand and 68 % in sphagnum moss at 5 °C.

Qu. 1.5b. How likely is the organism to survive existing management practices during transport and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	**low** medium high

Response: Soil is unlikely to be treated as it is moved through the pathway and as such plant material would survive. Thus, a low rating of confidence has been given.

Qu. 1.6b. How likely is the organism to be introduced into the risk assessment area undetected?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	**low** medium high

Response: It is likely that the organism will enter the risk assessment area undetected as seeds will be hidden in soil and may not be detected. The lack of data associated with this pathway is reflected by a low confidence.

Qu. 1.7b. Estimate the overall likelihood of introduction into the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely **moderately likely**	**CONFIDENCE**	**low** medium high

	likely very likely		

Response: The entry of *P. americana* via the pathway: Transport – Contaminant (transport of habitat material (soil, vegetation) has a moderately likelihood. The species can remain undetected within soil and other habitat material but the pathway remains closed for soil within EU countries (e.g. importation of soil and growing medium as such is prohibited in the EU, and is regulated when associated with plants (Regulation (EU) 2019/2072)). The lack of data associated with this pathway is reflected by a low confidence.

(3) Pathway name: **Transport – stowaway (machinery/equipment)**

Qu. 1.2c. 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)?

RESPONSE	**unintentional** intentional	**CONFIDENCE**	low medium **high**

Response: Entry via this pathway is unintentional movement of the species via machinery and equipment.

Qu. 1.3c. How likely is it that large numbers of the organism will be introduced through this pathway from the point(s) of origin over the course of one year?

including the following elements:

- 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.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in introduction whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely **moderately likely**	**CONFIDENCE**	**low** medium high

	likely very likely		

Response: Machinery and equipment used for forestry and agricultural purposes may include seeds of *P. americana* attached within tyre treads or other areas of machinery and equipment where soil is also attached.

There is no evidence that the species has entered the RA area via this pathway and there is no information available on the volumes of movement along this pathway. However, as in areas where the species is present, the seed bank density can be high, and thus there is a potential for seeds to become attached to tires of vehicles. Dumas (2011), when considering spread, highlight that 'the transport of seeds by the soil retained in the tread pattern of machine tires is a 'hypothesis that we cannot exclude'. Thus, it should also be considered for movement into the RA area.

The lack of data associated with this pathway is reflected by a low confidence.

Qu. 1.4c. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response: The species is unlikely to reproduce along this pathway. But as the seeds are small the species can survive along the pathway. See Qu.1.4b for details on the viability of the seeds.

Qu. 1.5c. How likely is the organism to survive existing management practices during transport and storage along the pathway?

RESPONSE	very unlikely **unlikely** moderately likely likely very likely	**CONFIDENCE**	**low** medium high

Response: If following cleaning methods suggested in ISPM 41 (FAO, 2017), removing debris or filters - abrasive blasting - pressure washing - steam cleaning - sweeping and vacuuming - compressed air cleaning, potential survival of the species should be considered as low. However, it is not known if all machinery/equipment introduced followed all the steps of the ISPM 41

Qu. 1.6c. How likely is the organism to be introduced into the risk assessment area undetected?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response: Seeds are small and therefore they can remain undetected within crevices of used machinery.

Qu. 1.7c. Estimate the overall likelihood of introduction into the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response: Based on international Standards and requirements within (ISPM 41: FAO, 2017), the entry of *P. americana* as a hitchhiker of used machinery is moderately likely. However, incorrect application of the cleaning of machinery could lead to the entry of seed via this pathway. In addition, volumes of movement of used machinery into the RA area is not known and therefore the uncertainty is scored low, in part to reflect this.

(4) Pathway name: unaided

Qu. 1.2d. 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)?

RESPONSE	**unintentional** intentional	**CONFIDENCE**	low medium **high**

Response: Entry via this pathway is the unintentional movement of the species into the risk assessment area. This pathway would cover the movement of the species from areas where it is non-native, into the risk assessment area (for example Serbia into the EU).

Unaided introduction is most likely to be via dispersal of birds, which feed on the berries and disperse the seeds across borders. Sauer (1952) report that the species is poorly suited to dispersal by wind or water.

Qu. 1.3d. How likely is it that large numbers of the organism will be introduced through this pathway from the point(s) of origin over the course of one year?

including the following elements:

- 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.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in introduction whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely **unlikely** moderately likely likely very likely	**CONFIDENCE**	**low** medium high

Response: Within the RA area, Balogh and Juhasz (2008) detail the following bird species feeding on fruits in the following countries: in Italy: blackcap (*Sylvia atricapilla*), whitethroat (*Sylvia communis*), song trush (*Turdus philomelos*), blackbird (*Turdus merula*), blue rock trush (*Monticola solitarius*), robin (*Erithacus rubecula*); in South France: robin and blackcap; in New-Zealand: the pheasant (*Phasianus colchicus*). Villemenot & Mischler (2012) list several bird species eating fleshy berries as responsible of *P. americana* spread: pigeons (*Columba* spp.), turtledoves (*Streptopelia decaocto*) and starling (*Sturnus vulgaris*), but also probably blackbirds (*Turdus merula*), thrushes (*Turdus* spp.) and warblers (*Sylvia* spp.).

There is no data available on the volumes or number of individuals or frequency of movement along this pathway. However, it is not expected that large numbers of *P. americana* will be introduced via this pathway into the RA area.

Only a small number of viable seeds would be enough to support an introduction.

Qu. 1.4d. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low **medium** high

Response: The germination of seed is increased when the seed moves through a bird digestive tract (Dumas, 2011). It is noted that, 'Orrock (2005) studied the influence that can have the transit of seeds in the digestive tract of birds where a positive effect on the germination rate, which goes from 67% for controls to 88% for seeds from the fruits consumed'.

Qu. 1.5a. How likely is the organism to survive existing management practices during transport and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low medium **high**

Response: It is likely that *P. americana* can survive existing management practices during movement along this pathway. *P. americana* is suited to disturbed habitats especially disused waste ground. It is therefore likely that the current urbanization trend occurring in Europe may favor the establishment of the species. Additionally, management practices in forests, may act to open the canopy and favour disturbance that would be beneficial for the germination of the seedbank. Birds can also disperse the seeds widely throughout the risk assessment area.

Qu. 1.6d. How likely is the organism to be introduced into the risk assessment area undetected?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low **medium** high

Response: It is very likely that *P. americana* will be introduced into the risk assessment area undetected along this pathway as the seeds will be inside a birds gut.

Qu. 1.7d. Estimate the overall likelihood of introduction into the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	**low** medium high

Response: It is likely the species will be introduced into the risk assessment area based on this pathway but a low confidence highlights the lack of data and the large unknown on the volumes of seed moved along this pathway.

(5) People and their luggage/equipment (in particular tourism)

Qu. 1.2e. 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)?

RESPONSE	**unintentional** intentional	**CONFIDENCE**	low medium **high**

Response: Introduction via this pathway is for this species considered the unintentional movement of the species via seeds. In the sense of this pathway, the main risk is of introduction into new areas by the species (seeds) being incorporated into the tread of hiking boots or other equipment and moved accidently to other areas.

This movement would relate from the introduction of the species from a non- EU country (e.g. Serbia, into an EU county).

Qu. 1.3e. How likely is it that large numbers of the organism will be introduced through this pathway from the point(s) of origin over the course of one year?

including the following elements:

- 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.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in introduction whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely **unlikely** moderately likely likely very likely	**CONFIDENCE**	**low** medium high

Response: There is no information available on the volumes of movement along this pathway. As the fruit of the species does not have any spiny spurs there is a low chance of the fruits attaching to clothes and other material.

Qu. 1.4e. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response: The seeds of the species are small and therefore they could survive during transport along this pathway. The substrate would be conducive to maintain survival. The species would not reproduce along this pathway or increase.

Qu. 1.5e. How likely is the organism to survive existing management practices during transport and storage along the pathway?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response: Careful methodical management practices coupled with inspection of tread on boots would be needed to ensure that the species is not introduced into the RA area. However, often biosecurity measures are not widely known by the general public.

Qu. 1.6e. How likely is the organism to be introduced into the risk assessment area undetected?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response: The seeds are relatively small and potentially can remain undetected within the tread of hiking boots. Additionally, the seeds may not be easily identifiable to non-botanists and thus may be overlooked.

Qu. 1.7e. Estimate the overall likelihood of introduction into the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response: There is no data on the movement of the species along this pathway and there is no information if the seeds can maintain being adhered to the tread of hiking boots for long periods of time.

End of pathway assessment, repeat Qu. 1.3 to 1.7 as necessary using separate identifier.

Qu. 1.8. Estimate the overall likelihood of introduction into the risk assessment area based on all pathways and specify if different in relevant biogeographical regions in current conditions.

Provide a thorough assessment of the risk of introduction in relevant biogeographical regions in current conditions: providing insight in to the risk of introduction into the Union.

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low **medium** high

Response: When considering all pathways into the RA area, it is likely that *P. americana* can enter the RA area with a medium confidence. All biogeographical regions would have similar likelihood scores based on the pathways described.

Qu. 1.9. Estimate the overall likelihood of introduction into the risk assessment area based on all pathways in foreseeable climate change conditions?

Thorough assessment of the risk of introduction in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5)
- what aspects of climate change are most likely to affect the likelihood of introduction (e.g. change in trade or user preferences)

The thorough assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment of likely introduction within a medium timeframe scenario (e.g. 30-50 years) with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	Low **Medium** high

Response: Within the next 30/50 years, under the medium climate change prediction (RCP 5.5), there is an overall likely score that *P. americana* will enter the RA area with a medium confidence. As this question is only considering introduction into the RA area, all biogeographical regions would have similar likelihood scores based on the pathways described. Climate change is unlikely to change the current pathways but it may extend the areas where the species can be grown to the north and restrict the areas where the species may grow in the Mediterranean region, i.e. regions where someone could introduce it for planting could change accordingly

2 PROBABILITY OF ENTRY

Important instructions:

- Entry is the release/escape/arrival in the environment, i.e. occurrence in the wild. Entry is not to be confused with spread, the movement of an organism within the risk assessment area.
- The classification of pathways developed by the Convention of Biological Diversity (CBD) should be used. For detailed explanations of the CBD pathway classification scheme consult the IUCN/CEH guidance document[5] and the provided key to pathways[6].
- 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 entry.

Qu. 2.1. List relevant pathways through which the organism could enter into the environment.

For each pathway answer questions 2.2 to 2.7 (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. 2.2a, 2.3a, etc. and then 2.2b, 2.3b etc. for the next pathway.

In this context a pathway is the route or mechanism of entry of the species into the environment.

If there are no active pathways or potential future pathways this should be stated explicitly here, and there is no need to answer the questions 2.2-2.8

Entry pathways considered in this section are:

(1) Horticulture (escape from confinement).
(2) Release in nature for use
(3) Transport – Contaminant (transport of habitat material (soil, vegetation)
(4) Transport – stowaway (machinery/equipment)

Pathway name: **(1) Horticulture (escape from confinement).**

Qu. 2.2a. Is entry into the environment intentional (e.g. the organism is released for a specific purpose) or unintentional (e.g. the organism escapes from a confinement)?

RESPONSE	**unintentional** intentional	**CONFIDENCE**	low **medium** high

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

Response: The pathway is the escape of the species from horticulture into the natural environment. Thus, this in its strictest definition would be an unintentional occurrence of the species in the environment outside of cultivation.

RHS reports the species being available in 16 nurseries in UK, see: https://www.rhs.org.uk/Plants/12895/i-Phytolacca-americana-i/Details

This pathway also involves the dumping of garden waste, which may include *P. americana* plant parts (seeds or root fragments).

Qu. 2.3a. How likely is it that large numbers of the organism will enter into the environment along this pathway from the point(s) of origin over the course of one year?

including the following elements:

- 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.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of entry into the environment based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in entry whereas for others high propagule pressure (many thousands of individuals) may not).

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response: There is no information on the volumes of movement along this entry pathway. A single plant can produce over 2 500 fruits and 25 000 seeds (Dumas 2011).

These fruit can be eaten by birds and seeds transferred from the confines of a garden into the wild of the RA area (Li et al., 2016). In addition, the species can grow to reasonable heights and potentially overhang garden fences and walls where it can release fruit into the natural environment.

If eradication measures are taken following dumping, there is the potential that the species can re-establish if it is dumped again. As one plant can produce up to 25000 seeds, only a small population is needed to result in subsequent establishment.

Qu. 2.4a. How likely is the organism to enter into the environment within the risk assessment area undetected?

RESPONSE	very unlikely	**CONFIDENCE**	low

	unlikely moderately likely likely **very likely**		medium **high**

Response: Fruit/seeds can enter the risk assessment area from garden sources and can remain undetected until they germinate and grow. Seeds can remain viable in the seed bank for a long period of time (DiTomaso et al., 2013).

The species can enter the natural environment via the dumping of garden waste. If plant waste has mature berries this would increase the likelihood. One plant can produce up to 25 000 seeds, large numbers of propagules can enter the natural environment as a result of a single dumping of one plant, if the plant contains material that contain viable seeds. *Phytolacca americana* can grow in dense stands where numerous plants would be managed and controlled and potentially dumped.

Qu. 2.5a. How likely is the organism to enter into the environment during the months of the year most appropriate for establishment?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response: Seeds would enter the environment during summer and autumn months and the seeds be included in the soil and remain viable in a seed bank. These times would also be the time that most management of gardens is occurring.

Qu. 2.6a. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host in the environment?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response: As previously mentioned, the fruit/seeds can be moved via birds and other entry pathways including small mammals and also via dropping seeds over walls or garden fences from plants contained within gardens. Dumping of garden waste would potentially place viable seeds directly in a suitable habitat.

Qu. 2.7a. Estimate the overall likelihood of entry into the environment within the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low **medium** high

Response: It is very likely that the species can enter the environment within the risk assessment area based on the pathway Horticulture (escape from confinement).

Pathway name: **(2) Release in nature for use**

Qu. 2.2b. Is entry into the environment intentional (e.g. the organism is released for a specific purpose) or unintentional (e.g. the organism escapes from a confinement)?

RESPONSE	**Intentional** Unintentional	**CONFIDENCE**	Low Medium **high**

Response: *Phytolacca americana* can be used for a number of purposes, especially medical purposes including use for achy muscles and joints (rheumatism); swelling of the nose, throat, and chest; tonsillitis; hoarse throat (laryngitis); swelling of lymph glands (adenitis); swollen and tender breasts (mastitis); mumps; skin infections including scabies, tinea, sycosis, ringworm, and acne; fluid retention (edema), skin cancers, menstrual cramps (dysmenorrhea), and syphilis. In addition, the species can be used as a food plant.

This entry pathway deals with the release of the species in nature for use other than horticulture. This would and would involve the deliberate planting of the species for utilization as detailed above.

Qu. 2.3b. How likely is it that large numbers of the organism will enter into the environment along this pathway from the point(s) of origin over the course of one year?

including the following elements:

- 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.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals /

propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication

- if relevant, comment on the likelihood of entry into the environment based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in entry whereas for others high propagule pressure (many thousands of individuals) may not).

RESPONSE	very unlikely **unlikely** moderately likely likely very likely	**CONFIDENCE**	**Low** Medium high

Response: The species would be deliberately planted within the environment. It is not expected that large numbers would enter the environment via this pathway mainly as the species is only likely to be used as a medical or food plant by a very limited number of the population within EU Member States.

