Risk Assessment of *Impatiens glandulifera*

Name of Organism:	*Impatiens glandulifera* Royle – Indian balsam
Objective:	Assess the risks associated with this species in EU
Version:	NAPRA EU amendment Final 30/11/2015
Author(s)	Ewa Pisarczyk[1], Barbara Tokarska-Guzik[2]
Expert reviewer	Jan Pergl[3]

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.

[1] General Directorate for Environmental Protection in Poland
[2] University of Silesia in Katowice
[3] Institute of Botany, Academy of Sciences of the Czech Republic

EU CHAPPEAU	
QUESTION	**RESPONSE**
1. In how many EU member states has this species been recorded? List them.	23: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom (Perrins et al. 1993; Gudžinskas 1998; Drescher and Prots 2003; Tokarska-Guzik 2003, 2005; Helmisaari 2010, CABI 2015, Helmisaari 2010, DAISIE 2016)
2. In how many EU member states has this species currently established populations? List them.	23: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom CABI 2015, Helmisaari 2010, DAISIE 2016
3. In how many EU member states has this species shown signs of invasiveness? List them.	23: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Romania, Slovakia, Slovenia, Sweden, United Kingdom (Perrins et al. 1993; Eliás 2001; Essel and Rabitsh 2004; Tanner 2008; Balogh 2008; Tokarska-Guzik et al. 2012) also CABI 2015, Helmisaari 2010, DAISIE 2016 http://www.europe-aliens.org/speciesTheWorst.do
4. In which EU Biogeographic areas could this species establish?	Alpine, Atlantic, Boreal, Continental, Mediterranean, Pannonian (Biogeographic Areas in Europe, 2011. European Environment Agency see: http://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-1) CABI 2015, Helmisaari 2010, DAISIE 2016
5. In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them.	25: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom CABI 2015, Helmisaari 2010, DAISIE 2016
6. In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)?	25: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom CABI 2015, Helmisaari 2010, DAISIE 2016

Stage 1 - Organism Information			
N	**QUESTION**	**RESPONSE**	**COMMENT**
1	Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	YES	Synonyms: *I. glanduligera* Lindley, *I. roylei* Walpers Family: Balsaminaceae The most commonly used English names: Himalayan balsam, Indian balsam, policeman's helmet, ornamental jewelweed

Stage 1 - Organism Information			
N	**QUESTION**	**RESPONSE**	**COMMENT**
			Three 'forms' of the species have been noted, forma albida (Hegi) B. Boivin, forma pallidaflora Weath., and forma glandulifera Vahl (Missouri Botanical Garden, 2008). Attention should be paid to the taxonomic authority, as the true species is *I. glandulifera* Royle, whereas *I. glandulifera* Arn. is a synonym of *I. taprobanica* Hiern, a native of Sri Lanka (CABI 2015).
2	If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	N\A	
3	Describe the organism.		*I. glandulifera* is a tall glabrous annual species/plant reaching 50 to 250(300) cm in height. It is now Europe's tallest annual species. 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. The leaves are opposite, the upper ones sometimes in whorls of three, 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, their posterior sepal forming a sac that ends in a straight spur. Their colours vary from white to pink and purple. Seeds are gathered in capsule (Beerling and Perrins 1993, CABI 2015).
4	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	YES	One preliminary risk assessment was previously carried out for Poland. The study (Tokarska-Guzik et al. 2012) designated *I. glandulifera* as highest invasive plant, especially for hydrophilous tall herb fringe communities (habitat type 6430), alpine rivers and the ligneous vegetation along their banks (3240) and alluvial forests (91E0). In Belgium the species was allocated to the black list (high impact and widespread species) on a simplified environmental impact assessment protocol (ISEIA) (Harmonia database 2016). It can cause damage in freshwater habitats (3270), grasslands (6430, 6510) and forests (91E0, 91F0). The species was assessed as a widespread and high risk species in the method ISEIA for the Netherlands and Luxembourg (Matthews et al. 2015). The Dutch study contains a comprehensive risk analysis for the species. According to NAPRA conducted in Ireland, the Himalayan balsam poses a major risk to native biodiversity (Millane, Caffrey 2014). Moreover, *I. glandulifera* was assessed in Germany as potentially invasive and included in the Grey List-Action List (Nehring et al. 2013). In the Czech Republic it is listed in the Black list with reccomended stratified approach (Pergl et al. 2016).
5	If there is an earlier risk assessment is it still entirely valid, or only partly valid?	YES	All the assessments have been recently conducted (refer to Question 4).

