RISK ASSESSMENT SUMMARY SHEET

Grass-leaved Goldenrod (*Solidago graminifolia*)

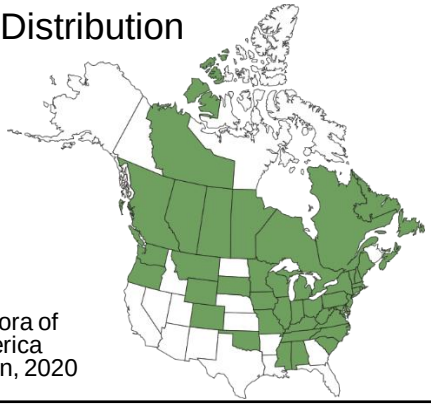

Photograph: User:SB_Johnny, Wikimedia

- An erect perennial wildflower with branched inflorescences bearing dense flat clusters of 20-35 pale to bright yellow flowers.
- One of a number of non-native Solidago species in GB native to Canada and mainland USA.
- Introduced to GB over 250 years ago.
- No significant impacts recorded to date – demonstrated to be a weak competitor compared to other *Solidago* species.

History in GB

First recorded in GB in 1809, but probably cultivated since the 1750s. There are currently 55 records in GB, fewer than for other non-native *Solidago* species (e.g. *S. gigantea* 1,934 records and *S. canadensis* 4,727 records) despite being introduced at a similar time.

Native Distribution



Source: Flora of North America Association, 2020

GB Distribution

Source: NBN Atlas, 2021

Impacts

No significant impacts reported in GB – does not appear to be as invasive as other *Solidago* species.

Environmental: (minimal, high confidence)

- None reported.
- May have allelopathic properties, but limited invasion success in Europe indicates this does not provide a major advantage against native plants.
- May alter vegetation composition and plant-insect food-webs in invaded habitats, but the extent of these changes are likely to be limited to only the largest, densest patches.

Economic: (minimal, high confidence)

- None reported.
- Limited GB distribution primarily in marginal habitat of little economic value.

Societal: (minimal, high confidence)

- None reported.

Introduction pathway

Originally introduced to GB as an ornamental plant and potentially as a bee food plant.

Spread pathway

Natural: (minor, high confidence) – seeds are wind dispersed, but this species has a lower dispersal ability than others in the genus.

Human: (low, medium confidence) – seeds and rhizomes can be spread through contaminated soil and dumping of garden waste. No longer a popular ornamental plant.

Summary

	Response	Confidence
Entry	VERY LIKELY	VERY HIGH
Establishment	MODERATELY LIKELY	HIGH
Spread	VERY SLOWLY	HIGH
Impact	MINOR	HIGH
Overall risk	LOW	HIGH

RISK ASSESSMENT COVERING PAGE - ABOUT THE PROCESS

It is important that policy decisions and action within Great Britain are underpinned by evidence. At the same time it is not always possible to have complete scientific certainty before taking action. To determine the evidence base and manage uncertainty a process of risk analysis is used.

Risk analysis comprises three component parts: risk assessment (determining the severity and likelihood of a hazard occurring); risk management (the practicalities of reducing the risk); and risk communication (interpreting the results of the analysis and explaining them clearly). This tool relates to risk assessment only. The Non-native Species Secretariat manages the risk analysis process on behalf of the GB Programme Board for Non-native Species. During this process risk assessments are:

- Commissioned using a consistent template to ensure the full range of issues is addressed and maintain comparable quality of risk and confidence scoring supported by appropriate evidence.
- Drafted by an independent expert in the species and peer reviewed by a different expert.
- Approved by the NNRAF (an independent risk analysis panel) only when they are satisfied the assessment is fit-for-purpose.
- Approved by the Programme Board for Non-native Species.
- Placed on the GB Non-native Species Secretariat (NNSS) website for a three month period of public comment.
- Finalised by the risk assessor to the satisfaction of the NNRAF and Programme Board if necessary.

Common misconceptions about risk assessments

The risk assessments:

- Consider only the risks (i.e. the chance and severity of a hazard occurring) posed by a species. They do not consider the practicalities, impacts or other issues relating to the management of the species. They also only consider only the negative impacts of the species, they do not consider any positive effects. They therefore cannot on their own be used to determine what, if any, management response should be undertaken.
- Are advisory and therefore part of the suite of information on which policy decisions are based.
- Are not final and absolute. They are an assessment based on the evidence available at that time. Substantive new scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

Period for comment

Once placed on the NNSS website, risk assessments are open for stakeholders to provide comment on the scientific evidence which underpins them for three months. Relevant comments are collated by the NNSS and sent to the risk assessor for them to consider and, if necessary, amend the risk assessment. Where significant comments are received the NNRAF will determine whether the final risk assessment suitably takes into account the comments provided.

To find out more: published risk assessments and more information can be found at http://www.nonnativespecies.org/index.cfm?pageid=143

GB NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Name of organism: *Solidago graminifolia*, Grass-leaved Goldenrod
Author: Wayne Dawson, Durham University
Risk Assessment Area: Great Britain
Version: Draft 1 (Dec 2020), Peer Review (Feb 2021), NNRAP 1 (May 2021), Draft 2 (May 2021), NNRAF 2 (Jul 2021), Draft 3 (March 2022)
Signed off by NNRAF: July 2021
Approved by Programme Board: January 2023
Placed on NNSS website: January 2024