Qu. 2.4b. How likely is the organism to enter into the environment within the risk assessment area undetected?

RESPONSE	**very unlikely** unlikely moderately likely likely very likely	**CONFIDENCE**	Low Medium **high**

Response: The species would be deliberately planted within the environment.

Qu. 2.5b. How likely is the organism to enter into the environment during the months of the year most appropriate for establishment?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	Low Medium **high**

Response: The species would be deliberately planted within the environment. Seeds would most likely be planted during the spring and summer months and the seeds be included in the soil and remain viable in a seed bank.

Qu. 2.6b. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host in the environment?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	Low Medium **high**

Response: The species would be deliberately planted within the environment and it is very likely that those people who plant the species would be planting it in habitats that are suitable for its growth.

Qu. 2.7b. Estimate the overall likelihood of entry into the environment within the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	Low **Medium** high

Response: It is moderately likely that the species can enter the environment within the risk assessment area based on the pathway release in nature for use. The overall score is lower than that for horticulture escape from confinement as the use of the species for medicinal purposes or as a food plant would be considerably lower than that for horticulture use.

Pathway name: **(3) Transport – Contaminant (transport of habitat material (soil, vegetation)**

Qu. 2.2c. Is entry into the environment intentional (e.g. the organism is released for a specific purpose) or unintentional (e.g. the organism escapes from a confinement)?

RESPONSE	**unintentional** intentional	**CONFIDENCE**	Low **Medium** high

Response: The pathway is the entry of the species as a contaminant of habitat material (soil or vegetation) into the natural environment. Thus, this is the unintentional occurrence of the species in the environment.

Qu. 2.3c. How likely is it that large numbers of the organism will enter into the environment along this pathway from the point(s) of origin over the course of one year?

including the following elements:

- 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.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of entry into the environment based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in entry whereas for others high propagule pressure (many thousands of individuals) may not).

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**Low** Medium high

Response: There is no information on the volumes of movement along this entry pathway. As the pathway is mainly closed within EU Member States, the likelihood is only moderately likely with a low uncertainty.

Qu. 2.4c. How likely is the organism to enter into the environment within the risk assessment area undetected?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	Low **Medium** high

Response: Seeds can enter the environment as a contaminant undetected as they are small and may be hidden in habitat material.

Qu. 2.5c. How likely is the organism to enter into the environment during the months of the year most appropriate for establishment?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	Low **Medium** high

Response: Such material could enter the environment at any time of the year and seeds can be long lived and can remain viable for up to 50 years (UC Weed Science, 2018) .

Qu. 2.6c. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host in the environment?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	Low **Medium** high

Response: The material relevant to this pathway is habitat material (soil or vegetation) and as such this material could be deliberately placed in a suitable habitat within the environment where the seed contaminants could enter the environment.

Qu. 2.7c. Estimate the overall likelihood of entry into the environment within the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	Low **Medium** high

Response: It is moderately likely that the species can enter the environment within the risk assessment area based on this pathway.

Pathway name: **(4) Transport – stowaway (machinery/equipment)**

Qu. 2.2d. Is entry into the environment intentional (e.g. the organism is released for a specific purpose) or unintentional (e.g. the organism escapes from a confinement)?

RESPONSE	**unintentional** intentional	**CONFIDENCE**	Low **Medium** high

Response: The pathway is the entry of the species as a stowaway of machinery/equipment into the natural environment. Thus, this is the unintentional occurrence of the species in the environment.

Qu. 2.3d. How likely is it that large numbers of the organism will enter into the environment along this pathway from the point(s) of origin over the course of one year?

including the following elements:

- 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.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of entry into the environment based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in entry whereas for others high propagule pressure (many thousands of individuals) may not).

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**Low** Medium high

Response: There is no information on the volumes of movement along this entry pathway. There is also no information on the volumes of movement of used machinery/equipment from outside the RA area into the RA area. Used equipment and machinery may enter the risk assessment area for a number of purposes including forest management and industrial machinery for major infrastructure renovations.

As detailed in the response to Qu. 1.3.c, movement along this pathway has been considered for spread and it is also possible for the movement from non-EU countries bordering EU countries.

Qu. 2.4d. How likely is the organism to enter into the environment within the risk assessment area undetected?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	Low **Medium** high

Response: Seeds are small and can remain undetected within crevices of used machinery. Without proper cleaning of equipment at source, or before it enters the environment, it is likely that seed can remain as a contaminant of used machinery

Qu. 2.5d. How likely is the organism to enter into the environment during the months of the year most appropriate for establishment?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	Low **Medium** high

Response: Used equipment, especially equipment used for forestry management etc. could enter the environment at any time of the year and seeds are long lived and can remain viable for a number of years.

Qu. 2.6d. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host in the environment?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	Low **Medium** high

Response: Used equipment, especially equipment used for forestry management etc. could be deliberately placed in a suitable habitat within the environment where the seed hitchhikers could enter the environment.

Qu. 2.7d. Estimate the overall likelihood of entry into the environment within the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low **medium** high

Response: It is moderately likely that the species can enter the environment within the risk assessment area based on this pathway.

Qu. 2.8. Estimate the overall likelihood of entry into the environment within the risk assessment area based on all pathways in current conditions and specify if different in relevant biogeographical regions. Provide a thorough assessment of the risk of entry into the environment in relevant biogeographical regions in current conditions.

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low **medium** high

Response: When considering all pathways into the RA area, it is likely that *P. americana* can enter the environment within the RA area with a high confidence. All biogeographical regions would have similar likelihood scores based on the pathways described.

Qu. 2.9. Estimate the overall likelihood of entry into the environment within the risk assessment area based on all pathways in foreseeable climate change conditions and specify if different in relevant biogeographical regions. Thorough assessment of the risk of entry in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk, specifically if likelihood of entry is likely to increase or decrease for specific pathways.

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	Low Medium **high**

Response: When considering all pathways into the RA area, it is likely that *P. americana* can enter habitats within the RA area with a high confidence. Climate change may extend the areas where the species can be grown to the north and restrict the areas where the species may grow in the Mediterranean region. Both increased summer and winter temperatures would benefit the species. Increased precipitation and CO2 levels as a result of climate change may also favor the species. All biogeographical regions would have similar likelihood scores based on the pathways described.

3 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.

Qu. 3.1. How likely is it that the organism will be able to establish in the risk assessment area based on the history of invasion by this organism elsewhere in the world (including similarity between other abiotic conditions within it and the organism's current distribution)?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	Low **Medium** high

Response: *Phytolacca americana* is already established within the RA area (Austria, Bulgaria, Croatia, Czech Republic, Cyprus, France, Germany, Greece, Hungary, Italy, Netherlands, Malta, Portugal, Romania, Slovakia, Slovenia, Spain). It is likely that further areas of establishment are present within the RA area.

In its native range, the species is established in Kőppen-Geiger climate zones of Dfa, Dfb, Cfa, Csa. All of these Kőppen-Geiger climate zones are present within the EU and the habitats where the species can persist are present throughout the RA area.

Species modelling shows that *P. americana* has the potential to establish over much of the European Union, see Annex VII.

Qu. 3.2. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in the risk assessment area?

RESPONSE	very isolated isolated moderately widespread **widespread** ubiquitous	**CONFIDENCE**	Low Medium **high**

Response: Balogh and Juhasz (2008) detail that *P. americana* is mostly a ruderal species growing in disturbed habitats. The species is able to grow in both sunny and shady sites. In its native range, *P. americana* primarily grows as a pioneer plant of disturbed and open surfaces of damp soiled forests (for example around badger's burrows), on the fringe of forests and on riverbanks. Of the anthropogenic habitats it can be found in cuttings, waysides, fields and fallows. The species prefer the eutrophic, flimsy, damp soils. It occurs rarely on sites where the temperature goes under –15 °C permanently in the winter, propagation is favourable if the average temperature is around 20 °C in July. In its native range it occurs up to 1400 m of elevation.

Within the Europe, the species occurs in clear-cut areas (for example in Austria, Lajta hills), and along hedgerows and wasteland (e.g. in Switzerland). Balogh and Juhasz (2008) report that in Italy it can be found on field sides, along canals, along the coast, and in black locust plantations. The species is found in forest plantations in Hungary and in disturbed woodlands. In addition, in Hungary, the species is found in sandy grassland and alder swamp forests that has no surface water. It prefers the more humid habitats, and the half-shade; on sunny sites it grows usually under shrubs or trees. Balogh and Juhasz (2008) highlight that the species generally favours loose soils that developed on acidic or neutral, sandy or pebble bedrock. Dumas (2011) detail that the species can also grow on limestone, the edges of streams. In France, the species can be found in riparian habitats, clearings and forest edges, near dwellings, in wastelands, railway stations, old quarries, rubble, and corn crops (Fried, 2017). It prefers sandy and / or humus soils.

In the EU, the species can be found growing in uncultivated vineyards, orchards, and arable fields and row crop cultures (paprika, tomato, sunflower) (Balogh and Juhasz,2008). The species is often found growing within urban areas where it can form dense stands if the land is left unmanaged.

The species has been recorded in natural habitats, in particular in Carei Plain Natural protected area in Western Romania where it is reported to occur in natural and planted forests and anthropogenically affected areas (Szatmari, 2012).

Many Slovene forests have been severely damaged by ice-storm, wind-throws and bark-beetle attacks since 2014. In disturbed forests *P. americana* formed great and dense stands very quickly. It spreads also very fast under power lines and from there to the forests. It has been detected also in corn fields and meadows. (Information system Invazivke (Life Artemis projects): https://www.invazivke.si/ (May 29, 2020))

All of the aforementioned habitats are widespread within the RA area.

Qu. 3.3. 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?

RESPONSE	**N/A** very unlikely unlikely moderately likely likely very likely	**CONFIDENCE**	low medium **high**

Response: *Phytolacca americana* does not require another species for any critical stage in its lifecycle.

Qu. 3.4. How likely is it that establishment will occur despite competition from existing species in the risk assessment area?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low **medium** high

Response: It is very likely that *P. americana* will establishment despite competition from existing species (Dumas, 2011a/b). *P. americana* is highly competitive species which has been shown to successfully outcompete native plant species within the RA area. The ability of the species to form dense monocultures, coupled with the lack of natural enemies provides the species with an advantage over native species (Dumas, 2011a/b).

Qu. 3.5. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area?

RESPONSE	N/A very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**		low medium **high**

Response: *Phytolacca americana* is native to North America and thus co-evolved natural enemies would be present in this region and not within the risk assessment area. Those more generalist organisms naturally present in the risk assessment area, which might feed on the species, are unlikely to prevent the establishment of the species.

Qu. 3.6. How likely is the organism to establish despite existing management practices in the risk assessment area?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low **medium** high

Response: There are a number of management practices applied to *P. americana* within the risk assessment area (see management annex for this species). However, these management practices are mainly applied to established populations or where populations may start to establish in areas of high conservation value. Other areas, such as ruderal habitats may be overlooked and therefore provide habitats for establishment despite existing management practices.

Qu. 3.7. How likely are existing management practices in the risk assessment area to facilitate establishment?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low **medium** high

Response: As detailed in section (3.2), the establishment of *P. americana* is suited to disturbed habitats especially disused waste ground. It is therefore likely that the current urbanization trend occurring in Europe may favor the establishment of the species. Additionally, management practices in forests, or maintenance of power lines, may act to open the canopy and favour disturbance that would be beneficial for the germination of the seedbank.

Qu. 3.8. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the risk assessment area?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response: The species produces a large amount of seed, which can remain dormant for long periods of time (DiTomaso et al., 2013). It also has a high seed bank density and thus all seeds would need to be removed DiTomaso et al., 2013). Therefore, these factors may hinder eradication efforts. In addition, the seed bank may be widespread as the plant can be widely spread by birds and other animals.

Qu. 3.9. How likely are the biological characteristics of the organism to facilitate its establishment in the risk assessment area?

including the following elements:

- a list and description of the reproduction mechanisms of the species in relation to the environmental conditions in the Union
- an indication of the propagule pressure of the species (e.g. number of gametes, seeds, eggs or propagules, number of reproductive cycles per year) of each of those reproduction mechanisms in relation to the environmental conditions in the Union.

If relevant, comment on the likelihood of establishment based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in establishment whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response: *Phytolacca americana* can reproduce by both seed and regeneration from a tuberous taproot. Each inflorescence can contain numerous berries, each containing 10 seeds. McDonnell *et al.* (1984) counted up to 78 ripe fruits per inflorescence. A single plant can produce over 2 500 fruits and 25 000 seeds (Dumas 2011). Dumas (2011), citing Armesto (1983) estimate a density of 592 seeds per m-1. The species is self-fertilizing and flowering can occur in the first year of growth. Mature berries can occur from August to early November (France) and germination rates have been reported as high as 80 % though it varies within the population (0 – 100 %) (Dumas, 2008; Armesto *et al.*, 1983; Vuillemenot & Mischler, 2012). Seeds can remain viable in the soil for approximately forty years (Dumas, 2011; Vuillemenot & Mischler, 2012) and can germinate following disturbance in the soil and/or a clearing of an area (for example a woodland). This has been shown to be the case in all the lowland forests of the Jura, France (Vuillemenot & Mischler, 2012).

It is interesting to note that germination of seed is increased when the seed moves through a bird digestive tract (Dumas, 2011). It is noted that, 'Orrock (2005) studied the influence that can have the transit of seeds in the digestive tract of birds where a positive effect on the germination rate, which goes from 67% for controls to 88% for seeds from the fruits consumed'.

In addition, the species appears to be resistant to a number of environmental constraints. For example, the species can withstand high levels of heavy metals in soils enabling the species to grow in polluted habitats (Min *et al.* 2006; Peng, 2008). It is noted that soil texture and acidity does not limit the occurrence of *P. americana* (Sauer, 1952). The species is reported to tolerate a wide range of soil pH (Sauer, 1952).

Seed of the species appears to be tolerant of fire and can promote its germination. After forest fires, seed can germinate from the seed bank (Glasgow *et al.*, 2007).

Qu. 3.10. How likely is the adaptability of the organism to facilitate its establishment?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low **medium** high

Response: *Phytolacca americana* has a high level of plasticity being tolerant to a variety of environmental conditions and as such habitats. The species thrives in ruderal habitats where disturbances occur (Dumas, 2011).

There are some indications that the species has adapted to the RA area and as detailed by Dumas (2011a), the climatic limits of the species in the RA area are unlikely to have been reached. Dumas (2011a) highlight that if the climatic characteristics defined by Sauer (1952) in the area of origin, are applied to France, the species should not be present in the Fontainebleau region, where it is currently widespread. This region of France does not meet the temperature and rainfall requirements.

Qu. 3.11. How likely is it that the organism could establish despite low genetic diversity in the founder population?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low medium **high**

Response: The species has established within the RA area though it is not known how many introductions have taken place from founder populations to realize this establishment.

Qu. 3.12. If the organism does not establish, then how likely is it that casual populations will continue to occur?

Consider, for example, a species which cannot reproduce in the risk assessment area, because of unsuitable climatic conditions or host plants, but is present because of recurring introduction, entry and release events. This may also apply for long-living organisms.

RESPONSE	very unlikely unlikely moderately likely l**ikely** very likely	**CONFIDENCE**	low medium **high**

Response: The species is already established within the RA area. In areas in the RA area where it is not established, as the species is spread by birds and other animals, casual population of the species may occur with the RA area in space and time.

