

Risk Assessment of *Gunnera tinctoria*

Name of Organism:	<i>Gunnera tinctoria</i> (Molina) Mirbel – Giant Rhubarb
Objective:	Assess the risks associated with this species in Ireland
Version:	Final 15/09/2014
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Expert reviewer	Bruce Osborne

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About the risk assessment

This risk assessment is based on the **Non-native species Application based Risk Analysis (NAPRA)** tool (version 2.66). NAPRA is a computer based tool for undertaking risk assessment of any non-native species. It was developed by the European and Mediterranean Plant Protection Organisation (EPPO) and adapted for Ireland and Northern Ireland by Invasive Species Ireland. It is based on the Computer Aided Pest Risk Analysis (CAPRA) software package which is a similar tool used by EPPO for risk assessment.

Notes: Confidence is rated as low, medium, high or very high.
Likelihood is rated as very unlikely, unlikely, moderately likely, likely or very likely.
The percentage categories are 0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%.
N/A = not applicable.

This is a joint project by Inland Fisheries Ireland and the National Biodiversity Data Centre to inform risk assessments of non-native species for the European Communities (Birds and Natural Habitats) Regulations 2011. It is supported by the National Parks and Wildlife Service.

DOCUMENT CONTROL SHEET

Name of Document:	Risk Assessment of <i>Gunnera tinctoria</i>				
Author (s):	Dr Erin O'Rourke and Ms. Colette O'Flynn				
Authorised Officer:	Dr Liam Lysaght				
Description of Content:	Non-native species risk assessment				
Approved by:	Dr Liam Lysaght				
Date of Approval:	15/09/2014				
Assigned review period:	n/a				
Date of next review:	n/a				
Document Code	n/a				
This documents comprises	TOC	Text	List of tables	List of Figures	No. Appendices
	n/a	YES	n/a	n/a	n/a

Version Control Table

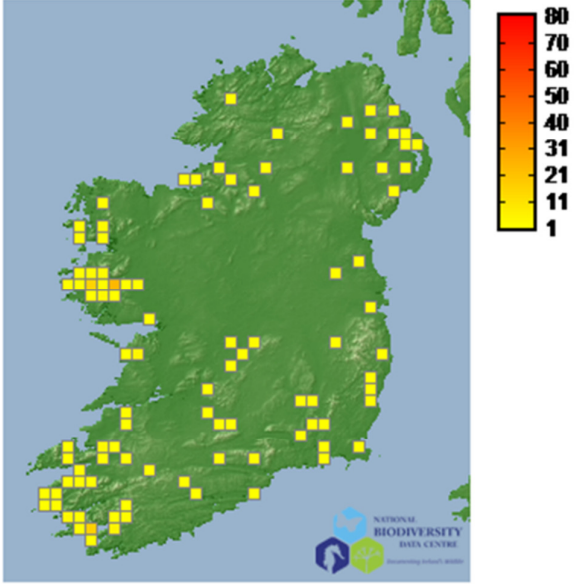
Version No.	Status	Authors(s)	Reviewed by	Approved by	Date of issue
Draft 1	Complete	Dr Erin O'Rourke	Ms Colette O'Flynn		29/01/2014
Expert review	Complete	Dr Erin O'Rourke	Prof. Bruce Osborne	Dr Liam Lysaght	19/03/2014
Public consultation	Complete	Dr Erin O'Rourke		Dr Liam Lysaght	09/05/2014
Public consultation 2	Complete	Dr Erin O'Rourke		Dr Liam Lysaght	14/08/2014
Final	Complete	Dr Erin O'Rourke		Dr Liam Lysaght	15/09/2014

Stage 1 - Organism Information			
<i>The aim of this section is to gather basic information about the organism.</i>			
N	QUESTION	RESPONSE	COMMENT
1	What is the reason for performing the risk assessment?		A risk assessment is required as this species is listed as a "Non-native species subject to restrictions under Regulations 49 and 50" in the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011, SI 477/2011.
2	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>
3	If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)		The taxonomy of this species and the related <i>G. manicata</i> is somewhat unclear. The inflorescences are typically rather open in <i>G. manicata</i> and closed in <i>G. 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, per. comm., 19 th March 2014).
4	Describe the organism.		<i>Gunnera tinctoria</i> is a clump-forming, herbaceous, perennial; that grows up to 2 m in height. It has inflorescences < 1 m, with stout branches < 8 cm; petiole ≤ 2 m, with pale-red bristles and weak spines; and leaves < 2 m across, cordate at base (Stace, 1997). It is difficult to tell <i>G. tinctoria</i> apart from <i>G. manicata</i> ; the spike shape and dimensions prove the most easily distinguishable features (Sheehy Skeffington and Hall, 2011).

