

Risk Assessment of *Gunnera tinctoria* – submission for consideration of Union listing under EU IAS Regulation No. 1143/2014

Name of Organism:	<i>Gunnera tinctoria</i> (Molina) Mirbel – Giant rhubarb
Objective:	Assess the risks associated with this species for Union listing under EU Regulation No. 1143/2014
Version:	EU amended template for submission July, 2016. Version 1.0-6
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Expert reviewer	Bruce Osborne

EU Chapeau

Stage 1 - Organism Information

Stage 2 - Detailed Assessment

Section A - Entry

Section B - Establishment

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This risk assessment is based on the **Non-native species APplication based Risk Analysis** for Ireland (NAPRA Ireland) tool (version 2.66) and the EU Non-native Organism Risk Assessment Scheme template.

Quality assurance procedure

In 2014, the *NAPRA Ireland* version of this risk assessment was drafted and then internally reviewed by the National Biodiversity Data Centre. This was then reviewed by an external third party expert. The final draft version was made widely available for key stakeholder and general public consultation through a series of open meetings and online consultation. All consultation comments were documented and also reviewed by the external expert. The final *NAPRA Ireland* version was published online on 15/09/2014 and is accessible from: <http://nonnativespecies.ie>.

Prior to initial submission for its consideration as a species of Union concern, an EU Chapeau and inclusion of reference to ecosystem services were added. This was reviewed by Professor Bruce Osborne, University College Dublin, Ireland.

In consideration of initial comments received by the Scientific Forum, responses to the risk assessment questions have been revised to focus at the European level. This revised version has been reviewed by Professor Bruce Osborne.

Notes: Confidence is rated as Low, Medium, High or Very High.
Likelihood is rated as Very unlikely, Unlikely, Moderately likely, Likely or Very likely.
Magnitude of risk is rated as Minimal, Minor, Moderate, Major and Massive
The percentage categories are 0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%.
N/A = not applicable.

DOCUMENT CONTROL SHEET

Version Control Table

Version No.	Status	Authors(s)	Reviewed by	Approved by	Date of issue
Draft 1	Complete	Dr Erin O'Rourke	Ms Colette O'Flynn		29/01/2014
Expert review	Complete	Dr Erin O'Rourke	Prof. Bruce Osborne	Dr Liam Lysaght	19/03/2014
Public consultation	Complete	Dr Erin O'Rourke		Dr Liam Lysaght	09/05/2014
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NAPRA EU amendments Draft	Final	Ms Colette O'Flynn	Prof. Bruce Osborne	Dr Ferdia Marnell, National Parks and Wildlife Service, Ireland	24/11/2015
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NAPRA EU Minor amendments	Complete	Ms Colette O'Flynn		Dr Mike Wyse Jackson, National Parks and Wildlife Service, Ireland	25/07/2016

EU CHAPEAU	
QUESTION	RESPONSE
1. In how many EU member states has this species been recorded? List them.	6: France, Germany, Ireland, Portugal (only recorded in the Azores archipelago (São Miguel island)), Spain, United Kingdom
2. In how many EU member states has this species currently established populations? List them.	4: France, Ireland, Portugal (only recorded in the Azores archipelago (São Miguel island)), Spain, United Kingdom
3. In how many EU member states has this species shown signs of invasiveness? List them.	3: Ireland, Portugal (only recorded in the Azores archipelago (São Miguel island)), United Kingdom
4. In which EU Biogeographic areas could this species establish?	Atlantic and Macaronesia (Biogeographic Areas in Europe, 2011. European Environment Agency see: http://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-1)
5. In how many EU member states could this species establish in the future [given <u>current</u> climate] (including those where it is already established)? List them.	09: Belgium, Denmark, France, Germany, Ireland, Netherlands, Portugal, Spain and the United Kingdom. These are countries that have territory completely or partially within the Atlantic or Macaronesia biogeographic regions. <i>Gunnera tinctoria</i> is a plant of cool, humid regions (Gioria and Osborne, 2013; Sheehy Skeffington and Hall, 2011) therefore persistent establishment in some of these EU Member States may be limited by dry summers and severe winters.
6. In how many EU member states could this species become invasive in the future [given <u>current</u> climate] (where it is <u>not</u> already established)?	2: Spain and Portugal (mainland Portugal). Where <i>Gunnera tinctoria</i> has become invasive, hyper-oceanic climates prevail (Sheehy Skeffington and Hall, 2011; and Gioria and Osborne, 2013) thus the invasive potential of this species may be restricted to these areas. Hyper-oceanic climates for Spain and Portugal mainland are very restricted to the north-west of the Iberian peninsula.

Stage 1 - Organism Information			
<i>The aim of this section is to gather basic information about the organism.</i>			
N	QUESTION	RESPONSE	COMMENT
1	Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	YES	<p><i>Gunnera tinctoria</i> (Molina) Mirbel – Giant rhubarb</p> <p>Taxonomy: Class: Angiosperm Order: Gunnerales Family: Gunneraceae Subgenus: Panke Genus: <i>Gunnera</i> Species: <i>tinctoria</i></p> <p>Synonyms: <i>Gunnera chilensis</i> Lam., <i>Gunnera scabra</i> (Ruiz.&Pav.), <i>Panke tinctoria</i> Molina (basionym), <i>Gunnera pilosa</i> Kunth (Gioria and Osborne, 2013).</p> <p>Common names: Chilean gunnera, Chilean rhubarb, Giant rhubarb, Nalca, Panque (GISD, 2005).</p>
2	If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)		<p>The taxonomy of this species and the related <i>Gunnera manicata</i> is somewhat unclear. The inflorescences are typically rather open in <i>Gunnera manicata</i> and closed in <i>Gunnera tinctoria</i> (club-like) but these visual differences between the two species may be much smaller than often thought.</p> <p>There are no records of <i>Gunnera tinctoria</i> forming viable hybrids (Gioria and Osborne, 2013) and no evidence of hybridity has been observed so far [in Connemara, Ireland at least] (Sheehy Skeffington and Hall 2011)). Also, in the 2015 <i>Hybrid Flora of the British Isles</i> (Stace <i>et al</i>, 2015) <i>Gunnera</i> is not mentioned. However, although it cannot be verified at this time, there may be intermediate forms i.e. both types of inflorescences have been noted on the same plant (Bruce Osborne, pers. comm., 19th March 2014).</p>

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N	QUESTION	RESPONSE	COMMENT
3	Describe the organism.	-	<i>Gunnera tinctoria</i> is a clump-forming, herbaceous, perennial that grows up to 2m in height. It has inflorescences < 1m, with stout branches < 8cm; petiole ≤ 2m, with pale-red bristles and weak spines; and leaves < 2m across, cordate at base (Stace, 1997). It is difficult to tell <i>Gunnera tinctoria</i> apart from <i>Gunnera manicata</i> ; the spike shape and dimensions prove the most easily distinguishable features (Sheehy Skeffington and Hall, 2011). While there may be a hybrid or intermediate form of these two species, there is currently no evidence to verify it (See answer to Q 2).
4	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	NO	No European level risk assessment exists for this species. However, the species has gone through a prioritization process for invasive alien plants in the EPPO Region where it is listed under the List of Invasive Alien Plants (EPPO, 2014). It was also assessed and ranked in the Top 100 Invasive Alien Plants in European Macaronesia (Silva <i>et al.</i> , 2008). Many European countries including Great Britain, Ireland, Scotland and Spain have assessed this species at the national level (GB Non-native Species Secretariat, 2015; O'Rourke and O'Flynn, 2014; Scottish Natural Heritage (in prep.); Andreu and Vilà, 2009).
5	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?	N/A	
6	Where is the organism native?		<i>Gunnera tinctoria</i> is native to South America, predominantly in Chile, from Coquimbo to Magallanes (Osborne 1988; Gioria and Osborne, 2013; Sheehy Skeffington and Hall, 2011). It is also considered to be native to parts of Argentina, and in the Andean region of Colombia, Venezuela, Peru and Ecuador (Gioria and Osborne, 2013; Silva <i>et al.</i> , 1996). Detailed records of its distribution in its native range are not available (Gioria and Osborne, 2013).
7	What is the current global distribution of the organism (excluding Europe)?		Including its native range (refer to question 6) the species has a current global distribution spanning both the northern and southern hemispheres including California (Howell, 1970), Bolivia (TROPICOS, 2016), Tasmania (Duretto, 2013), New Zealand (Heenan <i>et al.</i> , 2009; Williams <i>et al.</i> , 2005) and the Chatham Islands (de Lange <i>et al.</i> , 2011).
8	What is the current distribution of the organism in Europe?	-	It is found in England (Hawksford and Hopkins, 2011; Pilkington, 2011; Preston <i>et al.</i> , 2002), Wales (Wade <i>et al.</i> , 1994), Scotland (Gioria and Osborne, 2013; Preston <i>et al.</i> , 2002) and was first introduced into cultivation in Great Britain in 1849 and recorded from the wild in at least 1908 (Preston <i>et al.</i> , 2002). The earliest record on the Isle of Man was 1972 at Onchan Harbour (Allen, 1984); Isles of Scilly (French, 2009), the Channel Islands (McClintock 1975), France (Osborne <i>et al.</i> , 1991; Tela Botanica, 2016) and Ireland (Reynolds, 2002; National