Qu. 3.13. Estimate the overall likelihood of establishment in the risk assessment area based on the similarity between climatic conditions within it and the organism's current distribution under current climatic conditions. In addition, details of the likelihood of establishment in relevant biogeographical regions under current climatic conditions should be provided.

Thorough assessment of the risk of establishment in relevant biogeographical regions in current conditions: providing insight in the risk of establishment in (new areas in) the Union.

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	CONFIDENCE	low **medium** high

Response: *Phytolacca americana* is present in the Koppen Giger climate zones of Csb, Csc, Cfb within the EU. Csb (warm-summer Mediterranean climate) and Cfb (oceanic climate with warm summers) are widespread zones within the EU.

Phytolacca americana is present in the following biogeographical regions: Alpine, Atlantic, Black Sea, , Continental, Mediterranean, Pannonian, Steppic (based on GBIF data, 2019).

The species still has the potential for further establishment in the aforementioned biogeographical regions.

Qu. 3.14 Estimate the overall likelihood of establishment in the risk assessment area under foreseeable climate change conditions. In addition, details of the likelihood of establishment in relevant biogeographical regions under foreseeable climate change conditions should be provided.

Thorough assessment of the risk of establishment in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5)
- what aspects of climate change are most likely to affect the likelihood of establishment (e.g. increase in average winter temperature, increase in drought periods)

The thorough assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment of likely establishment within a medium timeframe scenario (e.g. 30-50 years) with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	CONFIDENCE	low **medium** high

Response: Under a climate change scenario of (RCP 4.5, over the next 30/50 years), when considering establishment into the RA area, it is likely that *P. americana* will establish within the RA area with a medium confidence. Climate change may extend the areas where the species can be grown to the north and restrict the areas where the species may grow in the Mediterranean region (see species distribution modelling annex). Both increased summer and winter temperatures would benefit the species. Increased precipitation and CO2 levels as a result of climate change may also favor the species. An increase in fires within the RA area due to increased temperature may act to promote the germination of the seed bank and increase the population. All biogeographical regions would have similar likelihood scores based on the pathways described. See Annex VII for more details.

4 PROBABILITY OF SPREAD

Important instructions:

- 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 continuous spread and should be considered in the probability of entry section. In other words, intentional anthropogenic “spread” via release or escape (“jump-dispersal”), should be dealt within the entry section. However, as repeated releases contribute to the spread of the target organism in the risk assessment area, the relevant pathway(s) should be briefly discussed here too, with an explicit reference to the entry section for additional details.

Qu. 4.1. How important is the expected spread of this organism within the risk assessment area by natural means? (List and comment on each of the mechanisms for natural spread.)

including the following elements:

- a list and description of the natural spread mechanisms of the species in relation to the environmental conditions in the risk assessment area.
- an indication of the rate of each of those spread mechanisms in relation to the environmental conditions in the Union.

The description of spread patterns should include elements of the species life history and behavioural traits able to explain its ability to spread, including: reproduction or growth strategy, dispersal capacity, longevity, dietary requirements, environmental and climatic requirements, specialist or generalist characteristics.

RESPONSE	minimal minor moderate **major** massive	**CONFIDENCE**	low **medium** high

Response: Natural spread is a key factor in the dispersal of *P. americana* in the RA area. Birds have been reported to spread the species within the RA area. In America, it is reported that up to 29 bird species feed on the fruits of *P. americana* (Armesto, 1983). Within the RA area, some data exist. For example, Balogh and Juhasz (2008) detail the following species feeding on fruits in the following countries: in Italy: blackcap (*Sylvia atricapilla*), whitethroat (*Sylvia communis*), song trush (*Turdus philomelos*), blackbird (*Turdus merula*), blue rock trush (*Monticola solitarius*), robin (*Erithacus rubecula*); in South France: robin and blackcap; in New-Zeland: the pheasant (*Phasianus colchicus*). Villemenot & Mischler (2012) list several bird species eating fleshy berries as responsible of *P. americana* spread: pigeons (*Columba* spp.), turtledoves (*Streptopelia decaocto*) and starling (*Sturnus vulgaris*), but also probably blackbirds (*Turdus merula*), thrushes (*Turdus* spp.) and warblers (*Sylvia* spp.). Birds can also feed on the dried berries in the winter.

Sauer (1952) report that the species is poorly suited to dispersal by wind or water (information from the native range, Sauer, 1952).

Benvenuti (2004) detail that the starling (*Sturnus vulgaris*), is the main species responsible of this spread in the city of Pisa, *P. americana* grows under trees the species chooses as nesting sites. He also notes that the latter germinate faster (4 to 5 days earlier) than the control seeds.

Balogh and Juhasz (2008) write: 'Ad hoc observations prove that the young shoots of *P. americana* is eaten by big games (red deer, fallow deer) living in the Hungarian forests. The sheep and the goat kept on sandy pasture-land consume this plant too'. However, it is not known if they can act to spread the plant through seed. In addition, Dumas (2011b) include rodents as seed feeders. In the forest of Fontainebleau, cervids are also suspected to be vectors of the seeds (Villemenot & Mischler, 2012). Indeed, all such species have the potential to spread seed within the RA area.

It should be noted, that in Belgium, there are increasing observations of the species in the natural enviroment, along with other *Phytolacca* species, in particular *P. acinosa*) indicating the increased spread of the species (Adriaens *et al*, 2019).

Qu. 4.2. How important is the expected spread of this organism within the risk assessment area by human assistance? (List and comment on each of the mechanisms for human-assisted spread and provide a description of the associated commodities.)

including the following elements:

- a list and description of the anthropogenic spread mechanisms of the species in relation to the environmental conditions in the Union.
- an indication of the rate of each of those spread mechanisms in relation to the environmental conditions in the Union.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Response: Human assisted spread can play a factor in the spread of the species due to the use of machinery and management of certain habitats (such as woodland management). Vuillemenot & Mischler (2012), detail that harvesters in softwood plantations have acted to promote the spread of the species. The intervention of harvesters in the softwood plantations of would trigger the germination of the seed bank, due to ground disturbances.

Vuillemenot & Mischler (2012) also highlight that seeds can become incorporated into the tread of tyres and hiking boots that can then act to spread the species into new areas.

Soil can also contain large amounts of seeds (and it is detailed that the seed bank can have a longevity of up to 50 years (UC Weed Science, 2018)), thus the movement of soil may also act to facilitate the spread of the species within the RA area.

Qu. 4.2a. 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 4.3 to 4.9 (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. 4.3a, 4.4a, etc. and then

4.3b, 4.4b etc. for the next pathway.

including the following elements:

- a list and description of pathways with an indication of their importance and associated risks (e.g. the likelihood of spread in the Union, based on these pathways; likelihood of survival, or reproduction, or increase during transport and storage; ability and likelihood of transfer from the pathway to a suitable habitat or host). Where possible details about the specific origins and end points of the pathways shall be included.
- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after eradication.
- All relevant pathways should be considered. The classification of pathways developed by the Convention of Biological Diversity shall be used.

Spread pathways considered in this section include:

1. **Transport – stowaway: Machinery/ equipment**
2. **Unaided (natural spread)**
3. **Pathway name: Transport – contaminant (transport of habitat material (soil, vegetation)**
4. **Pathway name: People and their luggage/ equipment (in particular tourism)**

Pathway name: Transport – stowaway: Machinery/ equipment

Qu. 4.3a. Is spread along this pathway intentional or unintentional (e.g. the organism is a contaminant of translocated goods within the risk assessment area)?

RESPONSE	**unintentional** intentional	**CONFIDENCE**	Low Medium **high**

Response: The spread of *P. americana* via machinery/ equipment is the unintentional spread of the species within the RA area.

Qu. 4.4a. 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?

including the following elements:

- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if appropriate, indicate the rate of spread along this pathway
- if appropriate, include an explanation of the relevance of the number of individuals for spread with regard to the biology of species (e.g. some species may not necessarily rely on large

numbers of individuals).

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	Low **Medium** high

Response: There is no information available on the volumes of movement along this pathway. However, as in areas where the species is present, the seed bank density can be high, and thus there is a potential for spread. Dumas (2011b), when considering spread, highlight that 'the transport of seeds by the soil retained in the tread pattern of machine tires is a hypothesis that we cannot exclude'. Buhk (2016) also highlight the role of machines used in forestry as a potential for the spread of the species.

Qu. 4.5a. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	Low **Medium** high

Response: The seeds of the species are small and therefore they could survive during transport along this spread pathway. The species is unlikely to increase along the pathway until it finds a suitable habitat.

Qu. 4.6a. How likely is the organism to survive existing management practices during spread?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**Low** Medium high

Response: With the right cleaning and disinfecting of used machinery, the species would probably be removed from the machinery. However, such practices are not always common and therefore the species may survive existing management practices during this mode of spread.

Qu. 4.7a. How likely is the organism to spread in the risk assessment area undetected?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	Low **Medium** high

Response: The seeds are relatively small and potentially can remain hidden in soil in cracks and crevices in machinery and equipment. Such machinery can be moved around the RA area transporting the seed to new areas.

Qu. 4.8a. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host during spread? (including, where possible, details about the specific origins and end points of the pathway)

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	Low **Medium** high

Response: It would be very likely that *P. americana* can transfer to a suitable habitat if the species is a stowaway on machinery/ equipment. The machinery in question, such as forest vehicles or harvesters are utilized in suitable habitats.

Qu. 4.9a. Estimate the overall potential rate of spread within the Union based on this pathway? (please provide quantitative data where possible).

RESPONSE	very slowly **slowly** moderately rapidly very rapidly	**CONFIDENCE**	**Low** Medium high

Response: The overall potential rate of spread within the RA area for the pathway Transport – stowaway: Machinery/ equipment is rated as moderately with a low confidence. Dumas (2011b), has highlight this pathway as a potential pathway, but as previously mentioned, there is no information on rates of spread, hence the low confidence score.

Pathway name: UNAIDED (natural spread)

Qu. 4.3b. Is spread along this pathway intentional or unintentional (e.g. the organism is a contaminant of translocated goods within the risk assessment area)?

RESPONSE	unintentional	**CONFIDENCE**	high

Response: The spread of *P. americana* via natural methods (birds and other small mammals) is the unintentional spread of the species within the RA area. As highlighted in question 4.1, natural spread is considered a significant pathway for spread of the species in the RA area.

Qu. 4.4b. 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?

including the following elements:

- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if appropriate, indicate the rate of spread along this pathway
- if appropriate, include an explanation of the relevance of the number of individuals for spread with regard to the biology of species (e.g. some species may not necessarily rely on large numbers of individuals).

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low **medium** high

Response: There is no information available on the volumes of movement along this pathway. Natural spread is a key factor in the dispersal of *P. americana* in the RA area. In particular, birds have been reported to spread the species with the RA area. In America, it is reported that up to 29 bird species feed on the fruits of *P. americana* (Armesto, 1983). Within the RA area, some data exist. For example, Balogh and Juhasz (2008) detail the following species feeding on fruits in the following countries: in Italy: blackcap (*Sylvia atricapilla*), whitethroat (*Sylvia communis*), song trush (*Turdus philomelos*), blackbird (*Turdus merula*), blue rock trush (*Monticola solitarius*), robin (*Erithacus rubecula*); in South France: robin and blackcap; in New-Zeland: the pheasant (*Phasianus colchicus*).

Sauer (1952) report that the species is poorly suited to dispersal by wind or water (information from the native range, Sauer, 1952).

Benvenuti (2004) detail that the starling (*Sturnus vulgaris*), is the main species responsible of this spread in the city of Pisa, *P. americana* grows under trees the species chooses as nesting sites. He also notes that the latter germinate faster (4 to 5 days earlier) than the control seeds.

Balogh and Juhasz (2008) write: ‘Ad hoc observations prove that the young shoots of *P.. americana* is eaten by big games (red deer, fallow deer) living in the Hungarian forests. The sheep and the goat kept on sandy pasture-land consume this plant too'. In addition, Dumas (2011b) include rodents as seed feeders. Indeed, all such species have the potential to spread seed within the RA area.

Qu. 4.5b. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low medium **high**

Response: The seeds of the species can remain viable following movement through the digestive system of animals and birds. Thus, seeds can survive, though they will not reproduce or increase during this spread pathway.

Qu. 4.6b. How likely is the organism to survive existing management practices during spread?

RESPONSE	very unlikely unlikely moderately likely **l**ikely **very likely**	**CONFIDENCE**	low **medium** high

Response: Management practices will be very limited for this spread pathway. Controlling birds and small mammal movement is not an option for management.

Qu. 4.7b. How likely is the organism to spread in the risk assessment area undetected?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response: Birds and other small mammals can carry the seeds over long distances (e.g. < 10 km) and can be dispersed in areas undetected. The seeds will remain in the gut of the species for some time and be deposited in the soil.

Qu. 4.8b. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host during spread? (including, where possible, details about the specific origins and end points of the pathway)

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response: Birds and other small mammals can carry the seeds over large distances and the seeds can be dispersed in habitats suitable for the species.

Qu. 4.9b. Estimate the overall potential rate of spread within the Union based on this pathway? (please provide quantitative data where possible).

RESPONSE	very slowly slowly moderately **rapidly** very rapidly	**CONFIDENCE**	low **medium** high

Response: The overall potential rate of spread via this pathway is estimated as rapidly with a medium confidence.

Pathway name: Transport – contaminant (transport of habitat material (soil, vegetation)

Qu. 4.3c. Is spread along this pathway intentional or unintentional (e.g. the organism is a contaminant of translocated goods within the risk assessment area)?

RESPONSE	**unintentional** intentional	**CONFIDENCE**	low medium **high**

Response: The spread of *P. americana* via transport of habitat material (soil, vegetation) is the unintentional spread of the species within the RA area.

Qu. 4.4c. 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?

including the following elements:

- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if appropriate, indicate the rate of spread along this pathway
- if appropriate, include an explanation of the relevance of the number of individuals for spread with regard to the biology of species (e.g. some species may not necessarily rely on large numbers of individuals).

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low **medium** high

Response: There is no information available on the volumes of movement along this pathway. However, as in areas where the species is present, the seed bank density can be high, and thus there is a potential for spread (Hyatt and Casper, 2000).

Qu. 4.5c. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	low **medium** high

Response: The seeds of the species are small and therefore they could survive during transport along this spread pathway. The substrate would be conducive to maintain survival.

Qu. 4.6c. How likely is the organism to survive existing management practices during spread?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	low **medium** high

Response: Careful methodical management practices coupled with inspection would be needed to ensure that the species did not spread with contaminated soil. This is often not feasible with such small seeds.

Qu. 4.7c. How likely is the organism to spread in the risk assessment area undetected?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low **medium** high

Response: The seeds are relatively small and potentially can remain undetected within soil. Soil and other habitat material can be moved throughout the RA area and seeds can be spread within such material.

Qu. 4.8c. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host during spread? (including, where possible, details about the specific origins and end points of the pathway)

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low medium **high**

Response: It would be very likely that *P. americana* can transfer to a suitable habitat if seed of the species is incorporated in soil. Topsoil and habitat material is often physically transferred to suitable habitats and thus it is very likely that the species will transfer to suitable habitats.

This fact that the species is often recorded in urban development areas further supports the hypothesis that the species can be moved by soil and habitat material.

Qu. 4.9c. Estimate the overall potential rate of spread within the Union based on this pathway? (please provide quantitative data where possible).