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N	QUESTION	RESPONSE	COMMENT
5	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment for Ireland)	YES	In Ireland, a preliminary risk assessment was previously carried out. This was a prioritisation risk assessment as part of the Risk Analysis and Prioritisation for Invasive and Non-native Species in Ireland and Northern Ireland (ISI, 2012). It designated <i>Gunnera tinctoria</i> as a “high risk” invasive species.
6	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?	PARTIAL	Only a preliminary risk assessment was previously conducted in Ireland (refer to Question 5).
7	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).
8	What is the current global distribution of the organism (excluding Ireland)?		Including its native range (refer to question 6) the species has a current global distribution spanning both the northern and southern hemisphere. In the northern hemisphere it is found in England (Hawksford and Hopkins, 2011; Moyes and Willmot, 2002; Pilkington, 2011; Preston <i>et al.</i> , 2002), Wales (Chater 2010; Wade <i>et al.</i> , 1994), Scotland (Gioria and Osborne, 2013; Preston <i>et al.</i> , 2002), Isles of Scilly (French, 2009), the Isle of Man (McClintock, 1975; Preston <i>et al.</i> , 2002), the Channel Islands (McClintock 1975), France (Osborne <i>et al.</i> 1991), Spain (Sanz Elorza <i>et al.</i> , 2001), São Miguel Island, in the Azores (Silva and Smith, 2004; Silva <i>et al.</i> , 1996) and California (Howell 1970). In the southern hemisphere it is found in 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).
9	What is the current distribution of the organism in Ireland?		<i>Gunnera tinctoria</i> was first recorded as naturalised in Ireland in the late 1930's by Praeger (1939); at the time this was probably mistakenly recorded as <i>G. manicata</i> ; he described it as plentiful on rough hillsides both south and north of Killary Harbour near Leenane, Co. Galway and on the south side of Curraun Achill, Co Mayo. Today, in its naturalised state, it is found scattered throughout Ireland (Figure 2; Sheehy Skeffington and Hall, 2011), and is listed in twelve vice counties (Reynolds, 2002). It is most frequently recorded in the west and south-west, close to sea level at low altitudes (Gioria & Osborne 2009, 2013; Hickey & Osborne 1998; Preston <i>et al.</i> , 2002). The majority of invasive populations are found in Co. Mayo (Achill Island, Blacksod bay and Roonagh), Co. Galway (near Leenane, Connemara, near Letterfrack, and at Kylemore Estate) and on Clare Island (Gioria and Osborne,

Stage 1 - Organism Information

The aim of this section is to gather basic information about the organism.

N	QUESTION	RESPONSE	COMMENT
			<p>2013; Sheehy Skeffington and Hall, 2011)</p>  <p>Figure 2. Map showing most of the verified records for <i>Gunnera tinctoria</i> (Giant rhubarb) per 10km² in Ireland. Colour scale bar shows density of records per 10km (National Biodiversity Data Centre, 2014).</p>
10	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). 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 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 & Foss 1986; Hickey and Osborne, 1998). It is invasive on São Miguel Island, in the Azores, mainly in the east of the island (Silva <i>et al.</i>, 1996). In New Zealand it is invasive on Mount Taranaki, in the North Island (Williams <i>et al.</i> 2005).</p>

Stage 2 - Detailed assessment: Section A - Entry				
<i>This section evaluates the probability of entry of an organism into Ireland. 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.</i>				
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	MEDIUM	There are very few active/future pathways relevant to the entry of <i>G. tinctoria</i> .
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 trade	HIGH	<p>Potential for the species to be sourced through the horticultural trade for use as a popular ornamental garden plant. What's more, its seeds can be purchased over the internet from a range of gardens (Gioria and Osborne, 2013). 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 and as such is not at this time considered significant but may in the further require examination.</p>

Pathway 1 – Horticultural 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)?	INTENTIONAL	MEDIUM	The species may be imported for the horticultural trade.
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	Movement of <i>G. tinctoria</i> along this pathway would be dependent on the level of supply and demand.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	LIKELY	MEDIUM	It is likely that the species could enter Ireland undetected and without the knowledge of the relevant authority, particular as seed via internet trade or by young and/or mature plants being mistakenly identified as <i>G. manicata</i> ; with the two species difficult to tell apart (Sheehy Skeffington and Hall, 2011; Gioria and Osborne, 2013).