Stage 1 - Organism Information			
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N	QUESTION	RESPONSE	COMMENT
			Biodiversity Data Centre, 2016) where it was first recorded as naturalised in Ireland in the late 1930's by Praeger (1939) under the name <i>Gunnera manicata</i> . It is recorded in Spain as a transient species that is under eradication (EPPO, 2016; Sanz Elorza <i>et al.</i> , 2001). The species was mentioned for the first time as naturalised in the Azores (São Miguel Island) in Flora Europaea (Silva and Smith, 2004; Silva <i>et al.</i> , 1996). There are a few records of <i>Gunnera tinctoria</i> in Germany (GBIF, 2016).
09	Is the organism known to be invasive anywhere in the world?	YES	<p>In England, <i>Gunnera tinctoria</i> is invasive in western parts of Cornwall (Pilkington 2011; Richardson <i>et al.</i>, 2000).</p> <p>In Scotland, it is invasive in the Outer Hebrides, in parts of North Harris and in the Lewis Castle grounds at Stornoway (Gioria and Osborne, 2013). In a recent Scottish rapid risk assessment for established invasive non-native species, plant experts assessed <i>Gunnera tinctoria</i> as being high impact and on a par with some of the knotweeds (certain <i>Fallopia</i> species) and Giant hogweed (<i>Heracleum mantegazzianum</i>). Therefore, Scottish Natural Heritage are proposing to include it as a management priority on Scottish Islands (SNH, in prep).</p> <p>A recent GB Non-Native Species Secretariat Rapid Risk Assessment, assessed the species at medium risk, with a high confidence level (GB Non-native Species Secretariat, 2015). This was after a review of its previous assessment of Low risk listing it for urgent detailed risk assessment (Thomas, 2010).</p> <p>In Ireland it is invasive in Co. Mayo, at Achill Island, Blacksod Bay and Roonagh; Co. Galway, at Leenane, Letterfrack and Kylemore Estate; and on Clare Island (Doyle and Foss 1986; Hickey and Osborne, 1998). The outcome of a detailed risk assessment (NAPRA Ireland) in 2014 for <i>Gunnera tinctoria</i>, assessed it as a MAJOR risk in Ireland (O'Rourke and O'Flynn, 2014). In Ireland, it is also prohibited for introduction and dispersal (Statutory Instrument No. 477/2011).</p> <p>It is invasive on São Miguel Island in the Azores, mainly in the east of the island (Silva <i>et al.</i>, 1996) and is included on the list of alien invasive species under Azores regional regulation (Decreto-Lei Regional n.º 15/2012/A) and classified as a species of identified ecological risk and of priority control/eradication. Under project Interreg III-B Açores-Madeira-Canárias BIONATURA ("Gestão e Conservação da Biodiversidade na Macaronésia") this species was included on the list of the Top 100 potentially more dangerous invasive species in Macaronesia (flora and fauna) (Silva <i>et al.</i>, 2008).</p> <p><i>Gunnera tinctoria</i> is on the EPPO Lists of Invasive Alien Plants. EPPO recommends countries endangered by these species to consider measures to</p>

Stage 1 - Organism Information			
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N	QUESTION	RESPONSE	COMMENT
			<p>prevent their introduction and spread or to manage unwanted populations (EPPO, 2016).</p> <p>In New Zealand it is invasive on Mount Taranaki, in the North Island (Williams <i>et al.</i>, 2005).</p>
10	Describe any known socio-economic benefits of the organism in the risk assessment area.		<p>The species is known to be used as a waterside ornamental plant. The European online portal (the PPP Index website) for searching for plant, fruit or seed traders reports 34 sellers for this plant in Europe in September 2014 (EPPO, 2014) and April, 2016 (Authors observation.) 'There are various websites selling this plant.' (EPPO, 2014).</p> <p><i>Gunnera tinctoria</i> was introduced for ornamental purposes in Ireland and the United Kingdom (Gioria and Osborne, 2013; Wyse Jackson, 2014) and is still available for purchase in Ireland (National Biodiversity Data Centre, 2015). It is also for sale from 21 published suppliers in Great Britain (Royal Horticultural Society, 2016). In 2006, <i>Gunnera tinctoria</i> received the the Award of Garden Merit by the Royal Horticultural Society (Gioria and Osborne, 2013). In Poland, an interest in <i>Gunnera tinctoria</i> and <i>Gunnera manicata</i> (a similar species) as ornamental garden plants is growing (Paulo Carmo, pers. comm. March, 2016). The Scottish rapid risk assessment notes that as an impediment to tackling the horticulture pathway for this species, there is an attachment to its use as a 'structural' plant in landscaping (Scottish Natural Heritage (in prep.).</p> <p>While the plant has several ethnobotanical uses, including as a dye, being edible and possibly has some medicinal uses (Wyse Jackson, 2014; Plants for a Future, 2016) it is not known if it is used for these purposes in the risk assessment area.</p> <p>No overall monetary value for trade in <i>Gunnera tinctoria</i> in Europe could be found. However prices available for internet trade vary from €2.61 for seeds imported from the United States (E-bay, 2016b), €4.25 for one small potted plant (E-bay, 2016a) or €4.97 for ten <i>Gunnera tinctoria</i> seeds imported from Israel (E-bay, 2016c). Volumes already sold from the sellers for each of the advertised products range from 39 of the potted plants (E-bay, 2016a); 26 of the seed packs from the U.S. sold (E-bay, 2016b) and 21 of the seed packs from Israel sold (E-bay, 2016c). All adverts noted there were more than 10 products still available to purchase.</p>

Stage 2 - Detailed assessment: Section A - Entry
This section evaluates the probability of entry of an organism into Europe. Not to be confused with spread, the movement of an organism within Europe. For organisms which are already present, only complete the entry section for currently active pathways of entry and potential future pathways. The entry section need not be completed for pathways which have allowed an organism to enter in the past but are no longer active.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.01	How many active/future pathways are relevant to the potential entry of this organism (n/a, very few, few, moderate number, many or very many)?	VERY FEW	HIGH	The only known and documented pathway for introduction of <i>Gunnera tinctoria</i> is through horticultural/ornamental trade.
1.02	List <u>significant</u> pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.	1. Horticultural/ornamental trade	VERY HIGH	<p>The species can be sourced through the horticultural trade for use as an ornamental garden plant. What's more, its seeds can be purchased over the internet from a range of gardens (Gioria and Osborne, 2013) and traders (EPPO, 2014; E-bay, 2016a; E-bay, 2016b; E-bay, 2016c). From gardens to which it is introduced it may escape and become naturalised/invasive, under suitable mild and moist climatic conditions (Gioria and Osborne, 2013).</p> <p>The increased occurrence of the species on cliffs may be indicative of a possible seaward pathway i.e. arrival of migratory birds/wildfowl carrying the seed that forage and/or nest on sea cliffs. This has not been verified as a pathway into Europe and as such is not at this time considered significant but may in the future require examination. Spread by this means would be more relevant as a vector of spread within Europe.</p>

Pathway 1 – Horticultural/ornamental trade				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)? (If intentional, only answer questions 1.04, 1.08, 1.09 and 1.11)	INTENTIONAL	VERY HIGH	The species has been and is available for import through the horticultural trade (EPPO, 2014; E-bay, 2016a; E-bay, 2016b; E-bay, 2016c; Gioria and Osborne, 2013; Paulo Carmo, pers. comm. March, 2016; Q-bank, 2016; Silva <i>et al.</i> , 1996; Silva <i>et al.</i> , 2008; Wyse Jackson, 2014). <i>Gunnera tinctoria</i> is one of the most popular architectural garden plants, promoted throughout the 1990s for use around ponds and in damp areas (Law, 2003 cited in GISD, 2005).
1.04	How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	MODERATELY LIKELY	MEDIUM	<p>Movement of <i>Gunnera tinctoria</i> along this pathway would be dependent on the level of supply and demand. While the overall extent of trade for Europe could not be determined, it is clear that there is a demand for this species and trade of this plant is currently active and available for import into Europe from third countries (See answers to questions 10 and 1.03).</p> <p>In 2011, a query was made to the Author (C. O'Flynn) about sourcing in Ireland six articulated truckloads of fully grown <i>Gunnera tinctoria</i> plants</p>

Pathway 1 – Horticultural/ornamental trade				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				for use as a structural/large scale feature for scenes in the Universal Pictures movie <i>Snow White and the Huntsman</i> to be then filmed in England. Demand for this volume of plants is likely to be uncommon.
1.05	How likely is the organism to enter Europe undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	HIGH	It is likely that the species could enter Europe undetected and without the knowledge of the relevant authority, particularly as seed via internet trade or by young and/or mature plants being mistakenly identified as <i>Gunnera manicata</i> ; with the two species difficult to tell apart (Sheehy Skeffington and Hall, 2011; Gioria and Osborne, 2013, Paulo Carmo, pers. comm. March, 2016). <i>Gunnera tinctoria</i> can be sold under the name <i>Gunnera manicata</i> (GISD, 2010).
1.06	How likely is the organism to survive during passage along the pathway?	VERY LIKELY	VERY HIGH	Past and existing trade of this species has shown that it can survive transport as potted plants, seeds and rhizomes. It is likely for the species housing requirements to be catered for by the horticultural trader and subsequently by the gardener.
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	VERY LIKELY	VERY HIGH	Establishment would be aided by the cultivation of adult plants or seed before the start of <i>Gunnera tinctoria</i> 's growing season (March-August/September). Experienced traders and gardeners are likely to transport and plant the species at this time.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	VERY LIKELY	VERY HIGH	The species is intentionally traded for planting in horticultural habitat i.e. gardens or parks, but can spread naturally from where originally planted or from garden discards. Typical habitat where it is known to invade or naturalise include stream and river banks, lake and pond margins, coastal cliffs as well as disturbed areas, such as agricultural land, roadsides, quarries and ditches in Ireland and Great Britain (Gioria and Osborne, 2013). In the São Miguel Island (Azores, Portugal) it is recorded in Laurel forest, Juniper forest, pastures, <i>Holcus</i> meadows, <i>Calluna</i> scrubland, water streams, ravines, ditches and drainage lines, cultivated land and anthropogenous vegetation, urban areas and roadsides (Silva <i>et al.</i> , 2008). The species is likely to encounter such suitable habitats within the Atlantic and Macaronesia biogeographic regions in Europe.
1.09	Estimate the overall likelihood of entry into Europe based on this pathway?	VERY LIKELY	VERY HIGH	<i>Gunnera tinctoria</i> is one of the most popular architectural garden plants, promoted throughout the 1990s for use around ponds and in damp areas (Law, 2003 cited in GISD, 2005). The species has been and continues to be available for import through the horticultural trade. Therefore it is very likely that <i>Gunnera tinctoria</i> will enter into Europe through pathway of horticultural/ornamental trade.