RESPONSE	very slowly slowly **moderately** rapidly very rapidly	**CONFIDENCE**	low **medium** high

Response: Response: The overall potential rate of spread via this pathway is estimated as moderately with a medium confidence.

Pathway name: People and their luggage/ equipment (in particular tourism)

Qu. 4.3d. Is spread along this pathway intentional or unintentional (e.g. the organism is a contaminant of translocated goods within the risk assessment area)?

RESPONSE	**unintentional** intentional	**CONFIDENCE**	Low Medium **high**

Response: The spread of *P. americana* via people and their luggage/equipment in particular tourism is for this species considered the unintentional movement of the species via seeds. In the sense of this pathway, the main risk is of introduction into new areas via spread is that the species could be incorporated into the tread of hiking boots or other equipment and moved accidently to other areas.

Qu. 4.4d. 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?

including the following elements:

- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if appropriate, indicate the rate of spread along this pathway
- if appropriate, include an explanation of the relevance of the number of individuals for spread with regard to the biology of species (e.g. some species may not necessarily rely on large numbers of individuals).

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response: There is no information available on the volumes of movement along this pathway. As the fruit of the species does not have any spiny spurs there would be less chance of the fruits attaching to clothes and other material. This spread pathway is not considered by the authors of this RA as a major spread pathway.

Qu. 4.5d. How likely is the organism to survive, reproduce, or increase during transport and

storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	low **medium** high

Response: The seeds of the species are small and therefore they could survive during transport along this spread pathway. The substrate would be conducive to maintain survival. The species would not reproduce along this pathway or increase.

Qu. 4.6d. How likely is the organism to survive existing management practices during spread?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low **medium** high

Response: Careful methodical management practices coupled with inspection of tread on boots would be needed to ensure that the species did not spread. However, often biosecurity measures are not widely known by the general public.

Qu. 4.7d. How likely is the organism to spread in the risk assessment area undetected?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low medium **high**

Response: The seeds are relatively small and potentially can remain undetected within the tread of hiking boots. Additionally, the seeds may not be easily identifiable to non-botanists and thus may be overlooked.

Qu. 4.8d. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host during spread? (including, where possible, details about the specific origins and end points of the pathway)

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low medium **high**

Response: It would be very likely that *P. americana* can transfer to a suitable habitat if seed of the species is attached to hiking boots. Top soil and habitat material is often physically transferred to suitable habitats and thus it is very likely that the species will transfer to suitable habitats.

This fact that the species is often recorded in urban development areas (per sobs, authors) further supports the hypothesis that the species can be moved by soil and habitat material.

Qu. 4.9d. Estimate the overall potential rate of spread within the Union based on this pathway? (please provide quantitative data where possible).

RESPONSE	very slowly slowly **moderately** rapidly very rapidly	**CONFIDENCE**	**low** medium high

Response: Response: The overall potential rate of spread via this pathway is estimated as moderately with a medium confidence. Seeds and plant material can be moved by human means.

Qu. 4.10. Within the risk assessment area, how difficult would it be to contain the organism in relation to these pathways of spread?

RESPONSE	very easy easy with some difficulty **difficult** very difficult	**CONFIDENCE**	low medium **high**

Response: The spread pathways are numerous and varied making the management of the spread pathways difficult. In particular, natural spread is a difficult pathway to manage.

Qu. 4.11. Estimate the overall potential rate of spread in relevant biogeographical regions under current conditions for this organism in the risk assessment area (indicate any key issues and provide quantitative data where possible).

Thorough assessment of the risk of spread in relevant biogeographical regions in current conditions, providing insight in the risk of spread into (new areas in) the Union.

RESPONSE	very slowly slowly **moderately** rapidly very rapidly	**CONFIDENCE**	low **medium** high

Response: The species is currently present in the following biogeographical regions: Alpine, Atlantic, Black Sea, Continental, Mediterranean, Pannonian, Steppic (based on GBIF data, 2019). Within all of these regions, the spread is likely to be rapidly.

Qu. 4.12. Estimate the overall potential rate of spread in relevant biogeographical regions in foreseeable climate change conditions (provide quantitative data where possible).

Thorough assessment of the risk of spread in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk, specifically if rates of spread are likely slowed down or accelerated.

RESPONSE	very slowly slowly moderately **rapidly** very rapidly	**CONFIDENCE**	low **medium** high

Response: Climatic change will allow *P. americana* to establish further north than present but its inherent rate of spread should remain rapidly with a medium confidence.

5 MAGNITUDE OF IMPACT

Important instructions:

- Questions 5.1-5.5 relate to biodiversity and ecosystem impacts, 5.6-5.8 to impacts on ecosystem services, 5.9-5.13 to economic impact, 5.14-5.15 to social and human health impact, and 5.16-5.18 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)

Biodiversity and ecosystem impacts

Qu. 5.1. How important is the 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?

including the following elements:

- Biodiversity means the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems
- impacted chemical, physical or structural characteristics and functioning of ecosystems

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	**low** medium high

Comment: *Phytolacca americana* is reported to form dense stands that can outcompete native vegetation and can act to retard forest regeneration (FOEN, 2006; Orwig and Foster 1998). Apart from this and other references to the species being invasive (e.g. in China, Dong et al., 2011, where they do not provide specific details), there are no other known studies that have evaluated the impact of the species on biodiversity.However, as the species is able to form dense stands these impacts may include outcompeting native plant species for space, light and nutrients.

In Switzerland, *P. americana* is listed on a ‘watch list’.

Qu. 5.2. 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)?

Discuss impacts that are currently occurring or are likely occurring or have occurred in the past in the risk assessment area. Where there is no direct evidence of impact in the risk assessment area (for example no studies have been conducted), evidence from outside of the risk assessment area can be used to infer impacts within the risk assessment area.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comment: Dumas (2007) indicates that as soon as *P. americana* reach 50% cover, there is 24% decrease in species richness of invaded communities. When it is abundant, *P. americana* can modify several plant resident plant communities, by competing with notably *Rubus* spp. and *Cytisus scoparius*, especially in all the open environments associated with forest, such as the hems and the clearings, megaphorbiaies, wastelands and moors, etc. (Villemenot & Mischler, 2012).

However, Dumas (2011a) considers that studies on the impact of *P. americana* on native biodiversity within the RA area is poorly documented. In addition, Fried (2012) considers that overall the impact of this species is low, since the vast majority of *P. americana* populations are found in ruderal or post-crop areas (vines abandoned).

A study by Schirmel (2019) in southwest Germany, showed that *P. americana* invasion resulted in an altered arthropod community structure. The cricket *Nemobius sylvestris* was negatively affected by *P. Americana*.

There are suggestions, that chemical leaching from seeds fallen to the ground may also be toxic to the soil macro- and micro-biota (Dumas, 2011a).

Balogh and Juhasz (2008) detail that *P. americana* can out-compete native species on sandy grasslands by completing for space and light. The species can shade out native species and in different forest communities its presence can reduce the conservation value. Dispersion of *P. americana* in the protected area of Barcsi Borokas (originally with dominance of *Juniperus communis*) causes large problems, where along with an invasive tree, black cherry (*Prunus serotina*) it occurs in mass in open perennial grasslands (*Festuco-Corynephoretum*), Molinia-Turkey oak forests (*Molinio litoralis-Quercetum*) and alder swamp forests (*Carici elongatae-Alnetum*) too. In West Hungary it also endangers the oak-hornbeam forests.

In Slovenia *Phytolacca americana* spreads very rapidly in the last few (about 5) years and threatens natural forests, including Natura 2000 sites and their biodiversity. While these observations have not been published yet, they seem to be important and can initiate further research. Out of all 1173 (https://www.invazivke.si/, 19.11.2020) locations, it was mostly found in the forest gaps after logging, in areas impacted by different natural disturbances, e.g. bark-beetles attack, wind-throws, ice-storm. Those locations are often in sustainably managed forests, also Natura 2000 sites and some protected areas, not only ruderal habitats of low conservation importance. The species is common also at the forest edges and under power lines/cable, beside forest roads and skidding trails. From these areas, it spreads without human intervention (by birds) into forests. *Phytolacca americana* has also been observed in bright pine tree forests. The seeds are though present in healthy mature forests and when the canopy opens due to forest management or natural disturbances, they germinate and form dense stands very quickly. It looks that *Phytolacca americana* is causing long-term ecosystem changes and the species can outcompete native plant species for space, light and nutrients and also restrain forest regeneration (S. Rozman, pers. comm. 2020).

Campana *et al.* (2002) detail a disruptive impact on earthworm populations highlighting that the species seem to repel most earthworm species. This may be due to the allelopathic properties of the species. Given its molluscicidal potency, *P. americana* probably has the same effect on gastropods (Dumas, 2011; Villemenot & Mischler, 2012).

Henneuse *et al.* (2007) observed a reduction in plant species richness when the recovery of *P. americana* increases.

Phytolacca americana has been detailed as one of the top invasive plants (most harmful) by Protected Area Managers where it was recorded as present in 4 Protected Areas (Monaco and Genovesi, 2014). In comparison, *Fallopia japonica* was recorded as present in 48 Protected Areas

Qu. 5.3. 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?

See comment above. The potential future impact shall be assessed only for the risk assessment area.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	**low** medium high

Comment: Impacts, although not currently scientifically evaluated, are likely to be moderate in the future as the species can form dense monocultures which can potentially outcompete native plant species. Further spread is likely throughout the RA area, especially in ruderal habitats and forests.

Qu. 5.4. 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?

including the following elements:

- native species impacted, including red list species, endemic species and species listed in the Birds and Habitats directives
- protected sites impacted, in particular Natura 2000
- habitats impacted, in particular habitats listed in the Habitats Directive, or red list habitats
- the ecological status of water bodies according to the Water Framework Directive and environmental status of the marine environment according to the Marine Strategy Framework Directive

RESPONSE	minimal minor	**CONFIDENCE**	**low** medium

	moderate major massive		high

Comment: There are no detailed scientific studies to evaluate the impact of *P. americana* on native species and thus any decline in conservation value to habitats. As mentioned, the species predominantly grows in ruderal habitats within the RA area and these are often of little conservation importance. However, in the areas where the species is established, *P. americana* has invaded natural habitats which can act to decrease local biodiversity (see question 5.2). In Hungary, the species is present in protected areas (Balogh and Juhasz 2008). *Phytolacca americana* has been detailed as one of the top invasive plants (most harmful) by Protected Area Managers where it was recorded as present in 4 Protected Areas (Monaco and Genovesi, 2014). In comparison, *Fallopia japonica* was recorded as present in 48 Protected Areas.

Qu. 5.5. 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?

including the following elements:

- native species impacted, including red list species and species listed in the Birds and Habitats directives
- protected sites impacted, in particular Natura 2000
- habitats impacted, in particular habitats listed in the Habitats Directive, or red list habitats
- the ecological status of water bodies according to the Water Framework Directive and environmental status of the marine environment according to the Marine Strategy Framework Directive

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	**low** medium high

Comment: There are no detailed scientific studies to evaluate the impact of *P. americana* on native species and thus any decline in conservation value to habitats. As mentioned, the species predominantly grows in ruderal habitats within the RA area and these are often of little conservation importance. However, in the areas where the species is established, *P. americana* has invaded natural habitats which can act to decrease local biodiversity (see question 5.2).

Ecosystem Services impacts

Qu. 5.6. How important is the impact of the organism on provisioning, regulating, and cultural services in its non-native range excluding the risk assessment area?

- For a list of relevant services use the CICES classification V5.1 provided as an annex.

- Impacts on ecosystem services build on the observed impacts on biodiversity (habitat, species, genetic, functional) but focus exclusively on reflecting these changes in relation to their links with socio-economic well-being.
- Quantitative data should be provided whenever available and references duly reported.
- In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer "No information has been found on the issue". This is necessary to avoid confusion between "no information found" and "no impact found".

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	**low** medium high

No information was found on scientific studies that have evaluated the impact of *P. americana* on ecosystem services in its non-native range excluding the risk assessment area. There is some anecdotal evidence from China that the species can retard forest regeneration (Dong et al., 2011) though further research is needed on the subject.

Qu. 5.7. 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)?

- See guidance to Qu. 5.6.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comment: Vuillemenot & Mischler (2012) detail that the impact of the species to natural forest regeneration is often mentioned as negative. The presence of the species may affect some recreational activities especially if the species forms dense monocultures in natural habitats blocking pathways and other recreational areas.

The species has been reported as having allelopathic properties which can affect the microbial soil community other organisms though there has not been any research conducted on this aspect at present. According to Dumas (2011a), another effect of *P. americana* on abiotic conditions would be the enrichment of potassium that this species causes on soils, constituting reserves of this element in the biotope.

Qu. 5.8. 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?

- See guidance to Qu. 5.6.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comment: *Phytolacca americana* may spread northwards within the RA area as a result of climate change though the impacts score is likely to be the same as under the current situation (moderate with a medium confidence). Impacts in the Mediterranean may be less if the climate is not conducive to establishment.

Economic impacts

Qu. 5.9. 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.

- Where economic costs of / loss due to the organism have been quantified for a species anywhere in the world these should be reported here. The assessment of the potential costs of / loss due to damage shall describe those costs quantitatively and/or qualitatively depending on what information is available. Cost of / loss due to damage within different economic sectors can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage.

RESPONSE	minimal **minor** moderate major massive	**CONFIDENCE**	**low** medium high

Comment: *Phytolacca americana* can incur control costs within the risk assessment area particularly in clearing the species from areas where it has colonized urban development sites. In addition, the species can impact on woodland plantation as the species will need to be cleared and eradicated prior to planting of forest trees.

In the USA, there are reports the species can impact on yields of various crops though there are no direct studies that have evaluated crop yield reduction due to the presence of *P. americana.* In Pennsylvania, studies have been conducted to assess chemical control options for the species in maize and soybean fields highlighting there is management of the species and a cost associated (Patches et al., 2017).

Steckel (2006) highlights that the stain (from the berries) can impact on soybeans during harvest.

Although no monetary figure exist on costs associated with *P. americana* damage, costs are likely as Steckel (2006) highlights that the species can be very competitive for row crops. However, it is likely that the species is a minor economic problem compared to other weedy species in North America (e.g.

Amaranthus palmeri – where there are numerous publications highlighting 70 -80 % crop yield reductions).

Cucumber mosaic virus (CMV) has been reported in *P. americana* plants from northern Italy (Davino et al., 2012). This could have economic impacts to plant health within the EU.

Qu. 5.10. How great is the economic cost of / loss due to damage (excluding costs of management) of the organism currently in the risk assessment area (include any past costs in your response)?

- Where economic costs of / loss due to the organism have been quantified for a species anywhere in the EU these should be reported here. Assessment of the potential costs of damage on human health, safety, and the economy, including the cost of non-action. A full economic assessment at EU scale might not be possible, but qualitative data or different case studies from across the EU (or third countries if relevant) may provide useful information to inform decision making. In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer “No information has been found on the issue”. This is necessary to avoid confusion between “no information found” and “no impact found”. Cost of / loss due to damage within different economic sectors can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comments: The species has been shown to be problematic in maize crops, especially due to the berries that can release their liquid when crushed and stain the crops. Steckel (2006) highlights that the stain can impact on soybeans during harvest.