Pathway 1 – Horticultural trade				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.06	How likely is the organism to survive during passage along the pathway?	LIKELY	MEDIUM	Likely for the species housing requirements to be catered for by the horticultural trader and subsequent by the gardener.
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	LIKELY	MEDIUM	Establishment would be aided by the cultivation of adult plants or seed before the start of <i>G. tinctoria</i> 's growing season (March-August/September). Experienced gardeners are likely to 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?	LIKELY	MEDIUM	The species is intentionally planted domestically in horticultural habitat i.e. gardens, but can spread naturally from where originally planted or from garden discards. Typical wild habitat where is it known to invade or naturalise in Ireland include stream and river banks, lake and pond margins, coastal cliffs, as well as disturbed areas, such as agricultural land, roadsides, quarries and ditches (Gioria and Osborne, 2013). The species is likely to encounter such suitable habitats within the Irish landscape (Armstrong, 2008; CORINE, 2006; Fossitt, 2000).
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	MODERATELY LIKELY	MEDIUM	<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 (GISD, 2005). Today, despite their potential to escape and become naturalised and/or invasive, <i>G. tinctoria</i> (and <i>G. manicata</i>) is advertised as a giant, tropical species in gardens; receiving the Award of Garden Merit in 2006 by the Royal Horticultural Society (Gioria and Osborne, 2013). Responsible horticultural traders should not stock <i>G. tinctoria</i> . However, its seed can be sourced via the internet and garden centres may inadvertently trade the species.
1.10	Do other pathways need to be considered?	NO	MEDIUM	

Overall likelihood				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.11	Estimate the overall likelihood of entry into Ireland based on all pathways (comment on the key issues that lead to this conclusion).	LIKELY	HIGH	Refer to Question 1.09

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.01	Is the organism well established in Ireland (if there is any uncertainty answer 'unsure')	YES	HIGH	By the late 1930's <i>G. 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 et al (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 & 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 262 recording of the species, which are concentrated in west Galway and Mayo but also include south Kerry, west Cork, Waterford, north Tipperary, Dublin, Sligo, east Donegal, Down, Antrim and Derry (Figure 2).
2.02	How likely is it that the organism will be able to establish in Ireland based on the similarity between local <u>climatic conditions</u> and the organism's current global distribution?	VERY LIKELY	MEDIUM	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). 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>G. 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 1200 mm annually (Collins and Cummins, 1996).
2.03	How likely is it that the organism will be able to establish in Ireland based on the similarity between other local <u>abiotic conditions</u> and the organism's current global distribution?	LIKELY	MEDIUM	Water availability and temperature are the major factors limiting establishment of the species (Osborne and Sprent 2002; Osborne <i>et al.</i> , 1991). Establishment in Ireland may be restricted to areas typically characterised by an annual rainfall > 1100 m, with average winter temperatures ranging from 3 to 6 °C, and average summer temperatures between 12 and 15 °C (Gioria and Osborne, 2013). It responds strongly to variations in water supply and growth is severely constrained by both reduced as well as excessive water availability (Gioria and Osborne,

Stage 2 - Detailed assessment: Section B - Establishment

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				<p>2013). 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>G. 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 (Campbell, 1994). 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>
2.04	How likely is the organism to encounter habitats necessary for the survival, development and multiplication of the organism in Ireland?	VERY LIKELY	HIGH	<p>Typical wild habitat where it is known to invade or naturalise in Ireland include stream and river banks, lake and pond margins, coastal cliffs, as well as disturbed areas, such as agricultural land, roadsides, quarries and ditches (Gioria and Osborne, 2013). The species is likely to encounter such suitable habitat within the Irish landscape (Armstrong, 2008; CORINE, 2006; Fossitt, 2000).</p>
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?	LIKELY	MEDIUM	<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>G. palustre</i>, <i>Persicaria maculosa</i>, <i>Stachys sylvatica</i> and <i>Urtica dioica</i>; and 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, comes from a range of traits including its large stature, perenniality, 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). <i>Gunnera tinctoria</i> would be considered competitively superior, although a recent study reported the displacement of long term <i>G. tinctoria</i> stands by Japanese knotweed <i>Fallopia japonica</i> (Gioria et al., 2011). Any competitive potential of Japanese knotweed over <i>G. tinctoria</i> is of little benefit, as it too is highly invasive.</p>