Pathway 1 – Horticultural/ornamental trade				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.10	Do other pathways need to be considered?	NO	HIGH	There are no other documented significant pathways of introduction into Europe.

Overall likelihood				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.11	Estimate the overall likelihood of entry into Europe based on all pathways (comment on the key issues that lead to this conclusion).	VERY LIKELY	VERY HIGH	<p><i>Gunnera tinctoria</i> was historically introduced into Europe for ornamental purposes and there continues to be an active trade in this species both into and within Europe. However the exact extent of the trade into Europe is unknown.</p> <p>Past and existing trade of this species has shown this species can survive transport as potted plants, seeds and rhizomes. It is likely for the species requirements to be catered for by the horticultural trader and subsequently by the gardener.</p> <p>Due to the existing trade of <i>Gunnera tinctoria</i> in Europe, it being awarded the Award of Garden Merit in 2006 by the Royal Horticultural Society in Great Britain, and its use as an architectural/structural species in a garden/park landscape, there remains a societal association to the plant.</p>

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.01	Is the organism well established in Europe (if there is any uncertainty answer 'unsure')	PARTIALLY	HIGH	<p><i>Gunnera tinctoria</i> is well established and naturalized in areas of Ireland, Great Britain and the Azores (Gioria and Osborne, 2013). It also has established sea cliff populations on the Isle of Man (Allen, 1984; Richard Selman, Department of Food, Environment and Agriculture, Isle of Man, pers. comm. 2016) and the Channel Islands (McClintock, 1975; Preston <i>et al.</i>, 2002). It has been recorded as naturalised at one site in Brittany and is in a number of parks and gardens in France (Sheehy Skeffington and Hall, 2011). There is also a transient population in Spain and it is noted as being under eradication (EPPO, 2016). There are a few records for its occurrence in Germany (GBIF, 2016). It is not known to occur in any other European Member state (DAISIE, 2016; EPPO, 2014; GBIF, 2016; Riches, 2008).</p> <p>In Great Britain, 'it occurs predominantly in western coastal regions although records are increasing from central and eastern regions. It is established in England and is considered invasive (sensu Richardson <i>et al.</i>, 2000) in western parts of Cornwall (Pilkington 2011). In Scotland, it is naturalized in the Inner Hebrides and the Isle of Bute. Naturalised or invasive populations are also found where the species is only a recent introduction, such as in the Outer Hebrides, where it was introduced at Urgha about 1992 as an ornamental plant (Gioria and Osborne, 2013). In the Outer Hebrides, it is invasive in parts of North Harris (Cumming, 2015).</p> <p>It was introduced to Guernsey on the Channel Islands in 1851 and has formed naturalised populations there for over a century' (McClintock, 1975). In the Isles of Scilly, the first record of naturalised <i>Gunnera tinctoria</i> was as recent as 1992 (French, 2009). Despite being common in large gardens the species has not yet formed naturalised or invasive populations in Wales (Gioria and Osborne, 2013). On São Miguel Island, <i>Gunnera tinctoria</i>, spread from Furnas gardens was first recorded in the wild in 1964 and considered naturalised by 1968 (Silva <i>et al.</i>, 1996).</p> <p>In Ireland, <i>Gunnera tinctoria</i> displays a pronounced westerly distribution, where it is primarily found close to sea level at low altitudes (<100 m) (Hickey and Osborne, 1998; Gioria and Osborne, 2009). The majority of invasive populations are found in Co. Mayo and Co. Galway. It also occurs on Clare Island, Co. Mayo (Doyle and Foss 1986). Details of a</p>

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				<p>number of Irish records can be found in Reynolds, 2002.</p> <p>By the late 1930's <i>Gunnera tinctoria</i> was naturalised and plentiful on the rough hillsides on the south and north side of Killary Harbour, west Co. Galway and on the south side of Curraun Achill, west Co. Mayo. (Praeger, 1939). Fennel <i>et al.</i> (2014) presents molecular data, combined with known records that indicate persistence of the species for more than 70 years. It is a fairly common escape from cultivation, mainly in the west and south west; found extensively in parts of west Mayo (Achill Island and Curraun), Clare Island and west Galway (Connemara) where it is invasive (Gioria and Osborne 2009; Hickey and Osborne, 1998; Preston <i>et al.</i>, 2002; Sheehy Skeffington and Hall, 2011). It can also be found scattered throughout Ireland (Gioria and Osborne, 2013; Sheehy Skeffington and Hall, 2011) and is listed in twelve vice-counties (Reynolds, 2002). The National Biodiversity Data Centre have 395 records of the species most of which are concentrated in west Galway and Mayo but there are also widespread records throughout the country (National Biodiversity Data Centre, 2016).</p>
2.02	How likely is it that the organism will be able to establish in Europe based on the similarity between <u>climatic conditions</u> in Europe and the organism's current global distribution?	VERY LIKELY	VERY HIGH	<p><i>Gunnera tinctoria</i> has already established in some European Member states (See answer to question 2.01).</p> <p>Its native range encompasses a temperate climatic zone with a predominantly Mediterranean climate and a tropical moist climate sub-zone, where annual rainfall is high (> 2000 mm) and mean annual temperatures are cool (10°C-14°C) (Williams <i>et al.</i>, 2005). Outside of its native range, it occurs where winter temperatures are mild and precipitation and humidity are high (Gioria and Osborne, 2013). These climatic conditions are available in Europe.</p> <p>This range includes climatic conditions highly comparable with Ireland; a temperate oceanic climate which is mild, moist and changeable, with abundant rainfall and lack of temperature extremes (Keane and Collins, 2004). In the west of Ireland, where <i>Gunnera tinctoria</i> is invasive, mean daily temperatures range from 5-7°C (January) to 14.5-15.5°C (July) and year-round rainfall exceeds 1200mm annually (Collins and Cummins, 1996).</p> <p>Establishment may be restricted to areas typically characterised by an annual rainfall > 1100mm, with average winter temperatures ranging from 3 to 6 °C, and average summer temperatures between 12 and 15 °C</p>

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				(Gioria and Osborne, 2013).
2.03	How likely is it that the organism will be able to establish in Europe based on the similarity between other <u>abiotic conditions</u> in Europe and the organism's current global distribution?	VERY LIKELY	HIGH	<p><i>Gunnera tinctoria</i> has already established in some European Member states (See answer to question 2.01) and suitable abiotic conditions are available in Europe.</p> <p>Sheehy Skeffington and Hall, 2011 note that '<i>Gunnera tinctoria</i> is a plant of cool, humid regions. Where it has become extensively naturalised, an oceanic climate prevails with year-round rainfall and a low range of mean monthly temperatures. Where it has become seriously invasive, extreme or hyper-oceanic climates prevail.' Crawford (2000) describes hyper-oceanic regions as having a Conrad index of continentality of mostly less than 3. Using this index (which considers average annual temperature and latitude) and European climate data, a Conrad index of continentality map of Europe is given in Figure 1 of Crawford (2000).</p> <p>Water availability and temperature are the major factors limiting establishment of the species (Osborne and Sprent 2002; Osborne <i>et al.</i>, 1991). It responds strongly to variations in water supply and growth is severely constrained by both reduced and, predominantly at the seedling stage, by excessive water availability (Gioria and Osborne, 2013).</p> <p>Experiments conducted in an experimental garden at the University College Dublin campus, Co. Dublin, where precipitation is 30-100% lower than that experienced in the species invasive range in western Ireland, showed significantly lower biomass production and plants died after 4 years (Campbell, 1994). Four days without water has also been shown to cause permanent wilting and desiccation of <i>Gunnera tinctoria</i> leaves with no sign of recovery of the outer edges of the leaves after re-watering (Hennessy, 2009). Gioria (2007) showed that young seedlings were unable to survive two consecutive days under waterlogged conditions. Adults are rarely found in areas where the entire rhizome is permanently under water, although mature plants are resistant to soil waterlogging (Campbell, 1994).</p> <p>It grows on a range of soil types, but in Ireland is typically found on mineral soils and relatively acidic, wet soils (Gioria and Osborne, 2009, 2013) and is not common on organic/peat substrates.</p>

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				<p>In the Azores, <i>Gunnera tinctoria</i> 'was found in pomitic soils, in gravel, in organic rich soils and in the margins or rooted in water stream beds. <i>Gunnera tinctoria</i> is present in plane areas and highly sloped terrain and was found from 100 to 900 meters of altitude, although 85% of the invaded plots were found above 300 m, and 60% above 500 m.' (Silva <i>et al.</i>, 1996).</p>
2.04	<p>How likely is it that the organism will become established in protected conditions (In which the environment is artificially maintained, such as wildlife parks, glasshouses, aquaculture facilities, terraria, zoological gardens) in Europe? Subnote: gardens are not considered protected conditions</p>	LIKELY	HIGH	<p><i>Gunnera tinctoria</i> is deliberately imported for trade and subsequently sold in Europe as an ornamental plant for planting along artificial watercourses and ponds and this species has already become established under such protected conditions.</p>
2.05	<p>How widespread are habitats or species necessary for survival, development and multiplication of the organism in Europe?</p>	VERY LIKELY	VERY HIGH	<p>The species is likely to encounter suitable habitats within the European landscape as is evidenced in Ireland, Great Britain, Isle of Man, Channel Islands and the Azores but it may be restricted in its ability to survive and multiply by abiotic conditions outside of the Atlantic and Macaronesia biogeographical regions. (Refer to answers to questions: EU Chapeau Q4, Stage 1 Q1.08, 2.02 and 2.03).</p> <p><i>Gunnera tinctoria</i> is commonly associated with a range of ruderal or competitor-ruderal species, including <i>Apium nodiflorum</i>, <i>Galium aparine</i>, <i>Gallium palustre</i>, <i>Persicaria maculosa</i>, <i>Stachys sylvatica</i> and <i>Urtica dioica</i>; and in wet grasslands also <i>Juncus effusus</i> being very common and a range of grasses including <i>Agrostis</i>, <i>Festuca</i>, <i>Holcus</i> etc. In coastal areas it is associated with cliff faces dominated by <i>Armeria maritima</i>, <i>Festuca rubra</i> and <i>Plantago</i> species (Gioria and Osborne, 2010, 2013). Its competitive ability, said to be only realised in wet and/or humid habitats (Campbell, 1994), particularly along water courses, coastal cliffs and in wet meadows, may come from a range of traits including its large stature, perennality, a capacity for fixing nitrogen through a unique intracellular symbiosis with cyanobacteria (Nostoc), high relative growth rates, early season growth, dense leaf canopy, abundant litter and the persistence of its seeds and rhizomes (Gioria and Osborne, 2013). Of these, early growth may be the most important (Bruce Osborne, pers.</p>