It is locally an important weed in maize crops of southwestern France where its harmfulness is considered very high (Mamarot & Rodriguez, 2002). It is also a weed in forestry where it can damage young plantations of trees (Villemenot & Mischler, 2012). In forest patches driven by natural regeneration, such as a mature oak forest whose coppice has been cut, the invasion of *P. americana* seems much more important. In this case, the density of *P. americana* stands questions the possibility of germination and development of young trees (Villemenot & Mischler, 2012). It has also been supposed that the reduced dietary interest for cervids of plots largely invaded by *P. americana* can reduce the hunting interest of some forests and the related income for forest owners (Villemenot & Mischler, 2012).

Kumschick *et al*. (2015) score the species as 1 for socio-economic costs ‘Minor impacts, in the range of native species, only locally, negligible economic loss’.

Cucumber mosaic virus (CMV) has been reported in *P. americana* plants from northern Italy (Davino et al., 2012). This could have economic impacts to plant health within the EU.

Qu. 5.11. How great is the economic cost of / loss due to damage (excluding costs of management) of the organism likely to be in the future in the risk assessment area?

- See guidance to Qu. 5.10.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	**low** medium high

Comments: It is locally an important weed in maize crops of southwestern France where its harmfulness is considered very high (Mamarot & Rodriguez, 2002). It is also a weed in forestry where it can compete for light and resources with young plantations of trees (Villemenot & Mischler, 2002). In plots that have been cleared and where young tree seedlings have been introduced, the presence of *P. americana* can be an inconvenience to the forester, by requiring more regular clearing work until the tops of the young planted trees exceed the *P. americana* stands. Once this stage is over, the young trees released from competition will grow; but even if the density of the *P. americana* declines due to the shade created by the new settlement, this species seems to be maintained apparently for a long time and compete with species in shrub and herbaceous strata. In forest patches driven by natural regeneration, such as a mature oak forest whose coppice has been cut, the invasion of *P. americana* seems much more important. In this case, the density of *P. americana* stands questions the possibility of germination and development of young trees (Villemenot & Mischler, 2002). With an increase in geographical occurrence, the species may potentially cause greater economic costs.

Qu. 5.12. 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)?

- In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer "No information has been found on the issue". This is necessary to avoid confusion between "no information found" and "no impact found".

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	**low** medium high

Comments: The weeding of this species is costly in maize crop where herbicide spraying is only efficient on seedlings, but not on regrowth, and it requires an additional spray increasing the weed management cost (Mamarot & Rodriguez, 2003). Villemenot & Mischler (2012) also indicate that in forest, *P. americana* requires more regular clearance work until the top of the young trees exceeds *P. americana*. However, as the species often invades ruderal habitats and waste land, the economic management cost of the species is likely to be moderate within the RA area.

In southwest Germany, costs have been detailed for managing *P. americana* at the Hoher Stein dune where figures in Euros range from 700 euros per ha to 3 800 euros per ha depending on the time of year (Rupp et al., 2017).

Qu. 5.13. How great are the economic costs / losses associated with managing this organism likely to be in the future in the risk assessment area?

- See guidance to Qu. 5.12.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comments: No information has been found on the issue. With an increase in geographical occurrence, the species may potentially cause greater economic costs but this is difficult to predict.

Social and human health impacts

Qu. 5.14. 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).

The description of the known impact and the assessment of potential future impact on human health, safety and the economy, shall, if relevant, include information on

- illnesses, allergies or other affections to humans that may derive directly or indirectly from a species;
- damages provoked directly or indirectly by a species with consequences for the safety of people, property or infrastructure;
- direct or indirect disruption of, or other consequences for, an economic or social activity due to the presence of a species.

Social and human health impacts can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comments: *Phytolacca americana*, although edible, is a toxic species that cause vomiting and diarrhea when eaten raw. Balogh and Juhasz (2008) detail: ‘The most toxic part of the plant is the root, which contains saponins, among them phytolaccatoxin that is toxic to vertebrates. In respects of human health the most dangerous is the lectin content. In the new roots of *P. americana* hemagglutinin compound was detected – which is similar to the ones in the seeds of castor bean and Calabar bean – that contains much cysteine (a sulphur-laden amino-acid) and has mitogenic effect. It can stimulate the abnormal cell division of the poise B- and T- limphocytes, and it can damage the chromosomes too’.

Ogzewalla *et al.* (1962) highlights that in the USA, children can often eat the berries and become ill. The fruits, due to their deep red colour can be inviting to children and can resemble berries of other species (similar to that in the RA region). There are reports of deaths through consuming *P. americana*, though it is generally reported that such fatalities are uncommon.

Phytolacca americana can also be toxic to animal species. For example, Dumas (2011b), citing Barnett (1975) highlights that the species can be toxic to turkeys, where a 38 % mortality is recorded in birds who diet consisted of 10 % of *P. americana* seeds (data from the USA). Additionally, Dumas (2011a) detail that mortality has been recorded in pigs, cows and horses.

Qu. 5.15. 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.

- In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer "No information has been found on the issue". This is necessary to avoid confusion between "no information found" and "no impact found".

RESPONSE	minimal **minor** moderate major massive	**CONFIDENCE**	low **medium** high

Comments: All known and potential impacts are listed in the previous categories.

Other impacts

Qu. 5.16. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?

RESPONSE	**minimal** minor moderate major massive	**CONFIDENCE**	low **medium** high

Comments:
There is no information on this issue.

Qu. 5.17. How important might other impacts not already covered by previous questions be resulting from introduction of the organism?

RESPONSE	**minimal**	**CONFIDENCE**	low

	minor moderate major massive		**medium** high

Comments: The previous sections have covered all impacts known for the species and other impacts are likely to be minimal.

Qu. 5.18. 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?

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comments: The expected impacts of *P. americana* would remain the same within the RA area as there are no natural enemies that would impact on the species. Any generalist natural enemies that do attack the species would not inflict a significant impact on the population.

Qu. 5.19. Estimate the overall impact in the risk assessment area under current climate conditions. In addition, details of overall impact in relevant biogeographical regions should be provided.

Thorough assessment of the overall impact on biodiversity and ecosystem services, with impacts on economy as well as social and human health as aggravating factors, in current conditions.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

The overall impact in the risk assessment area under current climate conditions is moderate with medium uncertainty. There are studies that have highlighted the impact of the species on biodiversity where measurable damage to native species has been documents but it is nether evident that this damage is long term or irreversible. There is no evidence on local extinctions. There is no detailed evidence of the impact of the species on ecosystem services. There is some anecdotal evidence that the species can retard forest regeneration (Dong et al., 2011) though this is not supported at present with scientific studies. Kumschick *et al*. (2015) score the species as low for socio-economic costs 'Minor impacts, in the range of native species, only locally, negligible economic loss'.

Qu. 5.20. Estimate the overall impact in the risk assessment area in foreseeable climate change conditions. In addition, details of overall impact in relevant biogeographical regions should be provided.

Thorough assessment of the overall impact on biodiversity and ecosystem services, with impacts on economy as well as social and human health as aggravating factors, under future conditions.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comment: The overall impact in RA area in foreseeable climate change conditions is unlikely to change from that of the current climatic conditions. New (northern) areas of the RA area may be suitable for the establishment of the species but it is likely that the impact will remain moderate with a medium confidence to reflect the uncertainty of climate change prediction. Areas in the Mediterranean may become less suitable for the establishment of the species in the natural environment and thus less impact may be seen in these areas.

RISK SUMMARIES

	RESPONSE	CONFIDENCE	COMMENT
Summarise Introduction*	very unlikely unlikely moderately likely **likely** very likely	low **medium** high	When considering all pathways into the RA area, it is likely that *P. americana* can enter the region with a medium confidence. There are three potential active pathways of introduction: horticulture, release in nature for use and transport -contamination. However, it should be noted that the risk of these pathways is negligible in view of the already established populations of the species in the RA area.
Summarise Entry*	very unlikely unlikely moderately likely **likely** very likely	low **medium** high	When considering all pathways for entry into the RA area, it is likely that *P. americana* can enter the natural environment, with a medium confidence.
Summarise Establishment*	very unlikely unlikely moderately likely **likely** very likely	low **medium** high	The species is already established within the RA area and further establishment in climatically similar environments is likely. Habitats within the RA area are widespread.
Summarise Spread*	very slowly slowly moderately **rapidly** very rapidly	low **medium** high	The species can spread by human assisted and natural spread. Both are major spread pathways for the species within the RA area.
Summarise Impact*	minimal minor **moderate** major massive	low **medium** high	The species can form dense monocultures which can act to outcompete native plant species. Phytolacca americana can invade ruderal and natural habitats.
Conclusion of the risk assessment (overall risk)	low **moderate** high	low **medium** high	There are active pathways where the species can enter the RA area, and the natural environment. The species is capable of establishing in the RA area and spreading moderately. The impact of the species needs further research, but is within this RA considered as moderate. Based on these scores the overall assessment of risk is moderate with a medium uncertainty.

*in current climate conditions and in foreseeable future climate conditions

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Distribution Summary

Please answer as follows:

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

The columns refer to the answers to Questions A5 to A12 under Section A.
For data on marine species at the Member State level, delete Member States that have no marine borders. In all other cases, provide answers for all columns.

EU Member States and United Kingdom

	Recorded	Established (currently)	Possible establishment (under current climate)	Possible establishment (under foreseeable climate)	Invasive (currently)
Austria	YES	YES	YES	YES	
Belgium	YES		YES	YES	
Bulgaria	YES	YES	YES	YES	
Croatia	YES	YES	YES	YES	
Cyprus	YES	YES	YES	YES	
Czech Republic	YES	YES	YES	YES	
Denmark				YES	
Estonia			YES	YES	
Finland			YES	YES	
France	YES	YES	YES	YES	YES
Germany	YES	YES	YES	YES	
Greece	YES	YES	YES	YES	
Hungary	YES	YES	YES	YES	YES
Ireland					
Italy	YES	YES	YES	YES	YES
Latvia			YES	YES	
Lithuania			YES	YES	
Luxembourg			YES	YES	
Malta	YES	YES	YES	YES	
Netherlands	YES	YES	YES	YES	
Poland	YES		YES	YES	
Portugal	YES	YES	YES	YES	YES
Romania	YES	YES	YES	YES	YES
Slovakia	YES	YES	YES	YES	
Slovenia	YES	YES	YES	YES	YES
Spain	YES	YES	YES	YES	YES
Sweden				YES	
United Kingdom	YES			YES	

Biogeographical regions of the risk assessment area

	Recorded	Established (currently)	Possible establishment (under current climate)	Possible establishment (under foreseeable climate)	Invasive (currently)
Alpine	YES	YES	YES	YES	YES
Atlantic	YES	YES	YES	YES	YES
Black Sea	YES	YES	YES	YES	
Boreal			YES	YES	
Continental	YES	YES	YES	YES	YES
Mediterranean	YES	YES	YES	YES	YES
Pannonian	YES	YES	YES	YES	YES
Steppic	YES	YES	YES	YES	

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, and other impacts
	Question 5.1-5	*Question 5.6-8*	*Question 5.9-13*	*Question 5.14-18*
Minimal	Local, short-term population loss, no significant ecosystem effect	No services affected[7]	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 reversible; 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.

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[7] Not to be confused with “no impact”.

ANNEX III Scoring of Confidence Levels

(modified from Bacher *et al.* 2017)

Each answer provided in the risk assessment must include an assessment of the level of confidence attached to that answer, reflecting the possibility that information needed for the answer is not available or is insufficient or available but conflicting.

The responses in the risk assessment should clearly support the choice of the confidence level.

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[8]	**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*

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[8] 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.

			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

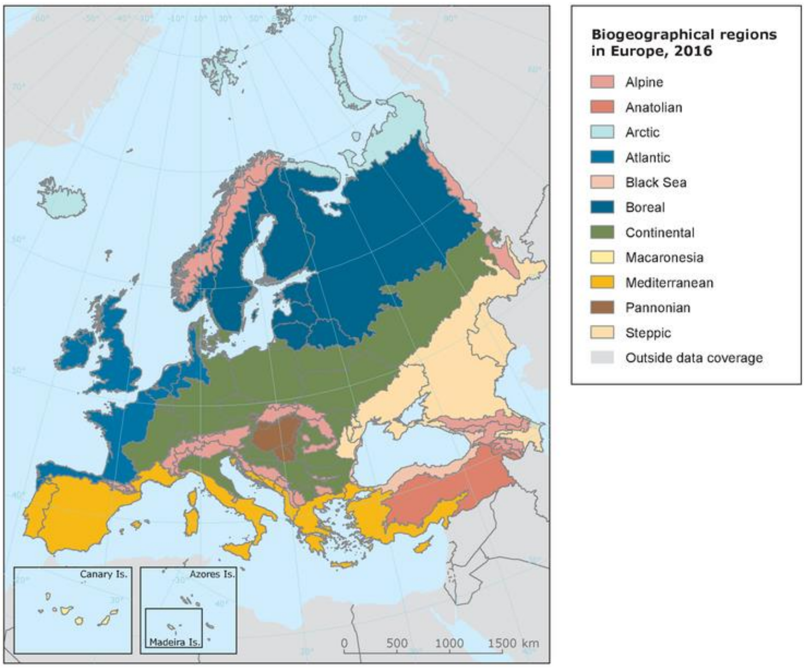
			Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that have cultural importance
	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	**Spiritual, symbolic** and other 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.*

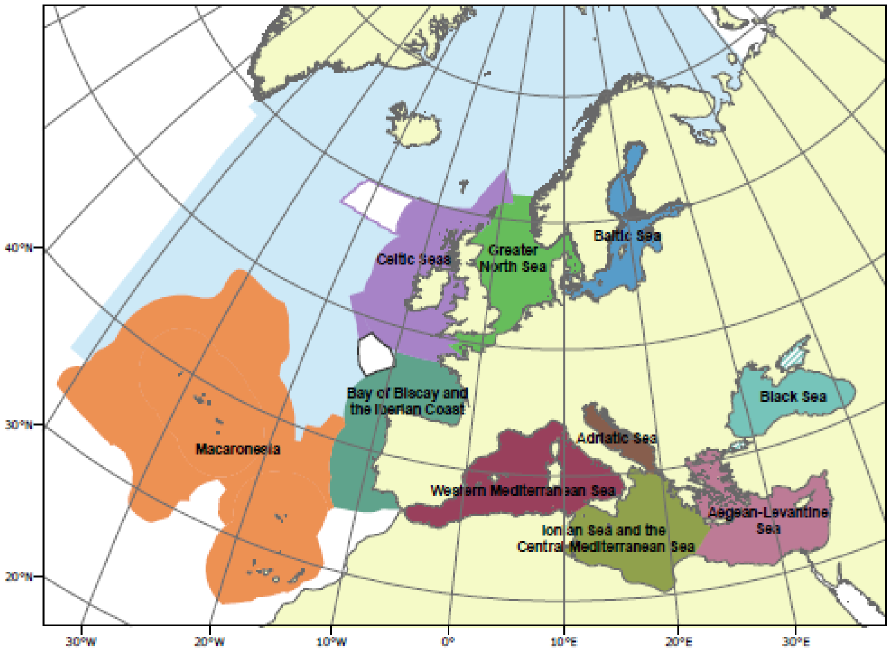
ANNEX V EU Biogeographic Regions and MSFD Subregions

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 Delegated Regulation (EU) 2018/968 of 30 April 2018

see https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32018R0968

ANNEX VII Projection of climatic suitability for *Phytolacca americana* establishment

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30 October 2019

Aim

To project the suitability for potential establishment of *Phytolacca americana* in Europe, under current and predicted future climatic conditions.

