

Risk assessment template developed under the "Study on Invasive Alien Species – Development of risk assessments to tackle priority species and enhance prevention"
Contract No 09.0201/2024/917978/ETU/D.2¹

Name of organism: *Solidago gigantea* Aiton & *Solidago canadensis* L.

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Risk Assessment Area: The risk assessment area is the territory of the European Union 27, excluding the EU-outermost regions.

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Date of completion: 20/05/2025

Date of revision: 03/08/2026

¹ This template is based on the Great Britain non-native species risk assessment scheme (GBNNRA). A number of amendments have been introduced to ensure compliance with Regulation (EU) 1143/2014 on IAS and relevant legislation, including the Delegated Regulation (EU) 2018/968 of 30 April 2018, supplementing Regulation (EU) No 1143/2014 of the European Parliament and of the Council with regard to risk assessments in relation to invasive alien species (see <https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32018R0968>).

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General remark

The two species *Solidago canadensis* (Canadian goldenrod) and *Solidago gigantea* (Giant goldenrod) belong to the same genus with the same origin in the Eastern part of North America, have comparable species traits and feature comparable ecological impacts. For these reasons, the two *Solidago* species are evaluated together in one risk assessment. Whenever the two species differ in any aspects, a note was added. Distribution maps and the species distribution models have been generated separately and are designed for a user-friendly visualization.

SECTION A – Organism Information and Screening

A1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?

including the following elements:

- the taxonomic family, order and class to which the species belongs;
- the scientific name and author of the species, as well as a list of the most common synonym names;
- names used in commerce (if any)
- a list of the most common subspecies, lower taxa, varieties, breeds or hybrids

As a general rule, one risk assessment should be developed for a single species. However, there may be cases where it may be justified to develop one risk assessment covering more than one species (e.g. species belonging to the same genus with comparable or identical features and impact). It shall be clearly stated if the risk assessment covers more than one species, or if it excludes or only includes certain subspecies, lower taxa, hybrids, varieties or breeds (and if so, which subspecies, lower taxa, hybrids, varieties or breeds). Any such choice must be properly justified.

Response: The risk assessment covers two species from the genus *Solidago* L. (Catalogue of Life 2025): *Solidago canadensis* L. and *Solidago gigantea* Aiton (Catalogue of Life 2024ab; Flora of North America 2024ab).

The genus *Solidago* L. comprises more than 100 species. Given the taxonomic uncertainties for this genus, the total number of species varies from 133 (Plants of the World Online 2025) up to 163 species (Catalogue of Life 2025) within this genus. There is considerable taxonomic confusion within the genus *Solidago*, notably within the *S. canadensis* complex (Flora of North America 2025c) within the subgenus *Triplinervae* with triple-nerved leaves. This complex covers the two assessed species *S. canadensis* and *S. gigantea*, furthermore *S. altissima* and *S. lepida*. *S. altissima* is found in Europe/Belgium (Euro+Med PlantBase 2025b; Verloove et al. 2017; Weber 2000).

S. canadensis is a highly variable species (CABI 2024a). However, *S. gigantea* appears to generally be one of the more clearly defined taxa within that complex (CABI 2024b). *S. gigantea* is usually the least hairy species of the *S. canadensis* complex. The stems may be somewhat glaucous and the array is usually somewhat more open than in *S. canadensis* and *S. altissima*, and less leafy than *S. lepida* (Flora of North America 2024b).

Sampe & Beck (2021) revised the infrageneric classification of *Solidago*. They proposed following new taxonomic membership of *S. canadensis* and *S. gigantea*:

- *Solidago* sect. *Unilaterales*
 - *Solidago* subsect. *Triplinerviae*
 - *Solidago* ser. *Canadensae*
 - *S. canadensis*
 - *Solidago* subsect. *Serotinae*
 - *S. gigantea*

However, the newly proposed classification by Semple & Beck (2021) is not used yet in referenced studies and scientific articles.

For the risk assessment, the two *Solidago* species are discussed in the broadest taxonomic sense.

S. canadensis and *S. gigantea* are perennial clonal herbaceous plants with small, wind-dispersed seeds. The species establish themselves quickly from wind-dispersed seeds and start flowering in their second year. *Solidago* spp. also spread clonally, forming monodominant stands (Nunes et al. 2024).

Solidago canadensis L.:

Flora of North America 2024a:

Plants 30–150(–200) cm; rhizomes short to long creeping. **Stems** 1–20+, erect, glabrate proximally or sparsely strigoso-villous, becoming more densely so distal to mid stem. **Leaves:** basal 0; proximal to mid cauline usually withering by flowering, tapering to sessile bases, blades narrowly ovate-lanceolate, 50–190 × 5–30 mm, margins sharply serrate, 3-nerved, apices acuminate, abaxial faces glabrous or more commonly hairy along main nerves, adaxial glabrous or slightly scabrous; mid to distal similar, 30–50(–120) × 8–12 mm, largest near mid stem, reduced distally, margins usually serrate or serrulate (teeth 3–8), sometimes entire proximal to arrays. **Heads** (70–)150–1300+, secund, in secund pyramidal-paniculiform arrays (obscurely so and club-shaped thyriform in small plants or shoots with small arrays), branches divergent and recurved, branches and peduncles hairy. **Peduncles** 3–3.4 mm, bracteoles 0–3, linear-triangular. **Involucre**s narrowly campanulate, 1.7–2.5(–3) mm. **Phyllaries** in 3–4 series, strongly unequal, acute to obtuse; outer lanceolate, inner linear-lanceolate. **Ray** florets (5–)8–14(–18); laminae 0.5–1.5 × 0.15–0.3(–0.5) mm. **Disc** florets (2–)3–6(–8); corollas 2.2–2.8(–3) mm, lobes 0.4–0.8(–1) mm. **Cypselae** (narrowly obconic) 1–1.5 mm (ribbed), sparsely strigose; pappi 1.8–2.2 mm.

CABI 2024a:

S. canadensis is a 25-250 cm (mean 150 cm) tall, erect rhizomatous perennial with annual aboveground shoots and persistent belowground rhizomes. One to several rhizomes emerge near the base of the dying shoots in autumn, thus leading to a branched rhizome system rooted mainly at the old and current shoot bases. Each rhizome has the potential to produce a single aerial stem arising from the apex of the rhizome in the following spring. Roots arise from the shoot base and reach a minimum depth of 20 cm. Stems are branched only in the inflorescence, glabrous at the base, weakly to densely pubescent at least in the upper half and often reddish. Plants of var. *scabra* have nodding shoot tips during growth. Leaves are triple-nerved, pubescent beneath, lanceolate, often acuminate, with margins mostly serrate, occasionally entire. Inflorescences form broad pyramidal panicles with recurving branches and a central axis. Bracts of the involucre are linear, obtuse or somewhat acute. Ray florets are lemon yellow, female and fertile, disc florets bisexual and fertile. The corolla is 2.4-2.8 mm long. Achenes are pubescent, 0.9-1.2 mm long, with a pappus of 2.0-2.5 mm.

Solidago gigantea Aiton:

Flora of North America 2024b:

Plants 50–200 cm (solitary or clustered); rhizomes short- to long-creeping. **Stems** 1–20+ or clustered, erect, glabrous or sparsely strigose in arrays, sometimes glaucous. **Leaves:** basal 0; proximal cauline usually withering by flowering time, sessile, lanceolate, 91–97 × 10–14 mm, margins sharply serrate, 3-nerved, apices acuminate, abaxial faces pilose on nerves or glabrous; mid to distal cauline similar, 57–76 × 0.7–1.2 cm, largest toward mid stem, decreasing distally. **Heads** 40–600, secund, in broadly secund, pyramidal paniculiform arrays, rarely rhombic or club-shaped, proximal branches divergent, recurved, glabrous-glabrate or strigose, sometimes glaucous. **Peduncles** 1.5–3 mm, sparsely to densely strigillose; bracteoles 0–2, linear-lanceolate. **Involucres** campanulate, (2–)2.5–4(–5) mm. **Phyllaries** in 3–4 series, unequal, acute; outer lanceolate, inner linear-lanceolate (hexaploids from far west can have minute stipitate glands, especially near base of outer phyllaries and peduncle bracts). **Ray** florets (7–)9–15(–24) (conspicuous); laminae 1–3 × (0.1–)0.2–0.4 mm. **Disc** florets (4–)7–12(–17); corollas (2.5–)3–3.5(–4.5) mm, lobes 0.6–1(–1.4) mm. **Cypselae** 1.3–1.5 mm, sparsely strigose; pappi 2–2.5 mm. **2n** = 18, 36, 54.

CABI 2024b:

S. gigantea is a 30-280 cm tall, erect rhizomatous perennial with annual aboveground shoots and persistent belowground rhizomes. One to several rhizomes emerge near the base of the dying shoots in autumn, thus leading to a branched rhizome system rooted mainly at the old and current shoot bases. Aerial stems arise from the rhizome apices in the following spring. Roots are inserted at the shoot base and reach a minimum depth of 20 cm. Stems are unbranched except in the inflorescence. Stems are glabrous and often glaucous below the inflorescence. They may be weakly hairy in the inflorescence only. Stems may have a purplish cast and a white, waxy bloom. A nodding shoot tip is occasionally observed in the native range. Leaves are simple and alternate, sessile, with the largest leaves towards mid-stem and decreasing in size upwards. Leaves are triple-nerved, glabrous or sometimes pubescent beneath, lanceolate, often acuminate, with margins mostly serrate, occasionally entire. Inflorescences form broad pyramidal panicles with recurving branches and a central axis. Bracts of the involucre are linear, obtuse or somewhat acute. Ray florets are golden yellow, female and fertile; disc florets bisexual and fertile. The capitula are 3-5 mm long. Achenes are pubescent, 1-2 mm long, with a pappus of 1 mm long.

Taxonomy (Catalogue of Life 2024ab; Flora of North America 2024ab; Plants of the World Online 2024ab)

Kingdom	<i>Plantae</i>
Phylum	<i>Tracheophyta</i>
Class	<i>Magnoliopsida</i>
Order	<i>Asterales</i>
Family	<i>Asteraceae</i>
Subfamily	<i>Asteroideae</i>
Genus	<i>Solidago</i> L.

Section	<i>Solidago</i> sect. <i>Solidago</i>
Subsection	<i>Solidago</i> subsect. <i>Triplinerviae</i>
Species	<i>Solidago gigantea</i> Aiton <i>Solidago canadensis</i> L.

Synonyms

Solidago canadensis L. (CABI 2024a ¹, Catalogue of Life 2024a ²; EPPO 2024a ³; Plants of the World Online 2024a ⁴; Flora of North America 2024a ⁵):

- *Aster canadensis* (L.) Kuntze ¹²⁴⁵
- *Doria canadensis* (L.) Lunell ¹²⁴
- *Solidago altissima* var. *gilvocanescens* (Rydb.) Semple ¹
- *Solidago anthropogena* H. Scholz ²
- *Solidago arcuata* Tausch ²
- *Solidago canadensis* f. *canadensis* ¹
- *Solidago canadensis* subsp. *altissima* (L.) O.Bolòs & Vigo ¹
- *Solidago canadensis* subsp. *canadensis* ¹
- *Solidago canadensis* var. *canadensis* ¹
- *Solidago canadensis* var. *lepida* (DC.) Cronquist ¹
- *Solidago elongata* Nutt. ¹
- *Solidago canadensis* var. *bartramiana* (Fernald) Beaudry ²
- *Solidago canadensis* var. *glabrata* Porter ²
- *Solidago canadensis* var. *intermedia* Torr. & A. Gray ²
- *Solidago eminens* Bischoff ex A. Gray ²
- *Solidago glabra* subsp. *canadensis* (L.) Bonnier ²⁴
- *Solidago hirsuta* L'Hér. ex DC. ²
- *Solidago hirsutissima* var. *hirsutissima* ¹
- *Solidago humilis* Mill. ²
- *Solidago lepida* DC. ¹
- *Solidago longifolia* Schrad. ex DC. ²
- *Solidago mollis* Rothr. ²
- *Solidago nervosa* Gaterau ²
- *Solidago nutans* Desf. ²
- *Solidago praecox* Moench ²
- *Solidago reflexa* Aiton ²
- *Solidago tournefortii* Tausch ²

Solidago gigantea Aiton (CABI 2024b ¹, Catalogue of Life 2024b ²; EPPO 2024b ³; Plants of the World Online 2024b ⁴; Flora of North America 2024b ⁵):

- *Aster latissimifolius* var. *serotinus* Kuntze ²⁴⁵
- *Doria dumetorum* (Lunell) Lunell ²⁴⁵
- *Doria pitcheri* (Nutt.) Lunell ²⁴⁵

- *Solidago cleliae* DC.²⁴⁵
- *Solidago deflexa* Moench²⁴
- *Solidago dumetorum* Lunell²⁴⁵
- *Solidago fragrans* A. Gray²⁴
- *Solidago gigantea subsp. serotina* (Kuntze) Mc Neill²³⁵
- *Solidago gigantea var. leiophylla* Fernald²³⁴⁵
- *Solidago gigantea var. pitcheri* (Nutt.) Shinnars²⁴⁵
- *Solidago gigantea var. serotina* (Kuntze) Cronquist²³⁴⁵
- *Solidago gigantea var. shinnarsii* Beaudry²⁴⁵
- *Solidago glabra* Desf. (Ambiguous)²³⁴
- *Solidago* × *leiophallax* Friesner¹⁴
- *Solidago pitcheri* Nutt.¹²⁴⁵
- *Solidago sera* J. F. Gmel.²⁴
- *Solidago serotina* Aiton (Ambiguous)¹²³⁴
- *Solidago serotina f. huntingdonensis* Beaudry²⁴
- *Solidago serotina var. dumetorum* (Aiton) A. Gray²⁴
- *Solidago serotina var. gigantea* (Aiton) A. Gray¹²⁴⁵
- *Solidago serotina var. minor* Hook.²⁴⁵
- *Solidago serotinoides* Á. Löve & D. Löve¹²⁴⁵
- *Solidago shinnarsii* (Beaudry) Beaudry¹²⁴⁵
- *Solidago somesii* Rydb.²⁴⁵

Common names

According to CABI (2024ab), EPPO (2024ab), Euro+Med PlantBase (2024ab), Plants of the World Online (2024ab), common names in the European region are:

- Bulgarian: *S. canadensis* канадска златица, канадски енчец; *S. gigantea*: едра златица
- Catalan: *S. canadensis*: solidago del Canadá, palma d'or; *S. gigantea*:
- Czech: *S. canadensis*: zlatobýl kanadský, celik kanadský, zlatobýl kanadský; *S. gigantea*: celík obrovský, zlatobýl obrovský
- Croatian: *S. canadensis*: gustocvjetna zlatnica, Kudjelja; *S. gigantea*: velika zlatnica
- Danish: *S. canadensis*: kanadisk gyldenris, canadisk gyldenris; *S. gigantea*: sildig gyldenris
- Dutch: *S. canadensis*: Canadese guldenroede; *S. gigantea*: Late guldenroede
- English: *S. canadensis*: Canadian goldenrot; *S. gigantea*: giant goldenrot, late goldenrod, smooth goldenrod
- Estonian: *S. canadensis*: Kanada kuldvits; *S. gigantea*: sügis-kuldvits
- Finnish: *S. canadensis*: kanadanpiisku; *S. gigantea*: isopiisku
- French: *S. canadensis*: verge d'or du Canada, solidage du Canada, Gerbe-d'or; *S. gigantea*: solidage tardif, verge d'or géant, solidage glabre, solidage géante
- German: *S. canadensis*: Kanadische Goldrute; *S. gigantea*: Riesen-Goldrute, Große Goldrute, Späte Goldrute
- Hungarian: *S. canadensis*: kanadai aranyvesszo; *S. gigantea*: magas aranyvesszo
- Italian: *S. canadensis*: verga d'oro canadese, verga d'oro del Canada; *S. gigantea*: verga d'oro maggiore
- Latvian: *S. canadensis*: Kanādas zeltgalvīte; *S. gigantea*: vēlīnā vībotne, Vēlīnā vībotnik

- Lithuanian: *S. canadensis*: kanadinė rykštenė; *S. gigantea*: vėlyvoji rykštenė
- Norwegian: *S. canadensis*: Kanadagullris; *S. gigantea*: Kjempegullris
- Polish: *S. canadensis*: nawłóć kanadyjska; *S. gigantea*: nawłóć olbrzymia, nawłóć późna
- Portuguese: *S. canadensis*: vara-de-ouro; *S. gigantea*: vara de ouro gigante
- Romanian: *S. canadensis*: sînzîiană de grădină; *S. gigantea*: roșu auriu uriaș, papagal de aur gigant
- Russian: *S. canadensis*: густоцветна златница; *S. gigantea*: золотарник гигантский, золотарник поздний, золотая розга гигантская
- Serbian: *S. canadensis*: золотарник канадский, куђеља; *S. gigantea*: голема златница
- Slovak: zlatobyľ kanadská, zlatá byľ kanadská; *S. gigantea*: zlatobyľ obrovská, zlatá byľ obrovská
- Slovenian: kanadska zlata rozga; *S. gigantea*: orjaška zlata rozga
- Spanish: *S. canadensis*: lechuguilla, vara de oro del Canadá, vara de San Jose, plumero amarillo; *S. gigantea*: vara de oro gigantiflora, vara de oro gigante,
- Swedish: *S. canadensis*: kanadensiskt gullris, Jättegullris; *S. gigantea*: höstgullris
- Turkish: *S. canadensis*: arsız altınbaşak; *S. gigantea*:
- Ukrainian: *S. canadensis*: золотушник канадський, золотушник канадський; *S. gigantea*: золотушник пізній

Most common subspecies, lower taxa, varieties, breeds or hybrids

In its native range in North America, several different taxonomic subunits have been recognised within the *S. canadensis* complex, which have been in the past granted species status by some authors (Beaudry & Chabot, 1957; Croat 1972; Scoggan & Ribes 1979). However, no subspecies have been accepted by the Integrated Taxonomic Information System (ITIS) (2025a). ITIS (2025a) refers to two varieties: *S. canadensis* var. *canadensis* L. and *S. canadensis* var. *hargeri* Fernald. *S. canadensis* var. *hargeri* is distinguished by its lower to mid stems being moderately hairy (University of Waterloo 2025). Typical var. *canadensis* is readily recognized; more hairy-stemmed plants are similar to var. *hargeri*, which usually has fewer disc florets (Flora of North America 2025a).

One former taxon, *S. canadensis* sp. *altissima*, or *S. canadensis* var. *scabra*, is now treated as a separate species, *S. altissima*, especially in Europe (Weber, 1997; Weber, 2000). ITIS (2025b) does not list any subspecies or varieties of *S. gigantea*.

Both species have ornamental, i.e. horticulturally selected, forms, and they were or are offered as ornamental plants in Europe, although sales have declined significantly in many countries for nature conservation reasons. The Canadian goldenrod (*Solidago canadensis*) has been bred to obtain more compact growth forms for gardens, as the wild species grows very tall. Well-known varieties that are (or were) offered in Europe include: *Solidago canadensis* “Goldkind” or “Golden Baby” and *Solidago canadensis* “Little Miss Sunshine”. There are hardly any established cultivars of *Solidago gigantea* with their own trade names. As there are no references available that these ornamental varieties behave differently in context of invasiveness, these are included in the risk assessment.