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				<p>comm., April, 2016).</p> <p>In Britain and Ireland, <i>Gunnera tinctoria</i> occurs in lowland damp rough grassland, shady areas or nears rivers and lakes (Preston <i>et al.</i>, 2002 cited in Sheehy Skeffington and Hall, 2011). In Connemara in Ireland, where the plant has naturalised in places, it is most closely associated with plant communities of damp and disturbed habitats and in study sites the association of <i>Gunnera tinctoria</i> with ruderals is common (Sheehy Skeffington and Hall, 2011).</p>
2.06	If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in Europe?	N/A		
2.07	How likely is it that establishment will occur despite competition from existing species in Europe?	VERY LIKELY	HIGH	<p><i>Gunnera tinctoria</i> has already established despite competition from existing species in Europe. This is likely due to its early growth characteristics, often 1-3 weeks prior to resident species (Gioria and Osborne, 2015).</p> <p><i>Gunnera tinctoria</i> would be considered competitively superior to existing species although a study reported the displacement of long term <i>Gunnera tinctoria</i> stands by Japanese knotweed (<i>Fallopia japonica</i>) (Gioria <i>et al.</i>, 2011). Any competitive potential of Japanese knotweed over <i>Gunnera tinctoria</i> is of little benefit, as it too is highly invasive.</p>
2.08	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Europe?	VERY LIKELY	VERY HIGH	<p><i>Gunnera tinctoria</i> has already established in parts of Europe.</p> <p>It has no significant predators, parasites or pathogens (Gioria and Osborne, 2013; Sheehy Skeffington and Hall, 2011; Pilkington 2011).</p>
2.09	How likely is it that establishment will occur despite existing management practices in Europe?	VERY LIKELY	HIGH	<p><i>Gunnera tinctoria</i> has established in parts of Europe despite existing management practices.</p> <p>Targeted control/eradication measures are known to have failed (Armstrong, 2008; Sheehy Skeffington and Hall, 2011). There is some evidence that herbicides can be effective in the short term or on young seedlings, but this is likely to have only a temporary effect unless follow-up measures are implemented (Armstrong, 2008).</p>
2.10	How likely is it that management practices in Europe will facilitate the	LIKELY	MEDIUM	Sectoral activities that result in disturbed and/or bare ground, such as housing or road development and abandoned agricultural land are known

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
	establishment of the organism?			<p>to favour establishment of the species (Gioria and Osborne, 2013; Sheehy Skeffington and Hall, 2011). Movement and use of contaminated quarry aggregate has previously facilitated <i>Gunnera tinctoria</i>'s spread and establishment (Sheehy Skeffington and Hall, 2011). In Connemara, it became very widespread around Leenane, following the widening of the road along Killary Harbour (Sheehy Skeffington and Hall, 2011).</p> <p>In Great Britain, it is noted that 'this type of plant is more likely to be dumped in garden waste than uncommon or tame plants' which may result in the plant growing from plant fragments or seeds depending on the time of year (GB Non-Native Species Secretariat, 2015; Reynolds, 2002; Sheehy Skeffington and Hall, 2011).</p>
2.11	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Europe?	LIKELY	MEDIUM	<p><i>Gunnera tinctoria</i>'s ability to reproduce sexually (seed) and asexually (vegetative) may allow it to survive eradication campaigns. The formation of a persistent soil seed bank may also allow the species to survive even longer-term eradication campaigns.</p> <p>Nevertheless, there are control and eradication campaigns that occur with varying degrees of success. Control and eradication measures most often used are physical, physical and chemical, and chemical alone.</p> <p>Physical <i>Hand pulling:</i> preferential methodology for seedlings and young plants and in small invaded areas. As much as possible, it should be guaranteed that there are no rhizomes and/or large rhizome fragments left in the ground because they regenerate very vigorously, diminishing the efficacy of this methodology (Invasive Plants in Portugal, 2016). <i>Physical/mechanical removal:</i> use of sharpened spades and machetes to cut down the plant and then remove rhizomes. Rhizome and seed pods need to be carefully disposed of, the leaves can be left on-site to rot. As this method is very labour intensive and there is a risk of inflicting serious wounds, it should only be chosen for large plants beside particularly vulnerable habitats where herbicides cannot be used. Success is also highly dependent on removal of all rhizomes (Cumming, 2015).</p> <p>Physical + chemical control <i>Stump cut method.</i> The stems should be cut as close to the ground as possible and herbicide applied (active substance: triclopyr, 2,4-D) to the</p>

Stage 2 - Detailed assessment: Section B - Establishment

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				<p>cut surface (Invasive Plants in Portugal, 2016). Cutting the leaves and flower stalks against the rhizomes and then applying 5% glyphosate by hand has been the most effective method for mature plants (GB Non-native Species Secretariat, 2015). Cumming, 2015 notes that stump cutting and chemical application is ideal for use on big plants as they have few stems and the wounds presents a large surface area for treatment, this also reduces cost. There is also a significantly less amount of herbicide required.</p> <p>Chemical control <i>Foliar application of herbicide:</i> For large areas of infestation, foliar spraying may the most suitable control method. Spray with herbicide (active substance: triclopyr, 2,4-D) limiting as much as possible its application to the target species (Invasive Plants in Portugal, 2016). Young plants can be effectively killed with chemical spraying undertaken early in the season using mixtures of glyosphate and metsulfuron methy (GB Non-native Species Secretariat, 2015). In Ireland, 'herbicide is most effective when applied in mid-late summer, when the plant is at its most vigorous. It should take about 3-4 years of annual treatments to clear the worst of the infestation, after which you should perform annual checks to control any new seedling growth.' (O'Riordan, year unknown).</p> <p>Trial experiments in a greenhouse and a large field experiment researching the effectiveness of Cut and Paint the stump with herbicide treatment <i>versus</i> Cut and Inject the stump with herbicide in Ireland, showed that after one year: 96% success for Cut & Paint and 83% success for Cut & Inject. After two years: 61% success for Cut & Paint 75% success for Cut & Inject (Armstrong and Osborne, 2009).</p> <p>Williams <i>et al.</i>, 2005 (cited in Riches, 2008), have observed that leaves of <i>Gunnera tinctoria</i> are browsed by cattle and noted a lack of seedlings in pasture - despite the many large plants adjacent and the consequent seed rain. This suggests that grazing will restrict encroachment in to pastures. However, Sheehy Skeffington and Hall (2011), note that the scattered occurrence of <i>Gunnera tinctoria</i> across fields in closed grassland in Connemara (Ireland) suggests it colonises by seed, taking</p>

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				<p>advantage of bare patches left by cattle.</p> <p>Overall, it is likely that the biological characteristics of <i>Gunnera tinctoria</i> would allow it to survive eradication campaigns as with physical methods, it might survive as it can re-grow from the unavoidable remains of plant fragments and the large amounts of material left to dispose of. All could generate new plants. Chemical control methods for use on mature plants are problematic largely due to the large rhizome, which is particularly resistant to herbicides. Several years of follow-up treatments may be required for effective control. If birds are a significant vector this would also be problematic given the large seed numbers. The persistence of a long-lived seed bank is particularly problematic irrespective of the treatment unless pre-emergence herbicides can be used (Bruce Osborne pers. comm. April, 2016).</p>
2.12	How likely is it that the biological characteristics of the organism will facilitate its establishment?	VERY LIKELY	HIGH	<i>Gunnera tinctoria</i> 's ability to reproduce sexually (seed) and asexually (vegetative) facilitates its establishment. Establishment is also aided by a high germination success and early season growth (Sheehy Skeffington and Hall, 2011). The species can have large and persistent seed banks and recruitment from seeds seems to be important for its initial establishment, while vegetative propagation is the main means of expansion leading to dense clonal stands (Gioria and Osborne, 2013).
2.13	How likely is it that the organism's capacity to spread will facilitate its establishment?	VERY LIKELY	HIGH	<i>Gunnera tinctoria</i> produces large numbers of seeds. Osborne <i>et al.</i> (1991) estimated c. 750,000 seeds per plant in an Irish population. Long-distance seed dispersal, primarily via wind and water, seems to be central to the colonisation of new areas (Gioria and Osborne, 2013). The colonisation of the plant in inaccessible areas along coastal cliffs would suggest the likely involvement of birds in spread of the <i>Gunnera tinctoria</i> . Once established at a new site, vegetative spread and dispersal of plant fragments appear to be the most important factors for the persistence of the species (Gioria and Osborne, 2009, 2013). In existing sites of <i>Gunnera tinctoria</i> spread clonally by a horizontal rhizome system is also important (Gioria and Osborne, 2013).
2.14	How likely is it that the organism's adaptability will facilitate its establishment?	LIKELY	MEDIUM	<i>Gunnera tinctoria</i> has an ability to grow on a range of soil types and this with its ability for Nitrogen fixation could benefit its spread, although it will be constrained by water availability. As it is quite tolerant of salinity, colonization of coastal areas may be significant.