Stage 1 - Organism Information			
N	**QUESTION**	**RESPONSE**	**COMMENT**
6	Where is the organism native?		*I. glandulifera* is native to the foothills of the Himalayas from north-west Pakistan to northern India. The native range in the western Himalayas is relatively small compared to its invasive range. The plant can grow up to 4000 m a.s.l. in its native range, mainly in humid riparian forest. The plant is also recorded as native in Nepal and possibly in Bhutan (CABI 2015).
7	What is the current global distribution of the organism?		*I. glandulifera* is introduced and invasive in much of Europe, and parts of Canada, the USA and New Zealand. It has restricted distribution in Japan. (CABI 2015, DAISIE 2016, NOBANIS 2016, USDA, NRCS. 2001. The PLANTS Database, Version 3.1. (http://plants.usda.gov).
8	What is the current distribution of the organism in EU?		The species is present in most of the UE countries. In Poland it was introduced to Sudety Mts. in 1890 (Zając and Zając 1973; Tokarska-Guzik 2005). By 1940, spontaneous occurrences of the *I. glandulifera* were recorded in several localities, mainly in south-western Poland and in isolated station in northern Poland, in the Wiślane marshland (Mierzeja Wiślana)(Tokarska-Guzik 2005). The first established populations in natural floodplain forests of valleys of Polish big rivers were observed at the beginning of 1960s (Dajdok and Anioł-Kwiatkowska 1998). Nowadays it is found almost in the whole country, but it is more frequent in the south and less common in the north-east.The regions of its frequent and massive occurrence are located in the southern part of Poland: the Carpathians, Silesian Upland, Kraków-Częstochowa Upland and Małopolska part of Vistula river valley (Tokarska-Guzik 2005; Dajdok 2009). Until now numerous localities of this species were being recorded in valleys of such rivers as: Odra, Vistula (Wisła), San, Bug, Czarna Hańcza, Nysa Łużycka (Dajdok 2009 and literature cited therein) In the Carpathian Mts. it grows primarily in river basins e.g. Soła, Skawa, Wisłok (Tokarska-Guzik et al. 2012). The history of its spreading in the Polish Carpathians and in their foreland have been presented within time intervals by Zając et al. 2011 and the actual distribution map (dot map) for this part of Poland was published recently (Zając and Zając, eds. 2015). In the Czech Republic, it was first planted in a garden in 1846 and in 1896 first observed in the wild. A rapid invasion of the species started in the mid-20th century and currently it is common in the country (Pyšek et. al. 2012). In Hungary, Himalayan balsam was introduced as ornamental plant and its spread accelerated after 1960s. Its occurrence concentrates in the western regions of Hungary (Csiszár and Korda 2015). In Belgium, it was first observed in nature in 1939. Nowadays *I. glandulifera* is widespread and causes high risk for biodiversity (Harmonia database 2016).
9	Is the organism known to be invasive anywhere in the world?	YES	*I. glandulifera* is introduced and invasive in much of Europe, and parts of Canada, the USA and New Zealand (Cronk and Fuller 2001; Weber 2003; CABI 2015).

Stage 1 - Organism Information			
N	**QUESTION**	**RESPONSE**	**COMMENT**
10	Describe any known socio-economic benefits of the organism in the risk assessment area.		*I. glandulifera* is used as a garden ornamental and as a honey plant. Cattle are known to feed on the whole plant (Beerling and Perrins, 1993) but the browse value is not known (CABI 2015). In its native area it is known as a balm plant (Balogh 2008).

Stage 2 - Detailed assessment: Section A - Entry				
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)?	MODERATE NUMBER	HIGH	
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. Beekeeping and horticulture 2. Rivers	VERY HIGH	Indian balsam is still being planted as a honey plant or in small gardens as an ornamental plant. It is still popular in some parts of Poland (Jędrzejewska 2015; personal observations). However now it's not more common to plant this species. It can also spread from the current locations with water flow (Moravcová et al. 2010).

Pathway 1 – Beekeeping and horticulture				
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	Indian balsam is deliberately cultivated for beekeeping and as ornamental plants.
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	Indian balsam is deliberately cultivated for beekeeping by private garden owners as well as by small honey producers. Small garden holders keep this plant for decorative purposes as well as for butterflies.
1.05	How likely is the organism to enter EU undetected or without the knowledge of relevant competent authorities?	LIKELY	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* trade, survival is considered very likely.

Pathway 1 – Beekeeping and horticulture				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	VERY LIKELY	VERY HIGH	Trade imports and purchases may occur throughout the year. The material is viable, so after planting in the growing season it can become invasive.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	VERY LIKELY	VERY HIGH	The threatened habitats such as rivers, lakes, meadows or forests can be situated next to patches of cultivated *I. glandulifera* or to its localities in the wild. Indian balsam can spread from these sites to a suitable habitat either by natural spread or from the disposal of plant material into the wild. *I. glandulifera* spreads only by seeds. When the mature fruit capsule is touched, it explodes and ejects the seeds. The seeds have been reported to disperse up to 7 m from the mother plant. A single plant can produce more than 4000 seeds, and in pure stands the production of 32 000 seeds/m² has been reported (Koenies and Glavac 1979). The expansion of the species in river systems is especially due to the dispersal of seeds by water currents since they can be transported both by flowing water (in the sediment) and the dry seeds are buoyant. Plant parts containing seeds have to be handled carefully since the small seeds are easily transported with soil and in crevices of shoes to new habitats. The seeds are probably also spread by ants (myrmecochory). Fruiting specimens or their fragments are also transported with soil or floating in water (Kurtto 1992, 1996). For Great Britain a dispersal ability of 2,6 – 5 km per year has been calculated (NeoFlora 2006). The reproductive strategy is based on active spreading of seeds and on rich seed-setting. The seeds have a high germination rate (80 %) according to Grime (1987). The plant competes on river banks by synchronous germination of a large amount of seeds to achieve sufficient biomass to suppress the performance of neighbouring species. It grows fairly fast and forms dense stands (Helmisaari 2010).
1.09	Estimate the overall likelihood of entry based on this pathway?	VERY LIKELY	VERY HIGH	The plant is already deliberately cultivated.
1.10	Do other pathways need to be considered?	YES		Internet sales should be taken into account.