A2. Provide information on the existence of other species that look very similar [that may be detected in the risk assessment area, either in the environment, in confinement or associated with a pathway of introduction]

Include both native and non-native species that could be confused with the species being assessed, including the following elements:

- other alien species with similar invasive characteristics, to be avoided as substitute species (in this case preparing a risk assessment for more than one species together may be considered);
- other alien species without similar invasive characteristics, potential substitute species;
- native species, potential misidentification and mis-targeting

Response:

Existence of other non-native species that look very similar

The *Solidago canadensis* complex (*S.* subsect. *Triplinerviae*) is a taxonomically challenging species assemblage in North America including several species that are widely grown as garden ornamentals (e.g. *S. canadensis*, *S. gigantea*). A third species from this complex from North America is *S. altissima*. *S. canadensis* and *S. altissima* were both described by Linnaeus (1753). They were considered similar species that could be distinguished on features such as stature, flowering time and leaf serration: the latter was characterized as a taller plant with entire leaves that flowered later than *S. canadensis* (Verloove et al. 2017). *S. altissima* was recently reported from Belgium (Verloove et al. 2017).

Solidago altissima L.

Flora of North America 2025b:

Plants 50–200 cm; rhizomes short- to long-creeping. **Stems** 1–40+, usually short-hairy throughout, sometimes proximally glabrescent. **Leaves:** basal 0; proximal cauline usually withering by flowering; sessile or subpetiolate, tapering to bases; blades oblanceolate, 95–150 × 16–20 mm, relatively thick and firm, entire to serrate along distal 1/2, strongly 3-nerved, apices acute to acuminate, abaxial faces finely strigose, more so along nerves, adaxial ± scabrous; mid to distal cauline blades oblanceolate (proximally) to lanceolate (distally), mid (30–)45–100(–170) × (5–)7–16(–25) mm, much reduced distally [(15–)25–55 × (3–)4.5–10(–17) mm], margins finely serrate (teeth 0–6(–14) per side on mid), distally usually becoming entire or remotely serrulate, adaxial faces ± scabrous, abaxial moderately strigillose, densely villosa-strigillose along nerves, distal sometimes minutely stipitate-glandular. **Heads** (15–)100–1200+, secund, in secund, pyramidal, paniculiform arrays, branches divergent and recurved, sometimes ascending-divergent, sometimes merely club-shaped thyriform in small plants, 5–30 × 2–25 cm (often 1.5–2 times as long as wide in southern plants). **Peduncles** 1–3.5 mm, moderately densely short hispiduloso-strigillose, sometimes minutely stipitate-glandular; bracteoles linear, sometimes minutely stipitate-glandular. **Involucre**s narrowly campanulate, 2.5–4.5 mm. **Phyllaries** in ca. 3 series, strongly unequal; outer lanceolate, acute, inner linear-lanceolate, margins rarely minutely stipitate-glandular, apices acute to obtuse. **Ray** florets (5–)8–13(–17); laminae 0.7–1.5(–2) × 0.1–0.4(–0.5) mm. **Disc** florets (2–)3–6(–9);

corollas usually 2.3–3.6 mm, lobes 0.5–0.9(–1.2) mm. **Cypselae** (narrowly obconic) 0.5–1.5 mm, sparsely to moderately strigillose; pappi 2.5–3.5 mm.

Solidago virgaurea L., the common goldenrod, is a species of this genus native to Europe covering the risk assessment area. The species is smaller than the two assessed *Solidago* species. The common goldenrod is a deciduous, perennial plant with a tightly upright growth habit. It grows to a height of 40 to 60 cm.

Blade of lower stem leaves mostly elliptic to ovate, narrowed into winged petiole; middle stem leaves lanceolate, 10-20 mm wide, with a wedge-shaped base, acute to acuminate, mostly ± hairy, especially below, sharply serrate-toothed especially in and above the centre; Capitulum usually much longer than wide, with hardly more than 100 capitula; capitula with 6-12 ray florets; capitulum base glabrous, honeycomb-shaped (the individual ovaries surrounded at the base by a corolla [small teeth]); involucre 5-9 mm long; ray florets 5-7 mm long, clearly exceeding the tubular flowers; hemicryptophyte. VIII-X. Folk medicinal plant; colouring plant (yellow) (Burgenlandflora 2025).

A3. Does a relevant earlier risk assessment exist? Give details of any previous risk assessment, including the final scores and its validity in relation to the risk assessment area.

Response:

Under Article 12 of Regulation (EU) No 1143/2014, EU Member States have the legal right to establish national lists of IAS of Member State concern. According to EEA (2026), both *Solidago* species are listed in such a national list in Denmark, Estonia, Finland, Lithuania, Slovakia. Further indication of a national or regional listing is given for Belgium (Wallonia: Listed on the Walloon Black List of IAS), Sweden (Swedish Species Information Centre - Artdatabanken), Poland (Act of 11 August 2021 on Invasive Alien Species - Dz.U. 2021 poz. 1718).

Inside of the risk assessment area

Invasion risk for a Mediterranean region (Gassó et al. 2010)

The scheme chosen for testing in the Mediterranean region was the Australian Weed Risk Assessment (WRA) in the European Mediterranean region. The WRA system consists of 49 questions, which encompass biogeography, undesirable plant attributes and biology/ecology. A high score (>6) identifies a species likely to be of high risk (weed) and rejects it for import; a low score (<1) accepts the plant for import (non-weed) and intermediate scores (1–6) require further evaluation. The WRA score ranges from -14 (benign species) to 29 (maximum risk). *Solidago gigantea* was given a risk assessment score of **10** in the group of casual species. The testing area partly covered the area of the current risk assessment.

Risk assessment in the Sava River Basin area (including countries Republic of Slovenia, Republic of Croatia, Bosnia and Herzegovina, Republic of Serbia) (Pavić et al. 2020)

The Non-native Risk Assessment (NNRA) methodology (Baker et al. 2008; Mumford et al. 2010) is used to evaluate *Solidago canadensis* and *S. gigantea* in the Sava River Basin area (which forms part

of the risk assessment area in Croatia). The study concluded that both *Solidago* species are highly invasive species in the Sava River Basin. It was estimated that there was a high likelihood of introduction of these species, the species had a high spread potential and their impact was estimated to be high. The assessment area partly covered the area of the current risk assessment.

Risk assessment for Germany (Nehring & Rabitsch 2025)

According to the methodology by Nehring et al. 2025, the plant species assessment leads to categorisation in several lists, from which action requirements and priorities for nature conservation can be derived. The set of criteria is geared towards recording and evaluating negative impacts in terms of nature conservation, whereby economic and health effects are named, but not included in the categorisation process. According to Nehring et al. (2025) those alien species that are considered invasive because there is evidence in the respective reference area that they either directly endanger native species or alter habitats in such a way that this (indirectly) jeopardises native species are categorized as “invasive species”. Alien species for which there are only well-founded assumptions or indications of invasiveness are categorized as “potentially invasive species”. Alien species which, according to current knowledge, do not pose a threat to native species or habitats are categorized as “species that have not yet become invasive”. According to the methodology *Solidago canadensis* and *S. gigantea* were categorized as “invasive species” (Nehring & Rabitsch, 2025). The assessment area partly covered the area of the current risk assessment.

Risk assessment of *Solidago canadensis* for Poland (Szymura et al. 2018ab)

Harmonia+ is a first-line risk assessment scheme for potentially invasive organisms, i.e. organisms that may raise concerns for environmental, plant, animal or human health (D’hondt et al. 2014). The assessment consists of 30 core questions, which are grouped in modules representing the different stages of invasion. An organism is to be considered invasive only when it scores high on the stages of Introduction, Establishment & Spread. Impacts are considered subsidiary issues to the process of invasion. Harmonia+ values range from 0 to 1. The Invasion score and the Impact score may become aggregated by taking the product. This yields an ultimate score for the Invasion risk posed by the organism assessed. Szymura et al. (2018a) applied that assessment scheme for *S. canadensis* in the area of Poland.

Table 1 Selected answers regarding *S. canadensis* characteristics following the Harmonia+ protocol

Assessment parameter	assessment	confidence level
The capacity of the species to disperse within Poland by natural means, with no human assistance	very high	high
The frequency of the dispersal of the species within Poland by human actions	high	high
The effect of the species on native species, through competition	high	high

The effect of the species on ecosystem integrity, by affecting its biotic properties	high	high
The effect of the species on cultivated plant targets through competition	high	high
The effect of the species on causing damage to infrastructure	high	high
The effect of the species on provisioning services	moderately negative	high
The effect of the species on regulation and maintenance services	moderately negative	high
The effect of the species on cultural services	moderately negative	high

In summary, Szymura et al. (2018a) assessed *S. canadensis* as “moderately invasive alien species” with a score of 0.75 for Poland.

Szymura et al. (2018b) applied that assessment scheme for *S. gigantea* in the area of Poland.

Table 2 Selected answers regarding *S. gigantea* characteristics following the Harmonia+ protocol

Assessment parameter	assessment	confidence level
The capacity of the species to disperse within Poland by natural means, with no human assistance	very high	high
The frequency of the dispersal of the species within Poland by human actions	high	high
The effect of the species on native species, through competition	high	high
The effect of the species on ecosystem integrity, by affecting its biotic properties	high	high
The effect of the species on cultivated plant targets through competition	high	medium
The effect of the species on causing damage to infrastructure	high	high
The effect of the species on provisioning services	moderately negative	high

The effect of the species on regulation and maintenance services	moderately negative	high
The effect of the species on cultural services	moderately negative	high

In summary, Szymura et al. (2018b) assessed *S. gigantea* as “moderately invasive alien species” with a score of 0.75 for Poland. The assessment area partly covered the area of the current risk assessment.

Risk assessment after the ISEIA and Harmonia+ protocol of invasive alien vascular plant species in Luxembourg (Ries et al. 2013, Ries et al. 2020)

The Belgian Forum on Invasive Species developed the Invasive Species Environmental Impact Assessment (ISEIA) protocol (Ries et al. 2013). The environmental impact of non-native species is assessed in a standard, objective and transparent way through a simplified protocol which consists of four sections matching the last steps of the invasion process, i.e. the potential for spreading and colonising natural habitats as well as the adverse impacts on native species and ecosystems. Scores for each section are based on organisms’ history of impact in neighbouring areas together with their ecological profiles according to the following scale: low risk (1), medium risk (2), high risk (3). The sum of the 4 scores allows assigning the species to one of the following categories: 4-8 = C (no list attribution); 9-10 = B (watch list); 11-12 = A (black list). The assessment area partly covered the area of the current risk assessment.

Table 3 Risk assessment according the ISEA protocol in Luxembourg (Ries et al. 2013)

Assessment parameter	<i>S. canadensis</i>	<i>S. gigantea</i>
dispersion potential or invasiveness	3	3
colonization of high conservation value habitats	2	2
adverse impact on native species	3	3
alteration of ecosystem functions	3	3
Total score	11	11

Both *Solidago* species were evaluated as A2 (high impact with a restricted spatial distribution) by a score of 11 according the ISEA protocol (Ries et al. 2013). According the Harmonia+ protocol, the *Solidago* species are assessed with an overall risk scoring of 0,39 (*S. canadensis*) and 0,26 (*S. gigantea*):

Table 4 Assessment following the Harmonia+ protocol in Luxembourg

Assessment parameter	<i>S. canadensis</i>	<i>S. gigantea</i>
Introduction	0,78	0,56
Establishment	1,00	1,00
Spread	0,46	0,46
Invasion (geometric)	0,71	0,63
Environment	0,55	0,42
Plants	0,17	0,15
Impact (maximum)	0,55	0,42
Overall risk (invasion x impact)	0,39	0,26

Invasive Species Ireland risk assessment - Amber list species (Invasive Species Ireland 2025)

The risk assessment procedure for Ireland and Northern Ireland generated prioritised lists of established and potential invasive species. The Amber list identifies species that, under the right ecological conditions, may have an impact on the conservation goals of a site or impact on a water body achieving good/high ecological status under the Water Framework Directive. The species listed in the Amber list of recorded species are those that could represent a significant impact on native species or habitats causing significant decline or loss; or species that could impact either/both Natura 2000 sites and the goals of the WFD. These species did not achieve a high risk rating overall in the risk assessment. *S. canadensis* is listed with a score of 12 and *S. gigantea* with a score of 14. The assessment area partly covered the area of the current risk assessment.

Prioritization of Potential Invasive Alien Plants in France (Fried 2010)

Fried (2010) used the risk assessment developed by Weber & Gut (2004) for Central Europe (abbreviated W-G WRA). It contains twelve questions dealing with: the area of origin, range size in the risk area, invasiveness elsewhere, mode of reproduction and dispersal, plant height and life form, population size and type of habitat invaded. As the W-G WRA was developed for continental areas, question 11: "Habitats of species. Allocate species to one of the following. If more than one statement applies, take the one with the highest score. Riparian habitats (3), Bogs/swamps (3), Wet grasslands (3), Dry (xeromorphic) grasslands (3), Closed forests (3), Lakes, lakeshores, and rivers (3), Other (0)" was adapted to the French conditions. Score obtained with the W-G WRA method are: 3-21: low risk; 21-27: intermediate risk, 28-39: high risk. The assessment area partly covered the area of the current risk assessment.

Table 5 W-G WRA scoring for France (Fried 2010)

Species	Region at risk	Main habitats	W-G WRA score	Type of impact
<i>Solidago canadensis</i>	Continental, Mediterranean	Ruderal habitats, damp meadows, disturbed forest	36 (high risk)	Environment
<i>Solidago gigantea</i>	Continental, Mediterranean	Ruderal habitats, damp meadows, disturbed forest	38 (high risk)	Environment

Environmental Impact Classification for Alien Taxa (EICAT) – France (De Solan et al. 2024)

The Environmental Impact Classification for Alien Taxa (EICAT) is the IUCN global standard for measuring the severity of environmental impacts caused by animals, fungi and plants living outside their natural range. The EICAT Categories and Criteria provide a simple, objective and transparent method to classify alien species into one of eight categories, according to the severity of their environmental impact. This is determined by the extent to which native species are affected and whether the impact is reversible (IUCN 2025).

De Solan et al. (2024) assessed *Solidago canadensis* and *S. gigantea* with a **major** impact according to the EICAT scheme. Goldenrods can colonize large areas (several thousand square meters) in a variety of habitats (calcareous and marly grasslands, alkaline fens, meadows on semi-peaty soils, sedge meadows, etc.). They form dense, tall stands (over 1 meter). Within these stands, competition from goldenrods and the allelopathic compounds they produce lead to a reduction in the species richness of graminoids. Their abundant flowering diverts pollinators away from flowers with a different morphology than goldenrods, thus reducing the reproductive success of these species (fewer seeds produced). The testing area partly covered the area of the current risk assessment.

Invasive species in the Barents region (Natur Vårds Verket 2024)

The “Barents region” consists of the northernmost parts of Finland, Sweden, Norway and the north-west parts of Russia. Due to a harsh climate, the Barents region has suffered less from invasive alien species (IAS) than southern areas of the Nordic countries and Russia. There are a number of species causing negative effects. Beside the EU, the Nordic countries also make separate risk assessments of alien species in order to determine which are presently problematic or will possibly become so in the future. Sweden and Norway are using the same risk assessment protocol, Generic Ecological Impact Assessment of Alien Species (GEIAA). The species are classified as: SE = Severe risk, HI = High risk, PH = Potentially High risk, LO = Low risk, NK = No Known risk.

According to Natur Vårds Verket (2024), *Solidago canadensis* is listed in the 50 worst invasive alien species in the Barents region as “presently problematic”. The Swedish as well the Norwegian Risk assessment list the species with a “severe risk (SE)” (Natur Vårds Verket 2024). The assessment area partly covered the area of the current risk assessment.

Outside of the risk assessment area

South-east Queensland (Batianoff & Butler 2002)

In this assessment, several species were ranked based upon invasiveness and frequency in non-agricultural areas and/or remnant natural areas. The categories of plant invasiveness are: **1** poorly known and/or early records only; **2** infrequent, poorly invasive; **3** common, invasive? (needs disturbance); **4** generally invasive; **5** highly invasive, forms monocultures. This risk assessment covers the closely related *Solidago canadensis* var. *scabra* (= *S. altissima*) with a score of **4**. The South East Queensland region has a sub-tropical climate influenced by tropical systems from the north and fluctuations in the high pressure ridge to the south. These conditions are marginally comparable to the risk assessment area.

A4. Where is the organism native?

including the following elements:

- an indication of the continent or part of a continent, climatic zone and habitat where the species is naturally occurring
- if applicable, indicate whether the species could naturally spread into the risk assessment area

Response: According to the Flora of North America (2024a), the native range of *Solidago canadensis* covers the North Eastern part of the North America (Canada, USA; Figure 1) with the Köppen-Geiger climate classes “**Dfa** - Cold, no dry season, hot summer”, “**Dfb** - Cold, no dry season, warm summer”, “**Dfc** - Cold, no dry season, cold summer”. The native range of *S. gigantea* spans more to the West and South of North America (Figure 1) (North America 2024a) and additionally covers the climate classes “**BSk** - Arid, steppe, cold” and “**Cfa** - Temperate, no dry season, hot summer”.

Solidago canadensis



Solidago gigantea



Figure 1 Native range of *Solidago canadensis* and *Solidago gigantea* (map designed by Umweltbundesamt/Environment Agency Austria - 2025/01/09)

Solidago species of North-American origin have broad ecological plasticity, and are highly tolerant in respect of water and nutrient supply. They are capable of forming extensive, closed clonal stands in various soil types, from calcareous to peat soils and are only absent from highly saline areas. Both *S. canadensis* and *S. gigantea* can tolerate shading, can occur in disturbed humid forests; however they tend to have reduced vigour in these areas. The soil preferences of the two species differ: while *S. gigantea* occurs on humid, occasionally heavy soils, and usually in close to natural habitats, *S. canadensis* occurs on rather loose, easily warmed soils in the vicinity of settlements. This corresponds to their behaviour in their natural habitats (the North American prairies), where *S. gigantea* prefers slightly more humid habitats than *S. canadensis* (Botta-Dukat & Dancza 2008). Habitat preference of the two species differs: while *S. gigantea* occurs on humid, occasionally heavy soils, and usually in close to natural habitats, *S. canadensis* occurs on rather loose, easily warming soils in the vicinity of settlements. This concurs to their behavior in their natural habitats (the North American prairies), where *S. gigantea* prefers slightly more humid habitats than *S. canadensis* (Botta-Dukat & Dancza 2008).

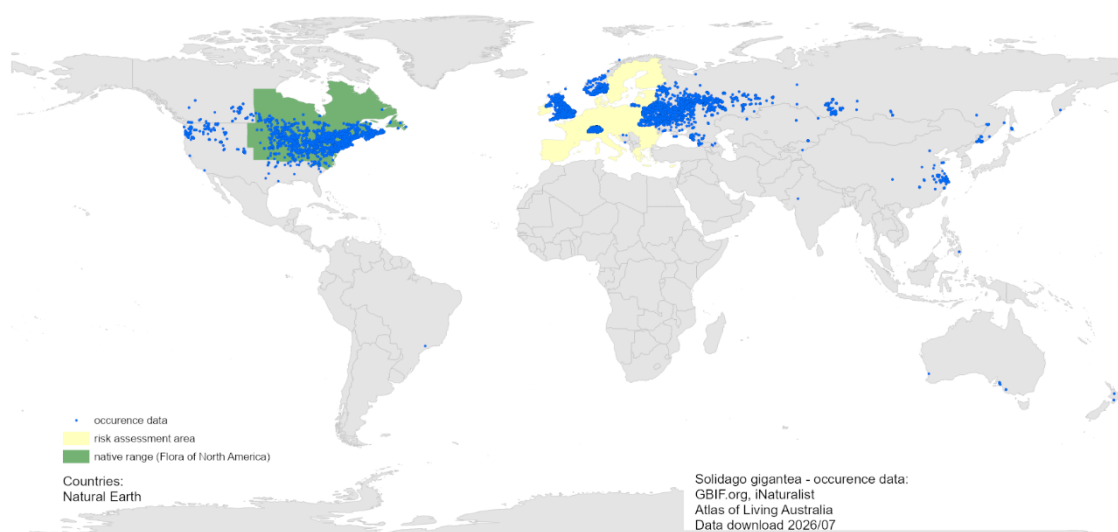
Habitats, where *S. canadensis* are found, include old fields (primarily agricultural or pasture land), pastures, disturbed grounds, roadsides, open woods, forest edges and roadsides, abandoned fields and other unmanaged areas, which are colonised rapidly after abandonment, between 0 to 1000 m a.s.l. (CABI 2024a; Flora of North America 2024a).