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Ireland?	LIKELY	MEDIUM	It has no significant predators parasites or pathogens (Gioria and Osborne, 2013; Sheehy Skeffington and Hall, 2011; Pilkington 2011)
2.07	How likely is it that establishment will occur despite existing management practices?	LIKELY	MEDIUM	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).
2.08	How likely is it that management practices in Ireland will facilitate the establishment of the organism?	LIKELY	LOW	Sectoral activities that result in disturbed and/or bare ground, such as housing development and abandoned agricultural land are known 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>G. 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).
2.09	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Ireland?	VERY LIKELY	MEDIUM	<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.
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	VERY LIKELY	MEDIUM	<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).
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?	VERY LIKELY	MEDIUM	<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>G. tinctoria</i> . Once established at a new site, vegetative spread and dispersal of plant

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				<p>fragments appear to be the most important factors for the persistence of the species (Gioria and Osborne, 2009, 2013). In existing sites of <i>G. tinctoria</i> spread clonally, by a horizontal rhizome system is also important (Gioria and Osborne, 2013).</p>
2.12	How likely is it that the organism's adaptability will facilitate its establishment?	LIKELY	MEDIUM	<p>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).</p>
2.13	How likely is it that the organism could establish despite low genetic diversity in the founder population?	LIKELY	MEDIUM	<p>Molecular analyses showed that genetic differentiation from a 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).</p>
2.14	Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in Ireland? If possible, specify the instances of invasion elsewhere in the justification box	VERY LIKELY	HIGH	<p>The species was introduced into Britain in 1849 as an ornamental plant, and evidence of its escape into the wild dates from the 1900s onwards (Sheehy Skeffington and Hall, 2011). It was introduced to Guernsey on the Channel Islands in 1851 and has formed naturalised populations there for over a century' (McClintock 1975; Sheehy Skeffington and Hall, 2011). 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 Isles of Scilly, the first record of naturalised <i>G. tinctoria</i> was as recent as 1992 (French, 2009). Despite being common in large gardens the species has not yet formed a naturalised or invasive populations in Wales (Gioria and Osborne, 2013). On São Miguel Island, <i>G. 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). In New Zealand, the plant was first recorded in the wild in 1958 (Williams <i>et al.</i> 2005).</p> <p>The first documented record in Ireland can be found in Praeger (1939) Between 1960 and 1988 there was a significant increase in the number of records (Preston <i>et al.</i>, 2002), in part related to agricultural land abandonment, as well as urban and tourism developments, suggesting that <i>G. tinctoria</i> may have a much greater potential range expansion and a larger impact in the future (Gioria and Osborne, 2013). Recent evidence suggest that this expansion was also associated with a major</p>

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				increase in genetic diversity (Fennell et al., 2014) The majority of records in Ireland are also post-1999 (Preston et al., 2002), confirming that the exponential invasion phase is a relatively recent phenomenon (Gioria and Osborne, 2013). The species current invasive range is restricted to areas of Co. Mayo (Achill Island, Blacksod bay and Roonagh), Co. Galway (near Ileenane, Connemara, near Letterfrack, and at Kylemore Estate) and Clare Island (Sheehy Skeffington and Hall, 2011; Giora and Osborne, 2013).
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?	N/A	N/A	Not applicable. The species is established on the western seaboard outside of which records for the species exist.
2.16	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	LIKELY	HIGH	Both within and outside of counties Mayo and Galway, where it is currently invasive, the species is likely to encounter suitable habitats, under equally suitable climatic conditions. The species competitive superiority and reproductive traits, in addition to human activities may aid in its establishment.

