Risk Assessment of *Impatiens glandulifera*

Name of Organism:	*Impatiens glandulifera* Royle – Himalayan Balsam
Objective:	Assess the risks associated with this species in Ireland
Version:	Final 15/09/2014
Author(s)	Michael Millane and Joe Caffrey
Expert reviewer	Rob Tanner

Stage 1 - Organism Information

Stage 2 - Detailed Assessment
Section A - Entry
Section B - Establishment
Section C - Spread
Section D - Impact
Section E - Conclusion
Section F - Additional Questions

About the risk assessment

This risk assessment is based on the **N**on-native species **AP**plication based **R**isk **A**nalysis (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 *Impatiens glandulifera*				
Author (s):	Dr Michael Millane and Dr Joe Caffrey				
Authorised Officer:	Dr Joe Caffrey				
Description of Content:	Non-native species risk assessment				
Approved by:	Dr Cathal Gallagher				
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	0

Version Control Table

Version No.	Status	Authors(s)	Reviewed by	Approved by	Date of issue
Draft 1	Complete	Dr Michael Millane	Dr Joe Caffrey		12/06/2014
Expert review	Complete	Dr Michael Millane	Dr Rob Tanner	Dr Joe Caffrey	16/06/2014
Public Consultation	Complete	Dr Michael Millane			08/07/2014
Final	Complete	Dr Michael Millane	Dr Joe Caffrey	Dr Cathal Gallagher	15/09/2014

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
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	*Impatiens glandulifera* Royle (preferred scientific name), *Impatiens glanduligera* Lindley; and *Impatiens roylei* Walpers 1842; Himalayan balsam (preferred common name), Indian balsam and policeman's helmet (Tanner 2008a); Bee Flower, Bobby's Helmet, Fireman's Hats, Jumping Jack, Poor Man's Orchid and Touch-me-not (Rotherham 2000).
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)	N\A	
4	Describe the organism.		*Impatiens glandulifera* is a tall glabrous annual reaching 50 to 250 cm in height". "Its stems can be 0.5 to 5 cm in diameter and are sometimes branched in the upper part. Roots are up to 15 cm deep, the plants often forming numerous adventitious roots from the lower nodes" (description from Tanner 2008a). The leaves are always in whorls of three from the base to the top of the stem (R. Tanner personal communication), "up to 25 cm long and 7 cm wide, lanceolate to obovate, petiolate and sharply serrated at the edges. The inflorescences are racemes of 2-14 flowers that are 25-40 mm long. Flowers are strongly zygomorphic [i.e. bilateral], their posterior sepal forming a sac that ends in a straight spur [flowers are 'trumpet-like' in shape]. Their colours vary from white to pink and purple. The capsule is 3-5 cm long and up to 1.5 cm wide. It contains up to 6 (Grime *et al*., 1988) or 4 to 16 seeds (Beerling and Perrins 1993), that are 4-7 mm long and 2-4 mm wide with a mean weight of 7.32 mg." (description from Tanner 2008a). When mature in the late summer to mid-autumn, the seed capsules 'pop' or 'explode' dispersing the seed.

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
5	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	YES	Two preliminary risk assessments were previously carried out in Ireland as follows. A stage one and two risk assessment as part of *Ireland's National Plant Conservation Strategy - Target 10 - Managing Invasive Alien Species* (Botanic Gardens 2007); and a prioritisation risk assessment as part of the *Risk Analysis and Prioritisation for Invasive and Non-native Species in Ireland and Northern Ireland* (Kelly *et al*. 2013). The former assessment designated the plant as a "most significant invasive plant" and the latter assessment designed the plant 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 preliminary risk assessments were previously conducted in Ireland (refer to Question 5).
7	Where is the organism native?		India (north); Pakistan (north-west); Nepal and possibly Bhutan from 2500 – 3500 m asl (reviewed in Tanner 2008a). i.e. in the vicinity of the western Himalayan mountains.
8	What is the current global distribution of the organism (excluding Ireland)?		Asia (India, Japan, Nepal and Pakistan, Russian Federation [far east]); Europe (Austria, Belgium, Britain, Croatia, Czech Republic, Denmark, Finland, France, Germany, Hungary, Macedonia [Pacanoski and Saliji 2014], The Netherlands, Northern Ireland, Norway, Poland, Romania, Russian Federation [east Siberia], Serbia, Slovakia, Spain, Sweden, Switzerland and Ukraine); North America (Canada and USA); and New Zealand (EPPO 2007; reviewed in Tanner 2008a).
9	What is the current distribution of the organism in Ireland?		*Impatiens glandulifera* is widespread in Ireland and is recorded in 281 x 10 km squares in the country (National Invasive Species Database 2010). The plant typically establishes dense stands along the riparian zone of watercourses and can spread away from this area to colonise any suitable adjacent damp habitat. It can also be found along road ditches, along field margins or on damp disturbed ground in urban or wasteland areas or in damp woodland habitat. It is also sometimes planted and maintained in private gardens as an ornamental plant (Beerling and Perrins 1993; authors observations).
10	Is the organism known to be invasive anywhere in the world?	YES	Austria, Britain, Czech Republic, Denmark, Germany, Hungary, Ireland, Northern Ireland, The Netherlands, Poland, Slovakia, Sweden and USA (in Washington State) (reviewed in Tanner 2008a).

Stage 2 - Detailed assessment: Section A - Entry

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.

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)?	MANY	VERY HIGH	As *Impatiens glandulifera* is already widespread in Ireland the pathways discussed are principally related to the anthropogenic-mediated internal spread of the plant. These pathways are: 1) ornamental, 2) boating and angling, other water activities and walking; and 3) inadvertent spread by soil movements. Natural spread is considered separately in the *Stage 2 Section C –Spread* section of the risk assessment.
1.02	List significant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.	1. Ornamental 2. boating and angling, other water activities and walking 3. inadvertent spread by soil movements		*Impatiens glandulifera* is spread throughout Ireland by ornamental practitioners, notably gardeners, and promoted by some bee keepers as a high quality nectar source for bees (it should be noted that there is an increased awareness of the threat from *Impatiens glandulifera* as an invasive species by this stakeholder group). *Impatiens glandulifera* has been sold in seed mixes through the ornamental trade in Ireland (e.g. Terra Nova 2005) and presently is available to buy on the internet (e.g. eBay) from sources located abroad. The plant does not appear to be sold directly in retail outlets in Ireland. The risk of spread by boats, anglers and other water users is in association with equipment which is inadvertently contaminated with seeds that can establish new populations elsewhere after the equipment has been moved. Walkers also have the potential to transfer seeds on their footwear or clothing. Inadvertent spread may also occur if soil contaminated with seeds or viable plant material is translocated, for example *via* construction works (Hartmann *et al*. 1995 as cited in EPPO 2007).