The habitats of *S. gigantea* are usually at least seasonally moister soils, flood plains, ditches, depressions, open woods, and thickets, moist depressions in grasslands and parklands, forest edges and roadsides, secondary old-fields and unmanaged areas where it colonised after establishment in a short time. It is found in elevations from 0 up to 1500 m a.s.l. (CABI 2024b; Flora of North America 2024b). Since the native distribution of both *Solidago* species (North America) and the European continent are separated by a large distance, natural spread into the risk assessment area is very unlikely.

A5. What is the global non-native distribution of the organism outside the risk assessment area?

Response: Figure 2 and Table 6 give an overview of the global native and non-native distribution outside the risk assessment area. Considering the native range in North America, available spatial and non-spatial data describe the non-native distribution of *S. canadensis* and *S. gigantea* covering **parts of Eastern and Northern Europe**, to a smaller extent **Asia** and **Oceania**. Occurrence information provided in literature without coordinates is listed in the table, but is not shown in the map.

Solidago canadensis



Solidago gigantea

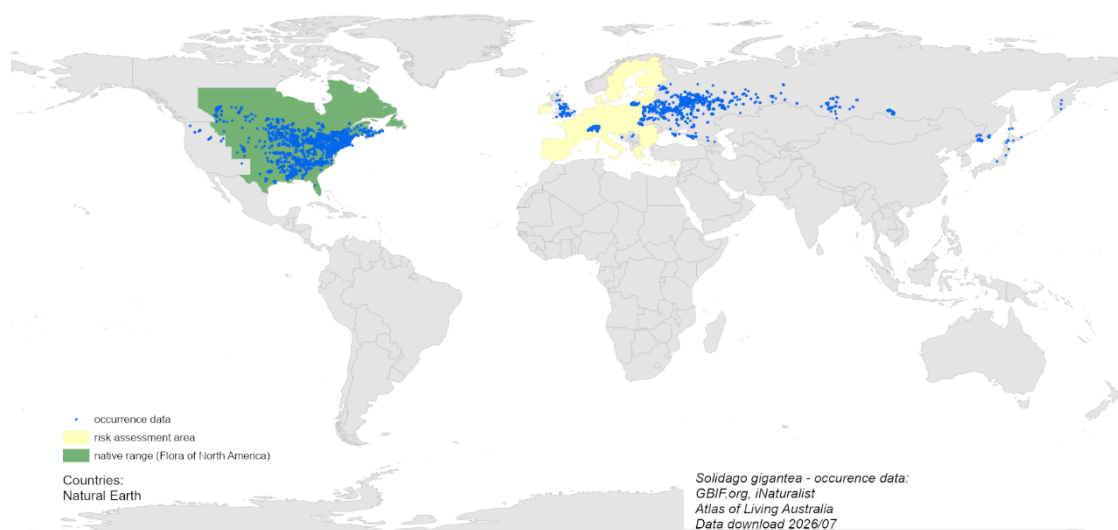


Figure 2 Native range and global non-native range occurrence records of *Solidago canadensis* and *Solidago gigantea* (GBIF - human observations and spatial accuracy < 5.000m; GBIF.org 2026ab; iNaturalist - spatial

accuracy < 5.000m: iNaturalist 2026ab; ALA - human observations and spatial accuracy < 5.000m: Atlas of Living Australia 2026ab) outside the risk assessment area (map designed by Umweltbundesamt/Environment Agency Austria - 2026/07/30)

Table 6 countries (outside the risk assessment area) with *Solidago canadensis* and *Solidago gigantea* occurrences mentioned in references and databases (* references without coordinates not shown in Figure 2; references and comments for *S. canadensis* in *italic*) – ^c *Solidago canadensis*, ^G *S. gigantea*

Continent/ region	country	general remarks	source
Africa	South Africa ^G	Introduced; present	CABI (2024b); Zengeya and Wilson (2021)
Asia	China ^c	<i>Introduced; present; naturalized</i>	<i>CABI (2024a); EPPO (2024a); GBIF (2024a); Guo et al. (2004); iNaturalist (2024a); Jin La et al. (2004); Seebens et al. (2017); Shen LiHua et al. (2007); Qi et al. (2017); Ping et al. (2003)</i>
	Georgia ^c	<i>Present</i>	<i>CABI (2024a); EPPO (2024a); GBIF (2024a); iNaturalist (2024a)</i>
	India ^c	<i>Introduced; present</i>	<i>CABI (2024ab); Chavan & Sushilkumar (2016); Dangwal et al. (2011); Khimani et al. (2005); Patil & Reddy (2005)</i>
	Japan ^{c G}	<i>Introduced; present; naturalized; Introduced; present; localized</i>	<i>CABI (2024ab); EPPO (2024a); GBIF (2026ab); iNaturalist (2024b); Morita (2002); PIER (2024); Shimizu (2001)</i>
	Kazakhstan ^c	<i>Introduced</i>	<i>GBIF (2024a); iNaturalist (2024a)</i>
	North Korea ^G	Introduced; present	Seebens et al. (2017)
	South Korea ^G	Introduced; present	Cho et al. (2013)
	Turkey ^c	<i>Introduced; present; naturalized</i>	<i>CABI (2024ab); EPPO (2024a); Terzioğlu et al. (2003)</i>

Continent/ region	country	general remarks	source
Europe	Albania ^{CG}	<i>Introduced; present;</i> Introduced; present; invasive	<i>CABI (2024ab); EPPO (2024a); Euro+Med PlantBase (2024ab)</i>
	Andorra ^C	<i>Introduced; present; invasive</i>	<i>CABI (2024ab); Euro+Med PlantBase (2024a)</i>
	Belarus ^{CG}	<i>Introduced; present;</i>	<i>CABI (2024ab); Dubovik et al. (2021); EPPO (2024ab); Euro+Med PlantBase (2024a); GBIF (2026ab); iNaturalist (2026ab)</i>
	Bosnia and Herzegovina ^{CG}	<i>Introduced; present; present, invasive</i>	<i>CABI (2024ab); EPPO (2024ab); Euro+Med PlantBase (2024a); GBIF (2024a); iNaturalist (2024b); Maslo (2023)</i>
	Faroe Islands ^{CG}	<i>Introduced; present; invasive;</i> Introduced; present; invasive	<i>CABI (2024ab); Euro+Med PlantBase (2024ab)</i>
	Iceland ^C	<i>Introduced; present</i>	<i>CABI (2024ab); EPPO (2024a); GBIF (2024b); Kabuce and Priede (2010); Euro+Med PlantBase (2024a)</i>
	Liechtenstein ^{CG}	<i>Introduced; present; invasive;</i> Introduced; present; invasive	<i>CABI (2024b); Euro+Med PlantBase (2024ab); GBIF (2026ab);</i>
	Montenegro ^C	<i>Present</i>	<i>CABI (2024a); EPPO (2024a); Stešević & Bubanja (2017)</i>
	North Macedonia ^C	<i>Introduced; present; invasive</i>	<i>CABI (2024a); EPPO (2024a); Euro+Med PlantBase (2024a)</i>
	Norway ^{CG}	<i>Introduced; present; invasive;</i> Introduced; present- widespread; invasive	<i>CABI (2024ab); Euro+Med PlantBase (2024a); GBIF (2026ab); Sunding (1989); iNaturalist (2024a)</i>

Continent/ region	country	general remarks	source
	Russia (Central Russia, Eastern Siberia, Northern Russia, Russian Far East, Southern Russia, Western Siberia) C G	<i>Introduced; present; invasive;</i> Introduced; present; invasive	<i>Artemov and Zykova (2019); CABI (2024ab); EPPO (2024ab); GBIF (2026ab); iNaturalist (2026ab); Ignatov (1986); Euro+Med PlantBase (2024ab); Seebens et al. (2017)</i>
	Serbia C G	<i>Introduced; present; invasive;</i> Introduced; present; invasive	<i>Andelković et al. (2022); CABI (2024ab); Euro+Med PlantBase (2024ab); GBIF (2024b)</i>
	Switzerland C G	<i>Introduced; present; invasive;</i> Introduced; present; invasive	<i>CABI (2024ab); Euro+Med PlantBase (2024ab); GBIF (2026ab); iNaturalist (2026ab); Info Flora (2021)</i>
	Ukraine C G	<i>Introduced; present; invasive;</i> Introduced; present; invasive	<i>CABI (2024ab); EPPO (2024a); Euro+Med PlantBase (2024ab); GBIF (2026ab); iNaturalist (2026ab); Seebens et al. (2017)</i>
	United Kingdom C G	<i>Introduced; present; invasive;</i> Introduced; present; invasive	<i>CABI (2024ab); Euro+Med PlantBase (2024ab); GBIF (2026ab); iNaturalist (2026ab)</i>
North America	Canada C G	<i>Native; introduced outside native range</i>	<i>Bradbury (1973); CABI (2024ab); EPPO (2024a); Flora of North America (2024ab); GBIF (2024a); iNaturalist (2026ab); USDA-ARS (2024ab); USDA-NRCS (2024ab); Seebens et al. (2017); Scoggan & Ribes (1979); Werner et al. (1980)</i>
	Mexico C G	<i>Introduced</i>	<i>CABI (2024ab); USDA-ARS (2024b); Weber (2001)</i>
	Nicaragua C	<i>Introduced</i>	<i>CABI (2024ab); Missouri Botanical Garden (2024)</i>
	United States C	<i>Native; introduced outside native range</i>	<i>CABI (2024ab); EPPO (2024a); Flora of North America (2024ab); GBIF (2024a); iNaturalist (2026ab); Seebens et al. (2017); USDA-ARS (2024ab); USDA-NRCS (2024ab);</i>

Continent/ region	country	general remarks	source
South America	Brazil ^C	<i>Introduced</i>	<i>CABI (2024a); EPPO (2024a); Francine et al. (1999); Loges et al. (2005)</i>
Oceania	Australia (New South Wales, Queensland, South Australia, Tasmania, Victoria, Western Australia) ^C	<i>Introduced; invasive</i>	<i>CABI (2024a); Council of Heads of Australasian Herbaria (2024); Seebens et al. (2017); EPPO (2024a); Weber (2001)</i>
	Cook Island ^C	<i>Introduced; invasive</i>	<i>CABI (2024a); PIER (2024)</i>
	New Caledonia ^C	<i>Introduced; invasive</i>	<i>CABI (2024a); PIER (2024)</i>
	New Zealand ^{C G}	<i>Introduced</i>	<i>CABI (2024ab); EPPO (2024b); GBIF (2024a); iNaturalist (2024a); Weber (2003)</i>

A6. In which biogeographic region(s) or marine subregion(s) in the risk assessment area has the species been recorded and where is it established? The information needs be given separately for recorded (including casual or transient occurrences) and established occurrences. “Established” means the process of an alien species successfully producing viable offspring with the likelihood of continued survival².

A6a. Recorded: List regions

A6b. Established: List regions

Freshwater / terrestrial biogeographic regions:

- Alpine, Atlantic, Black Sea, Boreal, Continental, Mediterranean, Pannonian, Steppic

Marine regions:

- Baltic Sea, North-east Atlantic Ocean, Mediterranean Sea, Black Sea

Marine subregions:

² Convention on Biological Diversity, Decision VI/23

- Greater North Sea, incl. the Kattegat and the English Channel, Celtic Seas, Bay of Biscay and the Iberian Coast, Western Mediterranean Sea, Adriatic Sea, Ionian Sea, Central Mediterranean Sea, Aegean-Levantine Sea.

Comment on the sources of information on which the response is based and discuss any uncertainty in the response.

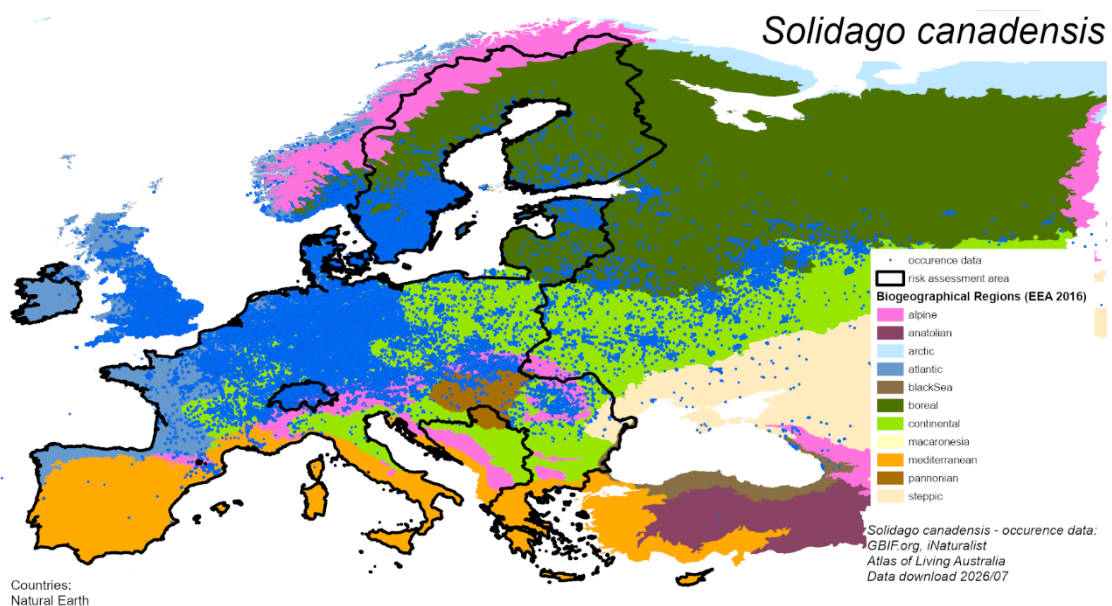
For delimitation of EU biogeographical regions please refer to <https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2> (see also Annex VI).

For delimitation of EU marine regions and subregions consider the Marine Strategy Framework Directive areas; please refer to <https://www.eea.europa.eu/data-and-maps/data/msfd-regions-and-subregions/technical-document/pdf> (see also Annex VI).

The Arctic, Anatolian and Macaronesian biogeographical regions are not part of the risk assessment area, but are included for completeness. Figure 3 and Table 7 give an overview about referenced occurrences of the species in the biogeographical regions.

Response (6a): Alpine, Atlantic, Boreal, Continental, Mediterranean, Pannonian (see Table 7 and Figure 3)

Response (6b): Alpine, Atlantic, Boreal, Continental, Pannonian (see Table 7 and Figure 3)



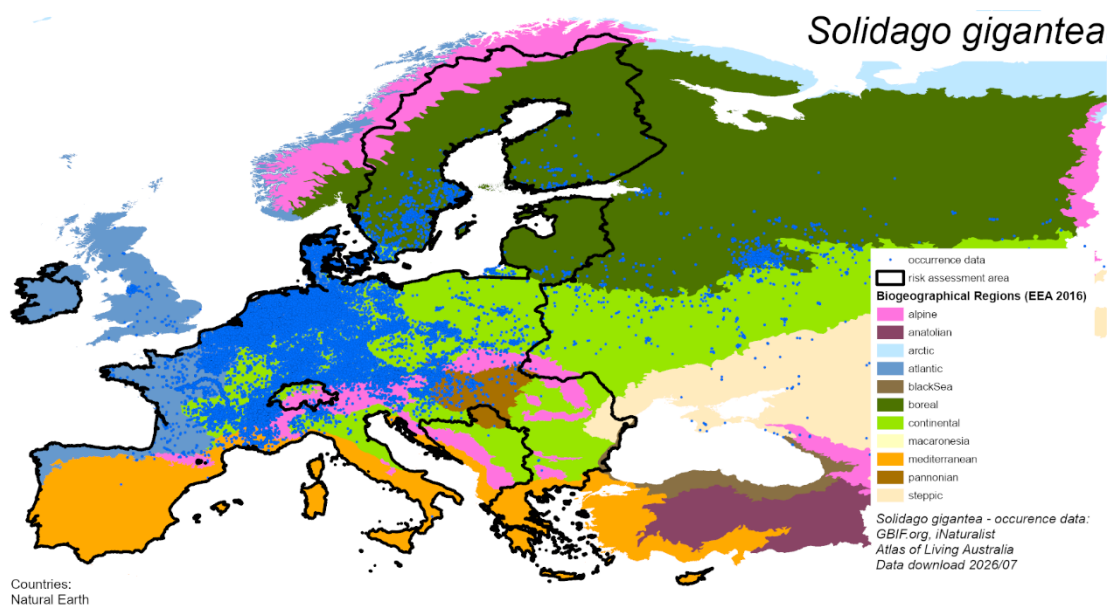


Figure 3 Occurrence records of *Solidago canadensis* and *Solidago gigantea* (GBIF human observations and spatial accuracy < 5.000m): GBIF.org 2026ab; iNaturalist - spatial accuracy < 5.000m: iNaturalist 2026ab; ALA - human observations and spatial accuracy < 5.000m: Atlas of Living Australia 2026ab) and biogeographical regions - map designed by Umweltbundesamt/Environment Agency Austria - 2026/07/30

Table 7 biogeographical regions with recorded/established *Solidago canadensis*^c and *Solidago gigantea*^g occurrences (grey cell indicate where the biogeographical region is not covered by the risk assessment area)

biogeographical region	recorded	established	source of recorded occurrences	source of established occurrences
Alpine	yes ^{CG}	yes	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2024ab) ^{CG} ; iNaturalist (2026ab) ^{CG}
Anatolian				
Arctic				
Atlantic	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}

biogeographical region	recorded	established	source of recorded occurrences	source of established occurrences
Black Sea	no ^{CG}	no ^{CG}	-	-
Boreal	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}
Continental	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}
Macaronesian				
Mediterranean	yes ^{CG}	no ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	-
Pannonian	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}
Steppic	no ^{CG}	no ^{CG}	-	-

A7. In which biogeographic region(s) or marine subregion(s) in the risk assessment area could the species establish in the future under current climate and under foreseeable climate change? The information needs be given separately for current climate and under foreseeable climate change conditions.

A7a. Current climate: List regions

A7b. Future climate: List regions

With regard to EU biogeographic and marine (sub)regions, see above.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5 or SSP 2-4.5)
- what aspects of climate change are most likely to affect the risk assessment (e.g. increase in average winter temperature, increase in drought periods)

The assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP or SSP scenarios shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065); SSP 1-2.6 (estimated warming 1.8°C by 2081-2100), SSP 2-4.5 (estimated warming 2.7°C by 2081-2100) and SSP 5-8.5 (estimated warming 4.4°C by 2081-2100). Otherwise, the choice of the assessed scenario has to be explained.

Response: The ensemble model suggested that suitability for *Solidago canadensis* was most strongly determined by Annual mean temperature (Bio1), accounting for 67.6% of variation explained, followed by Annual precipitation (Bio12) (16.8%) and Human influence index (HII) (15.6%). The ensemble model suggested that suitability for *Solidago gigantea* was most strongly determined by Annual mean temperature (Bio1), accounting for 47.3% of variation explained, followed by Human influence index (HII) (37.8%) and Annual precipitation (Bio12) (14.9%).