Data for modelling

Species occurrence data were obtained from the Global Biodiversity Information Facility (GBIF) (18598 records), the Biodiversity Information Serving Our Nation database (BISON) (6638 records), the Integrated Digitized Biocollections (iDigBio) (1327 records), the Atlas of Living Australia (179 records), the Berkeley Ecoinformatics Engine database (113 records), and a small number of additional records from the risk assessment team. We scrutinised occurrence records from regions where the species is not known to be established and removed any dubious records (e.g. fossils, captive records) or where the georeferencing was too imprecise (e.g. records referenced to a country or island centroid) or outside of the coverage of the predictor layers (e.g. small island or coastal occurrences). The remaining records were gridded at a 0.25 x 0.25 degree resolution for modelling, yielding 4321 grid cells with occurrences (Figure 1a). As a proxy for recording effort, the density of Tracheophyta records held by GBIF was also compiled on the same grid (Figure 1b).

(a) Species distribution used in modelling

(b) Estimated recording effort (log10-scaled)

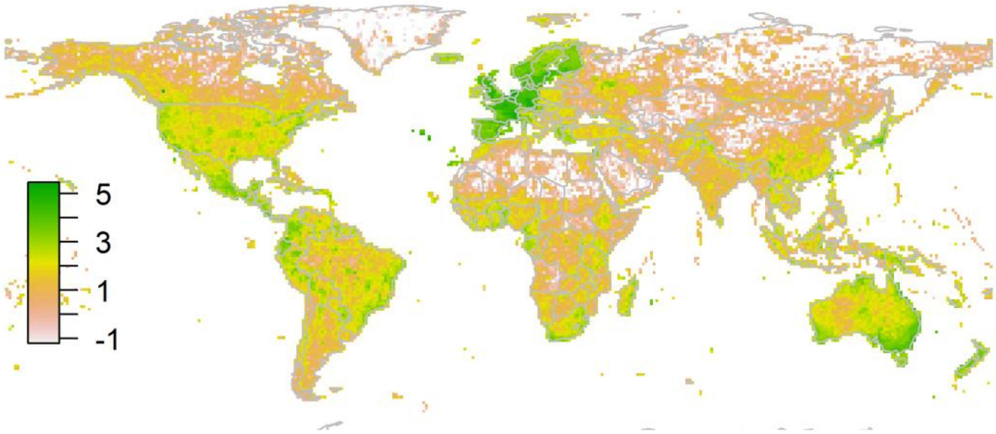


Figure 1. (a) Occurrence records obtained for *Phytolacca americana* and used in the modelling, showing native and invaded distributions. (b) The recording density of Tracheophyta on GBIF, which was used as a proxy for recording effort.

Climate data were selected from the 'Bioclim' variables contained within the WorldClim database (Hijmans et al., 2005), originally at 5 arcminute resolution (0.083 x 0.083 degrees of longitude/latitude) and aggregated to a 0.25 x 0.25 degree grid for use in the model.

Based on the biology of *Phytolacca americana*, the following climate variables were used in the modelling:

- Minimum temperature of the coldest month (Bio6)
- Mean temperature of the warmest quarter (Bio10)
- Climatic moisture index (CMI): ratio of mean annual precipitation to potential evapotranspiration, log+1 transformed. For its calculation, monthly potential evapotranspirations were estimated from the WorldClim monthly temperature data and solar radiation using the

simple method of Zomer et al. (2008) which is based on the Hargreaves evapotranspiration equation (Hargreaves, 1994).

To estimate the effect of climate change on the potential distribution, equivalent modelled future climate conditions for the 2070s under the Representative Concentration Pathways (RCP) 2.6 and 4.5 were also obtained. There represent low and medium emissions scenarios, respectively. The above variables were obtained as averages of outputs of eight Global Climate Models (BCC-CSM1-1, CCSM4, GISS-E2-R, HadGEM2-AO, IPSL-CM5A-LR, MIROC-ESM, MRI-CGCM3, NorESM1-M), downscaled and calibrated against the WorldClim baseline (see http://www.worldclim.org/cmip5_5m).

Species distribution model

A presence-background (presence-only) ensemble modelling strategy was employed using the BIOMOD2 R package v3.3-7.1 (Thuiller et al., 2019, Thuiller et al., 2009). These models contrast the environment at the species' occurrence locations against a random sample of the global background environmental conditions (often termed 'pseudo-absences') in order to characterise and project suitability for occurrence. This approach has been developed for distributions that are in equilibrium with the environment. Because invasive species' distributions are not at equilibrium and subject to dispersal constraints at a global scale, we took care to minimise the inclusion of locations suitable for the species but where it has not been able to disperse to (Chapman et al. 2019). Therefore the background sampling region included:

- The area accessible by native *Phytolacca americana* populations, in which the species is likely to have had sufficient time to disperse to all locations. Based on presumed maximum dispersal distances, the accessible region was defined as a 400km buffer around the native range occurrences; AND
- A 30km buffer around the non-native occurrences, encompassing regions likely to have had high propagule pressure for introduction by humans and/or dispersal of the species; AND
- Regions where we have an *a priori* expectation of high unsuitability for the species so that absence is assumed irrespective of dispersal constraints (see Figure 2). The following rules were applied to define a region expected to be highly unsuitable for *Phytolacca americana* at the spatial scale of the model:
  - Minimum temperature of the coldest month (Bio6) < -27
  - Mean temperature of the warmest quarter (Bio10) < 3
  - Climatic moisture index (CMI) < log1p(0.20)

Altogether, only 0.2% of occurrence grid cells were located in the unsuitable background region.

Within the background region, 10 samples of 5000 randomly sampled grid cells were obtained, weighting the sampling by recording effort (Figure 2).

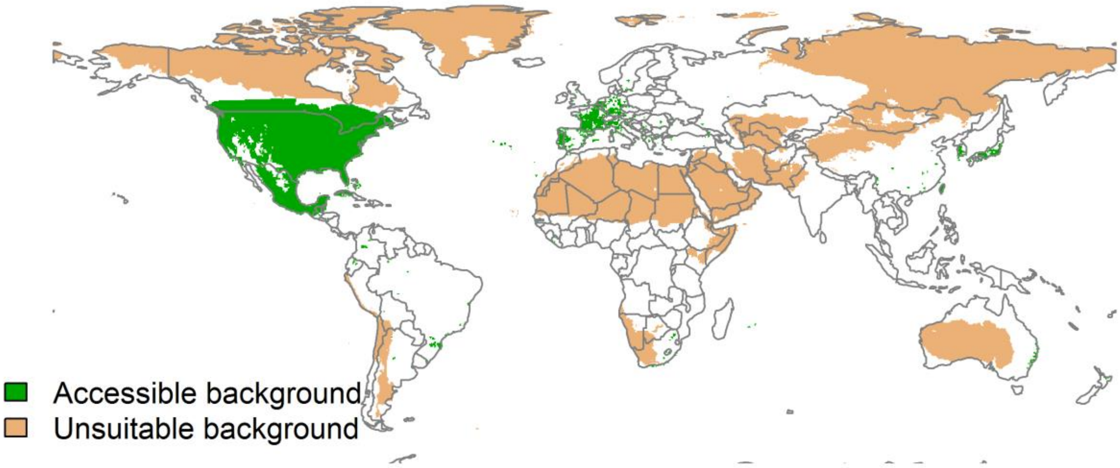


Figure 2. The background from which pseudo-absence samples were taken in the modelling of *Phytolacca americana*. Samples were taken from a 400km buffer around the native range and a 30km buffer around non-native occurrences (together forming the accessible background), and from areas expected to be highly unsuitable for the species (the unsuitable background region). Samples were weighted by a proxy for recording effort (Figure 1(b)).

Each dataset (i.e. combination of the presences and the individual background samples) was randomly split into 80% for model training and 20% for model evaluation. With each training dataset, seven statistical algorithms were fitted with the default BIOMOD2 settings and rescaled using logistic regression, except where specified below:

- Generalised linear model (GLM)
- Generalised boosting model (GBM)
- Generalised additive model (GAM) with a maximum of four degrees of freedom per smoothing spline
- Artificial neural network (ANN)
- Multivariate adaptive regression splines (MARS)
- Random forest (RF)
- Maxent

Since the background sample was larger than the number of occurrences, prevalence fitting weights were applied to give equal overall importance to the occurrences and the background. Normalised variable importance was assessed and variable response functions were produced using BIOMOD2's default procedure.

Model predictive performance was assessed by the following three measures:

- AUC, the area under the receiver operating characteristic curve (Fielding & Bell 1997). Predictions of presence-absence models can be compared with a subset of records set aside for model evaluation (here 20%) by constructing a confusion matrix with the number of true positive, false positive, false negative and true negative cases. For models generating non-dichotomous scores (as here) a threshold can be applied to transform the scores into a dichotomous set of presence-absence predictions. Two measures that can be derived from the confusion matrix are sensitivity (the proportion of observed presences that are predicted as such, quantifying omission errors), and specificity (the proportion of observed absences that are predicted as such, quantifying commission errors). A receiver operating characteristic (ROC) curve can be constructed by using all possible thresholds to classify the scores into confusion matrices, obtaining sensitivity and specificity for each matrix, and plotting sensitivity against the corresponding proportion of false positives (equal to 1 - specificity). The use of all possible thresholds avoids the need for a selection of a single threshold, which is often arbitrary, and allows appreciation of the trade-off between sensitivity and specificity. The area under the ROC curve (AUC) is often used as a single threshold-independent measure for model performance (Manel, Williams & Ormerod 2001). AUC is the probability that a randomly selected presence has a higher model-predicted suitability than a randomly selected absence (Allouche et al. 2006).

- Cohen’s Kappa (Cohen 1960). This measure corrects the overall accuracy of model predictions (ratio of the sum of true presences plus true absences to the total number of records) by the accuracy expected to occur by chance. The kappa statistic ranges from -1 to +1, where +1 indicates perfect agreement and values of zero or less indicate a performance no better than random. Advantages of kappa are its simplicity, the fact that both commission and omission errors are accounted for in one parameter, and its relative tolerance to zero values in the confusion matrix (Manel, Williams & Ormerod 2001). However, Kappa has been criticised for being sensitive to prevalence (the proportion of sites in which the species was recorded as present) and may therefore be inappropriate for comparisons of model accuracy between species or regions (McPherson, Jetz & Rogers 2004, Allouche et al. 2006).
- TSS, the true skill statistic (Allouche et al. 2006). TSS is defined as sensitivity + specificity - 1, and corrects for Kappa’s dependency on prevalence. TSS compares the number of correct forecasts, minus those attributable to random guessing, to that of a hypothetical set of perfect forecasts. Like kappa, TSS takes into account both omission and commission errors, and success as a result of random guessing, and ranges from -1 to +1, where +1 indicates perfect agreement and values of zero or less indicate a performance no better than random (Allouche et al. 2006).

An ensemble model was created by first rejecting poorly performing algorithms with relatively extreme low AUC values and then averaging the predictions of the remaining algorithms, weighted by their AUC. To identify poorly performing algorithms, AUC values were converted into modified z-scores based on their difference to the median and the median absolute deviation across all algorithms (Iglewicz & Hoaglin, 1993). Algorithms with $z < -2$ were rejected. In this way, ensemble projections were made for each dataset and then averaged to give an overall suitability, as well as its standard deviation. The projections were then classified into suitable and unsuitable regions using the ‘minROCdist’ method, which minimizes the distance between the ROC plot and the upper left corner of the plot (point (0,1)).

We also produced limiting factor maps for Europe following Elith et al. (2010). For this, projections were made separately with each individual variable fixed at a near-optimal value. These were chosen as the median values at the occurrence grid cells. Then, the most strongly limiting factors were identified as the one resulting in the highest increase in suitability in each grid cell.

Results

The ensemble model suggested that suitability for *Phytolacca americana* was most strongly determined by Climatic moisture index (CMI), accounting for 40.1% of variation explained, followed by Mean temperature of the warmest quarter (Bio10) (31.2%) and Minimum temperature of the coldest month (Bio6) (28.8%) (Table 1, Figure 3).

Table 1. Summary of the cross-validation predictive performance (AUC, Kappa, TSS) and variable importance of the fitted model algorithms and the ensemble (AUC-weighted average of the best performing algorithms). Results are the average from models fitted to 10 different background samples of the data.

					variable importance (%)		
Algorithm	AUC	Kappa	TSS	Used in the ensemble	Climatic moisture index (CMI)	Mean temperature of the warmest quarter (Bio10)	Minimum temperature of the coldest month (Bio6)
GLM	0.902	0.611	0.647	yes	42	32	26
GAM	0.902	0.609	0.644	yes	40	30	30
ANN	0.906	0.607	0.653	yes	38	32	30
GBM	0.906	0.604	0.649	yes	41	30	29
MARS	0.901	0.603	0.642	yes	43	30	27
RF	0.842	0.480	0.580	no	36	36	29
Maxent	0.901	0.593	0.635	yes	35	34	30
Ensemble	**0.906**	**0.608**	**0.650**		**40**	**31**	**29**