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				In regions where winter temperatures fall below 10°C, including the west of Ireland, the large leaves die back and the plant overwinters as a dominant rhizome (Osborne <i>et al.</i> , 1991). On the Azores leaf die back does not occur (Silva <i>et al.</i> , 1996).
2.15	How likely is it that the organism could establish despite low genetic diversity in the founder population?	LIKELY	MEDIUM	Molecular analyses showed that genetic differentiation from an assumed founding population in Ireland had occurred relatively rapidly and within a small geographic area, proving evidence for significant sexual reproduction (Fennell <i>et al.</i> , 2010). Presumably genetic diversity is enhanced through the exchange of pollen between distinct and separately introduced populations/individuals.
2.16	Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in Europe? If possible, specify the instances of invasion elsewhere in the justification box.	VERY LIKELY	VERY HIGH	It has already demonstrated this capacity in many European countries.
2.17	If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared terrapin, a species which cannot reproduce in GB but is established because of continual release, is an example of a transient species.	N/A	N/A	Not applicable. The species is already established in Europe.
2.18	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	VERY LIKELY	VERY HIGH	<i>Gunnera tinctoria</i> has already become established in many European Member states and is invasive in parts of Ireland, Scotland, England and Portugal (São Miguel island, the Azores). The species' contrasting phenology (early growth) and associated competitive superiority and reproductive traits, in addition to human activities that facilitate dispersal, aid in its establishment. <i>Gunnera tinctoria</i> 's ability to reproduce sexually (seed) and asexually (vegetative) may allow it to survive eradication campaigns. The formation of a persistence soil seed bank may also allow the species to survive even longer-term eradication campaigns.

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Europe. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.01	How important is the expected spread of this organism in Europe by <u>natural</u> means (minimal, minor, moderate, major or massive)? (Please list and comment on the mechanisms for natural spread.)	MODERATE	MEDIUM	<i>Gunnera tinctoria</i> produces large numbers of seeds which are dispersed by wind, water and birds; it also spreads clonally, by a horizontal rhizome system (Gioria and Osborne, 2013; Riches, 2008; Silva <i>et al.</i> , 1996; Silva <i>et al.</i> , 2008). Long-distance seed dispersal seems to be central to the colonisation of new areas (Fennell <i>et al.</i> , 2013; Gioria and Osborne, 2013).
3.02	How important is the expected spread of this organism in Europe by <u>human assistance</u> (minimal, minor, moderate, major or massive)? (Please list and comment on the mechanisms for human assisted spread.)	MODERATE	HIGH	Dispersal of the species is strongly associated with human activities. Vehicular traffic and disposal of contaminated soil play a major role in propagule spread (Gioria and Osborne, 2013). Sheehy Skeffington and Hall (2011), note that the species occurrence in Connemara National Park is most likely due to the use of gravel in the park from a nearby quarry, where the species contaminates aggregate. They also associate the spread of the species on roadsides in the area as a result of use of contaminated aggregate from the quarry. The species is also known to be discarded from gardens (Refer to question 2.10). 'G. tinctoria still has a limited distribution in the EPPO region as it is so far only present in 4 countries, and voluntary introduction for ornamental use and the consequent escape of the plant to unintended habitats remains superior to natural spread' (EPPO, 2014).
3.03	Within Europe, how difficult would it be to contain the organism (very easy, easy, with some difficulty, difficult, very difficult)?	DIFFICULT	HIGH	Due to the species being able to reproduce by both seed and rhizome and by current experiences with attempts to control the species, where the species establishes and has a seed bank, it would be difficult to contain the species. The species may also be further dispersed through natural and human aided means. The level of infestation and site conditions (access, near a watercourse etc.) would all influence the ability to contain it. It is targeted for eradication on Clare Island (Marchant, 2008), where it has been present since the 1980's (Doyle and Foss, 1986). It is targeted for eradication in Leenane, Connemara, since summer 2008 (Marchant, 2008). While control/eradication measures are known to have failed (Sheehy Skeffington and Hall, 2011), new methods and best approaches are being researched and refined all the time which may decrease the difficulty in containing the species in sites under control.

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Europe. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.04	What proportion (%) of the area/habitat in Europe suitable for establishment, if any, has already been colonised by the organism?	0-10%	HIGH	<p>The area suitable for establishment in Europe include the typical habitats it has been recorded in including: stream and river banks, lake and pond margins, coastal cliffs, as well as disturbed areas, such as roadsides, quarries and ditches, on moist loamy to sandy soils (Q-bank, 2016) and that are in the Atlantic and Macaronesia biogeographical regions.</p> <p>The climatic and abiotic factors conducive to establishment of the species such as moderate temperature, high rainfall or high humidity are also available within those regions (see answers to questions 2.02 & 2.03).</p> <p>The species is currently established in western areas of Ireland, western areas of Great Britain, the Azores (São Miguel), Isle of Man and France.</p>
3.05	What proportion of the area in Europe suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)? (0-10, 11-33, 34-67, 68-90, 91-100)	11-33%	MEDIUM	<p>While the Atlantic and Macaronesia biogeographical regions are most suited to support establishment of this species in Europe, where <i>Gunnera tinctoria</i> has become invasive, hyper-oceanic climates prevail (Sheehy Skeffington and Hall, 2011; Osborne <i>et al.</i>, 1991) thus the invasive potential of this species may be restricted to these areas.</p> <p>These hyper-oceanic regions could be crudely described as: the north-west of the Iberian peninsula (both Portugal and Spain), coastline of Ireland, north and north-west of Scotland, south-west tip of England, small area of north-west France and the Azores (See Figure 1 in Crawford, 2000; Skeffington and Hall, 2011).</p> <p>The number of hectads and records for this species in Great Britain and Ireland are far greater in recent decades suggesting that the species may be going through an exponential expansion phase after a long lag phase. Consideration however must also be given to the possibility that the species distribution was previously under-recorded (Gioria and Osborne, 2013; GB Non-native Species Secretariat, 2015).</p> <p>The species has the potential to expand its western range in Ireland in the next five years (Fennell <i>et al.</i>, 2013; Sheehy Skeffington and Hall, 2011).</p>
3.06	What other timeframe would be appropriate to estimate any significant further spread of the organism (10, 20, 40, 80 or 160 years)? Please comment	80 years	HIGH	<p>For those areas where the species is already recorded and which are climatically suitable with suitable habitats, they are at risk of invasion expansion and further spread of the species to new sites in the next 80 years.</p>

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Europe. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
	on why this timeframe is chosen.			<p>In Donegal, Ireland, it occurs in several large patches along the coast and may be at the point of invasion (Sheehy Skeffington and Hall, 2011).</p> <p>Modelling results of Fennell <i>et al.</i>, 2013, suggest that the areas occupied by this species in Ireland (could be representative of suitable areas elsewhere) could increase by 3-fold by 2100 in the absence of climate change. In the presence of climate change the figure could be 6-fold. For the number of individuals the figures could be a 5-fold increase in the absence of climate change and over 17-fold with climate change. This also indicates another important point that intensification of the invasion in areas already invaded as number of individuals increasing is greater than the number of localities. Management therefore becomes more difficult in existing areas.</p> <p>Despite many efforts at control/eradication programmes, most have failed (Sheehy Skeffington and Hall, 2011). Even if existing efforts to control the species are both sustained and expanded along with continued efforts to ascertain the most effective control/eradication methods, it is unlikely to significantly reduce further spread of the species. However, if control and eradication measures of existing populations combined with biosecurity measures (such as not using aggregate from infested quarries on road building or inappropriately discarding un-wanted <i>Gunnera tinctoria</i> plants) and trade restrictions on sale and import are implemented, then significant further spread would be reduced.</p>
3.07	In this timeframe, what proportion of the endangered area (including any currently occupied areas) is likely to have been invaded by this organism?	11-33%	LOW	The proportion of the area that may be invaded in the next 80 years may be in the upper end of the 11% to 33% range. Without more detailed regional data on the potential of the species to become invasive in the receiving environment (as noted in answer to question 3.05), the proportion of the endangered area is difficult to predict.
3.08	Based on the answers to questions on the potential for establishment and spread in Europe, define the area endangered by the organism	Belgium, Denmark, France, Germany, Ireland, Netherlands, Portugal, Spain and the United Kingdom.	MEDIUM	<p>These are countries that have territory completely or partially within the Atlantic or Macaronesia biogeographic regions. <i>Gunnera tinctoria</i> is a plant of cool, humid regions (Sheehy Skeffington and Hall, 2011) therefore persistent establishment in some of these EU Member States may be limited by dry summers and severe winters.</p> <p>The area suitable for establishment in Europe include the typical habitats it has been recorded in including: stream and river banks, lake and pond</p>

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Europe. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				<p>margins, coastal cliffs, as well as disturbed areas, such as roadsides, quarries and ditches, on moist loamy to sandy soils (Q-bank, 2016) and that are in the Atlantic and Macaronesia biogeographic regions. There are also suitable climatic and abiotic factors conducive to establishment of the species of the area (see answers to questions 2.02 & 2.03). The species has a tendency to become invasive in abandoned fields, where sheep and cattle have been removed, on waste ground along roadways and drainage ditches and also at sites associated with construction such as new houses and quarries (Fennell <i>et al.</i>, 2013;; Gioria and Osborne, 2013; Sheehy Skeffington and Hall, 2011).</p> <p>However, while the Atlantic and Macaronesia biogeographical regions are most suited to support <u>establishment</u> of this species in Europe, where <i>Gunnera tinctoria</i> has become <u>invasive</u>, hyper-oceanic climates prevail (Sheehy Skeffington and Hall, 2011; Osborne <i>et al.</i>, 1991) thus the invasive potential of this species may be restricted to these areas. These hyper-oceanic regions could be crudely described as: the north-west of the Iberian peninsula (both Portugal and Spain), coastline of Ireland, north and north-west of Scotland, south-west tip of England, a small area of north-west France and the Azores (Sheehy Skeffington and Hall, 2011).</p>
3.09	Estimate the overall potential for future spread for this organism in Europe (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues.	MODERATELY	MEDIUM	<p><i>Gunnera tinctoria</i> produces large numbers of seeds, which are dispersed by wind, water and birds; it also spreads clonally, by a horizontal rhizome system (Gioria and Osborne, 2013). Long-distance seed dispersal seems to be central to the colonisation of new areas (Gioria and Osborne, 2013). Dispersal of the species is strongly associated with human activities. It is targeted for eradication but such control measures are known to have failed (Sheehy Skeffington and Hall, 2011). The species has the potential to expand its invasive range.</p>

Stage 2 - Detailed assessment: Section D - Impact

This section evaluates the probability of impact of an organism within Europe.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.01	How great is the economic loss caused by the organism within its global	MAJOR	MEDIUM	There is a paucity of information available on the economic loss caused by <i>Gunnera tinctoria</i> within its global distribution.