Pathway 1 - Ornamental				
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	VERY HIGH	*Impatiens glandulifera* is spread throughout Ireland by ornamental practitioners, notably gardeners, and promoted by some bee keepers as a high quality nectar source for bees (it should be noted that there is an increased awareness of the threat from *Impatiens glandulifera* as an invasive species by this stakeholder group). In the past, the spread of *I. glandulifera* has been attributed to deliberate spread of seeds by 'balsam enthusiasts' (Rotherham, 2000). *Impatiens glandulifera* has been sold in seed mixes through the ornamental trade in Ireland (e.g. Terra Nova 2005) and presently is available to buy on the internet (e.g. eBay; search of listings 07/07/2014) from sources located abroad. The plant does not appear to be sold directly in retail outlets in Ireland (authors, personal observations).
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	There is no information to assess whether 'large numbers' travel along this pathway. However, it is known that the species is exchanged by gardeners (e.g. Garden.ie 2012), translocated from the wild to gardens and the seeds are occasionally offered for sale either directly or as part of a seed mix (e.g. Terre Nova 2005). As stated previously, the plant does not appear to be sold directly in retail outlets in Ireland (authors, personal observations).
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present.
1.06	How likely is the organism to survive during passage along the pathway?	VERY LIKELY	VERY HIGH	As the organism is distributed deliberately *via* this pathway, survival is considered very likely.
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	VERY LIKELY	VERY HIGH	The life-cycle of *Impatiens glandulifera* as described below provides an indication of the appropriate months of the year for establishment. Seed can be collected in the mid-/late summer to autumn period and plants could be transplanted from mid-spring to early autumn. During the winter period, soil containing dormant seeds could translocate the species for germination the following spring (authors personal observations; Beerling and Perrins 1993).

Pathway 1 - Ornamental				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				The typical life-cycle of *Impatiens glandulifera* in Ireland is as follows. Seeds germinate in springtime and the first seedlings appear in late March or April. This is followed by rapid shoot extension and leaf expansion. Flowering occurs from late May to October and seeds are produced from July to October. Plant dieback occurs in late autumn (authors personal observations; also reflective of British populations [Beerling and Perrins 1993]). Seeds can successfully over-winter to germinate the following spring (Beerling and Perrins 1993). Seeds can be viable in the soil for up to 18 months (reviewed in Beerling and Perrins 1993). *Impatiens glandulifera* has a limited tolerance to frost and British populations, at least, appear to be less frost tolerance than Himalayan ecotypes (Koenies and Glavač 1979 as cited in Beerling and Perrins 1993). Seedlings and adult plants can be killed by late spring and early autumnal frosts, respectively (Koenies and Glavač 1979 as cited in Beerling and Perrins 1993). Seed are viable for up to two years.
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	Available habitat for *Impatiens glandulifera* is widespread in Ireland. As previously stated, suitable habitats for the plant include the riparian zone of watercourses and adjacent damp habitat, road ditches, field margins, damp disturbed ground in urban or wasteland areas, damp woodland habitat and private gardens (Beerling and Perrins 1993; authors observations). As movement *via* this pathway is deliberate, successful transfer is highly likely.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	VERY LIKELY	VERY HIGH	It is already deliberately spread *via* this pathway. Rotherham (2000) documents many examples of the anthropogenic-mediated spread of *Impatiens glandulifera* throughout Britain for ornamental purposes including one instance where seeds were sent to Ireland.
1.10	Do other pathways need to be considered?	YES		

Pathway 2 – Boating, angling, other water activities and walking.				
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)?	ACCIDENTAL	VERY HIGH	The movement of angling equipment, boats, boat trailers and other boat equipment, and walkers from an infested to uninfested area has the potential to inadvertently spread this organism if seeds are attached.
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?	LIKELY	VERY HIGH	In the absence of implementing appropriate biosecurity measures, there is an increased potential for the inadvertent spread of seeds or viable plant material from infested to uninfested waters.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present.
1.06	How likely is the organism to survive during passage along the pathway?	LIKELY	HIGH	Survival is dependent on the conditions of transport. Seeds can remain viable for up to 18 months, in soil at least (reviewed in Beerling and Perrins 1993) but have the potential to be inadvertently transported from infested to uninfested areas.
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	VERY LIKELY	VERY HIGH	See response to Pathway 1 Question 1.07.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	LIKELY	HIGH	Available habitat for *Impatiens glandulifera* is widespread in Ireland. As previously stated, suitable habitats for the plant include the riparian zone of watercourses and adjacent damp habitat, road ditches, field margins, damp disturbed ground in urban or wasteland areas, damp woodland habitat and private gardens (Beerling and Perrins 1993; authors observations). Ability to transfer from this pathway to a suitable habitat is dependent on the movement of the vector and the conditions of transport.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	MODERATELY LIKELY	HIGH	It is likely that *Impatiens glandulifera* has already spread *via* this pathway.
1.10	Do other pathways need to be considered?	YES		