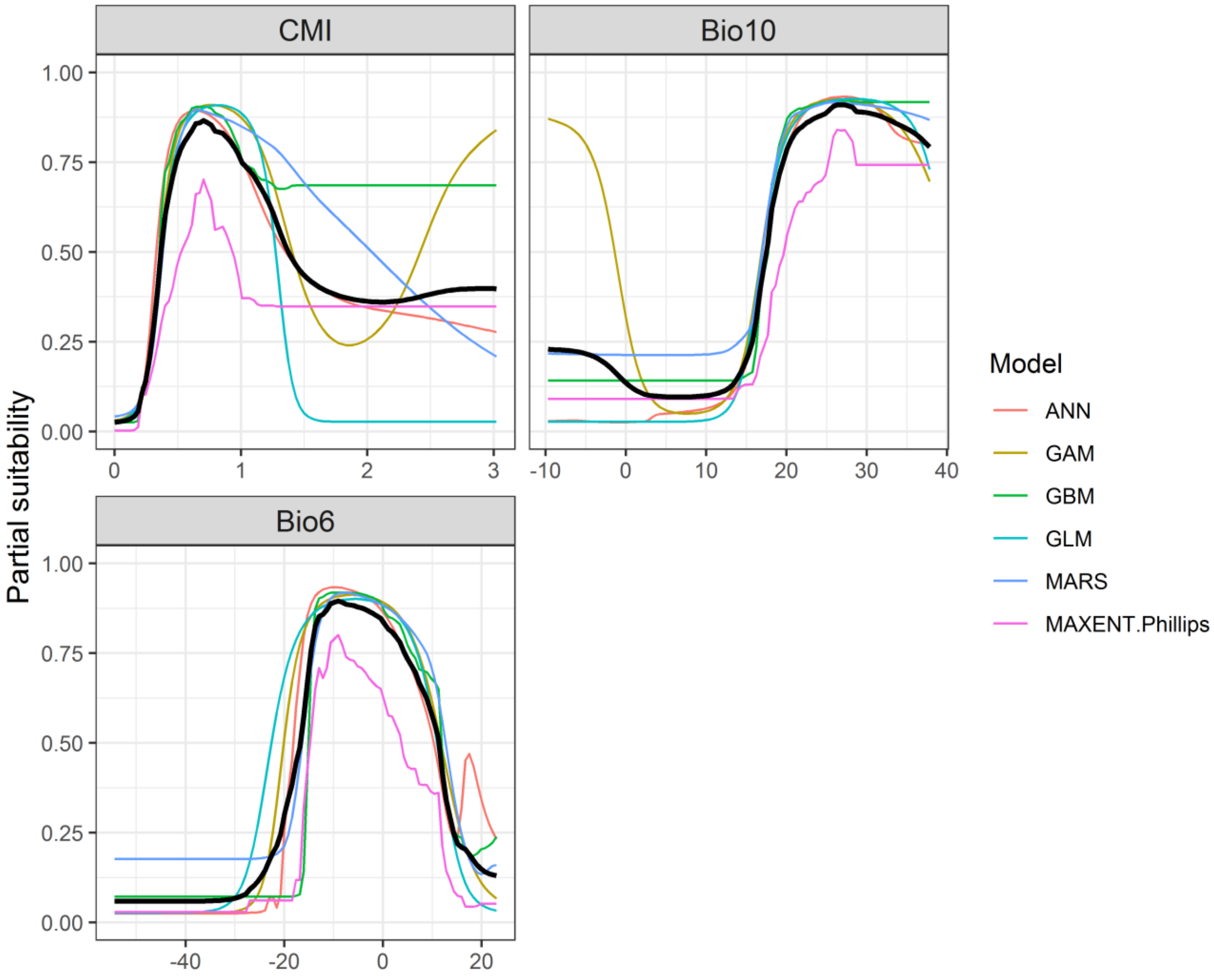
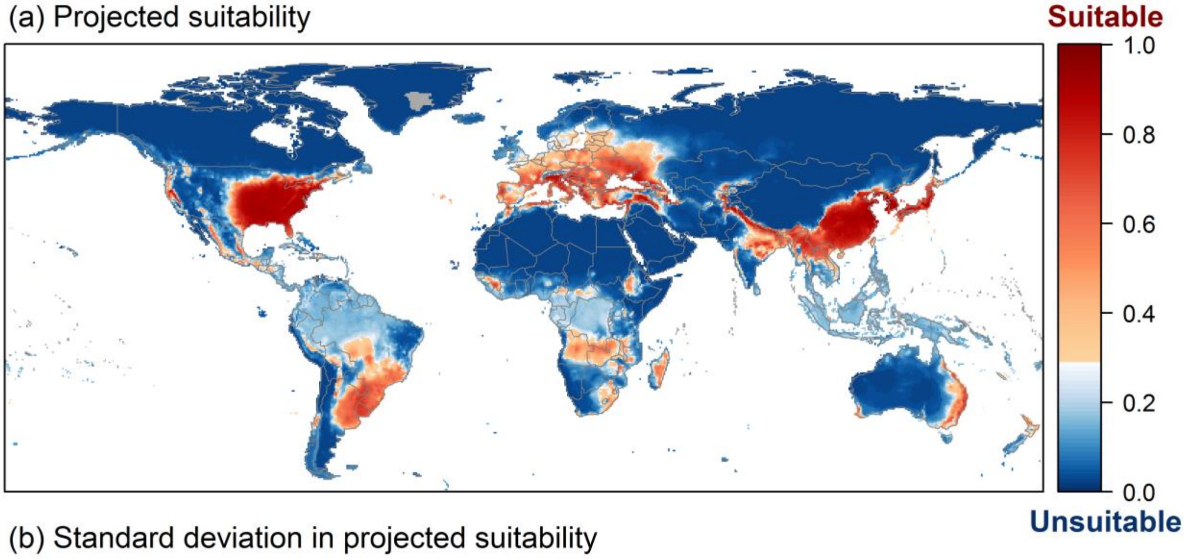


Figure 3. Partial response plots from the fitted models. Thin coloured lines show responses from the algorithms in the ensemble, while the thick black line is their ensemble. In each plot, other model variables are held at their median value in the training data. Some of the divergence among algorithms is because of their different treatment of interactions among variables.

(a) Projected suitability



(b) Standard deviation in projected suitability

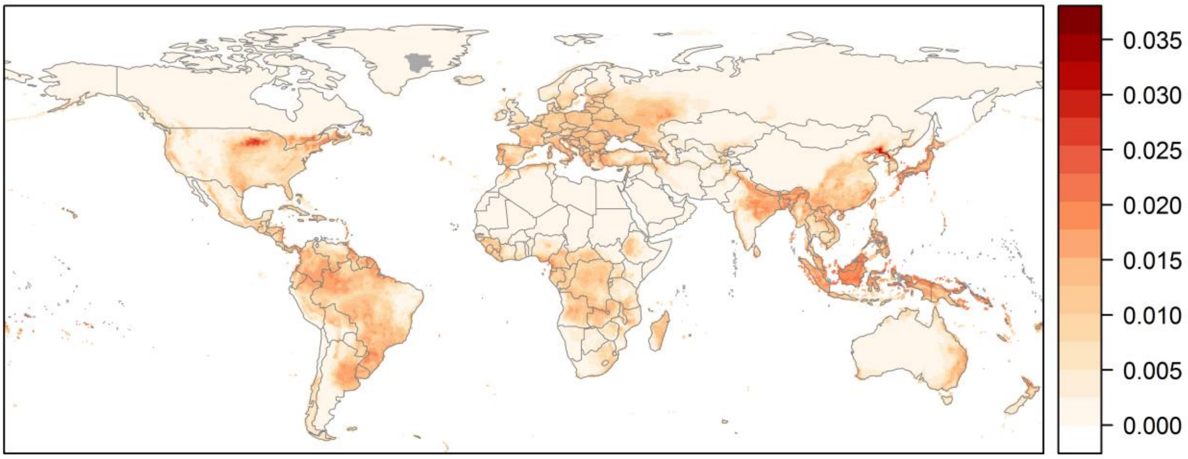
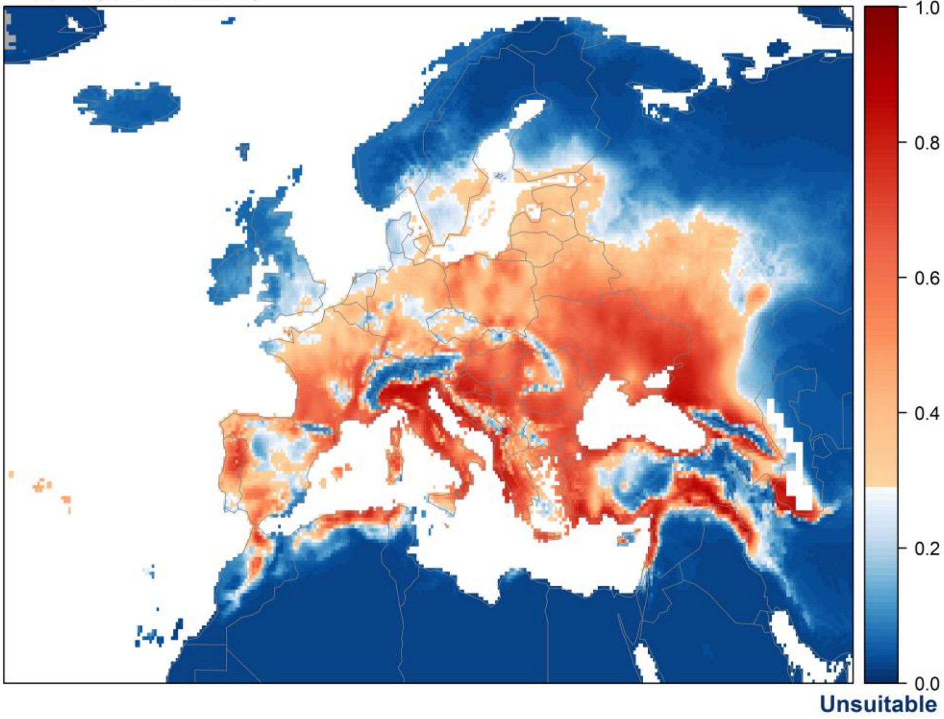


Figure 4. (a) Projected global suitability for *Phytolacca americana* establishment in the current climate. For visualisation, the projection has been aggregated to a 0.5 x 0.5 degree resolution, by taking the maximum suitability of constituent higher resolution grid cells. Values > 0.28 may be suitable for the species. Grey areas have climatic conditions outside the range of the training data and were excluded from the projection. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

(a) Projected suitability



(b) Standard deviation in projected suitability

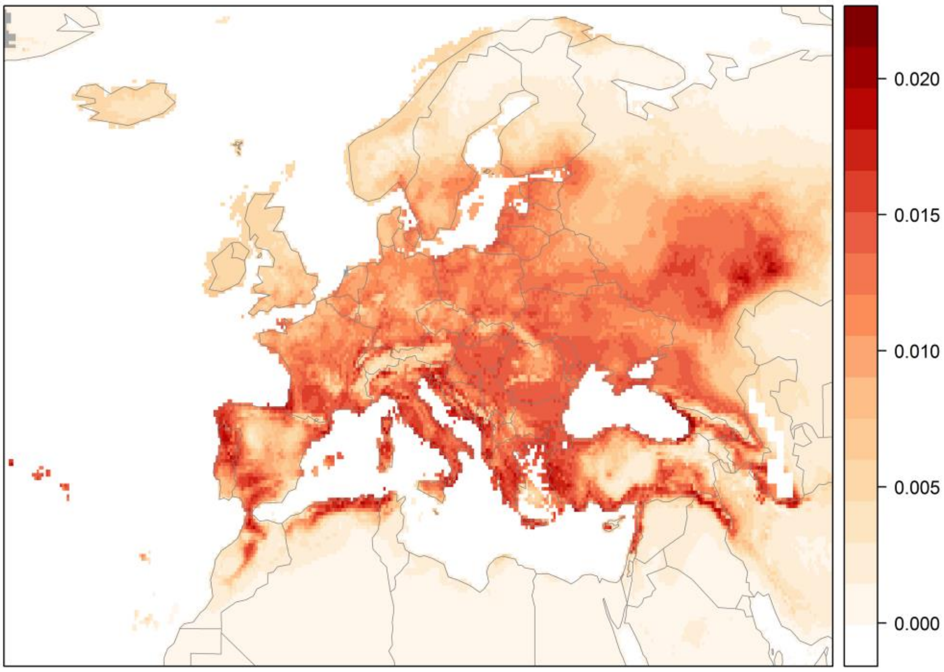


Figure 5. (a) Projected current suitability for *Phytolacca americana* establishment in Europe and the Mediterranean region. Grey areas have climatic conditions outside the range of the training data and were excluded from the projection. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

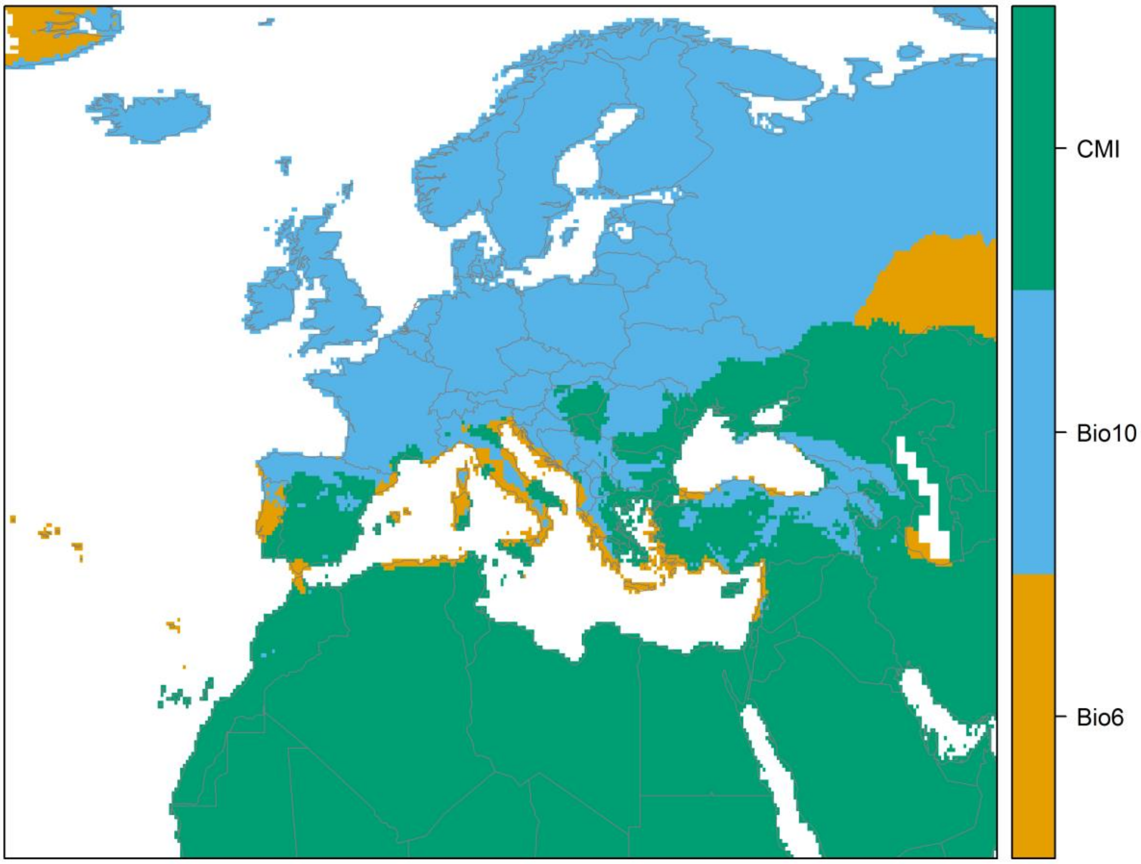
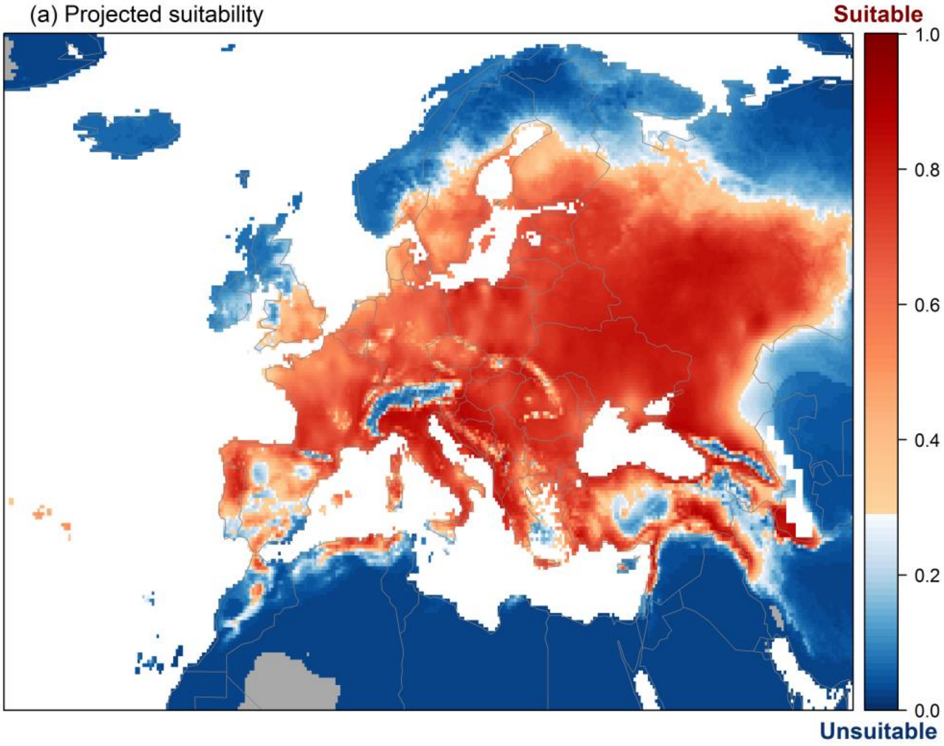
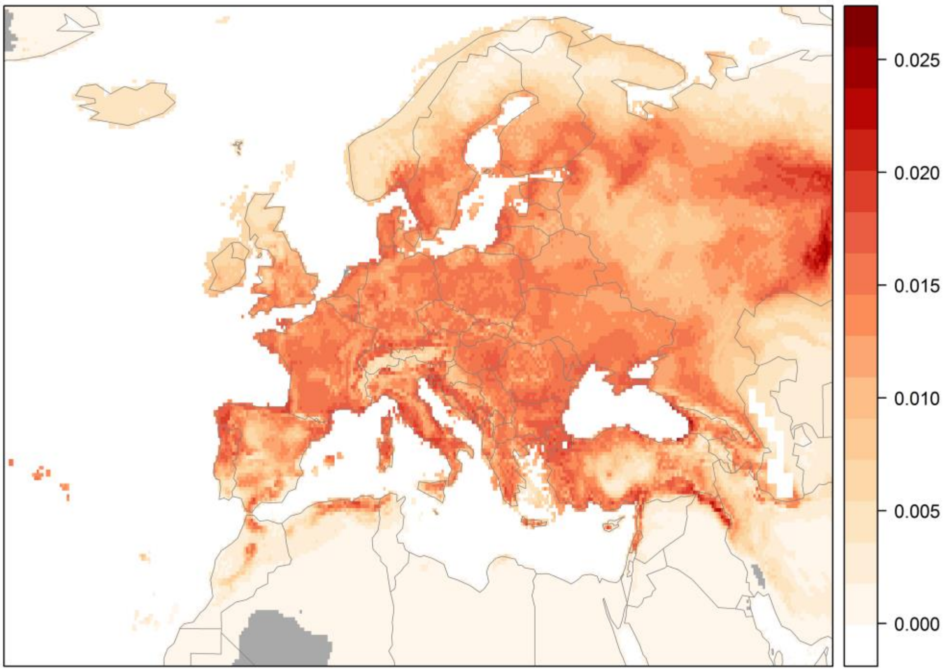