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Ireland. 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	What area (given in % or 10km squares) in Ireland could the organism establish (0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%)?	0-10%	MEDIUM	<p>The species can occupy flat terrain as well as steep slopes (Osborne <i>et al</i> 1991; Silva <i>et al.</i>, 1996; Williams <i>et al.</i>, 2005). In Ireland, <i>G. tinctoria</i> typically inhabits stream and river banks, lake and pond margins, coastal cliffs, as well as disturbed areas, roadsides, building sites, quarries and ditches (Gioria and Osborne, 2013; Preston <i>et al.</i>, 2002). With reference to the CORINE(2006) land cover data (categories and their percentage cover), <i>G. tinctoria</i> has the potential to establish in 0-10% of the land area (road and rail networks – 0.06%; mineral extraction sites – 0.12%; construction sites – 0.03%; moors and heath – 0.78%; bare rocks – 0.20%; sparsely vegetated land – 0.29% - stream courses – 0.11%; coastal lagoons – 0.01%). However, as reflected by an invasive range, with a predominantly western distribution, the area to which <i>G. tinctoria</i> has the potential to spread will be dependent on climatic suitability i.e. persistent mild and moist conditions. On Achill Island, Armstrong (2008) calculated a density rank of habitats where the species was dominant; in ranked order these habitats included improved and semi natural grassland, waterways, disturbed ground, roadsides and scrub.</p> <p>The species is also likely to grow in areas that do not fully match the characteristics for growth near lakes and streams. The species may be likely to invade cultivated land, particularly if climatic limitations during the germination-early seedling stage are over come. Such potential invasion of cultivated land will most likely occur on nutrient poor or abandoned land high water availability. Therefore, the area at risk is potentially much higher than 0-10%, with agricultural area constituting c. 66% of the total land cover in Ireland (CORINE, 2006).</p>
3.02	How important is the expected spread of this organism in Ireland by <u>natural</u> means (minimal, minor, moderate, major or massive)?	MAJOR	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 (Fennell <i>et al.</i>, 2013; Gioria and Osborne, 2013).</p>
3.03	How important is the expected spread of this organism in Ireland by <u>human assistance</u> (minimal, minor, moderate, major or massive)?	MAJOR	MEDIUM	<p>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 the nearby Guy's</p>

Stage 2 - Detailed assessment: Section C - Spread

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

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				quarry, where the species contaminates aggregate. They also associate the spread of the species on roadsides in the area as a result of contaminated aggregate from the quarry.
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MAJOR	MEDIUM	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). Control/eradication measures are known to have failed (Sheehy Skeffington and Hall, 2011).
3.05	What proportion (%) of the area in Ireland suitable for establishment, if any, has already been colonised by the organism?	0-10%	MEDIUM	The species invasive range is currently restricted to areas of Co. Mayo (Achill Island, Blacksod bay and Roonagh), Co. Galway (near leenane, Connemara, near Letterfrack, and at Kylemore Estate) and Clare Island (Sheehy Skeffington and Hall, 2011; Gioria and Osborne, 2013).
3.06	What proportion of the area in Ireland 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%	MEDIUM	The species has the potential to expand its western invasive range in the next five years (Fennell et al., 2013; Sheehy Skeffington and Hall, 2011).
3.07	What other timeframe would be appropriate to estimate any significant further spread of the organism (10, 20, 40, 80 or 160 years)? Please comment on why this timeframe is chosen.	10	MEDIUM	North west and south west counties of Ireland, where the species is already recorded, and which are climatically suitable with suitable habitats are at risk of invasion in the next 10 years. In Donegal it occurs in several large patches along the coast and may be at the point of invasion (Sheehy Skeffington and Hall, 2011).
3.08	In this timeframe, what proportion of the area (including any currently occupied areas) is likely to have been invaded by this organism?	0-10%	LOW	
3.09	Based on the answers to questions on the potential for establishment and spread in Ireland, define the area endangered by the organism. Be as specific as possible. If available, provide a map showing the area most likely to be endangered.	-	MEDIUM	The species has a tendency to become invasive in abandoned fields, where sheep and cattle have been removed, 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; Osborne <i>et al</i> 199, Gioria and Osborne, 2013; Sheehy Skeffington and Hall, 2011).

Stage 2 - Detailed assessment: Section C - Spread

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

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.10	Estimate the overall potential for future spread for this organism in (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues .	MODERATELY RAPIDLY	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). 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.