Pathway 3 – Inadvertent spread by soil movements				
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)?	ACCIDENTAL	VERY HIGH	There is potential for inadvertent spread of *Impatiens glandulifera* if top soil contaminated with seeds is translocated, for example *via* construction works.
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?	LIKLEY	HIGH	In the absence of implementing appropriate biosecurity measure in areas with *Impatiens glandulifera* during operations where soil is translocated (e.g. river enhancement works or construction), there is an increased potential for the inadvertent spread of seeds to uninfested areas. Response is given as 'likely' in such scenarios.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness by the relevant competent authorities to recognise and identify this species is limited or non-existent at present.
1.06	How likely is the organism to survive during passage along the pathway?	MODERATELY LIKELY	HIGH	As the seeds can remain viable in soil for up to 18 months (reviewed in Beerling and Perrins 1993), survival is very likely when any spoil is moved (notably seeds in top soil have a high potential to germinate when conditions are suitable).
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	LIKELY	HIGH	Refer to response in Pathway 1 Question 1.07.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	VERY LIKELY	HIGH	This depends on where any disturbed soil or spoil contaminated with *Impatiens glandulifera* seeds is disposed. As previously stated, suitable habitats for the plant include the riparian zone of watercourses and adjacent damp habitat, road ditches, field margins, damp disturbed ground in urban or wasteland areas, damp woodland habitat and private gardens (Beerling and Perrins 1993; authors observations)
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	LIKELY	VERY HIGH	it is considered likely that *Impatiens glandulifera* can be spread *via* this pathway.
1.10	Do other pathways need to be considered?	NO		

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).	VERY LIKELY	VERY HIGH	*Impatiens glandulifera* is already well established and widespread in Ireland (National Invasive Species Database 2010). Apart from spread by natural mechanisms, the principal pathway of anthropogenic-mediated spread in Ireland is considered to be by ornamental practitioners, notably gardeners. There is also a risk of spread by boats, anglers and other water users in association with equipment that is inadvertently contaminated with seeds. Walkers also have the potential to transfer seeds on their footwear and clothing. Inadvertent spread may also occur if soil contaminated with seeds or viable plant material is translocated, for example *via* construction works (Hartmann *et al*. 1995).

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	VERY HIGH	*Impatiens glandulifera* is well-established and widespread in Ireland and is recorded in 281 x 10 km squares in the country (National Invasive Species Database 2010). *For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.*
2.02	How likely is it that the organism will be able to establish in Ireland based on the similarity between local climatic conditions and the organism's current global distribution?			
2.03	How likely is it that the organism will be able to establish in Ireland based on the similarity between other local abiotic conditions and the organism's current global distribution?			
2.04	How likely is the organism to encounter habitats necessary for the survival, development and multiplication of the organism in Ireland?			
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?			
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Ireland?			
2.07	How likely is it that establishment will occur despite existing management practices?			
2.08	How likely is it that management practices in Ireland will facilitate the establishment of the organism?			
2.09	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Ireland?			

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
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?			
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?			
2.12	How likely is it that the organism's adaptability will facilitate its establishment?			
2.13	How likely is it that the organism could establish despite low genetic diversity in the founder population?			
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			
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?			
2.16	Estimate the overall likelihood of establishment. Mention any key issues in the comments box			

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%)?	34% - 67%, of 10 km squares	HIGH	This response is based on the current distribution of *Impatiens glandulifera* in Ireland, its wide tolerance of abiotic habitat conditions, and the potential for the plant to establish in numerous, as of yet uncolonised habitats, available in the country. In addition, the experience of the spread of *Impatiens glandulifera* in Britain which has a similar climate and landscape to Ireland is also taken into consideration. The plant is already widespread in Ireland and is recorded in 281 x 10 km squares in the country (National Invasive Species Database 2010). This represents *c.* 33% of 10 km squares in Ireland. As previously mentioned, *Impatiens glandulifera* typically establishes dense stands along the riparian zone of watercourses and can spread away from this area to colonise any suitable adjacent damp habitat. It can also be found along roadside ditches, along field margins or on damp disturbed ground in urban or wasteland areas or in damp woodland habitat. Furthermore, it is sometimes planted and maintained in private gardens as an ornamental plant (Beerling and Perrins 1993; authors observations). The plant is tolerant of a wide variety of soil textures and structure (e.g. fine and coarse alluvium, free-draining mineral soils and peat), has a wide tolerance to pH (3.5 – 7.6) and can grow on both relatively acidic and neutral soils of nutrient-rich and nutrient-poor status (reviewed in Beerling and Perrins 1993) In the UK, *Impatiens glandulifera* is “the most commonly occurring non-native plant species on riparian systems, occupying over 13% of rivers in England and Wales (Environment Agency 2010)” (as cited in Tanner *et al*. 2014). The distribution of the plant in Ireland is likely to be constrained by its requirements for high soil moisture, and its frost sensitivity in uplands, where it is not found >210 m above sea level (Beerling and Perrins 1993).

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
3.02	How important is the expected spread of this organism in Ireland by natural means (minimal, minor, moderate, major or massive)?	MASSIVE	VERY HIGH	*Impatiens glandulifera* has already demonstrated this in Ireland where spread by natural means *via* seeds is the principal mechanism responsible for the plant's dispersal within catchments along riparian zones and adjacent areas, and along corridors such as field margins and road ditches (authors, personal observations). Short-distance dispersal of seeds is dependent on explosive dehiscence of the seed capsule which can project seeds up to 5 m around the parent plant (Beerling and Perrins 1993). More long distance natural spread can occur when seeds are transported *via* water currents. This is also facilitated by flooding events which can disturb bankside top soil with seeds present and carry them downstream (reviewed in Beerling and Perrins 1993).
3.03	How important is the expected spread of this organism in Ireland by human assistance (minimal, minor, moderate, major or massive)?	MAJOR	VERY HIGH	To date, such anthropogenic-mediated transfer of *Impatiens glandulifera* for ornamental purposes (as detailed in Pathway 1 of this risk assessment) has been one of the two principal mechanisms of spread in Ireland, along with natural spread. However, the former is highly likely to have been solely responsible for introductions of the plant to new areas of the country, as has been the case in Britain (Beerling and Perrins 1993; Rotherham 2000).
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MASSIVE	HIGH	Containment of *Impatiens glandulifera* in Ireland as a whole is not feasible as it is widespread and well established throughout the country. Local containment or eradication may be achieved through considerable and repeated effort (Inland Fisheries Ireland 2013a). Such operations have been conducted in some waterways in Ireland with mixed success (e.g. River Barrow, River Allow and river in the Mulkear Catchment) where organised groups of 'balsam bashers' manually remove stands of the plant from the riparian zone of river banks typically in an upstream-downstream direction to prevent natural recolonisation. These actions must be conducted each year before the plant sets seed and require two to three years of manual removal to deplete the existing the seed reserve in the sediments (Inland Fisheries Ireland 2013a). One notable recent example of successful control in this regard comes from the Allow Catchment, where manual removal operations has reduced the number of *I. glandulifera* plants there from *c.*1800 to 55 in a three year time period (2012-2014) (Kieran Murphy – IRD Duhallow – consultation submission 07/08/2014).