Figure 6. The most strongly limiting factors for *Phytolacca americana* establishment estimated by the model in Europe and the Mediterranean region in current climatic conditions.



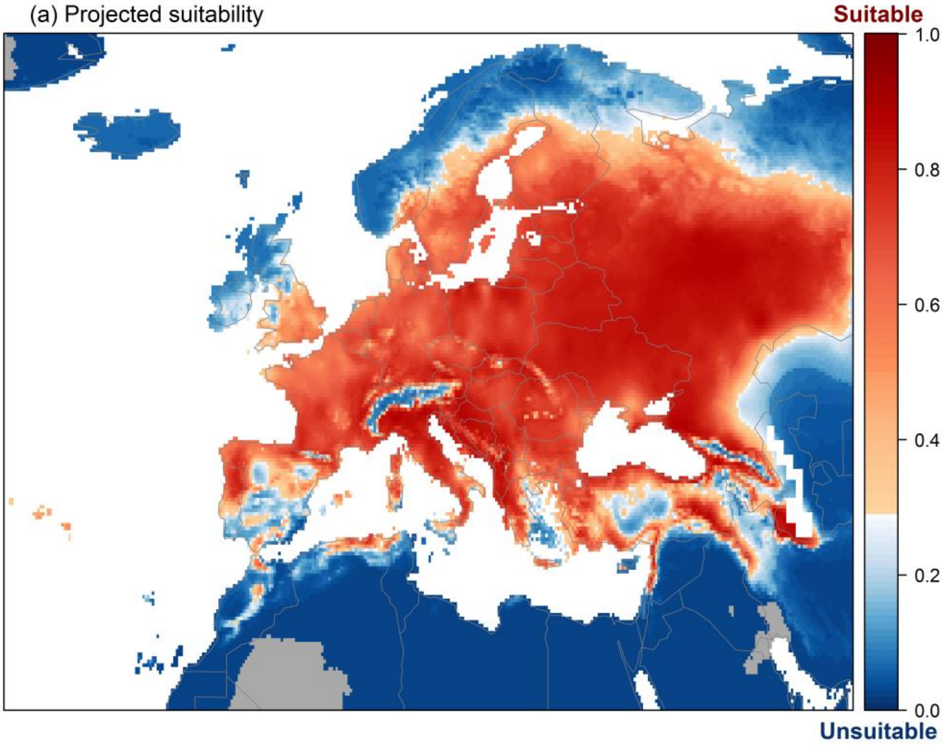
(a) Projected suitability



(b) Standard deviation in projected suitability

Figure 7. (a) Projected suitability for *Phytolacca americana* establishment in Europe and the Mediterranean region in the 2070s under climate change scenario RCP2.6, equivalent to Figure 5. Grey areas have climatic conditions outside the range of the training data and were excluded from the projection. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

(a) Projected suitability



(b) Standard deviation in projected suitability

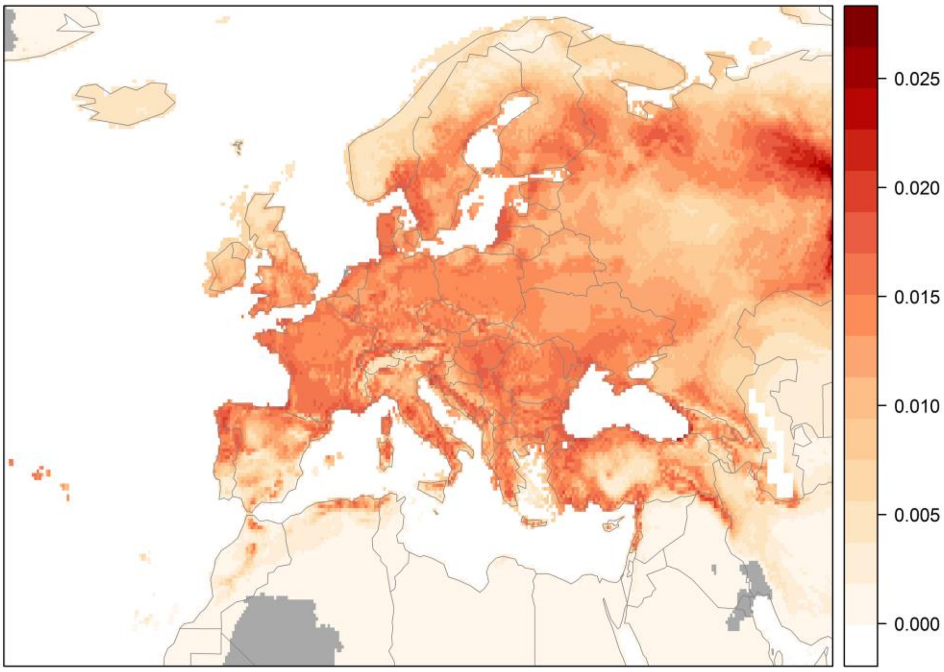


Figure 8. (a) Projected suitability for *Phytolacca americana* establishment in Europe and the Mediterranean region in the 2070s under climate change scenario RCP4.5, equivalent to Figure 5. Grey areas have climatic conditions outside the range of the training data and were excluded from the projection. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

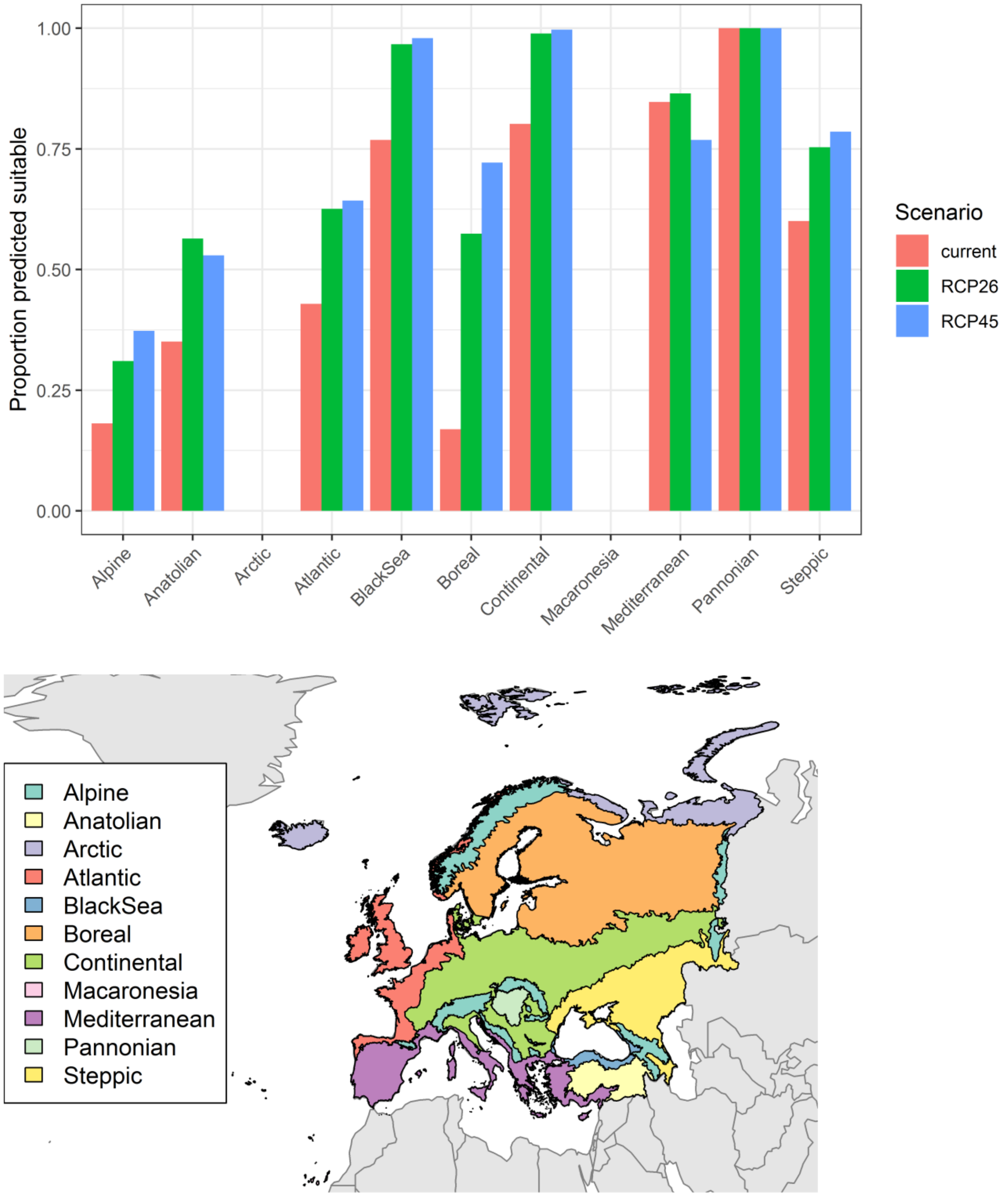


Figure 9. Variation in projected suitability for *Phytolacca americana* establishment among Biogeographical regions of Europe (Bundesamt für Naturschutz (BfN), 2003). The bar plots show the proportion of grid cells in each region classified as suitable in the current climate and projected climate for the 2070s under two RCP emissions scenarios. The location of each region is also shown. The Arctic and Macaronesian biogeographical regions are not part of the study area, but are included for completeness (although unsuitable for all scenarios for this species).

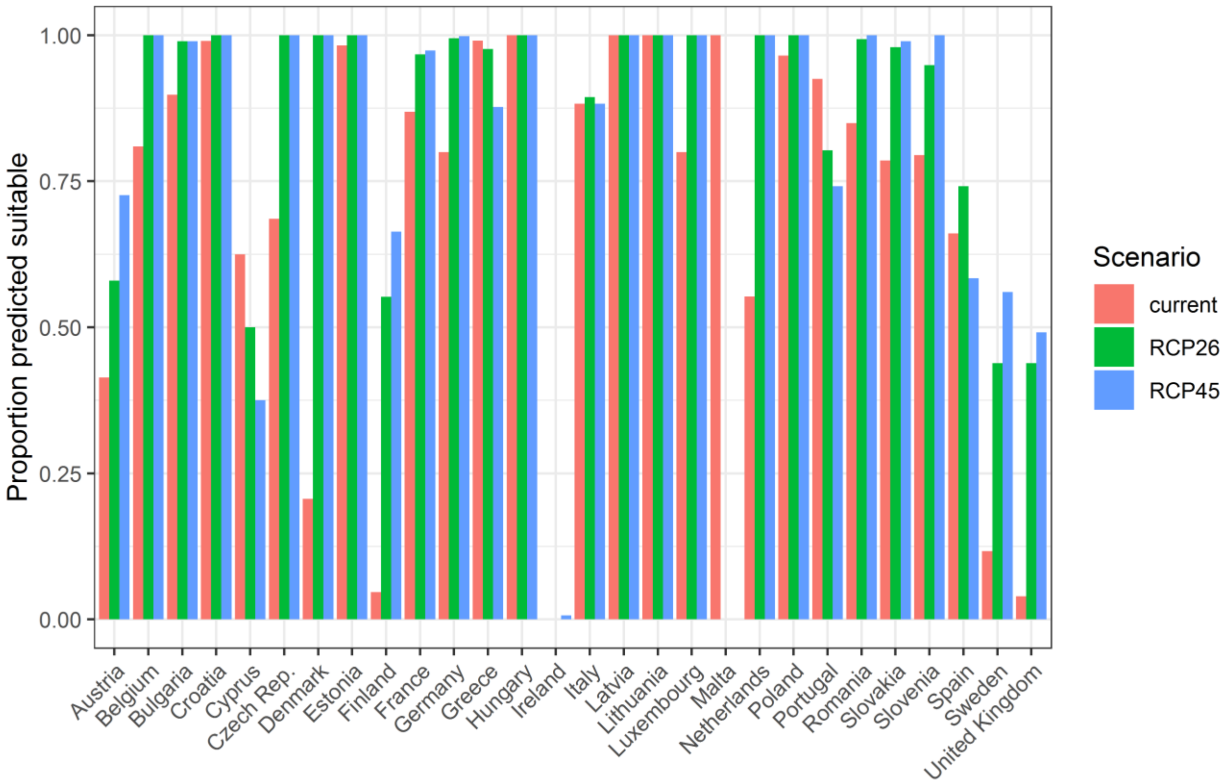


Figure 10. Variation in projected suitability for *Phytolacca americana* establishment among European Union countries. The bar plots show the proportion of grid cells in each country classified as suitable in the current climate and projected climate for the 2070s under two RCP emissions scenarios.

To remove spatial recording biases, the selection of the background sample was weighted by the density of Tracheophyta records on the Global Biodiversity Information Facility (GBIF). While this is preferable to not accounting for recording bias at all, it may not provide the perfect measure of recording bias.

There was substantial variation among modelling algorithms in the partial response plots (Figure 3). In part this will reflect their different treatment of interactions among variables. Since partial plots are made with other variables held at their median, there may be values of a particular variable at which this does not provide a realistic combination of variables to predict from.

Other variables potentially affecting the distribution of the species, such as land cover were not included in the model.

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