Stage 2 - Detailed assessment: Section D - Impact

This section evaluates the probability of impact of an organism within Europe.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
	distribution, <u>including</u> the cost of any current management?			<p><i>Gunnera tinctoria</i> is an environmental weed so its economic impact is largely through the cost of control measures rather than a reduction of agricultural or forest productivity. However there are sites in Ireland where the species has invaded native species-rich grassland, (Hickey and Osborne, 1998) which reduces the value of the land for grazing (Riches, 2008).</p> <p>In New Zealand, <i>Gunnera tinctoria</i> often persists on sites that are very steep or inaccessible, making control of the weed near-impossible and costly (Williams <i>et al.</i>, 2005).</p> <p>There are however some documented costs associated with management of the species. For pilot control studies in 2015 on the Isle of Harris in Scotland, £2,007.93 sterling was the total amount spent with highest costs for herbicide approximately £500 and employment of a spraying contractor £1,200. There were 20 man/days spent spraying, 8 days on stump treatment and 39 days on physical removal. It was a combination of paid and volunteer work. These resources were used to treat 10 sites, 8 of which were small satellite populations and 2 were core populations. Percent of plants treated varied from 40% to 100% for the satellite sites and 10% and 20% for the core populations (Cumming, 2015).</p> <p>In Ireland, the development of measures for control of the species has so far an indicative cost ~€32,000. The 2009 control <i>Gunnera tinctoria</i> in Leenane, Co. Galway, and the eradication efforts of <i>Gunnera tinctoria</i> from Clare and on the sea cliffs of Achill Island in Co. Mayo, have cost ~€3,500 and €21,000, respectively (Kelly <i>et al.</i>, 2013).</p> <p>The above examples represent the economic costs of managing the species for few sites over a short-term period. Additional money will have been spent on these sites for <i>Gunnera tinctoria</i> control and many other sites in its invaded and established regions.</p> <p>Additional cost of impact due to loss of land for agricultural use, activities to combat increased soil erosion, erosion along watercourses and coastal areas and blocked drainage leading to potential for enhancing flooding risk (Gioria and Osborne, 2013; Invasoras.pt, 2014; Q-bank, 2016;</p>

Stage 2 - Detailed assessment: Section D - Impact				
<i>This section evaluates the probability of impact of an organism within Europe.</i>				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				Sheehy Skeffington and Hall, 2011) should also be considered. There is however, a lack of information on the extent and economic cost of such impacts therefore a response of MAJOR is given based on £1million to £10million per year per year cost category in the classification provided in the 'Impact Assessment Guidance' from UK (GB Non-native Species Secretariat, 2016).
4.02	How great has the economic cost of the organism <u>currently</u> in Europe <u>excluding</u> any costs associated with managing the organism from your answer (include any past costs in your response)?	MINOR	LOW	There is a paucity of documented information available on the economic loss caused by <i>Gunnera tinctoria</i> in Europe excluding costs associated with management. It is on this basis that a response of MINOR is given but with a LOW level of confidence.
4.03	How great is the economic cost of the organism likely to be in the <u>future</u> in Europe? <u>Exclude</u> any costs associated with managing the organism from your answer.	MAJOR	LOW	Cost of impact due to loss of land for agricultural use, activities to combat increased soil erosion, erosion along watercourses and coastal areas, and, blocked drainage leading to potential for enhancing flooding risk (Gioria and Osborne, 2013; Invasoras.pt, 2014; Q-bank, 2016; Sheehy Skeffington and Hall, 2011) is likely to continue into the future where the species invades. However, there is a paucity of information on the extent and monetary cost for these impacts. Therefore a low level of confidence is given on the response of MAJOR.
4.04	How great are the economic costs of managing this organism <u>currently</u> in Europe?	MODERATE	LOW	There is a lack of information on the economic costs of managing this species in Europe. However, by extrapolating from the known cost examples given in answer to question 4.01 and the known areas where the species is invasive and is under control programmes, a response of MODERATE is given based on £100,000 to £1million per year cost category in the classification provided in the 'Impact Assessment Guidance' from UK (GB Non-native Species Secretariat, 2016). It is likely to be in the lower end of this range.
4.05	How great is the economic costs of managing this organism likely to be in the <u>future</u> in Europe?	MAJOR	LOW	Given the active trade pathway, the ability for the plant to establish and further establish in suitable regions in Europe and given that effective control/eradication programmes have varied levels of success and tend to need longer-term commitment, a response of MODERATE is given but with a low level of confidence. It is likely to be in the lower end of the £1million to £10million per year cost category in the classification provided in the 'Impact Assessment Guidance' from UK (GB Non-native Species Secretariat, 2016).
4.06	How important is environmental harm caused by the organism within its global distribution <u>excluding Europe</u> ?	MAJOR	MEDIUM	In New Zealand, the ecological impacts are particularly severe 'where it has formed dense stands in Egmont Ecological District, displacing native plants. Of most concern are the coastal cliffs that have become increasingly important for plant conservation as native biota

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				<p>in the surrounding landscape are depleted' (Williams <i>et al.</i>, 2005). Soil erosion may also occur in coastal areas and cliffs and along the banks of rivers and streams, where it can create large areas of exposed ground due to increasing instability (Gioria, 2007; Williams <i>et al.</i>, 2005).</p> <p>The species is currently restricted to coastal counties of California, USA (Riches, 2008). Riches (2008) also notes that the position in Australia is less clear with conflicting reports of its level of establishment and invasive status in New South Wales.</p>
4.07	How important is the impact of the organism on biodiversity (e.g. decline in native species, changes in community structure, hybridisation) currently in Europe (include any past impact in your response)?	MAJOR	MEDIUM	<p>Due to its large size and early growth shading, it significantly reduces the number of native species in colonised areas with the negative impacts of <i>Gunnera</i> species on plant diversity are well documented (Gioria and Osborne 2008, 2009, 2010).</p> <p>The most ecologically valuable communities invaded by <i>Gunnera tinctoria</i> in Ireland are those similar to species-rich <i>Salix cinerea-Galium palustre</i> woodlands, leading to the replacement of <i>Salix cinerea</i> and altering natural successional processes (Gioria and Osborne, 2013; Hickey and Osborne, 2001). The colonisation of coastal cliffs is also likely to degrade such habitats and impact on associated species.</p> <p>In São Miguel (the Azores), invasion of <i>Gunnera tinctoria</i> impacts on habitats by changes in the vegetation structure, in the abundance of native endemic species and on the natural succession of native vegetation. Affected habitats are: Laurel forest, Juniper forest, pastures, <i>Holcus</i> meadows, <i>Calluna</i> scrubland, water streams, ravines, ditches and drainage lines, cultivated land and anthropogenous vegetation, urban areas and roadsides. It also impacts on species through competition for space and resources and it impedes or reduces the recruitment/regeneration of endemic or native species. The affected species are: Endemics – <i>Erica azorica</i> and <i>Holcus rigidus</i>. Annex II species under the Habitats Directive – <i>Prunus azorica</i>, <i>Frangula azorica</i>, <i>Rumex azoricus</i>, <i>Lactuca watsoniana</i>, <i>Culcita macrocarpa</i> and <i>Woodwardia radicans</i>. Endangered or priority species are: <i>Juniperus brevifolia</i>, <i>Laurus azorica</i>, <i>Prunus azorica</i>, <i>Ilex perado</i> subsp. <i>azorica</i>, <i>Frangula azorica</i>, <i>Rumex azoricus</i>, <i>Vaccinium cylindraceum</i>, <i>Lactuca watsoniana</i>, <i>Angelica lignescens</i>, <i>Platanthera azorica</i>, <i>Leontodon filii</i>, <i>Viburnum treleasei</i>. Ameaçadas <i>Platanthera micrantha</i>, <i>Tolpis azorica</i>, <i>Elaphoglossum semicylindricum</i>, <i>Leontodon rigens</i>, <i>Deschampsia foliosa</i>.</p>