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
				In Britain, the fungal biocontrol agent *Puccinia komarovii* var *glanduliferae* is being considered to control *Impatiens glandulifera* (Tanner 2011; CABI 2013). If successful, such biocontrol may eventually offer a systemic solution to control extensive populations of the plant in Ireland where other currently used, more conventional control methods are not feasible to employ.
3.05	What proportion (%) of the area in Ireland suitable for establishment, if any, has already been colonised by the organism?	0% -10%	VERY HIGH	Despite its widespread distribution in Ireland (present in 281 x 10 km squares in the country [National Invasive Species Database 2010]), *Impatiens glandulifera* is unlikely to have colonised >10 % of the potential habitat suitable for establishment in the country to date. This is because it can establish in a variety of habitats which are abundant Ireland (e.g. along the riparian zone of watercourses and in adjacent damp areas, in road ditches, along field margins or on damp disturbed ground in urban or wasteland areas or in damp woodland habitat [Beerling and Perrins 1993; authors observations]).
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)?	11% - 33%	HIGH	*Impatiens glandulifera* is considered to be one of the most rapidly expanding non-native plants in Ireland in terms of distribution in the last *c.* 20 years (J. Caffrey, personal observation; also refer to Figure 1.1 in Tanner 2011). No known records of the plant exist in Ireland before 1900 and there is only a single record by 1920 (in Co. Wexford). Eight locations are recorded by 1940, and *c.* 65 locations of the plant were documented by 1970 (Beerling and Perrins 1993). By 2010, *Impatiens glandulifera* has been recorded in 1898 locations in the country (National Invasive Species Database 2010). Based on the recent historical expansion in range of the plant in Ireland (which cannot be accounted for by increased recording effort alone; also refer to Figure 1.1 in Tanner 2011), *Impatiens glandulifera* is highly likely to continue to spread rapidly along riparian zones and suitable adjacent areas within catchments where it is already present and most likely expand to establish in some presently uncolonised catchments within the next five years. The plant can spread through both local and long distance seed dispersal and its capacity for rapid spread in Ireland is illustrated by the following experiences in Britain. As regards local dispersal, a study from Askham Bog in England calculated the mean yearly rate of spread from the parent plant stand to be 2.47 m. Further to this, isolated instances of spread

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
				(attributed to seed dispersal by animals) of up to 10 m from the nearest parent plant were also recorded. At this location the plant was documented to have expanded to occupy an area > 25,000 m^2 within 16 years since it was first recorded there (reviewed in Beerling and Perrins 1993). In Britain, long-term dispersal based on an examination of historical records has been calculated by various authors to range from 1.9 km to 38 km per year (reviewed in Beerling and Perrins 1993). In addition to the above, the capability of *Impatiens glandulifera* to spread rapidly can be further illustrated by its historical expansion in the present-day Czech Republic and in Poland. Since the plant was first recorded in the Czech Republic there in 1893, by 1995, 56% of the total river length of the country was occupied by the plant (Hejda and Pyšek 2006; reviewed in Tanner 2011). In Poland, the plant was introduced *c.*1890, in the southern region of the Sudety Mountains. Since then, it has spread to almost all regions of the country (Torarska-Guzik 2005 as cited in Tanner 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 years	HIGH	Due to the already widespread distribution of the plant in Ireland and its capacity for rapid dispersal (as described above in response to Question 3.06), significant further spread is considered likely in the next 10 years.
3.08	In this timeframe, what proportion of the area (including any currently occupied areas) is likely to have been invaded by this organism?	11% - 33%	HIGH	Refer to Questions 3.06 and 3.07.

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
3.09	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.	-	VERY HIGH	Available habitat for *Impatiens glandulifera* is widespread in Ireland. As previously outlined, the plant is known to colonise the riparian zone of watercourses and can spread away from this area to colonise any suitable adjacent damp habitat. It can also be found along road ditches, along field margins or on damp disturbed ground in urban or wasteland areas or in damp woodland habitat. It is also sometimes planted and maintained in private gardens as an ornamental plant (Beerling and Perrins 1993; authors observations). The plant is tolerant of a wide variety of soil textures and structure (e.g. fine and coarse alluvium, free-draining mineral soils and peat), has a wide tolerance to pH (3.5 – 7.6) and can grow on both relatively acidic and neutral soils of nutrient-rich and nutrient-poor status (reviewed in Beerling and Perrins 1993). The distribution of the plant in Ireland is likely to be constrained by its requirements for high soil moisture, and is unlikely to establish in uplands >210 m above sea level (Beerling and Perrins 1993).
3.10	Estimate the overall potential for future spread for this organism in Ireland (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues .	RAPIDLY	VERY HIGH	Although, *Impatiens glandulifera* is already widely distributed in Ireland, there remains an abundance of suitable habitats throughout the country available for colonisation. The spread of the plant has been rapid in the last *c.* 20 years and this is very likely to continue to be the case in future through both natural and anthropogenic means.