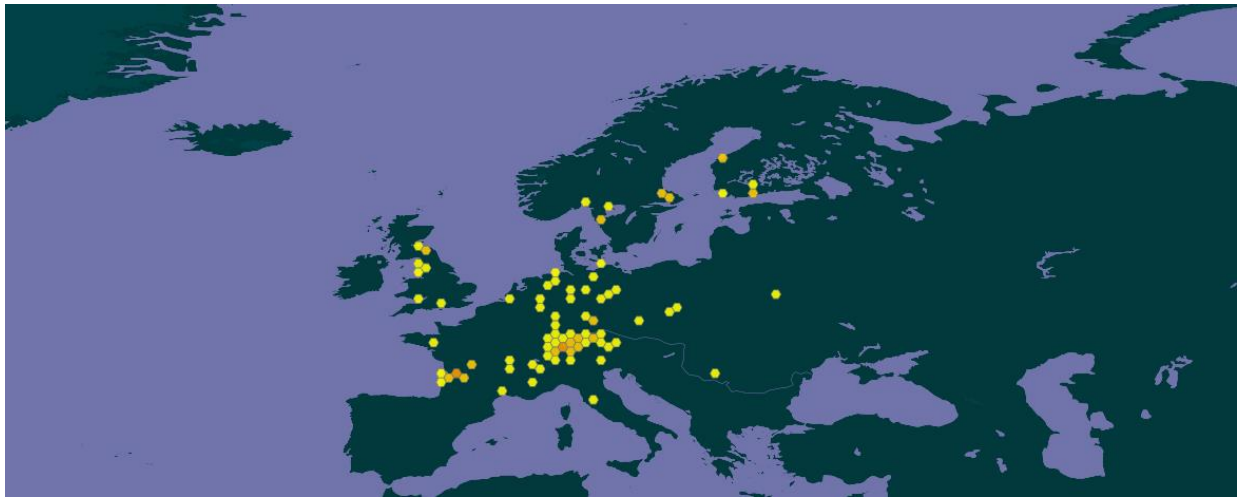
What is the principal reason for performing the Risk Assessment?

This species was identified as a potential threat by horizon scanning in 2020 and therefore prioritised for risk assessment.

SECTION A – Organism Information	
Stage 1. Organism Information	**RESPONSE and 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 *Solidago graminifolia* (L.) Salisb. is a synonym. The accepted name of the species is *Euthamia graminifolia* (L.) Nutt. (Plants of the World Online 2019). There are five members of the genus *Euthamia* (FNA website, sourced 28/01/20210; it is possible that other species are present within the risk assessment area, particularly *E. caroliniana* which is very similar to *E. graminifolia*
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)	NA
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No The species is listed by EPPO, as being on Switzerland's Watch List of invasive alien plants- 2014; the species is listed as being limited in distribution (EPPO 2020; Swiss Federal Council 2012).
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	NA
5. Where is the organism native?	Plants of the World Online (2019): North America (US, Canada)- Alabama, Alberta, British Columbia, Colorado, Connecticut, Delaware,

	Illinois, Indiana, Iowa, Kentucky, Maine, Manitoba, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, New Hampshire, New Jersey, New York, Newfoundland, North Carolina, Northwest Territories, Nova Scotia, Ohio, Oklahoma, Ontario, Oregon, Pennsylvania, Prince Edward I., Québec, Rhode I., Saskatchewan, South Carolina, South Dakota, Tennessee, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming. USDA Agricultural Research Service (2015): SUBARCTIC AMERICA: **Canada** [Northwest Territories] EASTERN CANADA: **Canada** [Québec, Nova Scotia, Ontario, Prince Edward Island, New Brunswick, Newfoundland and Labrador], **St. Pierre and Miquelon** WESTERN CANADA: **Canada** [Saskatchewan, Alberta, Manitoba, British Columbia] NORTHEASTERN U.S.A.: **United States** [Connecticut, Indiana, Maine, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia] NORTH-CENTRAL U.S.A.: **United States** [Illinois, Iowa, Minnesota, Missouri, Oklahoma, South Dakota, Wisconsin] NORTHWESTERN U.S.A.: **United States** [Colorado, Montana, Oregon, Washington, Wyoming (http://www.esb.utexas.edu/tchumley/wyomap/ast_e_h/eutgrama.pdf)] SOUTHEASTERN U.S.A.: **United States** [Alabama, Delaware, Kentucky, Maryland, Mississippi (Forrest Co.), North Carolina (w.), South Carolina, Tennessee, Virginia, District of Columbia] Native throughout Canada and mainland USA
6. What is the global distribution of the organism (excluding the	Introduced range according to Plants of the World Online (2020): Europe- Austria, Belgium, Czechoslovakia, France, Germany, Great Britain, Hungary, Italy, Krym, Norway,

risk assessment area)?	Poland, Romania, Sweden, Switzerland, Transcaucasus, Ukraine According to GRIN Taxonomy Database (2020): Naturalized in Europe EPPO (2020) notes that species is recorded in China, but original source of information is unavailable, and species does not feature in online Flora of China (http://www.efloras.org/flora_page.aspx?flora_id=2).
7. What is the distribution of the organism in the risk assessment area?	National Biodiversity Network (2020) map of UK records: NBN gateway lists 55 records, mostly in SW England (Dorset, Devon, Cornwall), Oxfordshire, fewer records in S Wales, W Lancashire, Scottish Borders, and either side of the Forth Estuary (W of Edinburgh). Earliest accepted record in NBN: 1809. Latest accepted record in NBN: 1995. Unconfirmed records to 2014. Record descriptions suggest establishment may be limited and localised, representing garden escapes. Examples of occurrence remarks in GB (NBN Gateway): Borders 2014 “Large colony” Devon 2001: “East Putford Narracott Plantation, small patch E verge of track” Devon 1983-1998: “E boundary hedge of field nr abattoir, in several places in hedge still there 1985”; “N hedgebank of the lane -large clumps on top of hedge in 1998” 