Stage 2 - Detailed assessment: Section D - Impact				
<i>This section evaluates the probability of impact of an organism within Ireland.</i>				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.01	How great is the economic loss caused by the organism within its global distribution (excluding Ireland), including the cost of any current management?			There is a paucity of information. Refer to Question 4.02.
4.02	How great has the economic cost of the organism been in Ireland from the <u>time of introduction to the present</u> ? Exclude any costs associated with managing the organism from your answer.	MODERATE	MEDIUM	Kelly <i>et al.</i> (2013) report the development of measures for the control of <i>G. tinctoria</i> on Achill Island in 2007 and 2008 costing €15,000 and €17,000, respectively. Kelly <i>et al.</i> (2013) do not expand on what the 'development of measures' encompasses and best present indicative costs.
4.03	How great is the economic cost of the organism likely to be in the <u>future</u> in Ireland? Exclude any costs associated with managing the organism from your answer.	MAJOR	MEDIUM	Dense stands of <i>G. tinctoria</i> can result in blocked drainage and the loss of usable agricultural land (Gioria and Osborne, 2013; Sheehy Skeffington and Hall, 2011). The development of measures for control of the species has, so far, indicate an indicative cost ~€32,000 (refer to Question 4.02). Future costs would be expected to equal, but most likely exceed this sum of money.
4.04	How great have the economic costs of managing this organism been in Ireland from the <u>time of introduction to the present</u> ?	MODERATE	MEDIUM	Including the economic costs detailed in Question 4.02, Kelly <i>et al.</i> (2013) report the 2009 control of <i>G. tinctoria</i> in Leenane, Co. Galway, and the eradication of <i>G. tinctoria</i> from Clare and Achill Island in Co. Mayo to have cost ~€3,500 and €21,000, respectively. This would bring the (known) total economic cost of <i>G. tinctoria</i> invasion to ~€56,500.
4.05	How great is the economic cost of managing this organism likely to be in the <u>future</u> in Ireland?	MAJOR	MEDIUM	Given that eradication campaigns are known to have failed (Armstrong, 2008; Sheehy Skeffington and Hall, 2011), the future costs would be expected to exceed the total (€56500) incurred costs to-date.
4.06	How important is environmental harm caused by the organism within its global distribution?	MAJOR	HIGH	Soil erosion may 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).
4.07	How important has the impact of the organism on biodiversity* been in Ireland from the time of introduction to the present? *e.g. decline in native species, changes in community structure, hybridisation	MAJOR	MEDIUM	Due to its large size and early growth shading, significantly reduces the number of native species in colonised areas. The most ecologically valuable communities invaded by <i>G. 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.

Stage 2 - Detailed assessment: Section D - Impact

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

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.08	How important is the impact of the organism on biodiversity likely to be in the <u>future</u> in Ireland?	MAJOR	MEDIUM	Gioria and Osborne (2009, 2010) report the capacity for <i>G. 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 increase the abundance of weed and rush seeds. These effects were also evident in deep soil layers, indication that invasion by <i>G. 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.
4.09	How important has alteration of ecosystem function* caused by the organism been in Ireland from the time of introduction to the present? *e.g. habitat change, nutrient cycling, trophic interactions	MAJOR	MEDIUM	There are significant increases in above- and below-ground biomass associated with <i>G. tinctoria</i> invasions, which may 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 & Osborne 1998; Gioria 2007).
4.10	How important is alteration of ecosystem function caused by the organism likely to be in Ireland in the <u>future</u> ?	MAJOR	MEDIUM	Refer to Question 4.09
4.11	How important has decline in conservation status* caused by the organism been in Ireland from the time of introduction to the present? *e.g. sites of nature conservation value, WFD classification, etc.	MAJOR	LOW	Potential spread of the species would have a major impact of the conservation status of, for example, Connemara National Park.
4.12	How important is decline in conservation status caused by the organism likely to be in the <u>future</u> in Ireland?	MAJOR	LOW	Potential establishment and spread of the species would have a major impact to the conservation status of any protected area in Ireland.
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?	MODERATE	MEDIUM	Within the symbiotic tissues of <i>G. 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 Osborne, 2013).
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within Ireland?	MODERATE	MEDIUM	The species may negatively affect Irish tourism. Large stands of <i>G. tinctoria</i> visually impact upon the indigenous landscape. Die back of leaf litter is reported to produce a rotten smell (Armstrong, 2008).