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
4.01	How great is the economic loss caused by the organism within its global distribution (excluding Ireland), including the cost of any current management?	MODERATE	HIGH	The tangible costs are difficult to accurately quantify. Nature conservation may involve costly control measures but these costs have not been quantified (EPPO 2007). According to Tanner and Gange (2013), "Impacts attributed to the species include erosion of the riverbank (Cockel and Tanner 2011), outcompeting native plant species (Hulme and Bremner 2006) and disrupting ecosystem services (Chittka and Schürkens 2001)." Accelerated river bank erosion can occur after seasonal plant dieback in the autumn which exposes a sparse or bare understory (Greenwood and Kuhn 2014). This can result in greater quantities of nutrient-rich sediment entering into aquatic environments and may ultimately steadily reduce water quality in all affected catchments (Greenwood and Kuhn 2014). It has been estimated that it would cost between £150-300 million GBP to eradicate *Impatiens glandulifera* from the UK and *c.* £1 million GBP is spent on controlling the plant there. In Switzerland, it was estimated that the cost of eradicating 95% of the *Impatiens glandulifera* population in the Canton of Zürich would be between £923,133 GBP and £5,839,691 GBP (reviewed in Tanner 2011).
4.02	How great has the economic cost of the organism been in Ireland from the time of introduction to the present? Exclude any costs associated with managing the organism from your answer.	MINIMAL	HIGH	This is difficult to quantify without figures on the cost of control and impact but is likely to be minimal. No such economic impacts have been reported in Ireland.
4.03	How great is the economic cost of the organism likely to be in the future in Ireland? Exclude any costs associated with managing the organism from your answer.	MODERATE	MEDIUM	No such economic costs have been reported in Ireland to date and are unlikely to be solely attributed to *Impatiens glandulifera* in future unless there is an increased understanding and quantification of any the specific potential economic impacts that may occur (e.g. increased sediment loads to rivers degrading salmonid spawning grounds, Pearl Mussel habitat or Water Framework Directive water quality assessments). It is reasonable to assume that dense infestations of the plant along river banks may deter some anglers from fishing, thereby impacting on related tourism revenue in infested areas. It is worth noting that, in total, angling tourism is worth €750 million to the Irish economy (Kieran Murphy – IRD Duhallow – consultation submission 07/08/2014). There may also be financial implications if conservations goals such as those specified in the EC Habitats Directive and the EU Water Framework Directive are under threat.

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
4.04	How great have the economic costs of managing this organism been in Ireland from the time of introduction to the present?	MODERATE	HIGH	The tangible costs are difficult to accurately quantify but are likely to be moderate (< €300,000). These costs are solely in association with nature conservation efforts such as *Impatiens glandulifera* field surveys, control programmes and associated reporting, which have only been conducted in Ireland since 2010. Inland Fisheries Ireland (IFI) have been the principal entity directly or indirectly involved in this work (e.g. through annual 'Balsam Bash' events undertaken during Fisheries Awareness Week [since 2011]; or through the Mulkear, Duhallow and CAISIE LIFE projects [Mulkear LIFE 2011; Duhallow LIFE 2012; CAISIE 2013, respectively]); Voluntary control efforts have also been undertaken by stakeholder groups (e.g. Irish Angling Development Alliance and Tidy Towns committees) in the last four years, sometimes with support from IFI. Duhallow LIFE have provided specific information on the economic cost of managing *Impatiens glandulifera* in their consultation submission as follows, "Duhallow LIFE has spent to date (including personnel costs) over €200,000 on field work, control and eradication measures and associated reporting of Himalayan Balsam in the Allow River Catchment. This does not include volunteers. The entire Allow Catchment is 310.9km^2 with the Dalua and Brogeen being the two major tributaries. Over 43km of infested bank and drain along the Allow and Dalau rivers have been treated by hand since 2011. This year [2014] a 6.8km stretch of the Brogeen River was found to contain Himalayan Balsam and is now being intensively treated".
4.05	How great is the economic cost of managing this organism likely to be in the future in Ireland?	MINOR	MEDIUM	The tangible costs are difficult to accurately quantify. Nature conservation efforts are likely to continue in the manner described above.
4.06	How important is environmental harm caused by the organism within its global distribution?	MODERATE	MEDIUM	According to Tanner (2011), "more research is needed into the perceived effects that [*Impatiens glandulifera*] could have on the ecosystems it invades which are often commonly cited on invasive species information websites." This is also considered to be the case by EPPO (2007), "Due

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				to its ability to form dense stands and its conspicuous appearance [*Impatiens glandulifera*] has been blamed for negative biodiversity effects. Even though these effects are less severe than often thought, further spread is undesirable and should not be facilitated by further use (i.e. planting), particularly in natural areas. Associated flora is often reduced in vigour and [abundance] due to the superior competitive strength of *I. glandulifera*. [This vegetation may not be excluded however as,] being an annual, [*I. glandulifera*] is not present in the vegetation for the whole growing season……the dominance of *I. glandulifera* may vary from year to year according to the weather conditions in the germination phase." In support of this synopsis, a study on the impact of *Impatiens glandulifera* on riparian plant communities in the Czech Republic found only minimal effects on the species composition of invaded communities (Hejda and Pyšek 2006) with no change to the presence/ absence of species and only minor reductions in the proportional cover of dominant plant species (Hejda and Pyšek 2006). However, it should be noted that in the aforementioned study sites the percentage cover of *I. glandulifera* was comparably low to the monocultures seen in the UK and Ireland. In a study in the north of England, *I. glandulifera* was shown to have a significant impact on the occurrence of plant species. By removing *I. glandulifera* from invaded sites Hulme and Bremner (2006) showed that recruitment was increased by an average of four species per metre. Extensive stands of *I. glandulifera* may reduce species richness by up to 25% (Hulme and Brenmer 2006). However, the species that benefit from this species removal may themselves be non-native species (Hulme and Bremner 2006). Contrary to Hulme and Bremner (2006), the IRD Duhallow LIFE project has not experienced an increase in non-native plant species in areas where *I. glandulifera* was removed (Kieran Murphy – IRD Duhallow – consultation submission 07/08/2014). In Ireland, only limited work has been done in this regard (CAISIE 2013) and this found no significant difference in plant species richness between invaded and control plots at a site on the River Barrow near Milford, Co. Carlow. One further point of note is that, although native plants do not appear to be excluded from an area infested with *Impatiens glandulifera*, any low frequency native species are likely to be particularly at risk of extirpation (Prowse 2001).