8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Introduced in multiple European countries (Plant of the World Online 2020), and listed in the Global Register of Introduced and Invasive Species for 9 countries (GBIF 2020): However, no evidence of impact in any country listed. Map below shows limited distribution of GBIF records in Europe:  The species appears to be less invasive in Europe than *Solidago canadensis* and *S. gigantea* (see comments). EPPO (2020) lists a report on invasive alien plants in China, stating that "This species was introduced into the Lushan Botanic Garden from which it begun to invade local ecosystems." However, the original source report is not available. Several studies have compared the invasion status of *E. graminifolia* with *Solidago canadensis* and S. *gigantea* in Europe. Weber (1998; 2001) found that distribution in Europe of *E. graminifolia* is much more limited, and colonisation rate is much lower than for the *Solidago* species based on herbarium records and observations, despite the fact that the potential range is large in Europe based on native range climate. Studies in Poland suggest that the distribution of *Euthamia* is limited compared to *Solidago* species, and *Euthamia* has not spread far from original sites of introduction (Guzikowa & Maycock 1986; Szymura & Szymura 2016a). Thus, *Euthamia graminifolia* appears to have lower invasion potential than *Solidago* species in Europe despite similar times since introduction, though the species may have been introduced

	with lower propagule pressure (Weber 1998; 2001).
9. Describe any known socio-economic benefits of the organism in the risk assessment area.	Ornamental plant, food plant for honeybees. Species was likely introduced to Europe as an ornamental plant (Weber 1998), and the Royal Horticultural Society (2020) lists the species; however, the RHS lists no nursery suppliers, this may suggest the species is not very popular. In the native range, the species attracts several pollinators, including European honeybees, and in continental Europe at least, the species may have originally been introduced as a bee food plant as well as an ornamental (Guzikowa & Maycock 1986). In the native range, the plant attracts beetles that predate on plant pests such as aphids (Sheahan 2012). These benefits are not reported in the RA area, however.

SECTION B – Detailed assessment

PROBABILITY OF ENTRY

Important instructions:

- Entry is the introduction of an organism into the risk assessment area. Not to be confused with spread, the movement of an organism within the risk assessment area.
- For organisms which are already present in the risk assessment area, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms which have entered in the past and have no current pathways of entry.

QUESTION	RESPONSE [chose one entry, delete all others]	CONFIDENCE [chose one entry, delete all others]	COMMENT
1.1. How many active pathways are relevant to the potential entry of this organism? (If there are no active pathways or potential future pathways respond N/A and move to the Establishment section)	very few	high	Species could gain entry as an ornamental plant, most likely through online purchase of seeds (e.g. B and T World Seeds 2020; Etsy 2020). The species is thought to have been introduced to some locations in Poland accidentally through import and planting of tree species (Szymura & Szymura 2016a). Most likely introduced into GB as an ornamental plant in the 1700s (Weber 1998).
1.2. List relevant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways. For each pathway answer questions 1.3 to 1.10 (copy and paste additional rows at the end of this section as necessary).	i. Ornamental Plant ii Contaminant		Ornamental Plants: Seeds, planting in gardens Contaminant: occurring in soils of live imported plants, planting in gardens, parks, and semi-natural habitats (trees).
Pathway name:	i Ornamental Plant		

1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)? (If intentional, only answer questions 1.4, 1.9, 1.10, 1.11)	intentional	high	
1.4. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	unlikely	high	Could find little evidence of live plants being grown and sold for import through ornamental plant trade: Neither Floraccess (2020) nor Jan Nieuwesteeg (2020) in NL sell the species. Seed collecting organization called KPR (founded in Slovakia) lists the species as one that can be collected and sent to growers on request in UK (KPR 2020). B and T World Seeds (2020) and Etsy (2020) list seeds of the species as being for sale. Overall, imports are unlikely to be in large numbers, given apparent lack of commercial suppliers.
1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	very likely	high	Direct planting in gardens will increase chances of survival to reproduction- wind-dispersed seeds may then be released into the environment resulting in further recruitment. Scattered, localised distribution in GB suggests historic garden escapes. Polish escapes are likely to be from ornamental plantings (Guzikowa & Maycock 1986).
1.10. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	unlikely	medium	The species has already entered GB, and this was most likely through introduction as an ornamental- according to Weber (1998) the species was most likely first cultivated in London around 1758. However, further introduction via this pathway is probably unlikely, given the apparent lack of commercial cultivation and sales.

End of pathway assessment, repeat as necessary.			
Pathway name:	Contaminant		
1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)? (If intentional, only answer questions 1.4, 1.9, 1.10, 1.11)	accidental	medium	Species' seeds are thought to have been transported accidentally in Silesia- southern Poland- in the soil of planted ornamental trees (Szymura & Szymura 2016a; Dajdok & Nowak 2007), though likelihood of seed contamination in plant imports from continental Europe to GB is unknown.
1.4. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	very unlikely	high	Importation via soil contamination from the limited number of locations in continental Europe where species occurs is likely to be very rare, though likelihood will depend on exact location of any nursery importing trees/saplings, and proximity to *Euthamia* seed sources.
1.5. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	moderately likely	high	The species may be able to form a transient seed bank lasting 1-5 years (Thompson et al. 1997), so short-term survival and transport in soils is a possibility.
1.6. How likely is the organism to survive existing management practices during passage along the pathway?	moderately likely	low	Seeds in soil of imported plants are less likely to be transported if soils are sterilised before use/weeds are suppressed in growing areas and growing periods are short and indoors. However, seeds are more likely to survive if in soils of larger, longer lived woody plants exposed to

			seed rain outside during cultivation. Unclear what management practices could be used to prevent contamination of potted trees by seeds that are wind-dispersed.
1.7. How likely is the organism to enter the risk assessment area undetected?	moderately likely	high	Risk of entering pathway is low to start with, but in the unlikely event that seeds are a soil contaminant of imported plants, they are likely to go undetected: seeds are small, and wouldn't be identifiable/visible without germination or screening of soil.
1.8. How likely is the organism to arrive during the months of the year most appropriate for establishment?	moderately likely	high	As seeds could be dormant in a seed bank, importation of plants with contaminated soil at any time of year could be appropriate for eventual establishment.
1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	high	If soils of imported plants contained seeds, direct planting into gardens or parks could result in germination and plant growth. Though only evidence of this in Europe is at a local scale in Poland (Szymura & Szymura 2016a; Dajdok & Nowak 2007).
1.10. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	Very unlikely	high	Limited current distribution in continental Europe means that risk of soil contamination of imported plants is very low, but this is tempered by the ability of seeds to survive transport in soil. If the species increases in abundance and distribution in continental Europe, overall likelihood of entry would increase.
End of pathway assessment, repeat as necessary.			
1.11. Estimate the overall likelihood of entry into the risk assessment area based on all pathways (comment on the key issues that lead to this conclusion).	Very likely	very high	Species is already present in GB, but establishment is likely limited and localised; unclear if populations are self-sustaining. Further introduction through pathways is unlikely.