Pathway 2 – Rivers				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**

Pathway 2 – Rivers				
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 seeds with water flow is unintentional.
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?	VERY LIKELY	VERY HIGH	Long-distance dispersal of seeds is aided by flowing water, with fresh seeds transported in sediment on the beds of rivers, and dry seeds being buoyant can float over large distances (Harmonia database 2016).
1.05	How likely is the organism to enter 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. There is no ongoing monioring of the river banks. However there is a monitoring of Natura 2000 sites which include habitats suitable for Indian balsam.
1.06	How likely is the organism to survive during passage along the pathway?	VERY LIKELY	VERY HIGH	The expansion of the species in river systems is especially due to the dispersal of seeds by water currents since they can be transported both by flowing water (in the sediment) and the dry seeds are buoyant (Helmisaari 2010).
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	VERY LIKELY	VERY HIGH	Transport in rivers may occur throughout the year. The seeds are viable, so they can become invasive during the growing season.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	VERY LIKELY	VERY HIGH	The threatened habitats such as other rivers, lakes, meadows or forests can be situated next to infested rivers. The plant competes on river banks by synchronous germination of a large amount of seeds to achieve sufficient biomass to suppress the performance of neighbouring species. It grows fairly fast and forms dense stands (Helmisaari 2010) (refer to Pathway 1 Question 1.08).
1.09	Estimate the overall likelihood of entry into EU based on this pathway?	VERY LIKELY	VERY HIGH	This pathway is alread a key pathway of invasion of Indain balsam.
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 based on all pathways (comment on the key issues that lead to this conclusion).	VERY LIKELY	VERY HIGH	Anthropogenic-mediated transfer (for beekeeping and gardens) is the initial phase of the Indian balsam invasion. However the magnitude of the invasion is mainly due to the further dispersion by natural means (transport of seeds along water courses). Seeds of Indian balsam may be also transported with contaminated soil (Balogh 2008; Dajdok 2009). Transport of seeds with river gravel, as well as contamination of building rubbish transported to waste disposal sites was reported so far (CABI 2015).

Stage 2 - Detailed assessment: Section B – Establishment

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.01	Is the organism well established (if there is any uncertainty answer 'unsure')	YES	VERY HIGH	*I. glandulifera* is introduced and invasive in much of Europe, and parts of Canada, the USA and New Zealand (Cronk and Fuller 2001; Weber 2003; CABI 2015).
2.02	How likely is it that the organism will be able to establish based on the similarity between local climatic conditions and the organism's current global distribution?	VERY LIKELY	VERY HIGH	Based on its present widespread occurrence in Europe, climatic conditions are not thought to be limiting. The species has still potential to establish in new localities in Poland, in particular in north-eastern part (see Question 8) (Tokarska-Guzik 2005; Zając et al. 2011; Tokarska-Guzik et al 2012)
2.03	How likely is it that the organism will be able to establish based on the similarity between other local abiotic conditions and the organism's current global distribution?	VERY LIKELY	VERY HIGH	Based on its present occurrence in Europe, there are no overriding abiotic factors to limit its further establishment in habitat types which are similar to those it occupies throughout its global range. *I. glandulifera* occurs in many different habitats, but it thrives best on moist and nutrient rich habitats, especially on lake- and seashores and along rivers and brooks (Kurtto 1992). It is also often found in human influenced and man-made habitats such as grasslands, shrubbery, ditches, roadsides and hedges (Kurtto 1996). Research done by Garkāje (2006) has shown that the biotopes that are most suitable for *I. glandulifera* are those that have been affected by humans. The studies of species dynamics in Latvia suggest that in the initial phases of invasion the species prefers human-affected, weedy sites and dump sites, while on later invasion stages it appears to be successful and frequent invader in riparian habitats (Priede, 2008). In these biotopes *I. glandulifera* most commonly grows together with species of plants that need nitrogen in the soil, like *Aegopodium podagraria, Urtica dioica, Calystegia sepium, Deschampsia cespitosa, Stellaria nemorum* and *Galium aparine.* It is found on a variety of soil types (Kowarik 2003). In Europe *I. glandulifera* plants of all ages are frost intolerant. Usually all adult plants are killed by the first frost in the autumn and seedlings are killed by late frosts in spring (Sebald et al. 1998). In Karelia region (in the