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				As regards the impact of *Impatiens glandulifera* on above- and below-ground invertebrate communities Tanner *et al*. (2013) found, "In the foliage-dwelling community, all functional feeding groups were less abundant in the invaded plots, and the species richness of Coleoptera and Heteroptera was significantly reduced. In the ground-dwelling community, herbivores, detritivores, and predators were all significantly less abundant in the invaded plots. In contrast, these functional groups in the below-ground community appeared to be largely unaffected, and even positively associated with the presence of *I. glandulifera*. Although the cover of *I. glandulifera* decreased in the invaded plots in the second year of the study, only the below-ground invertebrate community showed a significant response. These results indicate that the above- and below-ground invertebrate communities respond differently to the presence of *I. glandulifera*, and these community shifts can potentially lead to a habitat that is less biologically diverse than surrounding native communities; which could have negative impacts on higher trophic levels and ecosystem functioning." *Impatiens glandulifera* may have a preferential effect of attracting pollinators over native plant species (from EPPO 2007): "Another effect on other plants results from competition for pollinators, as *I. glandulifera,* with its nectar-rich and scented flowers, attracts many more pollinators than native plants, and thus has a negative effect on the fitness of the natives (Chittka and Schürkens 2001). The impact on wild fauna is both positive and negative and the net effect is not easily assessed. The rich nectar production supports many insects and aphid infestations support a food-chain of aphidophagous arthropods, although, the displacement of food plants may reduce mono- or oligophagous insects." *Impatiens glandulifera* has been shown to decrease the fitness of native plant species, indirectly, by being depauperate of Arbuscular Mycorrhizal Fungi (AMF) (Tanner and Gange 2013). When *I. glandulifera* invades an area, over time, the AMF community in the soil degrades due to the lack of a compatible host. This has consequences for habitat restoration, as when the *I. glandulifera* is mechanically removed, native plant species will find colonising the area difficult and this may suggest why Hulme and Bremner (2006) observed a significant influx of non-native species following the removal of *I. glandulifera* in the UK.

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				As previously outlined, accelerated river bank erosion can occur after seasonal plant dieback in the autumn which exposes a sparse or bare understory (Greenwood and Kuhn 2014). This can result in greater quantities of nutrient-rich sediment entering into aquatic environments and may ultimately steadily reduce water quality in all affected catchments (Greenwood and Kuhn 2014). Tanner (2011) summarises the known and perceived impacts of *Impatiens glandulifera* as follows*:* **Known effects** ***Outcompetes native plant species:*** In riparian system (Tickner *et al*., 2001) In woodland habitat (Maule *et al*., 2000) ***Indirect competition with plant species:*** For pollinators (Chittka and Schürkens, 2001) Restricts access to rivers (Tanner 2008b) Visually displeasing (Tanner 2008b) **Perceived effects** Blocks drainage systems Increases flooding Reduces invertebrate diversity Reduces soil mycobiota This has now been shown to occur (Tanner and Gange, 2013) Retards woodland regeneration – *Ammer et al*. (2011) showed no effect of the growth of *I. glandulifera* on the performance of *Betula pendula* and *Picea abies* in southern Germany.
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	MINIMAL	LOW	There is a paucity of specific information available to answer this. Although it is considered that dense stands would result in a reduction in the diversity of native plant species in the understory, through shading, this appears not be the case (as detailed in response to Question 4.06). Further to the above, reducing the percentage cover of native species in invaded stands acts to decrease the fitness of these species. In addition, as the question asks about community structure, due to its tall structure,

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				Impatiens glandulifera would change the community structure at least on a catchment scale. It would also act to decrease the structure of native plants (R. Tanner, personal communication).
4.08	How important is the impact of the organism on biodiversity likely to be in the future in Ireland?	MODERATE	LOW	It is clear from the response to Questions 4.06 and 4.07 that research is required to answer this question with any certainty. Increased sediment load to rivers resulting from accelerated erosion (as described by Greenwood and Kuhn 2014) could pose a threat to Salmonid spawning habitat, be detrimental to any local Pearl Mussel beds or locally displace other invertebrate taxa that prefer stony or sandy substrates.
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	MINIMAL	LOW	*Impatiens glandulifera* has become the dominant plant species in numerous riparian habitats in Ireland. However, it is clear from the response to Questions 4.06 that research is required to answer this question with any certainty. Impacts as detailed in response to Question 4.06 may have occurred, but no specific cases where ecosystem function has been altered have been reported or documented to date.
4.10	How important is alteration of ecosystem function caused by the organism likely to be in Ireland in the future?	MODERATE	LOW	It is clear from the response to Questions 4.06 and 4.08 that research is required to answer this question with any certainty. Increased sediment load to rivers resulting from accelerated erosion (as described by Greenwood and Kuhn 2014) could ultimately have an impact on ecosystem function.
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.	MINIMAL	VERY HIGH	There has been no official decline in conservation status observed to date in Ireland.
4.12	How important is decline in conservation status caused by the organism likely to be in the future in Ireland?	MODERATE	MEDIUM	*Impatiens glandulifera* is already widely distributed along many waterways in Ireland and will most likely continue to expand its range in the country. Dense infestations are present in areas of conservational importance, including along waters designated as Special Areas of Conservation (SAC) and Special Protection Areas under the EU Habitats Directive (e.g. the plant is present over *c.* 56 km of channel along the riparian zone of the Barrow River SAC). Although there has been no official decline in conservation status to date at any infested site, there may ultimately be implications for the classification of ecological status

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				under the EU Water Framework Directive and the conservation status of certain species and habitats and under the EU Habitats Directive.
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?	MINIMAL	VERY HIGH	No social or human health harm has been reported or documented except in relation to a reduction in the amenity value of some infested areas for fishing (due to restricted river bank access and impeded casting).
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within Ireland?	MINIMAL	VERY HIGH	There is no information relating to any social or human health damage caused by *Impatiens glandulifera* in Ireland. However, angling may be restricted in some infested areas as dense stands can reduce bankside access or impeded casting.
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?	MINIMAL	VERY HIGH	Highly unlikely - there is no evidence for this.
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)?	MINIMAL	VERY HIGH	*Impatiens glandulifera* is not known as a food, a host, a symbiont or a vector for other damaging organisms in Ireland.
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.	MINIMAL	VERY HIGH	There may be a positive impact for bees and honey producers as the plant is a high quality nectar source for bees (reviewed in Tanner 2011).
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?	MINIMAL	VERY HIGH	In general, *Impatiens glandulifera* is not naturally controlled by any predator, parasite or pathogen in Ireland. Slugs have been reported to cause considerable damage young plants however (Prowse 1998 as cited in EPPO 2007).