PROBABILITY OF ESTABLISHMENT

Important instructions:

- For organisms which are already well established in the risk assessment area, only complete questions 1.15, 1.21 and 1.28 then move onto the spread section. If uncertain, check with the Non-native Species Secretariat.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.12. How likely is it that the organism will be able to establish in the risk assessment area based on the similarity between climatic conditions in the risk assessment area and the organism's current distribution?	very likely	high	Previous work demonstrates a climate match between the species' native range and GB (Weber 1998): Given that scattered records are found across GB, and a number of these are persistent over time, climate suitability is likely to be high. USDA Hardiness Zones 3-9 (-34.4 to -1.1 °C). (Sheahan 2012). For context, GB would be in Zones 6-9.
1.13. How likely is it that the organism will be able to establish in the risk assessment area based on the similarity between other abiotic conditions in the risk assessment area and the organism's current distribution?	very likely	high	Abiotic conditions in RA area have considerable overlap with species' current distribution in native and introduced range; thus abiotic conditions are very unlikely to be a barrier to establishment. The USDA (native range) describes species as being "considered a ruderal species and can grow in strongly acidic to mildly alkaline conditions" (Sheahan 2012).
(1.14. How likely is it that the organism will become established in protected conditions (in which the environment is artificially maintained, such as wildlife parks, glasshouses, aquaculture facilities, terraria, zoological gardens) in the risk assessment area? Subnote: gardens are not considered protected conditions	very unlikely	high	Gardens are not considered protected conditions. No evidence of association with other protected conditions listed.

1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in the risk assessment area?	moderately widespread	high	Species described in NBN records as occurring in "upland fringe valleys", "hedge boundaries", "hedge banks", "mosaic habitats" (NBN Gateway 2020). Species is described as occurring in the following habitats in southern Poland: Over-represented in road verges, unpaved roads, and embankments, under-represented in arable fields (Szymura & Szymura 2016a). Occurs in meadows, ditches, ruderal sites, and in meadows (Guzikowa & Maycock 1986; Kompala-Baba & Baba 2006). Suggests species favours open, disturbed, anthropogenic but moist habitats. Personal observation in southern Germany: scattered individuals occurring in wet grassland/marginal, marshy habitat, Wollmatinger Ried nature reserve. In Switzerland, species occurs in shoreline/bank vegetation, gravel pits, dumps and tips. Confirmed records are mostly in lowland areas in NE of country, unconfirmed records in several alpine valleys to the south. (Flora Helvetica 2018). Species may be limited in its ability to establish in a wider range of habitats by other non-native successful *Solidago* species (Szymura and Szymura 2016a). In the native range, species is described as being less competitive for light than other *Solidago* species and declines in abundance with succession in old field communities (Banta et al. 2018). Overall, behaviour elsewhere suggests suitable habitats in GB are fairly widespread.
1.16. If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in the risk assessment area?	NA	very high	NA
1.17. How likely is it that establishment will occur despite	unlikely	high	In native range, species is likely a weak competitor aboveground with other herbaceous perennials in old field communities (Banta et al. 2008), and is

competition from existing species in the risk assessment area?			considered ruderal in the US (Sheahan 2012) and in Poland (Kompala-Baba & Baba 2006). Some evidence of stronger competition belowground (Szymura & Szymura 2016b; Szymura et al. 2018), but no evidence of species being a strong competitor in historic sites where species occurs in GB.
1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area?	very likely	high	No evidence of species suffering from predators, parasites or pathogens present in RA area.
1.19. How likely is the organism to establish despite existing management practices in the risk assessment area?	likely	high	No evidence that management practices would limit establishment in RA area.
1.20. How likely are management practices in the risk assessment area to facilitate establishment?	unlikely	high	While management of river banks and hedge banks could theoretically facilitate establishment through removal of native competing vegetation, disturbance, and creation of vegetative propagules, the general absence of large established populations in GB after a long period since introduction suggests that management practices are unlikely to benefit this species.
1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the risk assessment area?	moderately likely	medium	While relatively little is known about the ecology and biology of the species in Europe, it appears to be able to form a short-term (<5 year) seed bank (Thompson et al. 1997) and can regenerate from rhizomes (Sheahan 2012; Szymura & Szymura 2016a), which would make survival of eradication campaigns more likely. However, species has few populations, and there is evidence to suggest that seed viability and germination in European populations is relatively low (Szymura 2012). Anecdotal personal observation from S Germany suggested that seed production per plant may be low. More information on ecology and biology in GB required.
1.22. How likely are the biological characteristics of the organism to facilitate its establishment?	unlikely	high	While rhizomatous perennial characteristic may explain the species' persistence in the RA area, there are no other biological characteristics that make establishment in the RA area likely. If anything, limited seed germination reported in Poland may limit establishment (Szymura 2012).

1.23. How likely is the capacity to spread of the organism to facilitate its establishment?	very unlikely	high	Given the limited number of records in GB despite being introduced in the 1700s, it is very unlikely that the species has a high spread capacity that would facilitate establishment.
1.24. How likely is the adaptability of the organism to facilitate its establishment?	very unlikely	low medium	There is no evidence that the species is highly adaptable. The wide geographic range of the species and its wide pH tolerance suggest the species can persist in a wide range of conditions, but it is not known if this is a result of plasticity or local adaptation.
1.25. How likely is it that the organism could establish despite low genetic diversity in the founder population?	very unlikely	high	There is no evidence that the species is able to self-fertilise of reproduce apomictically. Low seed-set has been observed elsewhere in the introduced range (Germany; Dawson- pers. obs.; Poland; Szymura 2012), and this coupled with the limited number of records and small populations in the RA area suggest that sexual reproduction may be limited by low genetic diversity at introduction.
1.26. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in the risk assessment area? (If possible, specify the instances in the comments box.)	unlikely	high	
1.27. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in the risk assessment area but is established because of continual release, is an example of a transient species.	moderately likely	high	