Stage 2 - Detailed assessment: Section B – Establishment				
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				northern European part of Russia) seedlings are tolerant to late frosts in May-beginning of June (Антипина, Брюханчикова 2003). The species is also drought-intolerant and quickly wilts, and plants can survive only if the drought period is short. The species is relatively shade tolerant (Beerling and Perrins 1993; Helmisaari 2010).
2.04	How likely is the organism to encounter habitats necessary for the survival, development and multiplication of the organism?	VERY LIKELY	VERY HIGH	There is a high density and abundance of habitats (such as meadows, rivers, lakes, forests, etc.) susceptible to colonisation by *I. glandulifera* which can facilitate its subsequent survival, development and multiplication.
2.05	How likely is it that establishment will occur despite competition from existing species?	VERY LIKELY	VERY HIGH	Experience to date demonstrates that *I. glandulifera* can establish populations which can be competetive to native plant species (Kowarik 2003). The plant competes on river banks by synchronous germination of a large amount of seeds to achieve sufficient biomass to suppress the performance of neighbouring species. It grows fairly fast and forms dense stands (Helmisaari 2010).
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present?	VERY LIKELY	HIGH	*I. glandulifera* supports an impoverished diversity of phytophagous insects in the UK, but the extent to which these affect the ecology of the plant is not sufficiently studied. In the UK, only 3 arthropod species are known to feed on *I. glandulifera*, including two aphid species, *Aphis fabae* and *Impatientinum balsamines*, and the elephant hawk moth *Deilephila elpenor* (Beerling and Perrins, 1993;CABI 2015).
2.07	How likely is it that establishment will occur despite existing management practices?	LIKELY	HIGH	*I. glandulifera* is not resistant to grazing or cutting. That's why mowing and grazing can be successful in eliminating existing infestations, though this would need repeating annually and on a catchment scale (CABI 2015). However this method is only applicable in semi-natural habitats. On natural river and lake edges such management would destroy native riparian vegetation. Desired effects of the elimination of *Impatiens* were achieved as part of the combating conducted in Wigierski National Park (north Poland) as part of the Life project (Puza and Krzysztofiak 2015; Krzysztofiak and Krzysztofiak 2015). The method of repeated (5-7 times) tearing out / reaping plants during one growing season were introduced there. The measures were applied in the second year only 2 times. The management method was very successful. Due to absence of a persistent seed bank, it was possible to eliminate most of the seeds deposited in the soil.
2.08	How likely is it that management practices will facilitate the establishment	UNLIKELY	HIGH	*I. glandulifera* is not resistant to grazing or cutting. Refer to Question 2.07.

Stage 2 - Detailed assessment: Section B – Establishment				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
	of the organism?			
2.09	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns?	MODERATELY LIKELY	HIGH	Mechanical eradication efforts sometimes take place, especially in areas of high conservation interest. *I. glandulifera* can easily be removed by pulling, grazing or cutting. However, the effective transportation of seeds through the river corridor can result in a reinvasion (Csiszárand Korda 2015, DAISIE 2016). Additionally, if certain conditions are not met, the plant can regenerate. The removal has to be continued until no more growth occurs for at least 2 to 3 years. Eradication and control measures include removal and preventing the formation and spreading of seeds. The timing of the eradication effort is most important. If the removal is too early the plants will regenerate, and if it is made too late the seeds formed will be able to germinate. The right time is before (May) or when the first flowers appear (at the end of July). Due to its strong regeneration ability it is extremely important to remove all plant material and to dispose of it appropriately. Sheep and cattle may also be used to graze the plant. Since *I. glandulifera* is sensitive to grazing and grazing animals eat it, grazing is a good method to eradicate the species (Larsson and Martinsson 1998) (Csiszár and Korda 2015, Helmisaari 2010). Juvenile plants respond to spraying by herbicides, however, when the flowering plants are sprayed, they are still able to produce viable seeds (DAISIE 2016). Furthermore, the use of herbicides should be generally avoided and are often not permitted especially along waterways (Helmisaari 2010). Csiszár and Korda (2015) recommend only mechanical methods of eradictation, which are effective, selective and cheap (not many tools are needed). However long-term control can only be carried out successfully if upstream habitats are cleared beforehand. Mechanical control can be problematic as stands are often difficult to access. So far no biological control methods are available for *I. qlandulifera* (Sheppard et al. 2006). Large scale nationwide management and eradication activities in the region are lacking, but some local initiatives exist. In the Oslo area e.g. the municipality has developed a detailed yearly plan of action to control the spread of *I. glandulifera* (Helmisaari 2010).
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	VERY LIKELY	VERY HIGH	Both the seed characteristics and the distribution mechanism facilitate the establishment of Indian balsam. *I. glandulifera* is reported to be without any persistent seed bank

Stage 2 - Detailed assessment: Section B – Establishment				
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				(Beerling and Perrins 1993; Weber 2003; Balogh 2008, Perglová et al. 2009). However, from England there are reports that the seeds can occasionally survive up to 18 months. When the species is not exposed to frost, most seedlings appear over a period of four weeks (Beerling and Perrins 1993). There are no observations from the region of seed survival for more than one year. *I. glandulifera* has a good regenerative ability and on stems that have been cut down, new branches and flowers are formed. Also small individuals can develop flowers and seeds (even in the late autumn – Puza and Krzysztofiak 2015). The time from germination to the onset of flowering is 13 weeks in Germany and the flowering continues for a further 12 weeks (Sebald et al. 1998). The fruits germinate in spring, but somewhat later than the other vegetation, so the frost sensitive seedlings are protected by the milder microclimate created by other plants. Since seeds are the only persistent particles, their production and transport is crucial for spread of the plant (DAISIE 2016). The plant competes on river banks by synchronous germination of a large amount of seeds to achieve sufficient biomass to suppress the performance of neighbouring species. It grows fairly fast and forms dense stands (Helmisaari 2010).
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?	VERY LIKELY	VERY HIGH	Refer to Question 2.10.
2.12	How likely is it that the organism's adaptability will facilitate its establishment?	VERY LIKELY	VERY HIGH	Refer to Question 2.10. Elst et al. (2016) conclude thet "post-introduction evolution of traits thus probably did not boost the invasiveness of *I. glandulifera*. Instead, the species seems to be pre-adapted for invasion". They suggest that differences in habitat between the native and invasive range, more specifically the higher nutrient availability observed in the new environment, are the main factor driving the invasion of this species. Indeed, plants in the more nutrient-rich invasive range had greater seed mass, likely conferring a competitive advantage, while seed mass also responded strongly to nutrients in the glasshouse. Interactions between habitat productivity and herbivore defense may explain the lack of more vigorous growth in the new range.
2.13	How likely is it that the organism could establish despite low genetic diversity in	VERY LIKELY	VERY HIGH	The plant reproduces generatively. The degree of genetic heterogeneity is uncertain, though there is obvious variation in flower colour (Grime et