Stage 2 - Detailed assessment: Section D - Impact

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

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.19	Indicate any parts of Ireland 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	Although already widespread in Ireland, there remains an abundance of suitable locations for *Impatiens glandulifera* to establish dense populations in (refer to response to Question 3.01 for the habitat preferences of the plant). In theory, anywhere such dense infestations establish could result in detrimental impacts. The most obvious risk is from accelerated erosion of river banks after annual plant dieback which may increase sediment loads to adjacent waterways (Greenwood and Kuhn 2014) and in turn, have consequences for aquatic species and ecosystems sensitive to this. In addition, It is reasonable to assume that dense infestations of the plant along river banks may deter some anglers from fishing, thereby impacting on related tourism revenue in infested areas. It is worth noting that, in total, angling tourism is worth €750 million to the Irish economy (Kieran Murphy – IRD Duhallow – consultation submission 07/08/2014).
4.20	Estimate the overall potential impact of this organism in Ireland. Use the justification box to indicate any key issues.	MAJOR	MEDIUM	Globally, there remains to be an incomplete understanding of all the impacts that *Impatiens glandulifera* infestations can elicit. Some perceived impacts, which are intuitive and widely quoted in the non-scientific or grey literature, may not occur or be as severe as often stated (EPPO 2007; Tanner 2011). The principal potential impact that dense stands of *Impatiens glandulifera* may cause in Ireland is in relation to accelerated bankside erosion increasing sediment loads to waterways and in turn, negatively affecting native aquatic biota as described elsewhere in this risk assessment. Rare or conservationally important plant species may also be under threat of extirpation in sensitive habitats.

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	*Impatiens glandulifera* poses a major risk to native biodiversity, native ecosystems and conservation goals in principally riparian habitats in Ireland. Although it can spread rapidly and establish dense infestations, information on impacts is limited.

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?		LOW	Climate change is expected to increase water temperatures over time, with increased periods of drought in summer and higher rainfall in winter leading to more flooding events (Desmond *et al*. 2008). It is uncertain how this will affect the current risk assessment for *Impatiens glandulifera.* Increased flooding events have the potential to increase the rate of natural spread of *Impatiens glandulifera* within systems by enhancing seed dispersal. Increased flooding events in winter may accelerate bankside erosion and increase sediment loads to adjacent waterways and in turn result in negative impacts to resident aquatic biota sensitive to this. An increase in mean global temperature as a result of climate change should not affect the climatic suitability of *Impatiens glandulifera* to Ireland. In Europe, the northern distribution limits of *Impatiens glandulifera* appear to be controlled by the length of the growing season, where a 1.5 or 4.5 degree rise in mean global temperatures, is predicted to result in a further spread northwards (Beerling and Perrins 1993).
6.02	What is the likely timeframe for such changes (5, 10, 15 , 20, 50 or 100 years)?	100 YEARS	LOW	
6.03	What aspects of the risk assessment are most likely to change as a result of climate change		LOW	Refer to Questions 6.01.
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.			There is a paucity of scientific information available to comprehensively elucidate the impacts of *Impatiens glandulifera* on ecosystem functioning and biodiversity in Ireland. Such research would significantly strengthen the impact section (Stage 2, Section D) of this risk assessment. Priority research should include the effect of *Impatiens glandulifera* on soil erosion and the effect of *Impatiens glandulifera* on native plant fitness, i.e. does *Impatiens glandulifera* reduce the fitness/capacity of the plant community within invaded stands and does this have an impact on higher trophic levels? Studies that compare plant diversity between invaded and uninvaded stands may not accurately capture impacts. The percentage cover and the physical abundance of native plant species are more important measures to elucidate (R. Tanner, personal communication).

References

Ammer, C., Schall, P., Wördehoff, R., Lamatsch, K. and Bachmann, M. (2011). Does tree seedling growth and survival require weeding of Himalayan balsam (*Impatiens glandulifera*)? *European Journal of Forest Research* 130:107-116.

Beerling, D.J. and Perrins, J.M. (1993). *Impatiens glandulifera* Royle (*Impatiens roylei* Walp.). *Journal of Ecology* (Oxford) 81(2):367-382

Botanic Gardens (2007). Ireland's National Plant Conservation Strategy - Target 10 - Managing Invasive Alien Species. Botanic Gardens, Glasnevin, Dublin. http://www.botanicgardens.ie/gspc/targets/inspc10home.htm (accessed 07/05/2014).

CABI (2013). Progress with Weed Biocontrol projects CABI in the UK - June 2013. Centre for Agricultural Bioscience International 2 pp. http://www.cabi.org/uploads/projectsdb/documents/1352/update%20on%20biocontrol%20projects%20for%20GB.pdf (accessed 10/06/2014).

CAISIE (2013). Control of Aquatic Invasive Species and Restoration of Natural Communities in Ireland, EU LIFE+ Project NAT/IRL000341 Final Report to the European Commission. Inland Fisheries Ireland 73 pp.

Cockel, C.P. and Tanner, R.A. (2011). *Impatiens glandulifera* Royle (Himalayan balsam). A handbook of global freshwater invasive species. Earthscan, London, pp 67–77.

Chittka, L. and Schürkens, S. (2001). Successful invasion of a floral market. *Nature* 411:653 doi:10.1038/35079676.

Desmond, M., O'Brien, P. and McGovern, F. (2008). A Summary of the State of Knowledge on Climate Change Impacts for Ireland. EPA Climate Change Research Programme 2007-2013. Environmental Protection Agency, Wexford pp. 20.

Duhallow LIFE (2012). IRD Duhallow support Inland Fisheries Balsam bash http://www.duhallowlife.com/content/ird-duhallow-support-inland-fisheries-balsam-bash (accessed 11/06/2014).

Environment Agency (2010). Our river habitats: the state of river habitats in England, Wales and the Isle of Man: a snap shot. Environment Agency, London.