1.28. Estimate the overall likelihood of establishment (mention any key issues in the comment box).	moderately likely	high	Species has 55 recorded in locations across Britain, , and previous work demonstrates a climate match between the species' native range and GB (Weber 1998). However, the species is more limited in the range of habitats it occurs in on the continent than invasive *Solidago* species, and established populations are close to original sites of introductions (Szymura & Szymura 2016a). This, combined with uncertainty over seed production (Szymura 2012) and germination suggests that the species has a rather limited ability to establish self-sustaining populations. Existing records are often old, and may represent transient populations/garden escapes. On balance, future establishment is therefore only moderately likely

PROBABILITY OF SPREAD

Important notes:

- Spread is defined as the expansion of the geographical distribution of a pest within an area.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
2.1. How important is the expected spread of this organism in the risk assessment area by natural means? (Please list and comment on the mechanisms for natural spread.)	minor	high	Species has been present in GB since the mid-1700s, and was first recorded (presumably outside of cultivation) in 1864 (Weber 1998). It only has 55 records in GB's NBN Gateway; which contrasts with 1,934 records for *Solidago gigantea*, and 4,727 records for *S. canadensis*- all three species were introduced at a similar time. Thus, despite having a pappus that would aid wind dispersal, the species does not seem to have the same dispersal ability of other *Solidago* species, and viable seed production may be limited (Voser-Huber 1983), with germination success between 20-30% in Poland (Szymura 2012). Weber (1998) estimated the colonisation rate as 128 km^2/yr, compared to 741 and 910 km^2/yr for other *Solidago* species in Europe. However, the role of propagule pressure from human introductions and plantings versus natural dispersal in explaining these differences is not clear.
2.2. How important is the expected spread of this organism in the risk assessment area by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	low	medium	The species is able to resprout from rhizomes and can be propagated through dividing the root system (Sheahan 2012). In Poland, the plant is distributed along linear habitats such as roadside verges not far from the sites of introduction (Guzikowa & Maycock 1986; Szymura & Szymura 2016a), suggesting some limited human-assisted vegetative /and or seed spread. The species occurs in abandoned land and disturbed habitats, where seeds could be accidentally transported. Human spread through contaminated soil and dumping of garden waste are possible but are unlikely without more widespread planting. Hence low score.
2.3. Within the risk assessment area, how difficult would it be to contain the organism?	easy	medium	Provided the current reported distribution is reasonably accurate, and the apparent lack of widespread planting and ornamental popularity is true, the species should be moderately easy to contain. Evidence from elsewhere in Europe suggests limited dispersal and spread from original introduction sites, and the species does not tend to occur in monospecific stands as *S. altissima*, and *S. gigantea* consistently do (Szymura & Szymura 2016a), though patch size can range from 4 to 180 m^2 (Kompala-Baba & Baba 2006) and the species can reach 5-25% cover often in

			surveyed plots (Szymura & Szymura 2016a). The species appears to favour moist habitats, and establishment of populations in wetlands prone to flooding and river systems would become more difficult to contain. However, there is no evidence from Europe that the species is spread widely through hydrochory.
2.4. Based on the answers to questions on the potential for establishment and spread in the risk assessment area, define the area endangered by the organism.	See comments	medium	Moist open habitats, road verges and hedges/hedge banks in most of mainland Britain, except northern Scotland; Given current distribution, potential for greater spread in SW England. Species described in NBN records as occurring in "upland fringe valleys", "hedge boundaries", "hedge banks", "mosaic habitats". Species known to favour moist open habitats in continental Europe; northern Scotland's climate (Moray Firth onwards) falls outside climate range of native distribution (Weber 2001).
2.5. What proportion (%) of the area/habitat suitable for establishment (i.e. those parts of the risk assessment area were the species could establish), if any, has already been colonised by the organism?	0-10	high	Relatively few records compared to invasive *Solidago* species introduced at a similar time. If recording is representative of species distribution, then extent of colonisation is very limited.
2.6. What proportion (%) of the area/habitat suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	0-10	very high	Given the time since introduction (>250 years) and current distribution, the species is very unlikely to spread very far in 5 years.
2.7. What other timeframe (in years) would be appropriate to estimate any significant further spread of the organism in the risk assessment area? (Please comment on why this timeframe is chosen.)	>80	medium	The species has a relatively slow colonisation rate compared to other invasive *Solidago* spp (Weber 1998), and the long time since introduction without significant spread would suggest the species either has low potential for invasion or is still in a lag phase. This lag phase may be longer than other goldenrods because of low propagule pressure, thus requiring more time to build populations large enough to trigger greater spread rates. Failure to move out of a lag phase in a further 80 years would indicate that invasion potential is low.
2.8. In this timeframe what	0-10	low	Spread in a further 80 years, if following past spread rates, is likely to remain within

proportion (%) of the endangered area/habitat (including any currently occupied areas/habitats) is likely to have been invaded by this organism?			the 0-10% bracket. However, confidence is low if the species is in a lag phase now, but a threshold population size is eventually reached, triggering increased spread rates.
2.9. Estimate the overall potential for future spread for this organism in the risk assessment area (using the comment box to indicate any key issues).	Very slowly	high	If propagule pressure remains low, and the species maintains the same rate of limited spread close to introduction sites as seen on the continent, its potential for future spread should remain very slow in the RA area. However, there is still the risk that the species is in a lag phase and spread rate might increase if a threshold population size is reached. This risk will also depend upon seed production and viability, which remain unquantified in the RA area.

PROBABILITY OF IMPACT

Important instructions:

- When assessing potential future impacts, climate change should not be taken into account. This is done in later questions at the end of the assessment.
- Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).
- Note questions 2.10-2.14 relate to economic impact and 2.15-2.21 to environmental impact. Each set of questions starts with the impact elsewhere in the world, then considers impacts in the risk assessment area separating known impacts to date (i.e. past and current impacts) from potential future impacts. Key words are in bold for emphasis.

QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.10. How great is the economic loss caused by the organism within its existing geographic range **excluding the risk assessment area**, including the cost of any current management?	minimal	high	No evidence of economic impact from other parts of the introduced range, where the species distribution and abundance are probably too limited currently for economic impacts to be felt. Moreover, there is little evidence the species has characteristics that would result in economic impacts. It may produce chemical compounds with allelopathic properties (Butchko & Jensen 2002), and the USDA advises against growing of some crops in areas occupied by the species (Sheahan 2012). However, abundance and distribution in continental Europe are not high enough for this economic impact to be felt, and as a rhizomatous perennial, the species does not appear to be a weed of arable agriculture in Europe (Guzikowa & Maycock 1986; Kompala-Baba & Baba 2006; Infoflora 2020).
2.11. How great is the economic cost of the organism **currently** in the risk assessment area **excluding management** costs (include any past costs in your response)?	minimal	high	No evidence of economic costs in GB; distribution and abundance appears to be very limited, and occurrences are primarily in marginal habitats and not in land-use of high economic value.
2.12. How great is the economic cost of the organism likely to be **in the**	minimal	high	The species could have a minor economic cost if it becomes more abundant and widespread in agricultural (pastoral) land; but it shows little sign of doing this in

future in the risk assessment area **excluding management** costs?			continental Europe, particularly in Switzerland (Infoflora 2020). The species may become more abundant in abandoned land/areas with high anthropogenic disturbance, but this is unlikely to result in increased economic costs. Thus minimal, high confidence.
2.13. How great are the economic costs **associated with managing** this organism **currently** in the risk assessment area (include any past costs in your response)?	minimal	high	No evidence found on management costs for this species in the RA area, or in other areas where introduced. But, on the one hand the limited spread from introduction sites and discrete low number of populations described, should lower the costs of management, while on the other hand, rhizomatous growth/resprouting and short-term seed banks will increase management costs per site.
2.14. How great are the economic costs **associated with managing** this organism likely to be **in the future** in the risk assessment area?	minimal	high	Given the slow rates of spread observed for this species in the RA area and elsewhere, management costs are unlikely to increase markedly in the short to medium term. But, see spread section for lag-phase risk in the longer term.
2.15. How important is environmental harm caused by the organism within its existing geographic range **excluding the risk assessment area**?	minor	high	Species demonstrated to be a weak competitor compared to invasive *Solidago* species, in their native N American range, and usually declines in abundance fairly quickly as old-field communities succeed (Banta et al. 2008). While allelopathic properties have been described in the native range, the limited spread, abundance and range of habitats where the species occurs in Poland and other continental European countries suggest that allelopathy does not give *Euthamia* a competitive advantage in invaded communities (Kompala-Baba & Baba 2006; Szymura & Szymura 2016a). Patch size can range from 4 to 180 m^2 (Kompala-Baba & Baba 2006) and the species can reach 5-25% cover often in surveyed plots (Szymura & Szymura 2016a). The species may be a strong competitor with some species belowground (Szymura & Szymura 2016b; Szymura et al. 2018), but its relatively short, branched stature may make it a poorer competitor for light against native vegetation than invasive *Solidago* species (Weber 2001; Banta et al. 2008).
2.16. How important is the impact of the organism on biodiversity (e.g. decline in native species, changes in	minimal	high	There is no evidence of biodiversity impact from the RA area, but as described in 2.15, there is no evidence that the species reduced biodiversity markedly in invaded plant communities in continental Europe, though in the few cases where

native species communities, hybridisation) **currently** in the risk assessment area (include any past impact in your response)?			larger, more dense stands occur, local plant richness may be suppressed (Kompala-Baba & Baba 2006; Szymura & Szymura 2016a). The species is described as not being an aggressive invader in Poland (Guzikowa & Maycock 1986; Kompala-Baba & Baba 2006). However, in Switzerland the species is described as potentially becoming dominant in the vegetation it colonises (Infoflora 2020). In Switzerland, the species is on the country's invasive watch list. There is some evidence that the species can compete strongly against invasive *Solidago* species belowground, and native species (*Tanacetum vulgare, Lolium perenne*) (Szymura & Szymura 2016b, 2018). But there is no evidence this advantage benefits the species in the RA area.
2.17. How important is the impact of the organism on biodiversity likely to be in the **future** in the risk assessment area?	minimal	high	The species shows limited signs of biodiversity impacts elsewhere in the introduced range, so confidence is high; even if there is the risk the species is in a lag phase, there is no evidence of biodiversity impact from elsewhere in the introduced range.
2.18. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism **currently** in the risk assessment area (include any past impact in your response)?	minimal	high	Overall, there is little evidence that the species markedly alters ecosystem function in the RA area, especially given its very limited abundance
2.19. 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 risk assessment area in the **future**?	minor	high	If the species increases in abundance at established sites, it could in some cases alter vegetation composition, as suggested for Switzerland, and there may be exceptional sites where invaded areas are large and dense. The USDA describes the species as "a prolific rhizomatous perennial that spreads aggressively through vegetative reproduction (Sheahan 2012)." However, this behaviour so far better describes invasive *Solidago* species than *Euthamia* in Europe. But if very slow spread rates continue, impacts on ecosystem function in future are unlikely to change considerably. While the species is known to favour wetlands and moist habitats in the native and introduced ranges, where it could affect vegetation composition, there is no evidence that invasions are causing changes to processes

			involving hydrology, sedimentation, erosion, nutrient cycling or succession. In Switzerland, the species is classed as a nitrophile (Infoflora 2020), and in the native range, the species is described as follows: "Adding nitrogen will increase plant size, including an increase of stem height, number of leaves, and stem diameter. *E. graminifolia* seems to have a delayed response to nitrogen, and may store access N over winter in its rhizomes. Adding N has been shown to increase the density of stems in the second year after fertilization, thereby eliminating other plant species and reducing community diversity. Management of flat-top goldentop should consider the negative effect fertilization may have on existing community structure" (Sheahan 2012). The species may therefore have more of an impact in habitats where it coincides with high nitrogen inputs.
2.20. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism **currently** in the risk assessment area?	minimal	high	No evidence that the species has invaded areas of high nature conservation value in the RA area.
2.21. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism likely to be in the **future** in the risk assessment area?	minor	high	The species has the potential to establish in wetland habitats of high conservation value in the RA area, but given its behaviour elsewhere in Europe, the impacts are not likely to be very strong.
2.22. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their economic, environmental or social effects more serious?	minimal	high	No evidence that species readily hybridises with native species in the European Flora, or with any introduced species.
2.23. How important is social, human health or other harm (not directly included in economic and	minimal	high	No evidence that species poses a harm to humans in the existing geographic range.