Although the models slightly differ per variable between the two *Solidago* species, the ranking of the variables is more or less the same due the large overlapping origin in North America. According to SDM results (see Annex VIII) the biogeographical regions *S. canadensis* and *S. gigantea* (in and outside of the risk assessment area) could establish in under current conditions are as follows:

Response (7a):

Table 8 Biogeographical regions and suitability with confidence under current conditions – ^c *S. canadensis*, ^g *S. gigantea*

Biogeographical region	likeliness	confidence
Alpine	likely ^{CG}	high
Anatolian	likely ^{CG}	medium
Arctic	unlikely ^{CG}	high
Atlantic	likely ^{CG}	high
Black Sea	likely ^{CG}	high
Boreal	likely ^{CG}	high
Continental	likely ^{CG}	high
Macaronesian	unlikely ^{CG}	high
Mediterranean	likely ^{CG}	medium
Pannonian	likely ^{CG}	high
Steppic	likely ^{CG}	medium

Response (7b):

Table 9 Biogeographical regions and suitability with confidence under projected scenario conditions for the 2070s – ^c *S. canadensis*, ^g *S. gigantea* (grey cells indicate where the biogeographical region is not covered by the risk assessment area)

biogeographical region	Scenario SSP1-2.6		Scenario SSP2-4.5		Scenario SSP5-8.5	
	likeliness	confidence	likeliness	confidence	likeliness	confidence
Alpine	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Anatolian	likely ^{CG}	medium	unlikely ^{CG}	medium	unlikely ^{CG}	high
Arctic	unlikely ^{CG}	high	unlikely ^{CG}	high	unlikely ^{CG}	high
Atlantic	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Black Sea	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Boreal	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Continental	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Macaronesian	unlikely ^{CG}	high	unlikely ^{CG}	high	unlikely ^{CG}	high
Mediterranean	unlikely ^{CG}	medium	unlikely ^{CG}	high	unlikely ^{CG}	high
Pannonian	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Steppic	likely ^{CG}	high	likely ^{CG}	medium	unlikely ^{CG}	medium

A8. In which EU Member States has the species been recorded and in which EU Member States has it established? List them with an indication of the timeline of observations. The information needs be given separately for recorded and established occurrences.

A8a. Recorded: List Member States

A8b. Established: List Member States

Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden

The description of the invasion history of the species shall include information on countries invaded and an indication of the timeline of the first observations, establishment and spread.

Response: Figure 4 and Table 10 give an overview of the occurrences of the species in EU Member States. Sources of information are observational data (GBIF 2026ab, iNaturalist 2024ab), European wide overviews like Euro+Med PlantBase as well as national floras and invasive species references. An indication of the first observation is not possible for every Member State, but is given if possible.

Response (8a): Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden (see Table 10 and Figure 4)

Response (8b): Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia, Sweden (see Table 10 and Figure 4)

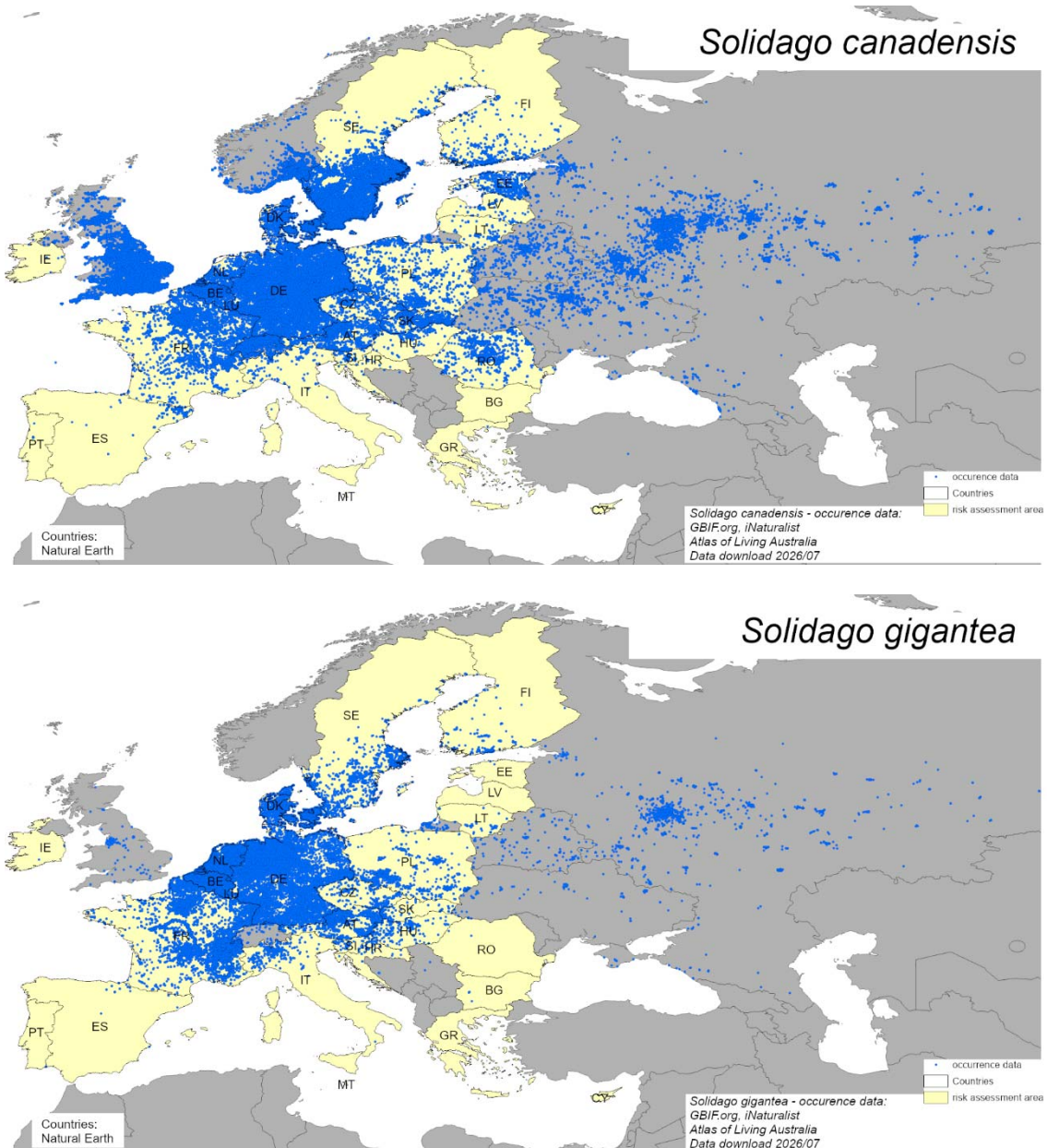


Figure 4 Occurrence data records of *Solidago canadensis* and *Solidago gigantea* (GBIF human observations and spatial accuracy < 5.000m: GBIF.org 2026ab; iNaturalist - spatial accuracy < 5.000m: iNaturalist 2026ab; ALA - human observations and spatial accuracy < 5.000m: Atlas of Living Australia 2026ab) in the EU Member States - map designed by Umweltbundesamt/Environment Agency Austria - 2026/07/30

Table 10 EU Member States with recorded/established *Solidago canadensis*^c and *Solidago gigantea*^g occurrences (* references without coordinates not shown in map)

country	recorded	established	source recorded	source established	timeline of observations
Austria	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG}	First reported 1838 ^C
Belgium	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG} Seebens et al. (2017);	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; Moniteur Belge (2013) ^{CG}	First reported 1863 ^C
Bulgaria	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2024b) ^G ; iNaturalist (2024b) ^G	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG}	-
Croatia	yes ^{CG}	yes ^C	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^C ; Euro+Med PlantBase (2024ab) ^C	-
Cyprus	no ^{CG}	no ^{CG}	-	-	-
Czechia	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG}	First reported 1838 ^C ; 1851 ^G
Denmark	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; Hartvig & Vestergaard 2015	First reported 1848 ^C ; 1854 ^G
Estonia	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med	CABI (2024ab) ^{CG} ; Euro+Med	First reported 1807 ^C ; 1896 ^G

country	recorded	established	source recorded	source established	timeline of observations
			PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^C	PlantBase (2024ab) ^{CG}	
Finland	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG}	First reported 1910 ^C
France (France, Corse)	yes ^C	yes ^C	CABI (2024ab) ^C ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^C ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^C ; De Solan et al (2024) ^{CG} ; Euro+Med PlantBase (2024ab) ^C	
Germany	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; FloraWeb (2026ab) ^{CG} ; Nehring & Rabitsch (2025) ^{CG}	First reported 1853
Greece	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; GBIF (2026ab) ^C ;	CABI (2024ab) ^{CG}	
Hungary	yes ^{CG}	yes ^{CG}	Botta-Dukat & Dancza (2008) ^{CG} ; CABI (2024ab) ^{CG} ;; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	Botta-Dukat & Dancza (2008) ^{CG} ; CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG}	
Ireland	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ;	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG}	
Italy	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF	Banfi & Galasso (2010) ^{CG} ; CABI	-

country	recorded	established	source recorded	source established	timeline of observations
			(2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	(2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG}	
Latvia	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^C ; iNaturalist (2026ab) ^C	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG}	First reported 1907 ^C
Lithuania	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG}	First reported 1977 ^G
Luxembourg	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^G ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^G ; Euro+Med PlantBase (2024ab) ^{CG}	-
Malta	no ^{CG}	no ^{CG}	-	-	-
The Netherlands	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2024b) ^G ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; Nederlands Soortenregister (2025ab)	First reported 1854 ^C , 1912 ^G
Poland	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; Kozłowska-Makulska et al. (2007) ^C ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG}	First reported 1872 ^C , 1853 ^G
Portugal	yes ^{CG}	no ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; GBIF (2026ab) ^C ;	-	-
Romania	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^C ; GBIF	CABI (2024ab) ^{CG} ; Danci& Dragulescu	Southern Transylvania:

country	recorded	established	source recorded	source established	timeline of observations
			(2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	2023 ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; Sirbu et al. (2022); Urziceanu et al. (2020) ^{CG}	1866 ^C , 1941 ^G
Slovakia	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG} ; Urziceanu et al. (2020) ^{CG}	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; Urziceanu et al. (2020) ^{CG} ; Wittlinger et al 2022	First reported 1872 ^C ; 1909 ^G
Slovenia	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^C ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^C ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	CABI (2024ab) ^C ; Jogan et al. (2012) ^{CG} ; Euro+Med PlantBase (2024ab) ^C	-
Spain	yes ^{CG}	no ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG}	-	-
Sweden	yes ^{CG}	yes ^{CG}	CABI (2024ab) ^{CG} ; EPPO (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; GBIF (2026ab) ^{CG} ; iNaturalist (2026ab) ^{CG} ; Kabuce & Priede (2010) ^C	CABI (2024ab) ^{CG} ; Euro+Med PlantBase (2024ab) ^{CG} ; Tyler et al. (2015) ^{CG}	First reported 1864 ^C

A9. In which EU Member States could the species establish in the future under current climate and under foreseeable climate change? The information needs be given separately for current climate and under foreseeable climate change conditions.

A9a. Current climate: List Member States

A9b. Future climate: List Member States

With regard to EU Member States, see above.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5 or SSP 2-4.5)
- what aspects of climate change are most likely to affect the risk assessment (e.g. increase in average winter temperature, increase in drought periods)

The assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP or SSP scenarios shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065); SSP 1-2.6 (estimated warming 1.8°C by 2081-2100), SSP 2-4.5 (estimated warming 2.7°C by 2081-2100) and SSP 5-8.5 (estimated warming 4.4°C by 2081-2100). Otherwise, the choice of the assessed scenario has to be explained.

The ensemble model suggested that suitability for *Solidago canadensis* was most strongly determined by Annual mean temperature (Bio1), accounting for 67.6% of variation explained, followed by Annual precipitation (Bio12) (16.8%) and Human influence index (HII) (15.6%). The ensemble model suggested that suitability for *Solidago gigantea* was most strongly determined by Annual mean temperature (Bio1), accounting for 47.3% of variation explained, followed by Human influence index (HII) (37.8%) and Annual precipitation (Bio12) (14.9%).

Response (9a):

Table 11 Member States and suitability with confidence under current conditions – ^c *S. canadensis*, ^g *S. gigantea*

country	likeliness	confidence
Austria	likely ^{CG}	high
Belgium	likely ^{CG}	high
Bulgaria	likely ^{CG}	high
Croatia	likely ^{CG}	high
Cyprus	unlikely ^{CG}	high
Czechia	likely ^{CG}	high
Denmark	likely ^{CG}	high
Estonia	likely ^{CG}	high
Finland	likely ^{CG}	high
France	likely ^{CG}	high
Germany	likely ^{CG}	high
Greece	likely ^{CG}	high
Hungary	likely ^{CG}	high
Ireland	likely ^{CG}	high
Italy	likely ^{CG}	high
Latvia	likely ^{CG}	high
Lithuania	likely ^{CG}	high

country	likeliness	confidence
Luxembourg	likely ^{CG}	high
Malta	unlikely ^{CG}	high
The Netherlands	likely ^{CG}	high
Poland	likely ^{CG}	high
Portugal	unlikely ^{CG}	high
Romania	likely ^{CG}	high
Slovakia	likely ^{CG}	high
Slovenia	likely ^{CG}	high
Spain	unlikely ^{CG}	medium
Sweden	likely ^{CG}	high

Response (9b):

**Table 12 Member States and suitability with confidence under projected scenario conditions for the 20270s –
^c *S. canadensis*, ^e *S. gigantea***

country	Scenario SSP1-2.6		Scenario SSP2-4.5		Scenario SSP5-8.5	
	likeliness	confidence	likeliness	confidence	likeliness	confidence
Austria	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Belgium	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Bulgaria	unlikely ^{CG}	high	unlikely ^{CG}	high	unlikely ^{CG}	high
Croatia	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Cyprus	unlikely ^{CG}	high	unlikely ^{CG}	high	unlikely ^{CG}	high
Czechia	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Denmark	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Estonia	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Finland	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
France	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Germany	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Greece	likely ^{CG}	medium	unlikely ^{CG}	high	unlikely ^{CG}	medium
Hungary	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Ireland	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Italy	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Latvia	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Lithuania	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Luxembourg	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Malta	unlikely ^{CG}	high	unlikely ^{CG}	high	unlikely ^{CG}	high
The Netherlands	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Poland	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Portugal	unlikely ^{CG}	high	unlikely ^{CG}	high	unlikely ^{CG}	high

Romania	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Slovakia	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Slovenia	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high
Spain	unlikely ^{CG}	high	unlikely ^{CG}	high	unlikely ^{CG}	medium
Sweden	likely ^{CG}	high	likely ^{CG}	high	likely ^{CG}	high

A10. Is the organism known to be invasive (i.e. to threaten or adversely impact upon biodiversity and related ecosystem services) anywhere outside the risk assessment area?

Response: In the introduced range, *Solidago canadensis* occupies the same habitats as in the native range, but also occurs in dry meadows of high conservation value and in the edges of wetlands (CABI 2024a). In Central Europe, *S. gigantea* is widely naturalized and is found in uncut grasslands, wetland edges, riparian habitats, forest edges, and along roadsides (CABI 2024b). Outside the risk assessment area, both assessed species are documented as invasive in e.g. Albania, Andorra, Australia, Bosnia and Herzegovina, Faroe Islands, Liechtenstein, North Macedonia, Norway, Russia, Serbia, Switzerland, Ukraine, United Kingdom (see Table 6; CABI 2024ab).

A11. In which biogeographic region(s) or marine subregion(s) in the risk assessment area has the species shown signs of invasiveness? Indicate the area endangered by the organism as detailed as possible.

Freshwater / terrestrial biogeographic regions:

- Alpine, Atlantic, Black Sea, Boreal, Continental, Mediterranean, Pannonian, Steppic

Marine regions:

- Baltic Sea, North-east Atlantic Ocean, Mediterranean Sea, Black Sea

Marine subregions:

Greater North Sea, incl. the Kattegat and the English Channel, Celtic Seas, Bay of Biscay and the Iberian Coast, Western Mediterranean Sea, Adriatic Sea, Ionian Sea, Central Mediterranean Sea, Aegean-Levantine Sea

Response: Both species show signs of invasiveness in the Alpine, Atlantic, Boreal, Continental, Pannonian biogeographic regions. Further, both species *S. canadensis* and *S. gigantea* exhibit a wide distribution in Europe and mostly with locally high abundance combined with a high environmental impact (Benelli et al. 2019; Perera et al. 2021). Moron et al. (2009) state that both *Solidago* species have been among the most successful invasive species in Europe and *S. gigantea* is considered to be one of the most aggressive plant invaders in Europe (Weber & Jakobs 2004).

A12. In which EU Member States has the species shown signs of invasiveness? Indicate the area endangered by the organism as detailed as possible.

Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden

Response: In the introduced range, *Solidago canadensis* occupies the same habitats as in the native range, but also occurs in dry meadows of high conservation value and in the edges of wetlands (CABI 2024a). In Central Europe, *S. gigantea* is widely naturalized and is found in uncut grasslands, wetland edges, riparian habitats, forest edges, and along roadsides (CABI 2024b). Both species show signs of invasiveness in the following EU Member States Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Sweden (Banfi & Galasso 2010; CABI 2024b; De Solan et al. 2024; Follak et al. 2018; Jogan et al. 2012; Kutlvašr et al. 2024; Moniteur Belge 2013; Nunes et al. 2024; Sirbu et al. 2022; Tokarska-Guzik et al. 2012, Tokarska-Guzik et al. 2021; Tyler et al. 2015; Urziceanu et al. 2020; Weber 2017; Wittlinger et al. 2022; Nehring & Rabitsch 2025).

A13. Describe any known socio-economic benefits of the organism.

including the following elements:

- Description of known uses for the species, including a list and description of known uses in the risk assessment area and third countries, if relevant.
- Description of social and economic benefits deriving from those uses, including a description of the environmental, social and economic relevance of each of those uses and an indication of associated beneficiaries, quantitatively and/or qualitatively depending on what information is available.

If the information available is not sufficient to provide a description of those benefits for the entire risk assessment area, qualitative data or different case studies from across the risk assessment area or third countries shall be used, if available.

Response: Both species were introduced to Europe in the 17th (*Senecio canadensis*) and 18th (*S. gigantea*) century for ornamental purposes and later on also as pasture for bees ('honey plant') (Nunes et al. 2024). Pollen and nectar may be utilised by honeybees as well as other insects like wild bees, butterflies and hoverflies.

S. canadensis is a medicinal plant (Šutovská et al. 2013), with extracts made from the dry shoots harvested at the beginning of flowering and it has been used in European phytotherapy as a urological and antiphlogistic remedy. An ethyl acetate extract from the roots of *S. canadensis* inhibited the growth of human gastric adenocarcinoma MK-1 cells in vitro and the compound, cis-dehydromatricaria ester (cis-DME) was isolated as the active component. Inhibition was stronger towards three types of tumour cells than towards normal cells. This compound is also known to inhibit the growth of rice seedlings. (CABI 2024a). *S. canadensis* has also been shown to have 'green

synthesis' capabilities, with noble metal nanoparticles and biologically active compounds found in their tissues. The plant itself can also be used for the production of natural dyes, cellulose, biopesticides, and as a pharmaceutical source (Poljuha et al. 2024).

S. gigantea-dominated areas are suitable for honey production (Stefanic et al., 2003). The species is also used as a medicinal plant (CABI 2024b).

SECTION B – Detailed assessment

Important instructions:

- In the case of lack of information the assessors are requested to use a standardized answer: “No information has been found.” In this case, no score and confidence should be given and the standardized “score” is N/A (not applicable).
- With regard to the scoring of the likelihood of events or the magnitude of impacts see Annexes I and II.
- With regard to the confidence levels, see Annex III.
- Highlight the selected response score and confidence level in **bold** but keep the other scores in normal text (so that the selected score is evident in the final document).