EPPO (2007). EPPO data sheet on Invasive Plants - Impatiens glandulifera *www.**eppo**.int/.../05-11831%20DS%20Impatiens%20glandulifiera.doc*

Garden.ie (2012). "Bruno, I will not forgive you, never, ever.....". Fran M's Journal 21/06/2012. Garden.ie website (accessed 07/07/2014).

Greenwood, P. and Kuhn, N.J. (2014). Does the invasive plant, Impatiens glandulifera, promote soil erosion along the riparian zone? An investigation on a small watercourse in northwest Switzerland. *Journal of Soils and Sediments* 14(3):637-650.

Grime, J.P., Hodgson, J.G. and Hunt, R. (1988). Comparative Plant Ecology. A Functional Approach to Common British Species. London, UK: Unwin Hyman Ltd.

Hartmann, E., Schuldes, H., Kübler, R. and Konold, W. (1995). Neophyten. Biologie, Verbreitung und Kontrolle ausgewählter Arten. ecomed, Landsberg, Germany.

Hejda, M. and Pyšek, P. (2006). What is the impact of Impatiens glandulifera on species diversity of invaded riparian vegetation? *Biological Conservation* 132:143-152.

Hulme, P.E. and Bremner, E.T. (2006) Assessing the impact of Impatiens glandulifera on riparian habitats: partitioning diversity components following species removal. *Journal of Applied Ecology* 43:43–50.

Inland Fisheries Ireland (2013a). Stop! The spread of invasive species and pathogens - Best practice for control of Himalayan Balsam *Impatiens glandulifera*. http://www.fisheriesireland.ie/invasive-species-1/365-best-practice-control-measures-for-himalayan-balsam-1/file (accessed 10/06/2014).

Kelly, J., O'Flynn, C. and Maguire, C. (2013). Risk analysis and prioritisation for invasive and non-native species in Ireland and Northern Ireland. A report prepared for the Northern Ireland Environment Agency and National Parks and Wildlife Service as part of Invasive Species Ireland. 59 pp.

Maule, H., Andrews, M., Watson, C. and Cherrill, A. (2000) Distribution, biomass and effect on native species of *Impatiens glandulifera* in a deciduous woodland in northeast England. *Aspects of Applied Biology* 58:31-38.

Mulkear LIFE (2011). Successful Conservation Outing – Bilboa River 25 June 2011. http://mulkearlife.com/successful-conservation-outing-bilboa-river-25-june-2011/ (accessed 11/06/2014).

National Invasive Species Database (2010). National Biodiversity Data Centre http://invasives.biodiversityireland.ie/ (accessed 07/07/2014).

Rotherham, I.D. (2000). Exotic Invasive Species – should we be concerned? Himalayan balsam - the human touch. Institute of Ecology and Environmental Management Conference, Birmingham, April, 2000. 10 pp. http://www.ukeconet.org/wp-content/uploads/2009/10/Himalayan_balsam_human_touch_2000.pdf (accessed 07/05/2014).

Pacanoski, Z. and Saliji, A. (2014). The invasive *Impatiens glandulifera* Royle (Himalayan balsam) in the Republic of Macedonia: first record and forecast. *EPPO Bulletin* 44(1):87-93.

Prowse, A. (1998). Patterns of early growth and mortality in Impatiens glandulifera. In: Starfinger, U., Edwards, K., Kowarik, I., and Williamson, M., eds. Plant Invasions: Ecological Mechanisms and Human Responses. Leiden, The Netherlands: Backhuys pp. 245-252.

Prowse, A. (2001). Ecological effects of the invasion of native plant communities by the alien Himalayan balsam (*Impatiens glandulifera* Royle).PhD thesis, University of Manchester 260 pp.

Tanner, R. (2008a). *Impatiens glandulifera* datasheet. Invasive Species Compendium, Centre for Agriculture and Biosciences International (CABI) http://www.cabi.org/isc/datasheet/28766 (accessed 07/07/2014).

Tanner, R. (2008b). A review on the potential for the biological control of the invasive weed *Impatiens glandulifera* Royle in Europe. Plant Invasions: Human Perception, Ecological Impacts and Management (eds B. Tokarska-Guzik, J.H. Brock, G. Brundu, L.E. Child, C. Daehler and P. Pysek), Backhuys Publishers, Leiden, Netherlands pp. 343-354.

Tanner, R. (2011). An ecological assessment *of Impatiens glandulifera* in its introduced and native range and the potential for its classical biological control. Ph.D thesis, University of London. 286 pp. http://digirep.rhul.ac.uk/file/a82ac41c-a078-cab1-a0e2-b05f7b13e7d1/5/2012Tannerraphd.pdf (accessed 09/06/2014).

Tanner, R.A. and Gange, A.C. (2013). The impact of two non-native plant species on native flora performance: potential implications for habitat restoration. *Plant Ecology* DOI 10.1007/s11258-013-0179-9.

Tanner, R.A., Varia, S., Eschen, R., Wood, S., Murphy, S.T., and Gange, A.C. (2013). Impacts of an invasive non-native annual weed, *Impatiens glandulifera,* on above- and below-ground invertebrate communities in the United Kingdom. *PLoS ONE* 8(6): e67271. doi:10.1371/journal.pone.0067271.

Tanner, R.A., Jin, L., Shaw, R., Murphy, S.T., and Gange, A.C. (2014). An ecological comparison of *Impatiens glandulifera* Royle in the native and introduced range. *Plant Ecology* DOI 10.1007/s11258-014-0335-x.

Terra Nova (2005). Seed List from Terra Nova 2005. http://homepage.eircom.net/~terranovaplants/seed_list.htm (accessed 07/07/2014).

Tickner, D.P., A gold, P.G., Gunnel, A.M., Mount ford, J.O. and Sparks, T. (2001). Hydrology as an influence on invasion: Experimental investigations into competition between the alien *Impatiens glandulifera* and the native *Urtica dioica* in the UK. Plant Invasions: Species Ecology and Ecosystem Management (eds G. Burundu, J. Brock, I. Camarda, L. Child and M. Wade), Backhuys Publishers, Leiden, Netherlands pp. 159-168.

Tokarska - Guzik, B. (2005). The establishment and spread of alien plant species (neophytes) in the flora of Poland. Wydawnictwo Uniwersytetu Śląskiego, Katowice, p. 192.