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	the founder population?			al., 1988). The chromosome number is 2n=18 or 2n=20 (Grime et al., 1988; Beerling and Perrins, 1993) (CABI 2015). Results of research by Hagenblad et al (2015) revealed that the genetic diversity in invasive populations of *I. glandulifera* is unusually low compared to native populations, in particular when compared to other invasive species. Genetic drift rather than mutation seems to have played a role in differentiating populations in Europe. The authors conclude that phenotypic plasticity may therefore be an important component of the successful spread of *Impatiens glandulifera* across Europe. Minden and Gorschlüter (2016), on the example of comparison of native and non-native *Impatiens* species across experimental light and nutrient gradients, claim, that the success of invasive species over their native congeners is based on a combination of similar trait responses to environmental site conditions, but the invasive species exhibit higher trait plasticity, facilitating establishment.
2.14	Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in EU? If possible, specify the instances of invasion elsewhere in the justification box	VERY LIKELY	VERY HIGH	*I. glandulifera* was introduced to Europe (Kew Gardens) in 1839 (Coombe 1956, Valentine 1971). In continental Europe it began spreading around 1900, almost half a century later than in England (Berger and Schmidt 1925). In south-west Germany it was already common at some places in the 1920s spreading from a Swiss population (first naturalisation in 1904) via the Rhine. In Belgium the species was introduced in 1939 and nowadays is widespread in the whole country (Harmonia database 2016). It was introduced to the Helsinki Botanic Gardens at the end of 1800s (Kurtto 1992). The first naturalized populations were observed in Finland in 1947, in Sweden in the late 1920s and in Norway in the late 1930s (Kurtto 1996). In Denmark the species was recorded in 1888. In 1956 approx. 40 findings/localities were recorded, mostly in the eastern part of Denmark (Pedersen 1956). In 1988 the species was recorded in all botanical districts in the country (Hansen 1991). It is found also in more or less natural habitats throughout the Baltic area (Kuusk et al. 1996). In Latvia *I. glandulifera* has been introduced as garden plant. The first record of *I. glandulifera* in Latvia is from 1898 (Herbarium RIG 1). In Lithuania this species as escaped from cultivation was recorded in 1959 (Gudžinskas 1998). In Poland it was introduced to Sudety Mts. in the southern parts of the country in 1890. Nowadays it is found almost in the whole country, but it is more frequent in the south (Tokarska-Guzik 2005; Zając and Zając 2015). The first established populations in natural floodplain forests in valleys of the largest Polish rivers were observed at the beginning of 1960s (Dajdok and Anioł-

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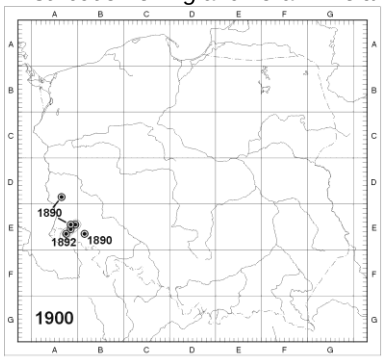
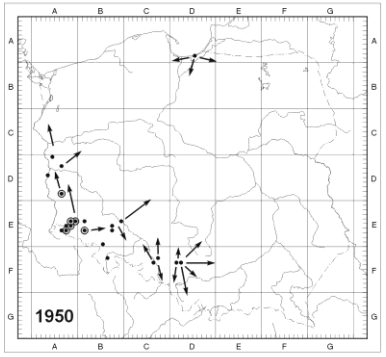
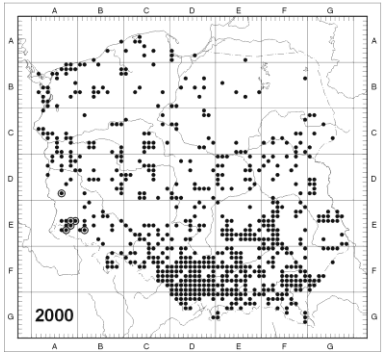
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				Kwiatkowska 1998). In Russia *I. glandulifera* has been cultivated from the end of the 19th century, and as escaped from cultivation it was recorded in 1914 (Moscow region: Сырейщиков 1914, Игнатов и др. 1990). Since 1960s, mass naturalization of species was observed (Марков и др. 1997). The plants with purple and pink flowers only are naturalizing (Виноградова 1992). In the last decades its proliferation was recorded also in southern Europe, among others in Croatia (Pandza et al. 2001), Spain (Dana et al., 2001), Macedonia (Pacanoski and Saliji 2014).
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?	N/A		
2.16	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	VERY LIKELY	VERY HIGH	Refer to Questions 2.09, 2.10 and 2.14.