1 PROBABILITY OF INTRODUCTION AND ENTRY

Important instructions:

- **Introduction** is the movement of the species into the risk assessment area (it may be either in captive conditions and/or in the environment, depending on the relevant pathways).
- **Entry** is the release/escape/arrival in the environment, i.e. occurrence in the wild
- Introduction and entry may coincide for species entering through pathways such as “corridor” or “unaided”, but it also may differ. If different, please consider all relevant pathways, both for the introduction into the risk assessment area and the entry in the environment.
- For each described pathway, in each of the questions below, ensure that there are separate comments explicitly addressing both the “introduction” and “entry” where applicable and as appropriate. The classification of pathways developed by the Convention of Biological Diversity (CBD) should be used (see Annex IV). For detailed explanations of the CBD pathway classification scheme consult the IUCN/CEH guidance document³ and the provided key to pathways⁴.
- For organisms which are already present (recorded or established) in the risk assessment area, the likelihood of introduction and entry should be scored as “very likely” by default.
- Repeated (independent) introductions and entries at separate locations in the risk assessment area should be considered here (see Qu. 1.7).

Qu. 1.1. List relevant pathways through which the organism could be introduced into the risk assessment area and/or enter into the environment. Where possible give details about the specific origins and end points of the pathways as well as a description of any associated commodities.

³ <https://op.europa.eu/en/publication-detail/-/publication/f8627bbc-1f15-11eb-b57e-01aa75ed71a1>

⁴ <https://circabc.europa.eu/sd/a/0aeba7f1-c8c2-45a1-9ba3-bcb91a9f039d/TSSR-2016-010%20CBD%20pathways%20key%20full%20only.pdf>

For each pathway answer questions 1.2 to 1.8 (copy and paste additional rows at the end of this section as necessary). Please attribute unique identifiers to each question if you consider more than one pathway, e.g. 1.2a, 1.3a, etc. and then 1.2b, 1.3b etc. for the next pathway.

In this context a pathway is the route or mechanism of introduction and/or entry of the species.

The description of commodities with which the introduction of the species is generally associated shall include a list and description of commodities with an indication of associated risks (e.g. the volume of trade; the likelihood of a commodity being contaminated or acting as vector).

If there are no active pathways or potential future pathways this should be stated explicitly here, and there is no need to answer the questions 1.2-1.9.

Nunes et al. (2024) states that *Solidago canadensis* (since 17th century) and *S. gigantea* (since 18th century) are introduced to Europe for ornamental purposes and as pasture for bees ('honey plant'). The use of 'honey plants' indicates that the floral resources is used as food source for honeybees; other insects like wild bees, butterflies and hoverflies may use the resources as well.

From this, the following introduction paths can be derived:

- (1): Release in nature for use (other than above, e.g. fur, transport, medical use) (release in Nature)
- (2): Horticulture (escape from confinement)
- (3): Ornamental purpose other than horticulture (escape from confinement)
- (4): Transport of habitat material (soil, vegetation) (transport – contaminant)

PATHWAY: Release in nature for use (other than above, e.g. fur, transport, medical use) (release in Nature)

Species released into the natural environment to be used by humans for purposes other than hunting, fishing, environmental control/barriers, or conservation and not introduced for aesthetic reasons only. Throughout history, plant and animal species that have been a source of food or fulfil an agricultural purpose have been taken from their natural ranges and introduced into new regions to enhance food production for the local human population.

Qu. 1.2a. Is introduction and/or entry along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)?

RESPONSE	intentional unintentional	CONFIDENCE	low medium high
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Response: *Solidago canadensis* and *S. gigantea* are cultivated and used as forage plants for bees (CABI 2024ab; Fenesi et al. 2015; Nehring et al. 2013b; Nunes et al. 2024; Stefanic et al. 2003) and as such are introduced intentionally.

Qu. 1.3a. How likely is it that large numbers of the organism will be introduced and/or enter into the environment through this pathway from the point(s) of origin over the course of one year?

including the following elements:

- discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction and/or entry based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in subsequent establishment whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Both assessed species are perennial clonal herbaceous plants with small, wind-dispersed seeds. *Solidago* spp. also spread clonally, forming monodominant stands. As such, *Solidago* cultivations serving as pastures for bees cover a kind of a monoculture with a very high number of individuals. Thus, the propagule pressure is high.

Qu. 1.4a. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: As the cultivations serve as forage plants for bees, it is very likely that the organism survives and reproduce along this pathway.

Qu. 1.5a. How likely is the organism to survive existing management practices before and during transport and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: As the cultivations have the purpose of pastures for bees, it is very likely that organism survives management practices. Cultivations of bee pastures include soil management following the establishment. In that way it may lead to dispersal of root fragments and thereby to further dispersal of the species within the risk assessment area later on.

Qu. 1.6a. How likely is the organism to be introduced into the risk assessment area or entry into the environment undetected?

Please note that “detection” here is considered as any system or event that may actively contribute to record the presence of a species in a way that appropriate management measures could be potentially undertaken by relevant authorities.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: As the pathway is intended, it is unlikely that the organism being introduced into the risk assessment area via this pathway would be undetected. On the other hand, an undetected dispersal of seeds by wind outside of cultivation into the environment may be likely.

Qu. 1.7a. How isolated or widespread are possible points of introduction and/or entry into the environment in the risk assessment area?

RESPONSE	isolated widespread ubiquitous	CONFIDENCE	low medium high
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Response: The *Solidago* cultivations as forage plants for bees are designed as additional and/or supporting food sources, the points of introduction may be isolated, though no information about the

spatial density of such bee pastures is available; references are available only on a local or regional level (e.g. Arany et al. 2017; Meinhardt et al. 2017; Meinhardt et al. 2024; Stefanic et al. 2003).

Qu. 1.8a. Estimate the overall likelihood of introduction into the risk assessment area and/or entry into the environment based on this pathway?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: The introduction (CABI 2024ab; Stefanic et al. 205) and entry (intentional or unintentional release of its propagules) are active and there is evidence that the species is being moved along this pathway. Based on this, a score of very likely with high confidence has been given.

PATHWAY: Horticulture (escape from confinement)

Species that have escaped from confined or controlled environments where they were commercially cultivated for purposes other than Agriculture, Forestry, or Aquaculture / mariculture. Horticulture is the science and/or practice of garden cultivation and management particularly for use of plants by humans as food, medicine, aesthetic purposes or for any other use. Species have been introduced outside their native range for the purposes of horticulture from ancient times.

Qu. 1.2b. Is introduction and/or entry along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)?

RESPONSE	intentional unintentional	CONFIDENCE	low medium high
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Response: Horticulture is the intentional introduction of the species into the risk assessment area for commercial cultivation. The pathway includes the movement of plant material via e-commerce. The species is available via the large retail suppliers (e.g. eBay and Amazon) (Lenda et al. 2014). The Horticulture pathway should be applied to plants escaping from commercial culturing facilities (nurseries, greenhouses) (including the deliberate dumping of plant material) or during transport to/from the nursery trade. Therefore, this pathway includes the bulk shipment of live plants for nurseries and gardens centres, and the intentional introduction of seeds for planting. *Solidago canadensis* and *S. gigantea* has been utilized as a garden ornamental species in the risk assessment area since the 17th and 18th centuries respectively (CABI 2024ab; EPPO 2024ab; Weber & Jakobs 2005).

Qu. 1.3b. How likely is it that large numbers of the organism will be introduced and/or enter into the environment through this pathway from the point(s) of origin over the course of one year?

including the following elements:

- discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction and/or entry based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in subsequent establishment whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: The pathway 'Horticulture' is the deliberate movement of the plant into the risk assessment area for use as an ornamental species. However, it should be noted that the frequency and volume of individuals entering the risk assessment area is potentially low as much of the material sold in nurseries and garden centers is likely to be propagated within the risk assessment area. Both *Solidago* species are ornamental species and grown in the risk assessment area. There are a number of suppliers listed throughout EU Member states. The species (seeds in particular) are available for sale via a number of e-commerce sites (e.g. eBay and Amazon). Although much of the stock that is sold within the risk assessment area is propagated in the risk assessment area, historically and to a lesser extent nowadays the species enters the risk assessment area via this pathway. It is moderately likely that the species will enter the natural environment via this pathway. Potentially, if planted in nurseries and garden centers, plant material may escape from confined areas into the natural environment. Additionally, dumping of material (containing seeds and root pieces) into the natural environment may occur, though unlikely with good horticulture industry practice. If eradication measures are taken following dumping, there is the potential that the species can re-establish if it is dumped again or if some small shoot or root material is left behind.

Qu. 1.4b. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely	CONFIDENCE	low medium
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	moderately likely likely very likely		high
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Response: The pathway ‘Horticulture’ is the deliberate movement of plant material into the risk assessment area and as such plant material would be maintained and moved to ensure survival. Both *Solidago* species are utilized as ornamental species and grown in the risk assessment area.

Qu. 1.5b. How likely is the organism to survive existing management practices before and during transport and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Plant material (most likely seeds) is the commodity itself and it is deliberately moved for sale within the risk assessment area. Therefore, management practices before and during transport are not considered in this question. Management practices during storage at the end point (nursery and garden centre) may affect the survival of the species for example cleaning, temperature storage etc. However, the species is very likely to survive.

Qu. 1.6b. How likely is the organism to be introduced into the risk assessment area or entry into the environment undetected?

Please note that “detection” here is considered as any system or event that may actively contribute to record the presence of a species in a way that appropriate management measures could be potentially undertaken by relevant authorities.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: It is moderately likely that the organism will enter the risk assessment area undetected via this pathway as this concerns the intentional movement of plant material into the risk assessment area.

The species could enter the environment undetected as the species may escape from garden centers and nurseries via seed or the dumping of plant material. If the species escapes the nursery, it would be difficult to quickly detect the plant, as only small fragments of the root are enough to form a viable plant.

Qu. 1.7b. How isolated or widespread are possible points of introduction and/or entry into the environment in the risk assessment area?

RESPONSE	isolated widespread ubiquitous	CONFIDENCE	low medium high
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Response: For live plant imports in the risk assessment area (introduction), each EU Member country has official entry points where plant material can be imported into. Therefore, these introduction points are widespread in the risk assessment area. For the introduction of plant material via e-commerce, the entry points are extremely widespread as anyone with an internet connection and a postal address can obtain seeds of the species from outside the risk assessment area. Therefore, introduction points are widespread within the risk assessment area. *Solidago canadensis* and *S. gigantea* can enter the environment from nurseries and garden centers (the end point of this pathway) which are widespread within the risk assessment area. This does not mean the species is widely propagated, but implies these possible points of introduction are widespread.

Qu. 1.8b. Estimate the overall likelihood of introduction into the risk assessment area and/or entry into the environment based on this pathway?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: This pathway is active, and it is moderately likely that the species is being moved along the pathway from outside the risk assessment area into the risk assessment area. However, the species is sold within the risk assessment area and nurseries will propagate the species and it is moderately likely that the species enters the natural environment from these types of facilities.

PATHWAY: Ornamental purpose other than horticulture (escape from confinement)

Species that have escaped from confined or controlled environments where they were introduced for decorative or ornamental reasons excluding commercial horticulture. The trade in species that provide striking structure and colour, or

show traits that make them suitable for landscaping in a variety of forms led to the movement of species around the world to improve or enhance municipal areas or private parks and gardens.

Qu. 1.2c. Is introduction and/or entry along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)?

RESPONSE	intentional	CONFIDENCE	low
	unintentional		medium
			high

Response: This pathway involves the intentional introduction of both *Solidago* species for ornamental purposes, though entry into the natural environment would be unintentional. This pathway includes the movement of all potential plant parts into the risk assessment area. *Solidago canadensis* and *S. gigantea* have been utilized as a garden ornamental species in the risk assessment area since the 17th and 18th centuries respectively (CABI 2024ab; EPPO 2024ab; Lenda et al. 2014; Weber & Jakobs 2005).

Qu. 1.3c. How likely is it that large numbers of the organism will be introduced and/or enter into the environment through this pathway from the point(s) of origin over the course of one year?

including the following elements:

- discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction and/or entry based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in subsequent establishment whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely	CONFIDENCE	low
	unlikely		medium
	moderately likely		high
	likely		
	very likely		

Response: There is no information on frequency or volumes entering the risk assessment area or the environment. Entry into the natural environment in large numbers is very likely as the species will be planted in gardens, sometimes in close proximity to the natural environment. The species establish themselves quickly from wind-dispersed seeds and start flowering in their second year. *Solidago* species also spread clonally, forming monodominant stands (CABI 2024ab; Nunes et al. 2024). Ornamental use

of the species has repeatedly been highlighted as a cause of introduction of the species into countries globally. If eradication measures are taken following planting, there is the potential that the species can re-establish if replanted. The number of potential areas where the species can escape from increases the difficulty of eradication at a large scale.

Qu. 1.4c. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Plant material is the commodity itself and it is deliberately moved for sale within the risk assessment area. Therefore, plant parts or whole plants are likely to survive along the pathway to the end point, where it is planted in a garden. The following section lists the plant parts of concern:

Seed (high concern)

Both species produce a high number of wind-dispersed seeds.

Root material (high concern)

Root material may spread outside the confines of a garden where it is deliberately planted. Additionally, if garden waste is placed on a suitable substrate, it is likely to be able to survive.

Qu. 1.5c. How likely is the organism to survive existing management practices before and during transport and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Management practices before and during transport are very likely to facilitate the survival of the species as it is the commodity itself. Management practices, i.e. removal and waste disposal may increase the propagule pressure of the species in the environment and facilitate the reproduction of the species. Therefore, management practices such as physical removal or cutting above and below ground material may lead to fragmentation of plant material. Other management practices (e.g. chemical control of weeds in gardens), may have an impact on the survival and reproduction of the species.

Qu. 1.6c. How likely is the organism to be introduced into the risk assessment area or entry into the environment undetected?

Please note that “detection” here is considered as any system or event that may actively contribute to record the presence of a species in a way that appropriate management measures could be potentially undertaken by relevant authorities.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: As the pathway is intended for ornamental use in gardens and parks, it is very unlikely that the organism introduction into the risk assessment area is undetected. However, it is likely both *Solidago* species can enter the environment undetected via the dumping of garden waste and the high number of wind-dispersed seeds as the species will be planted in parks and gardens, also in close proximity to natural habitats, where there is the potential for escape (CABI 2024ab).

Qu. 1.7c. How isolated or widespread are possible points of introduction and/or entry into the environment in the risk assessment area?

RESPONSE	isolated widespread ubiquitous	CONFIDENCE	low medium high
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Response: Private gardens associated with households are high. For example, data from 2014 shows that 58% of houses have a garden or outside space in France, 81% in the United Kingdom, 80.3% in Poland and 27% in Spain (Statista 2025). Though, there are no figures available how widely both *Solidago* species are planted.

Qu. 1.8c. Estimate the overall likelihood of introduction into the risk assessment area and/or entry into the environment based on this pathway?

RESPONSE	very unlikely unlikely moderately likely likely	CONFIDENCE	low medium high
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	very likely		
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Response: Through management practices or dumping of plant material and high numbers of wind dispersed seeds, plant material can readily and repeatedly enter into the natural environment. This introduction pathway is active and there is evidence that the species is being moved along the pathway into the risk assessment area (CABI 2024ab; Nunes et al. 2024). Based on this, a score of very likely with medium confidence has been given.

PATHWAY: Transport of habitat material (soil, vegetation) (transport – contaminant)

Species unintentionally introduced as contaminants of habitat material that includes soil, vegetation, wood products such as chips and mulch, straw, etc. when these products are the focus of trade and not simply transported with plants. The transportation of massive quantities of habitat material such as soil, vegetation, wood chips, mulch, straw etc. is a potential source of alien and potentially invasive taxa being introduced as contaminants to new environments.

Qu. 1.2d. Is introduction and/or entry along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)?

RESPONSE	intentional unintentional	CONFIDENCE	low medium high
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Response: Entry via this pathway is unintentional movement of the species via the contamination of habitat material (soil and vegetation) (CABI 2024ab; Nunes et al. 2024; Weber & Jakobs 2005) and as such is introduced unintentionally.

Qu. 1.3d. How likely is it that large numbers of the organism will be introduced and/or enter into the environment through this pathway from the point(s) of origin over the course of one year?

including the following elements:

- discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction and/or entry based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in subsequent establishment whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely	CONFIDENCE	low medium
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	moderately likely likely very likely		high
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Response: There is no information available on the volumes of movement along this pathway. The transport of topsoil, sand or other contaminated habitat material with seed or root material could facilitate entry into the risk assessment area. However, the pathway is mainly closed into the risk assessment area as there are prohibitions of the movement of soil into the EU from many countries outside. Short-distance dispersal is possible by rhizomes through infested soil. Accidental introduction is possible through human activity, such as collecting fruited shoots as an ornament and then disposing of them on rubbish heaps. Seeds and rhizomes may also be dispersed as a result of movement of soil e.g. in the course of building or other infrastructure work (CABI 2024ab; Weber & Jakobs 2005).

Qu. 1.4d. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: It is documented that root fragments are spread in contaminated soil indicating that it is likely both *Solidago* species can survive along this pathway. Root material is likely to survive transport along the pathway, especially as it would be moved with habitat material that is likely to retain moisture; this humid material facilitate resprouting (CABI 2024ab; Weber & Jakobs 2005). Walck et al. (1998) conducted a comparative study of the seed germination of a few *Solidago* species (e.g. *Solidago altissima*, *S. nemoralis*, *S. shortii*, and others). They found that *Solidago* species are able to form a persistent seed bank. For both species, there are no precise, experimentally validated maximum values for germination duration in the soil seed bank, as the lifespan depends heavily on the respective environmental conditions (soil moisture, temperature, soil depth). The seeds are generally classified as short- to medium-term perennials.

Qu. 1.5d. How likely is the organism to survive existing management practices before and during transport and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely likely	CONFIDENCE	low medium high
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	very likely		
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Response: The species are moderately likely to survive existing management practices along this pathway. To prevent secondary spread via movement of infected soil best practices should be adopted, and potentially supported by regulations and certification schemes which restrict the movement of soil from infested areas. In order to reduce the risk of seeds or rhizomes/stem fragments being transported attached to machinery, it is necessary to inspect and clean machinery used within or close to infested areas (IUCN 2019). However, there is no information available for this pathway.

Qu. 1.6d. How likely is the organism to be introduced into the risk assessment area or entry into the environment undetected?

Please note that “detection” here is considered as any system or event that may actively contribute to record the presence of a species in a way that appropriate management measures could be potentially undertaken by relevant authorities.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: The species are known to move as a contaminant of soil (CABI 2024ab; Weber & Jakobs 2005) and plants can regenerate from a small piece of root or rhizome. Root material can be buried in soil and other material, making them difficult to detect. Walck et al. (1998) conducted a comparative study of the seed germination of a few *Solidago* species (e.g. *Solidago altissima*, *S. nemoralis*, *S. shortii*, and others). They found that *Solidago* species are able to form a persistent seed bank. Werner et al. (1980) reported 3.000 up to 13.000 achenes per stem for *S. canadensis*. Therefore, it is likely that the species could be introduced into the risk assessment area undetected.

Qu. 1.7d. How isolated or widespread are possible points of introduction and/or entry into the environment in the risk assessment area?

RESPONSE	isolated widespread ubiquitous	CONFIDENCE	low medium high
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Response: There are no specific data on the points of introduction or entry. Based upon the already widespread distribution of *Solidago canadensis* and *S. gigantea* within the risk assessment area, the response is widespread, though with a low confidence.

Qu. 1.8d. Estimate the overall likelihood of introduction into the risk assessment area and/or entry into the environment based on this pathway?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Root and seed material may be able to move along this pathway, and the commodity is placed within the environment, where the propagules have the opportunity to establish. Confidence level is assessed as low due to rules on soil import into the European Union.