Stage 2 - Detailed assessment: Section D - Impact*This section evaluates the probability of impact of an organism within Ireland.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.15	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>G. tinctoria</i> forming viable hybrids (Gioria and Osborne, 2013). However, The taxonomy of this species and the related <i>G. manicata</i> is somewhat unclear. The inflorescences are typically rather open in <i>G. manicata</i> and closed in <i>G. 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, per. comm., 19 th March 2014).
4.16	How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?			There is a paucity of information.
4.17	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.
4.18	How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in Ireland?	MAJOR	MEDIUM	It has no significant predators parasites or pathogens (Gioria and Osborne, 2013; Pilkington, 2011; Sheehy Skeffington and Hall, 2011)
4.19	Indicate any parts of where economic, environmental and social impacts are particularly likely to occur. Provide as much detail as possible, where possible include a map showing vulnerable areas.	-	MEDIUM	Counties Galway and Mayo, where the species is currently invasive and where future expansion of the species is most likely, will primarily incur the larger economic, environmental and social impacts.
4.20	Estimate the overall potential impact of this organism in Ireland. Use the justification box to indicate any key issues.	MAJOR	MEDIUM	<i>Gunnera tinctoria</i> invasions may result in a range of environmental, economic and societal impacts (detailed above). Of much concern is the impact to indigenous biodiversity, alterations to ecosystem function and the provision of ecosystem services. Control and/or eradication of the species will impact on the Irish economy, particularly in counties Galway and Mayo.

Stage 2 - Detailed assessment: Section E - Conclusion

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.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
5.01	Estimate the overall risk of this organism in Ireland. Noting answers given in 1.11, 2.16, 3.10 & 4.20	MAJOR	MEDIUM	<p><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 (GISD, 2005). Today, despite their potential to escape and become naturalised and/or invasive, <i>G. tinctoria</i> (and <i>G. manicata</i>) is advertised as a giant, tropical species in gardens; receiving the Award of Garden Merit in 2006 by the Royal Horticultural Society (Gioria and Osborne, 2013). Responsible horticultural traders should not stock <i>G. tinctoria</i>. However, its seed can be sourced via the internet and garden centres may inadvertently trade the species as a result of mistaken identification with <i>G. manicata</i>; with the two species difficult to tell apart (Sheehy Skeffington and Hall, 2011; Gioria and Osborne, 2013)</p> <p>Both within and outside of counties Mayo and Galway, where it is currently invasive, the species is likely to encounter suitable habitats, under equally suitable climatic conditions. The species competitive superiority and reproductive traits, in addition to human activities may aid in its establishment.</p> <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 (Armstrong, 2008; Sheehy Skeffington and Hall, 2011). The species has the potential to expand its invasive range.</p> <p><i>Gunnera tinctoria</i> invasions may result in a range of environmental, economic and societal impacts. Of much concern is the impact to indigenous biodiversity, alterations to ecosystem function and the provision of ecosystem services. Control and/or eradication of the species will impact on the Irish economy, particularly in counties Galway and Mayo.</p>

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
6.01	What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	LIKELY	MEDIUM	Expansion of its range could be favoured by projected increases in winter rainfall and summer temperatures (Gioria & Osborne 2009). Modelling projections of Fennell et al. (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. 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>G. tinctoria</i> in north west Connemara in check and noted that if these cease to occur regularly <i>G. tinctoria</i> is likely to increase in its range.
6.02	What is the likely timeframe for such changes (5, 10, 15, 20, 50 or 100 years)?	50	LOW	The likely timeframe for such changes is 5 years as we are already experiencing the increasing frequency of milder, wetter winters (winter 2009/2010 is an exception).
6.03	What aspects of the risk assessment are most likely to change as a result of climate change	-	LOW	The increasingly different climatic conditions as a result of climate change would require for the risk assessment on the invasiveness of <i>G. tinctoria</i> to reconsider establishment and spread and their associated impacts to the Irish economy, environment and society.
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 provided, please list in order of priority.	-	LOW	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 rationale/accurate risk assessment. Increasingly the spread of introduced plants is seen as one of the major aspects of land cover change and land cover changes are thought to have the biggest impact on greenhouse gas inventories. An examination of this assumption is required and would benefit the risk assessment.

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