Stage 2 - Detailed assessment: Section C – Spread				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**

Stage 2 - Detailed assessment: Section C – Spread				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
3.01	What area (given in % or 10km squares) in Poland could the organism establish (0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%)?	68% - 90%	MEDIUM	The potential distribitution in Poland is not yet reached (see Question 8) Distribution of *I. glanulifera* in Poland (source: Tokarska-Guzik 2005)  **First recorded localities of occurrence, probably escapes from cultivation:** ◉ the Sudety Mountains: Siodło AD86, Płóczki Dolne AD48, Stępnica AD48 and Płonina BE61 (SCHUBE 1903b)  **Start of spread:** naturalisation close to cultivation sites: occupation of new localities, especially in the south-western part of the country directions of spread  **Subsequent phases of spread:** range increase and stabilisation further naturalisation from cultivation sites and autonomous spread from previously occupied localities Current wide distribution of the species in the territory of Poland with regions of clustered occurrences in the southern part of the country

Stage 2 - Detailed assessment: Section C – Spread				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
3.02	How important is the expected spread of this organism in EU by natural means (minimal, minor, moderate, major or massive)?	MAJOR	HIGH	Refer to Question 1.08 and 2.10.
3.03	How important is the expected spread of this organism in EU by human assistance (minimal, minor, moderate, major or massive)?	MINOR	MEDIUM	Anthropogenic-mediated transfer is the initial phase of the Indian balsam invasion. However the magnitude of the invasion is mainly due to the further dispersion by natural means (transport of seeds in water courses).
3.04	Within EU, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MAJOR	HIGH	The *I. glandulifera* is currently widespread in Poland, so it would be cost and labour intensive to eradicate it. However it is still possible to control it, especially in protected areas and other valuable sites (Refer to Question 8).Desired effects of the elimination of *Impatiens* were achieved as part of the combating conducted in Wigierski National Park (north Poland) as part of the LIFE project (Puza and Krzysztofiak 2015; Krzysztofiak and Krzysztofiak 2015). The method of repeated tearing out / reaping plants during one growing season were introduced there. It led to elimination of seeds deposited in the soil.
3.05	What proportion (%) of the area in Poland suitable for establishment, if any, has already been colonised by the organism?	34% - 67%	MEDIUM	Refer to Question 8.
3.06	What proportion of the area in Poland suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	34% - 67%,	LOW	It is most likely that the spread of *I. glandulifera* from sites where it currently exists will continue. Refer to Question 8.
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 – 20 years	MEDIUM	The spread of Indian balsam is quite rapid. For Great Britain a dispersal ability of 2,6 – 5 km per year has been calculated (NeoFlora 2006) (refer to Pathway 1 Question 1.08).
3.08	In this timeframe, what proportion of the endangered area (including any currently	68% - 90%	LOW	Refer to Questions 3.06 and 3.07.

Stage 2 - Detailed assessment: Section C – Spread				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
	occupied areas) is likely to have been invaded by this organism?			
3.09	Based on the answers to questions on the potential for establishment and spread in EU, 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.	N/A	HIGH	The species can invade hydrophilous tall herb fringe communities (habitat type 6430), alpine rivers and the ligneous vegetation along their banks (3240), alluvial forests (91E0, 91F0), freshwater habitats (3270), and grasslands (6430, 6510) (Kowarik 2003, Tokarska-Guzik et al. 2012, Harmonia database 2016).
3.10	Estimate the overall potential for future spread for this organism in EU (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues .	RAPIDLY	MEDIUM	Where *I. glandulifera* is already present within a system, further internal spread on suitable habitats will be most likely and quite rapid (see Question 3.07).

Stage 2 - Detailed assessment: Section D – Impact				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
4.01	How great is the economic loss caused by the organism within its global distribution, including the cost of any current management?	MODERATE	LOW	Himalyan balsam limits angling area of river and lakesides. *I. glandulifera* can lead to increased erosion of riverbanks as it leaves soils bare when it dies back in winter. However, this is not well proven by evidence, as the species is often integrated in perennial vegetation (CABI 2015).
4.02	How great has the economic cost of the organism been from the time of introduction to the present? Exclude any costs associated with managing the organism from your answer.	MODERATE	LOW	It is assumed that in UK £1,365,084 per annum costs this species for angling industry (Wiliams et al. 2010).
4.03	How great is the economic cost of the organism likely to be in the future in EU? Exclude any costs associated with managing the organism from your answer.	MODERATE	LOW	This is difficult to quantify (see Question 4.01 for an overview of economic impacts likely to occur).
4.04	How great have the economic costs of managing this organism been in EU from the time of introduction to the present?	MODERATE	LOW	In Poland the species was eradicated from a few localities (national parks, landscape parks and other valuable areas). The cost was 700-2000 euro/ha. In one national park it was conducted byt the protected