Qu. 1.9. Estimate the overall likelihood of introduction into the risk assessment area or entry into the environment based on all pathways and specify if different in relevant biogeographical regions in current conditions.

Provide a thorough assessment of the risk of introduction in relevant biogeographical regions in current conditions: providing insight in to the risk of introduction into the risk assessment area.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: The overall likelihood of *Solidago canadensis* and *S. gigantea* being introduced into the risk assessment area is very likely with a high confidence especially because the species are already present (recorded and established) in the risk assessment area. As such, the likelihood of introduction and entry should be scored as “very likely” by default. As the highest occurrences of the species in the environment are in the Alpine, Atlantic, Continental, Boreal and Pannonian biogeographical regions, it is these regions that would potentially see a higher likelihood of entry into the environment. The likelihood of introduction into the environment by plant fragments or wind-dispersed seeds is very high, particularly as they are grown in horticulture and planted as ornamentals across the risk assessment area.

The species distribution modelling shows that the Arctic and Macaronesian regions are currently largely unsuitable for the establishment of the species (see SDM in Annex VIII) and therefore the likelihood of the species being traded for horticultural purposes in these regions is low.

Qu. 1.10. Estimate the overall likelihood of introduction into the risk assessment area or entry into the environment based on all pathways in foreseeable climate change conditions?

Thorough assessment of the risk of introduction in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5 or SSP 2-4.5)
- what aspects of climate change are most likely to affect the risk assessment (e.g. increase in average winter temperature, increase in drought periods)

The assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP or SSP scenarios shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065); SSP 1-2.6 (estimated warming 1.8°C by 2081-2100), SSP 2-4.5 (estimated warming 2.7°C by 2081-2100) and SSP 5-8.5 (estimated warming 4.4°C by 2081-2100). Otherwise, the choice of the assessed scenario has to be explained.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Under foreseeable climatic scenarios, *Solidago canadensis* and *S. gigantea* are very likely to be introduced to the risk assessment area and the wider environment within this area based on the described pathways. This score is relevant for those parts of the biogeographical regions where the limiting factors (non temperate climate conditions) are decreasing.

2 PROBABILITY OF ESTABLISHMENT

Important instructions:

- For organisms which are already established in parts of the risk assessment area or have previously been eradicated, the likelihood of establishment should be scored as “very likely” by default.
- Discuss the risk also for those parts of the risk assessment area, where the species is not yet established.

Qu. 2.1. How likely is it that the organism will be able to establish in the risk assessment area based on similarity of climatic and abiotic conditions in its distribution elsewhere in the world?

RESPONSE	very unlikely	CONFIDENCE	low
	unlikely		medium
	moderately likely		high
	likely		
	very likely		

Response: *Solidago canadensis* and *S. gigantea* are already established in the natural environment in the risk assessment area (see Qu. A8b). It is likely that the species can establish in other countries within the risk assessment area where habitats and climate are suitable to establishment (see Qu. A9). The SDM (Annex VIII) shows the potential distribution of the species based on the current occurrences of the species both in the risk assessment area and elsewhere in the world. The potential for establishment under current conditions is highest in regions with temperate climate conditions.

Qu. 2.2. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in the risk assessment area? Consider if the organism specifically requires another species to complete its life cycle.

RESPONSE	very isolated	CONFIDENCE	low
	isolated		medium
	moderately widespread		high
	widespread		
	ubiquitous		

Response: The habitats of *Solidago canadensis* in its native range are old fields, pastures, disturbed grounds, roadsides, open woods, forest edges and roadsides, abandoned fields and other unmanaged areas which are colonised rapidly after abandonment in an elevation from 0 up to 1000 m a.s.l. (CABI 2024a; Flora of North America 2024a).

The habitats of *S. gigantea* in its native range are usually at least seasonally moister soils, flood plains, ditches, depressions, open woods, and thickets, moist depressions in grasslands and parklands, forest edges and roadsides, secondary old-fields and unmanaged areas where it colonized after establishment in a short time in an elevation from 0 up to 1500 m a.s.l. (CABI 2024b; Flora of North America 2024b).

In the introduced range, *S. canadensis* occupies the same habitats as in the native range, but also occurs in dry meadows of high conservation value and in the edges of wetlands (CABI 2024a). In Central Europe, *S. gigantea* is widely naturalized and is found in uncut grasslands, wetland edges, riparian habitats, forest edges, and along roadsides (CABI 2024b).

In summary, habitats necessary for the survival, development and multiplication of the organism are assessed to be widespread in the risk assessment area with a high confidence level.

Neither *Solidago* species require another organism to complete their life cycle.

Qu. 2.3. How likely is it that establishment will occur despite competition from existing species in the risk assessment area?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Competition with native vegetation is unlikely to limit the establishment of *Solidago canadensis* and *S. gigantea* in the risk assessment area. In areas outside and inside of the risk assessment area (see Qu. A5, A10, A11 and A12), where both *Solidago* species are present and invasive, it has been shown to successfully compete with native vegetation (CABI 2024ab) based upon the high propagule pressure of wind-dispersed seeds. The species establish themselves quickly from wind-dispersed seeds and start flowering in their second year. *Solidago* spp. also spread clonally, forming monodominant stands (Nunes et al. 2024).

Qu. 2.4. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area?

RESPONSE		very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: It is very likely that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area. Specialised North-American herbivores and pathogens for these species are absent from Europe (CABI 2024ab; Poljuha et al. 2024; Weber 2000). Some generalist insects consume *Solidago canadensis*, but their effects are not significant. This is perhaps one of the keys to the invasiveness of species of *Solidago*.

The phytophagous insect fauna on European *S. canadensis* was examined in Switzerland during 1992-93 and 18 of the 55 phytophagous insects were found to feed solely on *S. canadensis*; the specificity of the remaining 37 was not determined. These insects that have expanded their host range to feed on *S. canadensis* since its introduction to Switzerland are almost solely opportunistic, unspecialised ectophages not closely attuned to the growth cycle of *S. canadensis*. Only 4% of the insects were specialists and 9% were endophagous. In contrast, in North America, *S. canadensis* supports 25% specialist insects and 17% endophages (CABI 2024a).

A large diversity of insect herbivores attack *S. gigantea* in its native range. *S. gigantea* has a rich herbivore fauna in its native range but experiences very little herbivory in its introduced range. Jakobs et al. (2004) found that a majority of surveyed *S. gigantea* populations in North America had herbivore damage, compared to virtually no signs of herbivory in European populations. Plants in Europe were also larger and grew at greater density than plants in North America, suggesting that reduced herbivory may contribute to the invasiveness of *S. gigantea* in Europe (CABI 2024b).

Qu. 2.5. How likely is the organism to establish despite existing management practices in the risk assessment area? Explain if existing management practices could facilitate establishment.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: The establishment of both *Solidago* species is suited to a number of different habitat types, including disturbed habitats. The fact that the most suitable habitats are abandoned lands, it is unlikely that management practices exist to a large extent. Management of anthropogenically disturbed habitats is likely to increase disturbance of the habitat, which can act to break the roots of the plant and resprouting of these parts can occur if they have contact with the ground (Nunes et al. 2024).

Qu. 2.6. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the risk assessment area?

RESPONSE	very unlikely unlikely	CONFIDENCE	low medium
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	moderately likely likely very likely		high
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Response: The species thrives under irregular management practices, such as mowing followed by several years of no intervention. The species establish themselves quickly from wind-dispersed seeds and start flowering in their second year. *Solidago* spp. also spread clonally, forming monodominant stands. Incomplete eradication procedures stimulate regeneration, fragments the rhizomes, disturbs the soil and allows its re-colonisation by seeds (CABI 2024ab; Nunes et al. 2024). Therefore, unless eradication campaigns are thorough and remove all reproductive material, it is likely that the species can survive eradication campaigns.

Qu. 2.7. How likely are the biological characteristics of the organism to facilitate its establishment in the risk assessment area? including the following elements: • a list and description of the reproduction mechanisms of the species in relation to the environmental conditions in the risk assessment area • an indication of the propagule pressure of the species (e.g. number of gametes, seeds, eggs or propagules, number of reproductive cycles per year) of each of those reproduction mechanisms in relation to the environmental conditions in the risk assessment area. • If relevant, comment on the likelihood of establishment based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in establishment whereas for others high propagule pressure (many thousands of individuals) may not. • If relevant, comment on the adaptability of the organism to facilitate its establishment and if low genetic diversity in the founder population would have an influence on establishment.			
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RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: In the risk assessment area, *Solidago canadensis* and *S. gigantea* exhibit vegetative and sexual reproduction. Both species are perennial clonal herbaceous plants with small, wind-dispersed seeds (CABI 2024ab; Nunes 2024). The high propagule pressure (seeds) facilitates the colonization of new (disturbed) habitats. Small root/rhizome fragments can form viable plants and are spread clonally, forming monodominant stands.

S. canadensis is a rhizomatous hemicryptophyte and has a complex lifecycle with rhizome and seed propagation. Although seeds are essential for long-distance dispersal and the colonisation of unoccupied sites, they are not important for the expansion in established populations. Seeds of European plants do not show dormancy and do not need scarification or stratification for germination.

For establishment of *S. canadensis*, seed propagation is essential after which vegetative propagation becomes important. The wide native geographic range of *S. canadensis* in North America and introduced range in Europe suggests a broad climatic tolerance, combined with a tolerance of a fairly wide range of soil fertility and texture conditions (CABI 2024a).

S. gigantea is a rhizomatous hemicryptophyte and has a complex life cycle with rhizome and seed propagation. Seeds of European plants do not show dormancy and do not need scarification or stratification. Although seeds are essential for long-distance dispersal and the colonization of unoccupied sites, they are not important for the spatial extension of established populations. It establishes well in disturbed sites and becomes dominant due to extensive vegetative spread (CABI 2024b; Weber & Jakobs 2004).

Qu. 2.8. If the organism does not establish, then how likely is it that casual populations will continue to occur?

Consider, for example, a species which cannot reproduce in the risk assessment area, because of unsuitable climatic conditions or host plants, but is present because of recurring introduction, entry and release events. This may also apply for long-living organisms.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: In areas, where *Solidago canadensis* and *S. gigantea* are not established, casual populations may occur in disturbed habitats. Casual populations are likely to occur in areas outside the climatic conditions suitable for the establishment of the species.

Qu. 2.9. Estimate the overall likelihood of establishment in the risk assessment area under current climatic conditions. In addition, details of the likelihood of establishment in relevant biogeographical regions under current climatic conditions should be provided.

Thorough assessment of the risk of establishment in relevant biogeographical regions in current conditions: providing insight in the risk of establishment in (new areas in) the risk assessment area.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: The overall likelihood of *Solidago canadensis* and *S. gigantea* establishing in the risk assessment area is very likely with high confidence. Both species are already established in the Alpine, Atlantic, Boreal, Continental and Pannonian biogeographical regions. The mentioned biogeographical regions have a high proportion of area suitable for the establishment of the species and thus further establishment is likely in these areas under the current climatic conditions.

Qu. 2.10. Estimate the overall likelihood of establishment in the risk assessment area under foreseeable climate change conditions. In addition, details of the likelihood of establishment in relevant biogeographical regions under foreseeable climate change conditions should be provided.

Thorough assessment of the risk of establishment in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5 or SSP 2-4.5)
- what aspects of climate change are most likely to affect the risk assessment (e.g. increase in average winter temperature, increase in drought periods)

The assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP or SSP scenarios shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065); SSP 1-2.6 (estimated warming 1.8°C by 2081-2100), SSP 2-4.5 (estimated warming 2.7°C by 2081-2100) and SSP 5-8.5 (estimated warming 4.4°C by 2081-2100). Otherwise, the choice of the assessed scenario has to be explained.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: The overall likelihood of establishing in the risk assessment area under future climatic conditions (2070 RCP. 2.6 and 2070 RCP. 4.5) is very likely with high confidence. The species are already established in the Alpine, Atlantic, Boreal, Continental and Pannonian biogeographical regions. These areas will see a higher suitability of establishment under climate change (e.g. in higher altitude with more suitable climate conditions).

3 PROBABILITY OF SPREAD

Important instructions:

- Spread is defined as the expansion of the geographical distribution of an alien species within the risk assessment area.
- Repeated releases at separate locations do not represent continuous spread and should be considered in the probability of introduction and entry section (Qu. 1.7).

Qu. 3.1. How important is the expected spread of this organism within the risk assessment area by natural means? (List and comment on each of the mechanisms for natural spread.)
including the following elements:

- a list and description of the natural spread mechanisms of the species in relation to the environmental conditions in the risk assessment area.
- an indication of the rate of spread discussed in relation to the species biology and the environmental conditions in the risk assessment area.

The description of spread patterns here refers to the CBD pathway category “Unaided (Natural Spread)”. It should include elements of the species life history and behavioural traits able to explain its ability to spread, including: reproduction or growth strategy, dispersal capacity, longevity, dietary requirements, environmental and climatic requirements, specialist or generalist characteristics.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: *Solidago canadensis* and *S. gigantea* exhibit vegetative and sexual reproduction in the risk assessment area. Both species are perennial clonal herbaceous plants with small, wind-dispersed seeds (CABI 2024ab; Nunes 2024). The high propagule pressure (seeds) facilitates the colonization of new (disturbed) habitats. Small root/rhizome fragments can form viable plants and are spreading clonally, forming monodominant stands. They establish well in disturbed sites and become dominant due to extensive vegetative spread (CABI 2024ab; Weber & Jakobs 2004). Competition with native vegetation is unlikely to limit the establishment of *Solidago canadensis* and *S. gigantea* in the risk assessment area.

S. canadensis was introduced into Europe as an ornamental in 1645. The first observations of wild populations in Europe date back to about 1850. Cumulative numbers of localities as well as numbers of occupied grid squares showed a continuous increase since 1850, within Europe (Weber 1998). The spread of the species in area and time over Europe showed no clear front, with new localities separated by large distances colonised simultaneously (CABI 2024a), maybe caused by simultaneous introductions to many different European countries.

S. gigantea was introduced into Europe as an ornamental plant in the mid-1700s, and the first observations of wild populations date back to the mid-1800s. Cumulative numbers of localities as well

as numbers of occupied grid squares showed a continuous increase since 1850 for this species. The spread of the species in area and time over Europe showed no clear front, and new localities at large distances were colonized simultaneously (CABI 2024b), maybe caused by simultaneous introduction to many different European countries. A large part of the present range of *S. gigantea* was already occupied by 1950 (Weber 1998). *S. gigantea* may still be expanding its range in Europe (Weber 2001).

Perera et al. (2021) show for a region in Poland that distribution and spread of *S. canadensis* is positively correlated with human population density, which may be an indicator of disturbance intensity. Increasing urbanization, road and railway construction, and the abandonment of fields may have enhanced the spread of *S. gigantea* (Weber & Jakobs 2005).

While information in the risk assessment area is limited, some data are available from China, which may be used for assessing the risk of spread in the risk assessment area. Alien species can establish and spread rapidly in new environments to penetrate, alter, and replace native plant communities by outcompeting native taxa, thus reducing local biodiversity. Long-distance dispersal is a key mechanism by which many plants spread across landscapes to reach favorable habitats and enter new communities, which makes it possible for species to invade new sites successfully. Zhang et al. 2022 show some rate of *S. canadensis* spread examples for China. Based on the official record, *S. canadensis* was introduced to Shanghai as an ornamental plant in 1935. It has escaped from parks and gardens since the 1980s; it has rapidly spread to Southeast China, including Zhejiang, Jiangsu, Jiangxi, Anhui, Hubei, Taiwan, Sichuan, Hunan, Guangdong, Yunnan, Henan, and Liaoning Provinces. It is generally recognized that seed dispersal represents a critical stage in the life cycle of flowering plants, reducing the adverse effects of high seedling density around the parent plant and promoting colonization of new habitats. Parent plants disperse their offspring to a variety of microenvironments to maximize the chance that some will survive. For *S. canadensis*, it can produce a huge number of wind-disseminated seeds (diaspores), which will disperse away when mature. Werner et al. (1980) reported 3,000 up to 13,000 achenes per stem for *S. canadensis*. Wind dispersed *S. canadensis* seeds can move in all directions around the parent plants into different environments nearby or a long distance away. However, environmental factors influence the distance and direction of seed dispersal, but not all factors within a seed shadow are equally important. Wind had a modest effect on *S. canadensis* diaspore dispersal in that the number of diaspores dispersing outside the source plants gradually decreased with distance, leading to most diaspores being deposited within 50 m of the source. However, most of the total deposited diaspores and increased dispersal distance occurred in the prevailing wind direction. Although the number of *S. canadensis* diaspores dispersing far away from the source was relatively low, a small number of diaspores were directly shown to reach the maximum measured distance of 2000 m on the downwind side of the source patch and 500 m on the upwind side in this study. Distance and direction of seed dispersal affect a seed's fate. These events taking a small proportion of *S. canadensis* diaspores far away from their parent plants qualify as long-distance dispersal, which can have impacts at larger (regional) scales, directly affecting spatial spread and colonization rates, giving opportunities for these diaspores to reach remote, but suitable habitats. It was confirmed in that study that, after the diaspores' arrival at a new appropriate site, e.g., the abandoned field, seedlings would recruit from these deposited diaspores the following year, though with a germination proportion lower than one thousand dispersed diaspores. Once the adult plants establish, the subsequent colonization of the new site can begin. In this study, they observed that, in an already existent patch of *S. canadensis*, the rapid range expansion of the patch depends mainly on the asexual reproduction (propagules recruited from rhizomes) as *S. canadensis* can produce aggressive rhizomes. Patches can expand 2–4 m per year by plants recruited from rhizomes at a high density,

while the farther, scattered plants were all recruited from dispersed seeds. These results provide evidence that the two reproductive patterns of *S. canadensis* (both sexual reproduction by seeds and asexual reproduction by rhizomes) play different roles in the establishment, colonization, and spread of the invasion process (Zhang et al. 2022).

Lososová et al. (2024) compiled seed dispersal distance classes and dispersal modes for European native and non-native plant species. Based upon the species' anemochory with a seed mass of ~0,1 mg, *S. canadensis* and *S. gigantea* are classified in the dispersal distance class 5 with dispersal distances (m) for 50 and 99% seeds of 10–500m. Regarding anthropochory, both species are assessed in dispersal distance class 7 of 500–5.000 m.

Qu. 3.2a. List and describe relevant pathways of spread other than "unaided". For each pathway answer questions 3.3 to 3.9 (copy and paste additional rows at the end of this section as necessary). Please attribute unique identifiers to each question if you consider more than one pathway, e.g. 3.3a, 3.4a, etc. and then 3.3b, 3.4b etc. for the next pathway.

including the following elements:

- a list and description of pathways of spread with an indication of their importance and associated risks (e.g. the likelihood of spread in the risk assessment area, based on these pathways; likelihood of survival, or reproduction, or increase during transport and storage; ability and likelihood of transfer from the pathway to a suitable habitat or host) in relation to the environmental conditions in the risk assessment area.
- an indication of the rate of spread for each pathway discussed in relation to the species biology and the environmental conditions in the risk assessment area.
- All relevant pathways of spread (except "Unaided (Natural Spread)", which is assessed in Qu. 3.1) should be considered. The classification of pathways developed by the Convention of Biological Diversity shall be used (see Annex IV).

Poljuha et al. (2024) state for *Solidago canadensis* that its dispersal happens in several ways: naturally by seeds and rhizomes, accidentally through human activities, and intentionally for its ornamental value. Similar dispersal can be detailed for *S. gigantea* (CABI 2024ab; Nunes et al. 2024).

Spread pathways are detailed in order of importance:

Ornamental purposes other than horticulture (escape from confinement)

This spread pathway is the intentional spread of the species from private gardening and urban and semi-urban plantings (roadsides and roundabouts for example). This pathway also includes the dumping of plant material into the natural environment.