environmental categories) caused by the organism within its existing geographic range?			
2.24. 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	medium	No evidence the species poses this impact in the introduced range.
2.25. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA	high	No other potential impacts evident; however, in theory there may be subtle effects on plant-pollinator networks and plant-herbivore food-webs if this species were to become invasive and abundant/dominant in invaded communities.
2.26. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in the risk assessment area?	minimal	low	No evidence of natural control of species in the RA area, hence low confidence, but impacts are only likely to be minimal-minor at most in any case.
2.27. Indicate any parts of the risk assessment area where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	[SW England]	medium	See map in q. 7, section A. Most records are from Devon, Cornwall and Dorset, suggesting species is more likely to be well established there than other parts of GB. Thus any further spread and resulting impact that does occur will probably occur there first.
2.28. Estimate the overall impact of this organism in the risk assessment area (using the comment box to indicate any key issues).	minor	medium	Combined with information on slow spread rates both in the RA area and continental Europe, it seems unlikely that the species will have large overall impacts in the RA area; at most the species may alter vegetation composition and plant-insect food-webs in invaded habitats, but the extent of these changes are likely to be limited to only the largest, densest invaded patches. The species may have allelopathic properties, but the limited invasion success in Europe indicates allelopathy is not a major advantage against native plants; competitive ability of

			the species against natives seems unconvincing, but the species may be more competitive with high nutrient inputs.

RISK SUMMARIES

	RESPONSE	CONFIDENCE	COMMENT
Summarise Entry	very likely	very high	The species has already entered the RA area, but for future entry likelihood, the species has a limited distribution and abundance in continental Europe, making unintentional introduction via soil contamination of commercially grown plants unlikely. In addition, the species appears to be less popular as an ornamental plant than other goldenrod species (Weber 2001); sales of imported plants appear to be limited, and sales of seeds seem limited to specialist providers. Thus, the ongoing inward propagule pressure of both pathways is likely to be rather low.
Summarise Establishment	moderately	high	Species already has 55 recorded in locations across Britain (dating 1809-2014), thus it may have small persistent populations, likely resulting from garden escape. Previous work demonstrates a climate match between the species' native range and GB (Weber 1998). However, the species is more limited in the range of habitats it occurs in on the continent than invasive *Solidago* species, and established populations are close to original sites of introductions (Szymura & Szymura 2016a). This, combined with uncertainty over seed production and germination suggests that the species has a rather limited ability to establish self-sustaining populations.
Summarise Spread	very slowly	high	If propagule pressure remains low, and the species maintains the same rate of limited spread close to introduction sites as seen on the continent, its potential for future spread should remain slow in the RA area. However, there is still the risk that the species is in a lag phase and spread rate might increase if a threshold population size is reached. This risk will also depend upon seed production and viability, which remain unquantified in the RA area.
Summarise Impact	minor	high	Combined with information on slow spread rates both in the RA area and continental Europe, it seems unlikely that the species will have large overall impacts in the RA area; at most the species may alter vegetation composition and plant-insect food-webs in invaded habitats, but the extent of these changes are

			likely to be limited to only the largest, densest invaded patches. The species may have allelopathic properties, but the limited invasion success in Europe indicates allelopathy is not a major advantage against native plants; competitive ability of the species against natives seems unconvincing, but the species may be more competitive with high nutrient inputs. Minor with high confidence
Conclusion of the risk assessment	low	high	Compared to true *Solidago* species in the RA area and Europe more widely, *Euthamia graminifolia* has low invasion potential. This is borne out by is very limited distribution and abundance in the RA area and despite a long time since introduction, and limited spread from points of introduction elsewhere. It is possible the species is in a protracted lag phase, and this may result from a much lower propagule pressure than other invasive *Solidago* spp. The species is on Switzerland's invasive watch list, but records of distribution in that country indicate limited spread rate (Infoflora 2020); the species may become more abundant in nutrient-rich wetland habitats if propagules are able to reach them, but impacts are likely to be limited to local changes in vegetation composition and plant-insect food-webs, where density and extent becomes high. There is no evidence this has occurred yet in the RA area.

Additional questions are on the following page ...

ADDITIONAL QUESTIONS - CLIMATE CHANGE			
3.1. What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	Increasing temperatures in northern Scotland	medium	Most of Britain has a suitable climate for the species, based on the native range, except for Northern Scotland (northwards of Moray Firth) (Weber 2001). Warming temperatures could bring this area into a suitable climate for the species in future.
3.2. What is the likely timeframe for such changes?	100 years	medium	Temperatures may be warm enough in N Scotland for the species by the end of the century, but climate projections required.
3.3. What aspects of the risk assessment are most likely to change as a result of climate change?	Establishment Spread	medium	Temperatures are most likely going to limit over-winter survival and seed production, which will constrain ability of the species to establish new populations.
ADDITIONAL QUESTIONS - RESEARCH			
4.1. If there is any research that would significantly strengthen confidence in the risk assessment please summarise this here.	Population status and ecology in RA area Seed production and dispersal Effects of climate	very high	Little is known about the ecology of the species in the RA area, and in particular, we would benefit from more focused surveys to capture the distribution and abundance of the species; there is a risk that it is under-recorded by opportunistic observations; the most recent NBN record for the species is 2014, but the majority of records (40) are from before 1990. This includes records in habitats like hedges, which may mean the species is quite cryptic and thus more widespread than records suggest. There is some evidence from continental Europe that seed viability is low, but there are no data on sexual reproduction and seed viability/recruitment from the RA area. Population sizes and potential for population growth could be estimated at known sites of occurrence, and wide N-S distribution in RA area means that a climatic cline on plant performance could be

			investigated easily.