Stage 2 - Detailed assessment: Section D – Impact				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				area stuff and volunteers (unpubl 2015). It is estimated that in UK £1 million per year is spent on control, which is mainly carried out by Wildlife Trusts and volunteers (Wiliams et al. 2010).
4.05	How great is the economic cost of managing this organism likely to be in the future?	MAJOR	MEDIUM	The UK Environment Agency has estimated it would cost between £150-300 million to eradicate *I. glandulifera* from the UK should such a control programme be initiated. In Switzerland, Gelpke and Weber (2005) estimated it would cost between CHF 2,183,500 and CHF 13,812,696 (£923,133 to £5,839,691) to eradicate 95% of the current population of *I. glandulifera* in the Canton of Zürich alone. Such high costs coupled with the difficulty of implementing catchment scale control programmes due to the division of land makes controlling *I. glandulifera* on a national or regional level virtually impossible. Current control methods are labour intensive and difficult to implement also due to the often inaccessible habitats in which *I. glandulifera* grows. Control costs range from £0.50/m2 for a single chemical application, or manual control by strimming up to £10/m2 when habitat restoration is included (Tanner et al., 2008, CABI 2015). For this reason, only control of the plant is possible, mostly in the protected areas and other valuable areas.
4.06	How important is environmental harm caused by the organism within its global distribution?	MODEARATE	HIGH	*I. glandulifera* can lead to increased erosion of riverbanks as it leaves soils bare when it dies back in winter. However, this is not well proven by evidence, as the species is often integrated in perennial vegetation. The exclusion of other plants from the vegetation, however, is not as complete as in the case of other invasive species. This is due to the fact that *I. glandulifera*, as an annual, is not present in the vegetation for the whole growing season. It germinates in spring and reaches dominance in the summer. Plants completing their life cycle in spring or early summer are consequently little affected by the species. In addition, the dominance reached by *I. glandulifera* may vary from year to year according to the weather conditions in the germination phase. The effect on other plants consists of a change in cover/dominance. Another effect on other plants was shown to result from competition for pollinators: *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) (CABI 2015).
4.07	How important has the impact of the organism on biodiversity* been from the time of introduction to the present? *e.g. decline in native species, changes in	MODERATE	HIGH	The species invades the herbaceous perennial vegetation of river banks, light floodplain forests and wet meadows (Kowarik 2003). *I. glandulifera* may form dense stands that cover the soil, shade out and replace native annual and even perennial plant species because of early germination

Stage 2 - Detailed assessment: Section D – Impact				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
	community structure, hybridisation			and rapid growth. In some conditions, it can strongly reduce local species richness but this reduction is often temporary and concerns mostly widespread weed and even other non–native species in function of ground-water table and flooding conditions. It may also displace native species through competition for pollinators, e.g. *Stachys palustris* (Harmonia database 2016). It is capable of reducing native plant fitness by reduced seed set by luring pollinators away from native species with its high sugar nectar production. Over time, such competition between plant species for pollinators could leave native species which are unsuccessful at attracting pollinators genetically depauperate (Prowse and Goodridge, 2000) (CABI 2015). *I. glandulifera* was shown to reduce native species diversity in areas where it forms monocultures (Hulme and Bremner, 2005). However Hejda and Pyšek (2006) studies at six rivers in the Czech Republic indicated that the species doesn't represent threat to the plant species diversity. Plant species growing in similar habitats to that of *I. glandulifera* often have reduced in vigour and cover due to the superior competitive strength of *I. glandulifera*. Also Künzi et al. (2015) claim that increasing cover of *I. glandulifera* had no effect on the diversity of invaded plant communities. The rich nectar production may support some invertebrate groups and infestations with aphids supports a food-chain of aphidophagous arthropods. On the other hand, the displacement of food plants may reduce mono- or oligophagous insects. When the plant invades riparian habitats, specifically exposed riverine sediments the occurrence *of I. glandulifera* can potentially reduce the available niches for ground beetles endemic to those habitats (Hymen, 1992). As *I. glandulifera* can reduce the vigour and occurrence of native species it is plausible to suggest this may have consequences on the invertebrate community. The species is competitive with native species as regards pollinators (Chittka & Schürkens 2001; Tanner 2008). However, more studies are needed in this area (CABI 2015). The species can invade hydrophilous tall herb fringe communities (habitat type 6430), alpine rivers and the ligneous vegetation along their banks (3240), alluvial forests (91E0, 91F0), freshwater habitats (3270), and grasslands (6430, 6510) (Kowarik 2003, Tokarska-Guzik et al. 2012, Harmonia database 2016). In the Netherlands *I. glandulifera* has been recorded in 61 Natura 2000 sites. Most of its locations are situated along the Rhine and its tributaries

Stage 2 - Detailed assessment: Section D – Impact				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				and along the Rhine/Meuse estuary. It poses a high risk of establishment in a wide variety of high conservation value habitats. The species (potentially) threatens red listed and protected species in the Netherlands. Risks of local changes in population abundance (>80%), growth or distribution of one or more native species as a result of *I. glandulifera* establishment are high (Matthews et al. 2015).
4.08	How important is the impact of the organism on biodiversity likely to be in the future?	MAJOR	MEDIUM	If *I. glandulifera* continues to spread in Poland and colnise unifested habitats, detrimental impacts on biodiversity, as outlined in answer to Question 4.07, are probable. There may also be implications for the classification of conservation status of certain habitats under the EU Habitats Directive.
4.09	How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism in EU from the time of introduction to the present?	MODERATE	MEDIUM	See Question 4.06. Research results achieved by Pattison and co-authors (2016) show that *I. glandulifera* displayed a positive PSF and the PSF mechanism extended beyond the soil microbial community to affect foliar endophytes. The observed increase in endophytes in plants grown in conditioned soil could enhance resistance to herbivory, thus further accentuating the invasive properties of this species. Findings by Ruckli et al. (2016) demonstrate the negative impact of an annual invasive plant *I. glandulifera* on the ectomycorrhizal symbiosis and performance of native *F. sylvatica* saplings. According to Emer et al. (2015) “balsam invasion did not affect the loading of native pollen, nor did it affect pollen transfer network properties; networks were modular and poorly nested, both of which are likely to be related to the specificity of pollen transfer interactions. Our results indicate that pollination networks become more specialized when moving from the flower visitation to the level of pollen transfer networks. Therefore, caution is needed when inferring pollination from patterns of insect visitation or insect pollen loads as the relationship between these and pollen deposition is not straightforward”.
4.10	How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism likely to be in the future?	MODERATE	MEDIUM	The species can further change the nutrient cycling and alterate the ecosystem physically (Harmonia database 2016). See Question 4.06.