Release in nature for use (other than above, e.g. fur, transport, medical use) (release in nature)

This spread pathway deals with the intentional cultivation of both *Solidago* species as pasture for bees ('honey plants').

Transportation of habitat material (soil, vegetation) (transport - contaminant)

This spread pathway deals with the potential spread of contaminated habitat material.

Machinery/equipment (transport – stowaway)

This spread pathway details the potential spread of contaminated machinery and equipment. This may include machinery used for roadside management, forest management and associated equipment.

There are no known rates of spread associated with any of the spread pathways.

PATHWAY: Ornamental purposes other than horticulture (escape from confinement)

Qu. 3.3a. Is spread along this pathway intentional (e.g. the organism is deliberately transported from one place to another) or unintentional (e.g. the organism is a contaminant of translocated goods within the risk assessment area)?

RESPONSE	intentional unintentional	CONFIDENCE	low medium high
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Response: *Solidago canadensis* and *S. gigantea* are present in the risk assessment area as ornamental species. Additionally, the species may be planted in urban and semi-urban habitats. From gardens, the plant can spread naturally by seeds to the natural environment and via human assisted spread via dumping of plant material (CABI 2024ab; Nunes et al. 2024).

Qu. 3.4a. How likely is it that a number of individuals sufficient to originate a viable population will spread along this pathway from the point(s) of origin over the course of one year?

including the following elements:

- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if appropriate, indicate the rate of spread along this pathway
- if appropriate, include an explanation of the relevance of the number of individuals for spread with regard to the biology of species (e.g. some species may not necessarily rely on large numbers of individuals).

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: There is no quantitative information on the number of sales of these species in the risk assessment area or the numbers of sites where the species has been planted within the risk assessment area. Sales of the *Solidago* species within the risk assessment area will be mostly seeds.

Seeds can be purchased from garden centers or via online (garden) shops within the risk assessment area and are moved to private households where they are planted in the garden (CABI 2024ab; Lenda et al. 2014).

The species may also be dumped from waste garden material into the natural environment, though again, there are no details and the volume of movement or frequency. It is likely that a number of individuals sufficient to originate a viable population is spread via this pathway, though, due to missing sales figures, with a low confidence.

Qu. 3.5a. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: It is very likely that plant material of both *Solidago* species will survive during transport and storage along this pathway as seeds will be moved along the pathway and packaged to promote their survival. Plants can regenerate from a small piece of root or rhizome. Dumped plant material is likely to survive as long as the material makes contact with a substrate that will promote growth.

Qu. 3.6a. How likely is the organism to survive existing management practices during spread?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: *Solidago canadensis* and *S. gigantea* are likely to survive existing management practices during spread, as this is an intentional pathway. Management of urban and semi-urban habitats is likely to increase disturbance of the habitat, which can act to break the roots/rhizome of the plant and resprouting of these parts can occur if they have contact with the ground. If dumped, the species is likely to be deposited in ruderal habitats and potentially on waste ground where management practices may be minimal and the native vegetation sparse, this may make the survival of the species in these areas more likely.

Qu. 3.7a. How likely is the organism to spread in the risk assessment area undetected?

Please note that “detection” here is considered as any system or event that may actively contribute to record the presence of a species in a way that appropriate management measures could be potentially undertaken by relevant authorities.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Small root/rhizome fragments can produce a viable plant. These fragments and/or seeds may be spread via dumping of garden waste and therefore may be spread in the risk assessment area undetected (Weber 2011).

Qu. 3.8a. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host during spread?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Transfer of the species from a garden or a household into a suitable habitat is likely. Both *Solidago* species have been shown to occur in ruderal habitats and natural habitats. The presence of the species in urban and semi-urban habitats in the risk assessment area, including waste/abandoned lands highlights the species can transfer to a suitable habitat, especially via a high number of wind-dispersed seeds. Dumping of plant material can increase the likelihood of transfer to a suitable habitat as material would be directly transferred.

Qu. 3.9a. Estimate the overall potential rate of spread based on this pathway in relation to the environmental conditions in the risk assessment area. (please provide quantitative data where possible).

RESPONSE	very slowly slowly moderately	CONFIDENCE	low medium high
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	rapidly very rapidly		
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Response: *Solidago canadensis* and *S. gigantea* are household/garden ornamental species which are sold as seeds in the risk assessment area. Via this pathway the species could be spread throughout the risk assessment area, and it is likely that the species would survive as the plant is the commodity. There is no quantitative analysis on the spread of the species in the risk assessment area. Expert opinion, (authors of the risk assessment) suggests that the rate the spread of this species will be classified rapidly, but a low confidence is given.

PATHWAY: Release in nature for use (other than above, e.g. fur, transport, medical use)

Qu. 3.3b. Is spread along this pathway intentional (e.g. the organism is deliberately transported from one place to another) or unintentional (e.g. the organism is a contaminant of translocated goods within the risk assessment area)?

RESPONSE	intentional unintentional	CONFIDENCE	low medium high
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Response: *Solidago canadensis* and *S. gigantea* are used as bee forage plants and cultivated as pastures for bees (CABI 2024ab; Fenesi et al. 2015; Nehring et al. 2013b; Nunes et al. 2024; Stefanic et al. 2003).

Qu. 3.4b. How likely is it that a number of individuals sufficient to originate a viable population will spread along this pathway from the point(s) of origin over the course of one year?

including the following elements:

- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if appropriate, indicate the rate of spread along this pathway
- if appropriate, include an explanation of the relevance of the number of individuals for spread with regard to the biology of species (e.g. some species may not necessarily rely on large numbers of individuals).

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: *Solidago* cultivations serving as pastures for bee forage cover are a monoculture with a very high number of individuals. Both assessed species are perennial clonal herbaceous plants with small, wind-dispersed seeds. *Solidago* spp. also spread clonally, forming monodominant stands. Thus, the propagule pressure is high. There is no quantitative analysis on the spread rate available. It is very likely that a number of individuals sufficient to originate a viable population is spread via this pathway, due to a lack of quantitative figures, the confidence level is low.

Qu. 3.5b. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE		CONFIDENCE	
	very unlikely		low
	unlikely		medium
	moderately likely		high
	likely		
	very likely		

Response: As the cultivations serve as pastures for bees, it is very likely that the organism survives and reproduce along this pathway.

Qu. 3.6b. How likely is the organism to survive existing management practices during spread?

RESPONSE		CONFIDENCE	
	very unlikely		low
	unlikely		medium
	moderately likely		high
	likely		
	very likely		

Response: As the cultivations have the purpose of pastures for bees, it is very likely that organism survives management practices, which would be aimed at conserving the “crop”.

Qu. 3.7b. How likely is the organism to spread in the risk assessment area undetected?

Please note that “detection” here is considered as any system or event that may actively contribute to record the presence of a species in a way that appropriate management measures could be potentially undertaken by relevant authorities.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: As the pathway is intended, it is unlikely that the organism introduction into the risk assessment area via this pathway is undetected. On the other hand, an undetected dispersal of seeds by wind or dumped rhizome parts out of cultivation into the environment and suitable habitats may be possible.

Qu. 3.8b. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host during spread?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Both *Solidago* species have been shown to occur in ruderal habitats and natural habitats. The presence of the species in such habitats in the risk assessment area, including waste/abandoned lands, highlights the species can transfer to a suitable habitat, especially via a high number of wind-dispersed seeds. Dumping of plant material can increase the likelihood of transfer to a suitable habitat as material would be directly transferred.

Qu. 3.9b. Estimate the overall potential rate of spread based on this pathway in relation to the environmental conditions in the risk assessment area. (please provide quantitative data where possible).

RESPONSE	very slowly slowly moderately rapidly very rapidly	CONFIDENCE	low medium high
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Response: *Solidago canadensis* and *S. gigantea* are used as “honey plants” within the risk assessment area on some local or regional spatial level (Arany et al. 2017; Meinhardt et al. 2024; Stefanic et al. 2003). Via this pathway the species could be spread throughout the risk assessment area and it is likely

that the species survive as the plants are the commodity itself. There is no quantitative analysis on the spread of the species in the risk assessment area. Expert opinion (authors of the risk assessment) suggests that the rate of spread of this species will be rapidly, but a low confidence is given.

PATHWAY: Transportation of habitat material (soil, vegetation) (transport - contaminant)

Qu. 3.3c. Is spread along this pathway intentional (e.g. the organism is deliberately transported from one place to another) or unintentional (e.g. the organism is a contaminant of translocated goods within the risk assessment area)?

RESPONSE	intentional unintentional	CONFIDENCE	low medium high
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Response: The spread of both *Solidago* species via transport of habitat material (soil, vegetation) is the unintentional spread of the species within the risk assessment area. Both seed material and plant fragments can be spread via this pathway (CABI et al. 2024; Nunes et al. 2024): e.g. seeds and rhizomes dispersed by movement of soil in the course of building work (CABI et al. 2024; Norwegian Ministry of the Environment 2007).

Qu. 3.4c. How likely is it that a number of individuals sufficient to originate a viable population will spread along this pathway from the point(s) of origin over the course of one year?

including the following elements:

- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if appropriate, indicate the rate of spread along this pathway
- if appropriate, include an explanation of the relevance of the number of individuals for spread with regard to the biology of species (e.g. some species may not necessarily rely on large numbers of individuals).

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Seed and root material can be present on/in the soil, in potentially large amounts if such material is taken from an area where the species is present in a mass occurrence. Rhizome fragments are able to spread clonally, forming monodominant stands. There is no information available on the

volumes of movement along this spread pathway, though this pathway is reported to be active for originating viable populations in the risk assessment area (e.g. CABI et al. 2024; Nunes et al. 2024).

Qu. 3.5c. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Viable root material can be small and therefore it, and also seeds could survive during transport along this spread pathway. Habitat material would be suitable for the survival of the species over short periods. Root material can remain viable within soil material (Weber 2001). Walck et al. (1998) conducted a comparative study of the seed germination of a few *Solidago* species (e.g. *Solidago altissima*, *S. nemoralis*, *S. shortii*, and others). They found that *Solidago* species are able to form a persistent seed bank. For both species, there are no precise, experimentally validated maximum values for germination duration in the soil seed bank, as the lifespan depends heavily on the respective environmental conditions (soil moisture, temperature, soil depth). The seeds are generally classified as short- to medium-term perennials. Werner et al. (1980) reported 3.000 up to 13.000 achenes per stem for *S. canadensis*.

Qu. 3.6c. How likely is the organism to survive existing management practices during spread?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Careful methodical management practices coupled with inspection would be needed to ensure that the species did not spread with contaminated soil and vegetation. This is often not feasible with small root fragments and seeds. Existing management practices related to this spread pathway could not prevent the entry into the environment of sufficient propagules for establishment. The confidence level is low, as no references or figures are available.

Qu. 3.7c. How likely is the organism to spread in the risk assessment area undetected?

Please note that “detection” here is considered as any system or event that may actively contribute to record the presence of a species in a way that appropriate management measures could be potentially undertaken by relevant authorities.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Soil and other habitat material can be moved throughout the risk assessment area and plant propagules can be spread by such material. Seeds and root material may be small and buried in soil and other material, making them difficult to detect. Plants can regenerate from a small piece of rhizome. It is very likely that the spread is mostly undetected (CABI 2024ab; Nunes et al. 2024), though the confidence level is medium as no detailed references or figures are available.

Qu. 3.8c. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host during spread?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: It would be very likely that *Solidago. canadensis* and *S. gigantea* can transfer to a suitable habitat if seed and root material of the species is incorporated in soil. Topsoil and habitat material are often physically transferred and deposited in suitable habitats. This fact that the species is recorded e.g. in urban development areas further supports the hypothesis that the species can be moved by soil and habitat material (CABI 2024ab; Nunes et al. 2024).

Qu. 3.9c. Estimate the overall potential rate of spread based on this pathway in relation to the environmental conditions in the risk assessment area. (please provide quantitative data where possible).

RESPONSE	very slowly slowly moderately rapidly	CONFIDENCE	low medium high
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	very rapidly		
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Response: There is no quantitative data on the rate of spread of the species in relation to habitat material. The assessment as moderately is based upon expert opinion.

Habitat material can move freely within the single market in the EU enabling contaminated material to spread over long distances. Seed or root material may be included as a contaminant. Because of the lack of quantitative data, confidence is medium.

PATHWAY: Machinery/equipment (transport – stowaway)

Qu. 3.3d. Is spread along this pathway intentional (e.g. the organism is deliberately transported from one place to another) or unintentional (e.g. the organism is a contaminant of translocated goods within the risk assessment area)?

RESPONSE	intentional unintentional	CONFIDENCE	low medium high
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Response: This spread pathway includes machinery used for roadside and railway management, forest management and associated equipment. There are no quantitative figures for this unintentional spread pathway available, but high potential is highlighted in a number of references (e.g. CABI 2024ab; Kutlvař et al. 2024; Norwegian Ministry of the Environment 2007; Nunes et al. 2024; Weber 1998).

Qu. 3.4d. How likely is it that a number of individuals sufficient to originate a viable population will spread along this pathway from the point(s) of origin over the course of one year?

including the following elements:

- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if appropriate, indicate the rate of spread along this pathway
- if appropriate, include an explanation of the relevance of the number of individuals for spread with regard to the biology of species (e.g. some species may not necessarily rely on large numbers of individuals).

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: There is no information available on the volumes of movement along this pathway. However, any mechanisms involving equipment and vehicles could act to break root material into smaller fragments and therefore the number of viable rhizome pieces can be high. Based upon a strong regeneration ability from rhizome fragments, only small root pieces are needed to form a viable plant which may be suitable to form a viable population (Weber 2011). Additionally, tiny seeds of both *Solidago* species (*S. canadensis*: 0,9-1,2 mm long, with a pappus of 2,0-2,5 mm; *S. gigantea* 1-2 mm long, with a pappus of 1 mm long; CABI 2024ab) may be attached to machinery/equipment.

Qu. 3.5d. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Root/rhizome material and/or seeds could survive during transport along this spread pathway. The species is unlikely to increase along the pathway until it finds a suitable habitat.

Qu. 3.6d. How likely is the organism to survive existing management practices during spread?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Root and shoot material and/or seeds can also remain hidden within crevices of machinery and equipment. ISPM 41 (IPPC 2017) ‘Intentional movement of machinery and equipment’ provides international measures for cleaning, which can be applied to local level movement also. If done properly, this will decrease the potential for survival.

Qu. 3.7d. How likely is the organism to spread in the risk assessment area undetected?

Please note that “detection” here is considered as any system or event that may actively contribute to record the presence of a species in a way that appropriate management measures could be potentially undertaken by relevant authorities.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: Root/rhizome fragments are relatively small, are easily broken from the main stem or root and potentially can remain hidden in soil in cracks and crevices in machinery and equipment. Such machinery can be moved within the risk assessment area transporting root pieces to new areas, with the result that propagules can be spread over a large distance undetected. As plant material may be very small (root/rhizome fragments, seeds), these can be hidden on the underside of equipment and machinery and not obvious when inspected.

Qu. 3.8d. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host during spread?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: It would be moderately likely that *Solidago canadensis* or *S. gigantea* can transfer to a suitable habitat if the species is a stowaway on machinery/equipment. Landscaping machinery, roadside and railway management machinery or construction machinery are used in suitable habitats of the species and if there is plant material as a contaminant, this material may be deposited into a habitat that is suitable for the development of the plant. Seeds and rhizomes may also be dispersed as a result of movement of soil in the course of building work and by attachment to vehicles or in the slip-stream of road and rail vehicles (CABI 2024ab).

Qu. 3.9d. Estimate the overall potential rate of spread based on this pathway in relation to the environmental conditions in the risk assessment area. (please provide quantitative data where possible).

RESPONSE	very slowly slowly moderately rapidly very rapidly	CONFIDENCE	low medium high
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Response: Used machinery and equipment can be moved within the risk assessment area at a local and long distances scale. Any seed and root/rhizome material attached could be spread at a fast rate. However, it is scored moderately as a number of measures can be adopted against this spread pathway, including inspections of used machinery and equipment coupled with cleaning. A low confidence has been given as there is no quantitative data to support this assessment.

Qu. 3.10. Within the risk assessment area, how difficult would it be to contain the organism in relation to these pathways of spread?

RESPONSE	very easy easy with some difficulty difficult very difficult	CONFIDENCE	low medium high
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Response: Naturally dispersing organisms with strong regeneration ability from rhizome fragments and long seed dispersal by wind are difficult to contain. Control using traditional methods needs to be meticulous to remove all plant material (rhizome fragments and seeds).

As the species can spread as a contaminant of soil and habitat material, machinery and equipment, biosecurity measures and inspections would need to be adopted where these spread pathways are active, and the species is present. This would involve multiple stakeholders and communication and awareness raising to reduce the spread pathways. A ban on sale could act to prevent further spread of the species within the risk assessment area. Preventing the spread from already established populations would be difficult.

The natural enemy complex on *Solidago* species is well-known in the native range and some species are even used as model species in studies. Some of them show high fidelity to their host species and as such may be suitable for biocontrol use in the risk assessment area. There are native *Solidago* species in the risk assessment area, so host specificity of agents would need to be very high and there is also a risk of one weed replacing the other if biocontrol was only successful on one of them.

Qu. 3.11. Estimate the overall potential rate of spread in relevant biogeographical regions under current conditions for this organism in the risk assessment area (indicate any key issues and provide quantitative data where possible).

Thorough assessment of the risk of spread in relevant biogeographical regions in current conditions, providing insight in the risk of spread into (new areas in) the risk assessment area.

RESPONSE	very slowly slowly moderately rapidly very rapidly	CONFIDENCE	low medium high
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Response: In the risk assessment area, *Solidago canadensis* and *S. gigantea* reproduce and spread by vegetative and sexual reproduction with a long-distance wind-dispersed seeds. Therefore, spread by natural means can be assessed as rapidly.

Human mediated spread includes intentional movement of the species (through ornamental use and pasture for bees) and unintentional movement through contamination of habitat material and used machinery and equipment. For human mediated spread, the rate of spread can be estimated as moderately. Spread would be highest in biogeographical regions where the species is already present.

Cumulative numbers of localities as well as numbers of occupied grid squares showed a continuous increase since 1850 for both species. To sum up, both *Solidago* species have spread across all climatically suitable biogeographical regions in about 175 years.

Qu. 3.12. Estimate the overall potential rate of spread in relevant biogeographical regions in foreseeable climate change conditions (provide quantitative data where possible).

Thorough assessment of the risk of spread in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk, specifically if rates of spread are likely slowed down or accelerated.

RESPONSE	very slowly slowly moderately rapidly very rapidly	CONFIDENCE	low medium high
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Response: The overall potential rate of spread in the risk assessment area under foreseeable climatic conditions (2070 RCP. 2.6 and 4.5) is rapidly with a low confidence, as both species are occurring also on disturbed or abandoned land and there are no models available how disturbance will evolve over time considering the EU nature restoration law and land use change.

Rates of spread would be maintained in the areas where the species is already established; with an increased spread rate in the North and East with

increased temperate climate conditions. All this might also increase the likelihood of human-mediated spread in these regions.

4 MAGNITUDE OF IMPACT

Important instructions:

- Questions 4.1-4.5 relate to biodiversity and ecosystem impacts, 4.6-4.8 to impacts on ecosystem services, 4.9-4.13 to economic impact, 4.14-4.15 to social and human health impact, and 4.16-4.18 to other impacts. These impacts can be interlinked, for example, a disease may cause impacts on biodiversity and/or ecosystem functioning that leads to impacts on ecosystem services and finally economic impacts. In such cases the assessor should try to note the different impacts where most appropriate, cross-referencing between questions when needed.
- Each set of questions starts with the impact elsewhere in the world, then considers impacts in the risk assessment area (=EU excluding outermost regions) separating known impacts to date (i.e. past and current impacts) from potential future impacts (including foreseeable climate change).
- Only negative impacts are considered in this section (socio-economic benefits are considered in Qu. A.7)
- In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer “No information has been found on the issue”. This is necessary to avoid confusion between “no information found” and “no impact found”. In this case, no score and confidence should be given and the standardized “score” is N/A (not applicable). Note that in principle, even if no information is available for the risk assessment area, this does not apply to Qu. 4.2 and 4.3, because the information on impact can be inferred from regions outside the risk assessment area. If no information is available from regions outside the risk assessment area either, then this should be discussed explicitly.