Please provide a reference list on the following page ...

REFERENCES:

Banta JA, Stark SC, Stevens MHH, Pendergast IV TH, Baumert A & Carson WP (2008). Light reduction predicts widespread patterns of dominance between asters and goldenrods. Plant Ecology 199: 65-76.

B and T world seeds (2020). *Euthamia graminifolia*. https://b-and-t-world-seeds.com/cartall.asp?species=Euthamia%20graminifolia&sref=519670. Accessed 30.12.2020

BSBI DDB - https://database.bsbi.org/ Accessed 28.01.2021

Butchko VM & Jensen RJ (2002). Evidence of tissue-specific allelopathic activity in *Euthamia graminifolia* and *Solidago canadensis*. The American Midland Naturalist 148: 253-262.

Dajdok Z, Nowak A (2007) *Solidago graminifolia* (L.) Elliott in Poland—spreading and habitat preferences. In: Tokarska-Guzik B et al (eds) Plant invasions: human perception, ecological impacts and management. Backhuys Publishers, Leiden, pp 101–116

EPPO (2020). https://gd.eppo.int/taxon/ETIGR/reporting. Accessed 30.12.2020

Etsy (2020). Euthamia graminifolia. https://www.etsy.com/ie/listing/750682758/euthamia-graminifolia-flat-top-goldenrod?ref=shop_home_active_24. Accessed 30.12.2020

Flora Helvetica (2018). *Solidago graminifolia*. (K Lauber, G. Wagner). Haupt-Verlag AG, Switzerland.

Floraccess (2020). https://www.floraccess.com. Accessed 30.12.2020

Flora of North America (2021) http://beta.floranorthamerica.org/Euthamia Accessed 28.01.2021

GBIF (2020). *Euthamia graminifolia*. https://www.gbif.org/species/3092782. Accessed 30.12.2020

USDA Agricultural Research Service (2015). *Euthamia graminifolia*. https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomydetail?id=104230. Accessed 30.12.2020

Guzikowa M, Maycock PF (1986). The invasion and expansion of three North American species of goldenrod (*Solidago canadensis* L. *sensu lato*, *S. gigantea* Ait. and *S. graminifolia* (L.) Salisb.) in Poland. Acta Societatis Botanicorum Poloniae. 55: 367-384.

Infoflora (2020) https://www.infoflora.ch/de/flora/solidago-graminifolia.html. . Accessed 30.12.2020

Jan Nieuwesteeg (2020). https://www.jannieuwesteeg.nl/. Accessed 30.12.2020

Kompala-Baba A & Baba W (2006). *Solidago graminifolia* (L.) Elliott on anthropogenic sites of the Silesian Upland (Poland). *Biodiversity Research and Conservation* 3-4: 329-332.

KPR (2020). http://www.kpr-eshop.eu/en/flora-europe/. Accessed 30.12.2020

National Biodiversity Network Gateway (2020) *Euthamia graminifolia.* https://species.nbnatlas.org/species/NBNSYS0000004420#tab_recordsView. Accessed 30.12.2020

Plants of the World Online (2019). *Euthamia graminifolia*. http://www.plantsoftheworldonline.org/taxon/urn:lsid:ipni.org:names:1004467-1. Accessed 30.12.2020.

Royal Horticultural Society (2020). *Euthamia graminifolia*. https://www.rhs.org.uk/Plants/246042/Euthamia-graminifolia/Details. . Accessed 30.12.2020

Sheahan, C.M. 2012. Plant guide for flat-top goldentop (*Euthamia graminifolia*). USDA-NRCS, Cape May Plant Materials Center. Cape May, NJ. 08210.

Swiss Federal Council (2012). Ordinance on the Handling of Organisms in the Environment (Release Ordinance, RO) of 10 September 2008 (Status as at 1st June 2012). 814.911. http://www.admin.ch/ch/e/rs/814_911/index.html

Szymura M (2012). OCENA ZDOLNOŚCI DO ROZMNAŻANIA GENERATYWNEGO I WEGETATYWNEGO NAWŁOCI WYSTĘPUJĄCYCH W POŁUDNIOWO-ZACHODNIEJ POLSCE (EVALUATION OF ABILITY FOR GENERATIVE AND VEGETATIVE REPRODUCTION OF GOLDENRODS OCCURRED IN POLAND). Zesz. Nauk. UP Wroc., Rol. CI, 585: 103–112.

Szymura M & Szymura TH (2016a). Historical contingency and spatial processes rather than ecological niche differentiation explain the distribution of invasive goldenrods (*Solidago* and *Euthamia*). Plant Ecology 217: 565-582.

Szymura M & Szymura TH (2016b). Interactions between alien goldenrods (*Solidago* and *Euthamia* species) and comparison with native species in Central Europe. Flora 218: 51-61.
Szymura M, Szymura TH, Wolski K & Swierszcz S (2018). Can native grass species outcompete invasive goldenrods? Results of a replacement series experiment. Weed Research 58: 304-317.

Thompson, K., Bakker, J.P. and Bekker, R.M. (1997). The Soil Seed Banks of North West Europe: Methodology, density and Longevity. Cambridge University Press, Cambridge.

Voser-Huber MI (1983) Studien an eingebürgerten Arten der Gattung *Solidago* L. Diss Bot 68:1–97

Weber E (1998). The dynamics of plant invasions: a case study of three exotic goldenrod species (*Solidago* L.) in Europe. *Journal of Biogeography* 25: 147-154.

Weber E (2001). Current and potential ranges of three exotic goldenrods (*Solidago*) in Europe. *Conservation Biology* 15: 122-128.