Stage 2 - Detailed assessment: Section D – Impact				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
4.11	How important has decline in conservation status* caused by the organism been in EU from the time of introduction to the present? *e.g. sites of nature conservation value, WFD classification, etc.	MODERATE	MEDIUM	The species invades hydrophilous tall herb fringe communities (habitat type 6430), alpine rivers and the ligneous vegetation along their banks (3240), alluvial forests (91E0, 91F0), freshwater habitats (3270), and grasslands (6430, 6510) (Kowarik 2003, Tokarska-Guzik et al. 2012, (Harmonia database 2016). In the Netherlands *I. glandulifera* has been recorded in 61 Natura 2000 sites. Most of its locations are situated along the Rhine and its tributaries and along the Rhine/Meuse estuary. It poses a high risk of establishment in a wide variety of high conservation value habitats. The species (potentially) threatens red listed and protected species in the Netherlands. Risks of local changes in population abundance (>80%), growth or distribution of one or more native species as a result of *I. glandulifera* establishment are high (Matthews et al. 2015).
4.12	How important is decline in conservation status caused by the organism likely to be in the future in EU?	MODERATE	MEDIUM	See Question 4.11.
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	HIGH	There are no known negative impacts on social or human health.
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within EU?	MINIMAL	HIGH	See Question 4.10.
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	HIGH	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	HIGH	There is no evidence for this.
4.17	How important might other impacts not already covered by previous questions be resulting from introduction of the organism? Specify in the justification	MINIMAL	HIGH	

Stage 2 - Detailed assessment: Section D – Impact				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
	box.			
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 EU?	MINIMAL	HIGH	There is no evidence that *I. glandulifera* is naturally controlled by any predator, parasite or pathogen in Poland. In the UK *I. glandulifera* supports an impoverished diversity of phytophagous insects, but the extent to which these affect the ecology of the plant is not sufficiently studied. In the UK, only 3 arthropod species are known to feed on I. glandulifera, including two aphid species, Aphis fabae and Impatientinum balsamines, and the elephant hawk moth *Deilephila elpenor* (Beerling and Perrins, 1993) (CABI 2015).
4.19	Indicate any parts of EU 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.		HIGH	Significant impacts may occur in protected Natura 2000 habitats (See Question 4.07).
4.20	Estimate the overall potential impact of this organism. Use the justification box to indicate any key issues.	MODERATE	HIGH	*I. glandulifera* may form dense stands that cover the soil, shade out and replace native annual and even perennial plant species because of early germination and rapid growth. It may also displace native species through competition for pollinators. Its development can facilitate river bank erosion (Harmonia database 2016).

Stage 2 - Detailed assessment: Section E – Conclusion				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
5.01	Estimate the overall risk of this organism in EU (noting answers given in 1.11, 2.16, 3.10 & 4.20).	MODERATE	HIGH	This non-native species poses a major risk to native biodiversity and ecosystems especially for vulnerable riparian habitats and wetlands, including Natura 2000 habitats. It can be still controlled in protected areas and vulnerable areas and further spread from intentional introductions can be prevented.

Stage 2 - Detailed assessment: Section F – Additional questions

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?		MEDIUM	The results of climate scenarios that can influence the distribution of *I. glandulifera* analysis show: • temperature increasing trend across the country; temperature rise is properly reflected by all climatic factors based on this variable, for example, there is a certain trend of extending the growing season (its start is earlier noted), the number of days with minimum temperature less than 0 °C is decreased and there is more days with maximum temperature higher than 25 °C. • temperature characteristics such as the number of days, reflect upward trend in temperature changes. The characteristics of precipitation shows the extended periods without rainfall, increased number of maximum rainfalls and shortening the period of snow cover. It must be noted that the risk of invasion in Poland and other countries, in the face of projected climate change (higher temperatures and more droughts) can diminish (Nehring et al. 2013). However since *I. glandulifera* seems to react positively to an increase in CO^2 and temperature it is potentially a still more aggressive invader in a changing climate (NeoFlora 2006). For the Netherlands it is not expected that climate change will affect invasiveness of Himalayan balsam (Matthews et al. 2015).
6.02	What is the likely timeframe for such changes (5, 10, 15 , 20, 50 or 100 years)?	50 YEARS	MEDIUM	
6.03	What aspects of the risk assessment are most likely to change as a result of climate change		MEDIUM	The impact on biodiversity, ecosystem functions and cost of management would change.
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.	N/A		Künzi et al. (2015) suggest “including abiotic variables in further impact studies on biotic invasions. Furthermore, adapting measures to the respective environmental context can be a useful tool in priority setting for the management of invasive neophyte populations and the restoration of invaded habitats”. According to Meerbeek et al. (2015) the energetic valorization of the biomass of IAS (including *I. glandulifera*) can create an economic incentive for habitat restoration of invaded sites and offers the opportunity to reconcile the restoration of the invaded habitats with renewable energy goals.

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