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				<p><i>Dryopteris</i> spp., <i>Lycopodiella inundata</i> and <i>Lycopodiella cernua</i> (Silva <i>et al.</i>, 2008).</p> <p>In Great Britain, the impact of <i>Gunnera</i> species is primarily exclusion of native flora by shading (GB Non-native Species Secretariat, 2015; Scottish Natural Heritage, in prep.).</p>
4.08	How important is the impact of the organism on biodiversity likely to be in the <u>future</u> in Europe?	MAJOR	MEDIUM	<p>Gioria and Osborne (2009, 2010) report the capacity for <i>Gunnera tinctoria</i> to alter the soil seed bank of resident communities significantly, highlighting the tendency for the species to homogenise the seed flora by reducing the diversity of the resident seed bank and increasing the abundance of weed and rush seeds. These effects were also evident in deep soil layers, indicating that invasion by <i>Gunnera tinctoria</i> can alter the transient and the more persistent component of the seed bank, with potential long-term implications on the composition of the native vegetation. The modelling study in Gioria and Osborne, 2010 indicates a greater impact in the future.</p> <p>It is highly likely that similar impacts to those already experienced in invaded sites in Europe (See Q 4.08) and as those modelled, would be expected to occur in areas suitable for establishment and invasion in Europe. Of particular concern would be if the species spread/introduced to suitable sites of high conservation value such as existing NATURA 2000 sites like Connemara, Glenveagh and Killarney National Parks in Ireland.</p>
4.09	How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism in Europe from the time of introduction to the present?	MODERATE	LOW	<p>There are significant increases in above- and below-ground biomass associated with <i>Gunnera tinctoria</i> invasions, which is likely to but largely assumed to result in alterations in the quantity and quality of litter. Changes in water and biogeochemical cycles including the diversion of water in drainage channels (Hickey and Osborne, 1998; Gioria, 2007) can block drain and streams (J. Macfarlane, Cornwall County Council pers. comm. In GB Non-native Species Secretariat, 2015) and consequently enhance flooding (Invasoras.pt, 2014).</p> <p>Cliff erosion has been noted also, which could lead to significant impacts B. Osborne (pers. comm. 4th of December, 2014).</p> <p>There are major ecosystem service losses resulting from the impacts noted in Qs 4.07, 4.08 and 4.09, these are Regulation and Maintenance services including: Maintenance of</p>

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				physical, chemical, biological conditions - Lifecycle maintenance, habitat and gene pool protection; soil formation and composition. Mediation of flows: Liquid flows. Due to extensive dominant coverage in agricultural areas. There is also a loss of Provisioning services (Ecosystem service terminology following CICES v4.3, Haines-Young, R. and Potschin, M. (2013))
4.10	How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism likely to be in Europe in the <u>future</u> ?	MAJOR	MEDIUM	The impact on biodiversity, ecosystem function and losses to ecosystem services noted in Qs 4.07. 4.08, 4.09 could be major into the future in areas where it has already established and has the capacity to establish and invade. These are likely to be the hyper-oceanic regions (See: answer to question 3.08). It is worth noting that some large areas where <i>Gunnera tinctoria</i> has invaded is on past agricultural land and that the biodiversity loss in those habitats would be less than on coastal cliffs where the significance of the loss may be greater.
4.11	How important has decline in conservation status (e.g. sites of nature conservation value, WFD classification, etc.) caused by the organism been in Europe from the time of introduction to the present?	MODERATE	LOW	There has been no documented decline in conservation status caused by <i>Gunnera tinctoria</i> to date. However, Silva <i>et al.</i> , 1996 notes that ' <i>Gunnera tinctoria</i> invaded biotopes with high conservation value in São Miguel island'. As there is a paucity of information on this, a confidence level of LOW is given.
4.12	How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism likely to be in the <u>future</u> in Europe?	MAJOR	LOW	Potential establishment and spread of the species could have a MAJOR impact to the conservation status of protected areas in Europe that fall within the hyper-oceanic regions and have suitable habitats and abiotic conditions. As there is a paucity of information on this, a confidence level of LOW is given.
4.13	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within its global distribution?	MINOR	MEDIUM	There is very little documented on social or human health harm for <i>Gunnera tinctoria</i> . However, Cumming (2015) note that by engaging in physical removal of <i>Gunnera tinctoria</i> mature plants, there is 'the risk of inflicting serious wounds whilst using sharp hand tools'. Within the symbiotic tissues of <i>Gunnera tinctoria</i> the production of the cyanobacterial toxin β -N-Methyl amino-L-alanine (BMAA) has been reported to increase. BMAA may be linked to the myotrophic lateral sclerosis/Parkinsonism-dementia complex, suggesting that <i>Gunnera</i> invasion may have the potential to impact on human health (Gioria and

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				Osborne, 2013).
4.14	How important is it that genetic traits of the organism could be carried to other organisms/species, modifying their genetic nature and making their economic, environmental or social effects more serious?	UNLIKELY	LOW	There are no records of <i>Gunnera tinctoria</i> forming viable hybrids (Gioria and Osborne, 2013) and no evidence of hybridity has been observed so far [in Connemara, Ireland at least] (Sheehy Skeffington and Hall 2011)). Also, in the 2015 <i>Hybrid Flora of the British Isles</i> (Stace et al., 2015) <i>Gunnera</i> is not mentioned. However, the taxonomy of this species and the related <i>Gunnera manicata</i> is somewhat unclear. The inflorescences are typically rather open in <i>Gunnera manicata</i> and closed in <i>Gunnera tinctoria</i> (club-like) but these visual differences between the two species may be much smaller than often thought. Although it cannot be verified at this time, there may be any intermediate form i.e. both types of inflorescences have been noted on the same plant (Bruce Osborne, pers. comm., 19 th March 2014). Due to the uncertainty of hybridization occurring a low level of confidence in the 'unlikely' response is given.
4.15	How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	MINOR	MEDIUM	There is no known significant importance of <i>Gunnera tinctoria</i> as a food, a host, a symbiont or a vector for other damaging organisms.
4.16	How important might other impacts not already covered by previous questions be resulting from introduction of the organism? Specify in the justification box.	MINOR	LOW	The ability to 'fix' atmospheric nitrogen could potentially lead to soil nitrogen enrichment/increased N in water supplies but this has not been quantified. If true, this could have knock-on effects on species distributions for example. The high biomass could also result in higher soil Carbon concentrations that could impact on the soil biota (Bruce Osborne, pers. comm., April 2016). As these impacts have not been quantified, a low level of confidence in the response of minor is given.
4.17	How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in Europe?	MAJOR	MEDIUM	It has no significant predators, parasites or pathogens (Gioria and Osborne, 2013; Pilkington, 2011; Sheehy Skeffington and Hall, 2011)
4.18	Indicate any parts of Europe where economic, environmental and social impacts are particularly likely to occur. (Provide as much detail as possible)	-	MEDIUM	The hyper-oceanic areas in Ireland, Great Britain, the Azores and regions of mainland Portugal, Spain and France where the species is already established and where future expansion and intentional introduction of the species is most likely, will primarily incur the larger economic,

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				environmental and social impacts.
4.19	Estimate the <u>overall</u> potential impact of this organism in Europe. Use the justification box to indicate any key issues.	MODERTE	MEDIUM	<p>The most significant impacts of <i>Gunnera tinctoria</i> are on biodiversity. Due to its large size and early growth shading, it significantly reduces the number of native species in colonised areas and impacts on habitats by changes in the vegetation structure, and on the natural succession of native vegetation. The capacity for <i>Gunnera tinctoria</i> to alter the soil seed bank of resident communities significantly, indicate that invasion by <i>Gunnera tinctoria</i> can alter the transient and the more persistent component of the seed bank, with potential long-term implications on the composition of the native vegetation.</p> <p>With the exception of the São Miguel in the Azores, to date the sites of invasion tend to be species poor communities. However, there are few detailed studies on this and further investigation on the extent and scale of the impacts, especially on damp-wet heath habitats and coastal habitats and species would be desirable.</p> <p>Modelling results of Fennell <i>et al.</i>, (2013) suggest that the areas occupied by this species in Ireland could increase by 3-fold by 2100 in the absence of climate change. In the presence of climate change the figure could be 6-fold. For the number of individuals in infested areas, the figures could be a 5-fold increase in the absence of climate change and over a 17-fold increase with climate change. This also indicates another important point that intensification of the invasion in areas already invaded as the number of individuals' increases, is greater than the number of localities. Management therefore becomes more difficult in existing areas.</p> <p>It is highly likely that similar impacts to those already experienced in invaded sites in Europe and as those modelled, would be expected to occur in areas suitable for establishment and invasion in Europe.</p> <p>Existing and future projected costs are estimated to be major but these costs are associated with cost of control/eradication. There is likely to be a moderate level of impact to ecosystem functioning and services (and associated costs) such as changes in water and biogeochemical cycles; increased erosion along watercourses and coastal areas; loss of land for agricultural use and, cost of action taken to combat soil and blocked drainage which could lead to potential for enhanced flooding, but this requires further research.</p>

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				Further establishment and spread of the species could have a moderate impact on areas in Europe that fall within the hyper-oceanic regions and have suitable habitats and abiotic conditions. The hyper-oceanic areas in Ireland, Great Britain, the Azores and regions of mainland Portugal, Spain and France where the species is already established and where future expansion and intentional introduction of the species is most likely, will primarily incur the larger economic, environmental and social impacts.

Section E – Risk summaries and conclusion			
<i>This section requires the assessor to provide a score for the overall risk posed by an organism, taking into account previous answers to entry, establishment, spread and impact questions.</i>			
	RESPONSE	CONFIDENCE	COMMENT
Summarise Entry	VERY LIKELY	VERY HIGH	<p><i>Gunnera tinctoria</i> was historically introduced into Europe for ornamental purposes and there continues to be an active trade in this species both into and within Europe. However the exact extent of the trade into Europe is unknown.</p> <p>Past and existing trade of this species has shown this species can survive transport as potted plants, seeds and rhizomes. It is likely for the species requirements to be catered for by the horticultural trader and subsequently by the gardener.</p> <p>Due to the existing trade of <i>Gunnera tinctoria</i> in Europe, it being awarded the Award of Garden Merit in 2006 by the Royal Horticultural Society in Great Britain, and its use as an architectural species in a garden/park landscape, there remains a societal association to the plant. Therefore, it is very likely that <i>Gunnera tinctoria</i> will continue to enter into Europe through the pathway for horticultural/ornamental trade.</p>
Summarise Establishment	VERY LIKELY	VERY HIGH	<i>Gunnera tinctoria</i> has already become established in several European Member states and is invasive in parts of Ireland, United Kingdom and Portugal (São Miguel island, the Azores).

			<p>The species' early growth and associated competitive superiority and reproductive traits, in addition to human activities that facilitate dispersal, aid in its establishment.</p> <p><i>Gunnera tinctoria</i>'s ability to reproduce sexually (seed) and asexually (vegetative) may allow it to survive eradication campaigns. The formation of a persistent soil seed bank may also allow the species to survive even longer-term eradication campaigns.</p>
Summarise Spread	MODERATE	MEDIUM	<p>While <i>Gunnera tinctoria</i> can spread by natural means such as seed dispersal and rhizome spread, human aided spread is likely to be a more significant factor in <i>Gunnera tinctoria</i> extending its range. Those areas where the species is already recorded and which are climatically suitable and with suitable habitats, are at risk of invasion expansion and further spread of the species to new sites in the next 80 years.</p> <p>Modelling results of Fennell <i>et al.</i> (2013) suggest that the areas occupied by this species in Ireland (and this could be representative of suitable areas elsewhere) could increase by 3-fold by 2100 in the absence of climate change. In the presence of climate change the figure could be 6-fold. For the number of individuals in invaded sites the figures could be a 5-fold increase in the absence of climate change and an over 17-fold increase with climate change.</p> <p>Even if existing efforts to control the species are both sustained and expanded along with continued efforts to ascertain the most effective control/eradication methods, it is unlikely to significantly reduce further spread of the species. However, if control and eradication measures of existing populations combined with biosecurity measures (such as not using aggregate from infested quarries on road building or inappropriately discarding un-wanted <i>Gunnera tinctoria</i> plants) and trade restrictions on sale and import are implemented, then significant further spread would be reduced.</p> <p>While the Atlantic and Macaronesia biogeographical regions are most suited to support establishment of this species in Europe, where <i>Gunnera tinctoria</i> has become invasive, hyper-oceanic climates prevail (Sheehy Skeffington and Hall, 2011; Osborne <i>et al.</i>, 1991). Thus, the invasive potential of this species may be restricted to these areas. These hyper-oceanic regions could be crudely described as: the north-west of the Iberian peninsula (both Portugal and Spain), coastline of Ireland, north and north-west of Scotland, south-west tip of England, a small area of north-west France and the Azores (Sheehy Skeffington and Hall, 2011).</p>
Summarise Impact	MODERATE	MEDIUM	<p>The most significant impacts of <i>Gunnera tinctoria</i> are on biodiversity. Due to its large size and early growth shading, it significantly reduces the number of native species in colonised areas and impacts on habitats by changes in the vegetation structure, and on the natural succession of native vegetation. The capacity for <i>Gunnera tinctoria</i> to alter the soil seed bank of resident communities significantly, indicate that invasion by <i>Gunnera tinctoria</i> can alter the transient and the more persistent component of the seed bank, with potential long-term implications on the composition of the native vegetation.</p>

			<p>With the exception of São Miguel Island in the Azores, to date the sites of invasion tend to be species poor communities. However, there a few detailed studies on this and further investigation on the extent and scale of the impacts, especially on habitats and species of conservation significance would be desirable.</p> <p>Modelling results of Fennell <i>et al.</i> (2013) suggest that the areas occupied by this species in Ireland could increase by 3-fold by 2100 in the absence of climate change. In the presence of climate change the figure could be 6-fold. For the number of individuals in invaded sites, the figures could be a 5-fold increase in the absence of climate change and over 17-fold increase with climate change.</p> <p>It is highly likely that similar impacts to those already experienced in invaded sites in Europe and as those modelled, would be expected to occur in areas suitable for establishment and invasion in Europe.</p> <p>Existing and future projected costs are estimated to be major but these costs are associated with cost of control/eradication. There is likely to be a moderate level of impact to ecosystem functioning and services (and associated costs) such as changes in water and biogeochemical cycles; increased erosion along watercourses and coastal areas; loss of land for agricultural use and, cost of action taken to combat soil and blocked drainage which could lead to potential for enhanced flooding, but this requires further research.</p> <p>Further establishment and spread of the species could have a moderate impact on areas in Europe that fall within the hyper-oceanic regions and have suitable habitats and abiotic conditions. The hyper-oceanic areas of Europe where the species is already established and where future expansion and intentional introduction of the species is most likely, will primarily incur the larger economic, environmental and social impacts.</p>
<p>Conclusion of the risk assessment</p>	<p>MODERATE</p>	<p>MEDIUM</p>	<p>While <i>Gunnera tinctoria</i> has a major impact on sites where it has invaded and such invasion is likely to intensify and spread in the future, to date, the sites of invasion tend to be species poor communities with the exception of São Miguel Island in the Azores. Therefore, the overall conclusion is that <i>Gunnera tinctoria</i> poses as a MODERATE risk to Member states that have territory with a hyper-oceanic climate.</p> <p>However, as there are few detailed studies on impacted sites, further investigation on the extent and scale of impacts on habitats and species of conservation significance would be desirable and may increase the level of risk. In the absence of this information, a MEDIUM level of confidence is given for the overall conclusion.</p> <p>While ecosystem function and service impacts have been noted, there is a lack of information on the extent and scale of the impacts.</p> <p><i>Gunnera tinctoria</i> has been and continues to be traded into and within Europe for use as an ornamental plant and is spread by both natural and human-aided dispersal with</p>

			<p>human-aided dispersal a more significant factor in it extending its range. Once established, it can be very difficult to eradicate. Therefore, if control/eradication measures of existing populations combined with biosecurity measures and trade restrictions on sale and import are implemented, significant further introductions and spread would be reduced.</p> <p>The inadvertent trade of <i>Gunnera tinctoria</i> as a result of mistaken identification with <i>Gunnera manicata</i> may also need to be considered as the two species are difficult to tell apart. This is of particular concern when seed is being traded.</p>
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Stage 2 - Detailed assessment: Section F – Additional questions				
<i>This section is used to gather information about the potential effects of climate change on the risk posed by an organism. It is also an opportunity for the risk assessor to highlight high priority research that could help improve the risk assessment.</i>				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
6.01	What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	Increase in oceanic climate	LOW	<p>Predictions for climate change in north-western Europe suggest an overall increase in oceanicity (Crawford, 2000) which could further increase the suitability of the range area where <i>Gunnera tinctoria</i> could become establish and/or become invasive.</p> <p>Expansion of its range could be favoured by projected increases in winter rainfall and summer temperatures (Gioria and Osborne 2009). Modelling projections of Fennell <i>et al.</i> (2013) indicate that habitat availability may have a greater impact on spread than climate change. However, habitat availability will also be influenced by climate change and impact on spread indirectly.</p> <p>Modelling results of Fennell <i>et al.</i>, 2013, suggest that the areas occupied by this species in Ireland (could be representative of suitable areas elsewhere) could increase by 3-fold by 2100 in the absence of climate change. In the presence of climate change the figure could be 6-fold. For the number of individuals the figures could be 5-fold in the absence of climate change and over 17-fold with climate change. This also indicates another important point that intensification of the invasion in areas already invaded as number of individuals increasing is greater than the</p>

Stage 2 - Detailed assessment: Section F – Additional questions

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				<p>number of localities. Management therefore becomes more difficult in existing areas.</p> <p>Extreme weather events are also associated features of climate change in Europe. One such extreme weather event in Ireland was the exceptionally severe winter of 2009/2010, when such freezing temperatures had not been experienced since 1986. Sheehy Skeffington and Hall (2011) found that the severe frosts of 2009/2010 kept the invasive population of <i>Gunnera tinctoria</i> in north west Connemara in check and noted that if these cease to occur regularly <i>Gunnera tinctoria</i> is likely to increase in its range.</p> <p>A confidence level of LOW is given as how climate change predictions will affect species responses in the future can be difficult to be confident about, particularly in the absence of specific modelling for that species.</p>
6.02	What is the likely timeframe for such changes?	80 years	LOW	<p>The likely timeframe for such changes is 80 years but noting that the predicted increasing frequency of milder, wetter winters are already being experienced in Ireland (winter 2009/2010 being an exception).</p> <p>A confidence level of LOW is given as how climate change predictions will affect species responses and within what timeframe can be difficult to be confident about, particularly in the absence of specific modelling for <i>Gunnera tinctoria</i> beyond Ireland.</p>
6.03	What aspects of the risk assessment are most likely to change as a result of climate change	Increased distribution range to establish and/or become invasive and resulting increase in level of impacts	LOW	<p>It is likely that there would be an increase in areas suitable for the species to establish and become invasive. There could also be an increase in the intensity of the invasion with increased numbers of individuals. Therefore, the level of impact associated costs would also increase.</p> <p>EPPO 2014, note that 'its climatic potential range remains uncertain and could be wider considering the native distribution of the species in South America. The area of potential establishment would nevertheless remain moderate. The species still has a medium for further spread but the uncertainty on this point remains high'.</p>
6.04	If there is any research that would significantly strengthen confidence in the risk assessment, please note this here. If more than one research area is	YES	MODERATE	As there are few detailed studies on impacted sites, further investigation on the extent and scale of impacts on habitats and species of conservation significance would be desirable better inform the level of risk and confidence.

Stage 2 - Detailed assessment: Section F – Additional questions

This section is used to gather information about the potential effects of climate change on the risk posed by an organism. It is also an opportunity for the risk assessor to highlight high priority research that could help improve the risk assessment.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
	provided, please list in order of priority.			<p>An understanding of the actual ecosystem impacts is required. Much of the supposed effects on hydrology and nutrient cycling are still very speculative and such research is needed to provide a more rational/accurate risk assessment.</p> <p>The possibility that birds may be a significant vector for spread also needs investigation as this would affect the spread potential of the species in Europe and possibly also as a pathway into Europe.</p> <p>Research on whether there is hybridisation between <i>Gunnera tinctoria</i> and <i>Gunnera manicata</i> (or other <i>Gunnera</i> species) and if hybrids do occur, what is their invasive potential. This would affect the known distribution of <i>Gunnera tinctoria</i> whereby records may be of hybrids. If hybrids do occur, then the presence of <i>Gunnera manicata</i> (or other <i>Gunnera</i> species) both in trade and in the open environment would also have to be considered for trade restrictions and possible control.</p>

References

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