Biodiversity and ecosystem impacts

Qu. 4.1. How important is the impact of the organism on biodiversity at all levels of organisation caused by the organism in its non-native range excluding the risk assessment area?

including the following elements:

- Biodiversity means the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems
- impacted chemical, physical or structural characteristics and functioning of ecosystems

RESPONSE		CONFIDENCE	
	minimal		low
	minor		medium
	moderate		high
	major		
	massive		

Response: *Solidago canadensis* and *S. gigantea* are recognized invasive alien plant in various parts of the world, including Europe outside the risk assessment area, Asia and Oceania and have caused considerable biodiversity and ecosystem impacts in these non-native ranges (e.g. Anđelković et al.

2022; Artemov and Zykova 2019; CABI 2024ab; EPPO 2024ab; Info Flora 2021; Maslo 2024; Seebens et al. 2017; Stešević & Bujanja 2017; Sunding 1989). Large areas infested by *S. canadensis* are often the result of the inappropriate land-use management, allowing it to establish and outcompete native plants resulting in large changes negatively affecting both flora and fauna to the point where characteristic species within a plant community may disappear altogether (CABI 2024a). The dominance of the plant may be enhanced by allelopathy (Sun et al. 2006; Wang et al. 2006). Monoculture stands of *S. canadensis* homogenize the landscape. Lu et al. (2006) reported serious concerns with regards to its spread in China. Brisbane City Council (2024) details that the species is a strong invasive competitor, in part due to allelopathic compounds, and its ability to colonize an area by creeping rhizomes and self-seeding. Shelepova et al. (2019) studied invasiveness of *S. canadensis* in abandoned lands in Belarus and found that the invasion reduced the native plant species richness throughout a two year period and changed the vegetation succession, and altered the mutual links between the native elements of old fields. The native plants are outcompeted rapidly by the *Solidago* species. Without management interventions instead of valuable secondary grasslands, *S. canadensis* might dominate the abandoned lands for decades. Large areas covered by *S. gigantea* are mostly the result of inappropriate management of grasslands and abandoned fields. Once established, *S. gigantea* outcompetes native species and in this way negatively affects fauna and flora. Areas dominated by this plant lead to a decrease of field diversity, with a loss of protected native plant and animal species, and also loss of common characteristic species in the new homogenized landscape. Extensive stands in reeds are of concern to managers of conservation areas (CABI 2024b).

Qu. 4.2. How important is the current known impact of the organism on biodiversity at all levels of organisation (e.g. decline in native species, changes in native species communities, hybridisation) in the risk assessment area (include any past impact in your response)?

Discuss impacts that are currently occurring or are likely occurring or have occurred in the past in the risk assessment area. Where there is no direct evidence of impact in the risk assessment area (for example no studies have been conducted), evidence from outside of the risk assessment area can be used to infer impacts within the risk assessment area.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: *Solidago canadensis* and *S. gigantea* are widespread, established and invasive in the risk assessment area, especially in regions with temperate climate conditions (e.g. De Groot et al. 2007; Morón et al. 2009; Skórka et al. 2010). The species establish themselves quickly from wind-dispersed seeds and start flowering in their second year. Both *Solidago* species also spread clonally, forming monodominant stands. The *Solidago* species can be found spreading vigorously along transportation routes, roadsides, and in disturbed areas including construction sites (Nunes et al. 2024) and are invading also (semi-)natural habitats (see impact also in answer to Qu. 4.1).

Species richness

Szítár et al. (2024) studied the effects of goldenrod (*Solidago gigantea* and *S. canadensis*) invasion on a wet meadow in Hungary. The study revealed that goldenrod invasion had negative effects on species richness and community-level biomass in wet meadows, leading to a significant reduction in species diversity and total cover. Goldenrod invasion also impacted the richness and cover of both native and exotic species, with a decrease in richness but not cover, highlighting the competitive ability of goldenrods and their potential to alter vegetation composition. They found a decline in nature conservation value due to goldenrod invasion in terms of the shift in species composition from specialist, generalist and dominant species toward ruderal species.

It competitively excludes native species in direct correlation to the density of its own stand, exacerbating the reduction in species diversity (Pal et al. 2015). Besides this, *S. gigantea* seems to be more plastic in its introduced range (Jakobs et al. 2004), occurring in a wide range of environments affecting many different plant communities, e.g. wetlands and gallery forests (Török et al. 2003; Güsewell et al. 2005), forest plantations (Török et al. 2003) and disturbed sites (Török et al. 2003; Weber and Jakobs 2005).

Biomass and soil characteristics

Comparing aboveground productivity, nutrients pools in standing biomass and topsoil and mineral nutrient concentrations between invaded and adjacent uninvaded vegetation, Vanderhoeven et al. (2005) showed that invaded stands had increased aboveground productivity and lower nutrient concentrations in the standing phytomass. It appeared that *S. gigantea* enhances P turnover rates in invaded ecosystems (Chapuis-Lardy et al. 2006, Herr et al. 2007). Goossens et al. (2024) examined stands of *S. gigantea* in three Belgian nature reserves in order to cover different soil types and habitats, e.g. wet grasslands, open forests and forest edges, and heathland. In its introduced range, *S. gigantea* displays a higher production of rhizomes, greater biomass and stem density compared to its native range in North America (Jakobs et al. 2004; Güsewell et al. 2006; Pal et al. 2015). Goossens et al. (2024) reported that the presence of *S. gigantea* had a strong impact on soil and vegetation characteristics, and the strength and direction of the effect strongly depended on the initial soil conditions. The study details the *S. gigantea* increased pH and extractable N in soils of initially low pH and low N availability, but decreased these soil variables in soils with initially higher pH and N availability. The effect on pH also seemed to depend on stand density, with denser stands exacerbating the effects of invasion. *Solidago gigantea* decreased both species richness and diversity of the invaded plant communities, and this effect was stronger in dense stands and species-rich communities. *Solidago gigantea* showed to have a consistently homogenizing effect on its environment in the studied sites, both biotic and abiotic. The increased N availability in invaded plots on nutrient poor soils might be explained by the faster decomposing litter and rapid nutrient cycling of *S. gigantea*. The study results show that *S. gigantea* did not just decrease species richness and diversity by outcompeting some native species, but by actually replacing whole plant communities by other, less diverse and less specialist plant communities (Goossens et al. 2024).

Jakubcsiková et al. (2024) reported that the effect of invasion by *S. gigantea* on soil ecosystems and food webs can be evaluated using nematode communities as suitable and useful soil bioindicators. They compared the effect of *S. gigantea* on nematode communities in plots invaded with *S. gigantea* and non-invaded grasslands across three sites with varying soil and climatic conditions. Their findings indicated that invasion by *S. gigantea* did not strongly affect nematode taxonomic diversity but

negatively affected functional diversity. This effect was evident in the increased abundance of bacterivore and fungivore nematodes and decrease in values of ecological and functional indices. The evaluation of the soil food web using nematode communities confirmed that soil in plots with *S. gigantea* were less mature and more disturbed with a degraded or depleted food web indicated by lower values of maturity, enrichment and structure indices, compared with non-invaded grasslands. The interaction between site and invasion status confirmed the effect of invasion on nematode biomass, with the abundance of bacterivore and fungivore nematodes and the functional indices more prominent at sites characterised by cold and humid climates.

Insects

IUCN (2019) details modified ecosystems by outcompeting native flora and leading to a decrease in pollinator food sources as the one of the main impact by *S. canadensis*, *S. gigantea* and *S. altissima* (Hejda et al. 2021); compare Table 13.

Table 13 Native pollinators impacted by *Solidago canadensis* and *S. gigantea* (IUCN 2019)

Species	Native pollinators impacted		Impact mechanism
<i>Solidago ssp.</i>	<i>Coenonympha oedippus</i>	butterflies	Ecosystem stress / modification
<i>Solidago canadensis</i>	<i>Apidae, Andrenidae, Collettidae, Melittidae, Halictidae, Megachilidae, multiple butterflies, Syrphidae, Bombus spp.</i>	bees, bumblebees, butterflies, hoverflies	Ecosystem stress / modification
<i>Solidago gigantea</i>	<i>Colias myrmidone, multiple butterflies and bees, Syrphidae</i>	bees, butterflies, hoverflies	Ecosystem stress / modification

Nunes et al. (2024) detail that there is a negative effect on the diversity and abundance of wild pollinators, regardless of their nesting and food specialisation (Moron et al. 2009). Reduction in native plant species richness and negative effects on the abundance of bees, but not of hoverflies, have been reported. Native flowers experienced reduced visitation by wild bees, honeybees and hoverflies due to the augmented presence of *S. canadensis* (Fenesi et al. 2015). Native plant species richness and the richness, abundance and diversity of butterfly species were lower in invaded stands of *S. canadensis*. Hoverfly abundance, diversity and species richness were negatively affected in July before the onset of flowering of *S. canadensis*, but tended to be positively affected in August during the height of flowering (De Groot et al. 2007). Eckberg et al. (2023) demonstrated that *S. canadensis* is a dominant plant species that alters subdominant plant diversity and biomass in an old-field ecosystem, with indirect effects on arthropod community structure. A key mechanism by which *S. canadensis* reduces subdominant plant productivity and diversity is by reducing light availability.

S. canadensis and *S. gigantea* show a rapid growth rate in new habitats, reaching a high biomass of their aboveground parts, degrading habitats and posing a threat to biodiversity. The presence of the *Solidago* species, mainly before the flowering period, adversely affects the abundance of insect communities, including wild bees, hoverflies, moths and some ground beetles (de Groot et al. 2007; Morón et al. 2009; Fenesi et al. 2015). Insect species, which have narrow food preferences, are particularly vulnerable to the presence of invasive plant species such as the *Solidago* species (de Groot et al. 2007; Nunes et al. 2024). Goldenrod reduces the size of the ant colonies but increases the range of foraging ants; in the goldenrod habitat, worker ants travel greater distances from their mother colony in search of food. In the habitats occupied by goldenrod, there is a decrease in the diversity of bird species and the number of breeding pairs associated with meadow habitats. These changes especially affect insectivorous birds (Królak 2021).

Hybridization

The presence of *S. canadensis* in the environment may contribute to the formation of new taxa in Europe. The formation of the *Solidago* × *niederederi* hybrid, which arises from the crossing of *S. canadensis* with native *S. virgaurea*, has been reported. It occurs in anthropogenic habitats together with both parental species, and its presence attests to the invasive character of *S. canadensis* (Pliszko, Zalewska-Gałosz 2016). Becker et al. (2024) reported negative forest development along a river section restoration, when the *S. gigantea* cover exceeded 90% and hindered forest regenerating.

So overall, both *Solidago* species show impacts from the genetic to the ecosystem level. As all the impact levels are well documented, a major score with high confidence level is given.

Qu. 4.3. How important is the potential future impact of the organism on biodiversity at all levels of organisation likely to be in the risk assessment area?

See comment above. The potential future impact shall be assessed only for the risk assessment area. A potential increase in the distribution range due to climate change does not *per se* justify a higher impact score.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: It is likely that the plant will expand its range through natural and assisted spread and new introductions/escapes. If both *Solidago* species behave the same as in the already invaded regions, the potential future impact is major with a high confidence.

Qu. 4.4. How important is decline in conservation value with regard to European and national nature conservation legislation caused by the organism currently in the risk assessment area?

including the following elements:

- native species impacted, including red list species, endemic species and species listed in the Birds and Habitats directives
- protected sites impacted, in particular Natura 2000
- habitats impacted, in particular habitats listed in the Habitats Directive, or red list habitats
- the ecological status of water bodies according to the Water Framework Directive and environmental status of the marine environment according to the Marine Strategy Framework Directive

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: Natura 2000 sites, based upon the Habitats and Birds Directive, is a network of protected areas covering Europe's most valuable and threatened species and habitats. Considering *Solidago canadensis*/*S. gigantea* observations from GBIF (2026ab) and iNaturalist (2026ab) with a spatial accuracy $\leq 100\text{m}$, the species are already present in 1.656 Natura 2000 sites across most of the EU Member States (see Table 14). To sum up, this is a threat of sensitive species and habitats in $\sim 6,1\%$ of the Natura 2000 sites within the European wide network of protected areas.

Table 14 Natura 2000 sites with presence of *Solidago gigantea* / *Solidago canadensis* based on GBIF (2026ab) and iNaturalist (2026ab) with a spatial accuracy $\leq 100\text{m}$ Site; type A= designated under the Birds directive, B=designated under the Habitats directive, C= designated under both Directives; total number of Natura 2000 sites (status 2022; EEA 2024): n=27193

SITETYPE	A	A	B	B	C	C
<i>S. gigantea</i> / <i>S. canadensis</i>	no	yes	no	yes	no	yes
MS						
AT	25	22	218	35	29	24
BE	7	22	15	40	114	112
BG	107		220		13	
CY						
CZ	30	11	1 084	28		
DE	471	185	4 079	379	75	11
DK	53	36	180	57	15	9
EE	25	1	499	2	40	
ES	390	1	1 195	2	271	
FI	145		1 392	2	325	1
FR	348	59	1 260	94		
GR	180	1	238	1	26	
HR	35	3	741	4		
HU	38	8	444	25	4	6
IE	165		439			

IT	265	14	1 962	38	347	13
LT	72	4	584	12	7	2
LU	11	7	35	13		
LV	4		235		93	1
MT	15		33		7	
NL	51	7	106	14	17	3
PL	107	28	794	64	6	4
PT	59		105		3	
RO	167	4	433	2		
SE	81	16	3 427	144	414	43
SI	27	4	315	9		
SK	27	14	724	15		
Total	2 931	447	20 793	980	1 813	229
% of all Natura 2000 sites	10,8%	1,6%	76,5%	3,6%	6,7%	0,8%

In these 1.656 Natura 2000 sites, 236 different habitat types of European interest are listed in the standard data forms there. The listed habitats most sensitive habitat to alien species with high competition capacity like both *Solidago* species are e.g. (* priority habitat type: habitat types in danger of disappearance and whose natural range mainly falls within the territory of the European Union):

- 2130 Fixed coastal dunes with herbaceous vegetation ("grey dunes")*
- 3220 Alpine rivers and the herbaceous vegetation along their banks
- 3230 Alpine rivers and their ligneous vegetation with *Myricaria germanica*
- 3240 Alpine rivers and their ligneous vegetation with *Salix elaeagnos*
- 6110 Rupicolous calcareous or basophilic grasslands of the *Alyso-Sedion albi**
- 6120 Xeric sand calcareous grasslands*
- 6130 Calaminarian grasslands of the *Violetalia calaminariae*
- 6140 Siliceous Pyrenean Festuca eskia grasslands
- 6190 Rupicolous pannonic grasslands (*Stipo-Festucetalia pallentis*)
- 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (* important orchid sites)
- 6220 Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea**
- 6230 Species-rich Nardus grasslands, on silicious substrates in mountain areas (and submountain areas in Continental Europe)*
- 6240 Sub-Pannonic steppic grasslands*
- 6250 Pannonic loess steppic grasslands*
- 6260 Pannonic sand steppes*
- 6270 Fennoscandian lowland species-rich dry to mesic grasslands*
- 6280 Nordic alvar and precambrian calcareous flatrocks*
- 6410 Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)
- 6420 Mediterranean tall humid grasslands of the Molinio-Holoschoenion
- 6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
- 6440 Alluvial meadows of river valleys of the *Cnidion dubii*
- 6450 Northern boreal alluvial meadows

- 6460 Peat grasslands of Troodos
- 6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*)
- 6520 Mountain hay meadows
- 6530 Fennoscandian wooded meadows*
- 6540 Sub-Mediterranean grasslands of the *Molinio-Hordeion secalini*

Qu. 4.5. How important is decline in conservation value with regard to European and national nature conservation legislation caused by the organism likely to be in the future in the risk assessment area?

- See guidance to Qu. 4.3. and 4.4.

RESPONSE		CONFIDENCE	
	minimal		low
	minor		medium
	moderate		high
	major		
	massive		

Response: Decline in conservation values would be exhibited in the areas where the species is already established and additionally in new parts of the risk assessment area with more suitable climate conditions due to climate change. In the absence of specific and detailed studies, the score is assessed as major with a low confidence, building up on the scores of Qu. 4.4.

Ecosystem Services impacts

Qu. 4.6. How important is the impact of the organism on provisioning, regulating, and cultural services in its non-native range excluding the risk assessment area?

- For a list of services use the CICES classification V5.1 provided in Annex V.
- Impacts on ecosystem services build on the observed impacts on biodiversity (habitat, species, genetic, functional) but focus exclusively on reflecting these changes in relation to their links with socio-economic well-being.
- Quantitative data should be provided whenever available and references duly reported.

RESPONSE		CONFIDENCE	
	minimal		low
	minor		medium
	moderate		high
	major		
	massive		

Response: Several studies (e.g. Pergl et al. 2023) indicate the impact of both *Solidago* species on soil properties and soil quality (Regulation & Maintenance - Regulation of physical, chemical, biological

conditions - Soil quality regulation) (see also answers to Qu. 4.2: Goossens et al. (2024)). Brisbane City Council (2024) details that the species is a strong invasive competitor, in part due to allelopathic compounds, and its ability to colonize an area by creeping rhizomes and self-seeding. The dominance of the weed plant may be enhanced by allelopathy (Sun et al. 2006; Wang et al. 2006). For example, Wang et al. (2023) details that exotic plants on soil nitrogen (N) transformations may influence species invasion success. The results of their study in China suggested that *S. canadensis* can influence the mineralization-immobilization turnover (MIT) to optimize its N requirements while limiting N supply for other plants in the system. Both *Solidago* species have an impact on provisioning services as the biomass of wild plants become fewer and less diverse as a result of invasion and any associated valued by-products would be lost too though none have been identified specifically. The species has an impact on cultural services, as valued native habitats are invaded and transformed and ultimately degraded thereby making these habitats less attractive for e.g. leisure and recreation activities.

All the mentioned ecosystem services impacts are significant and measurable and a moderate score is given with medium confidence.

Qu. 4.7. How important is the impact of the organism on provisioning, regulating, and cultural services currently in the different biogeographic regions or marine sub-regions where the species has established in the risk assessment area (include any past impact in your response)?

- See guidance to Qu. 4.6.

RESPONSE	minimal	CONFIDENCE	low
	minor		medium
	moderate		high
	major		
	massive		

Response: Bobuľská et al. (2019) reported that invasion of *Solidago gigantea* significantly altered several soil properties and is associated with different soil properties in study site in Slovakia in the Continental biogeographical region. Soil acidity increased, organic carbon and moisture content decreased, while total nitrogen content was not significantly affected by invasion. *S. gigantea* can influence several soil microbial properties. The activity of soil microbial population mainly represented by soil enzymatic content plays an important role in soil functioning and depends on environmental changes in the natural ecosystems. Invasion by *S. gigantea* in the studied area generated a soil environment that might significantly alter several soil physicochemical and microbial indices, and invasion is associated with different soil properties. This is especially relevant in vulnerable and/or protected sites across the risk assessment where both *Solidago* species are widespread and invasive (Goossens et al. 2024). Changes in ecosystem functioning may influence ecosystem services. Both *Solidago* species have an impact on provisioning services as the biomass of wild plants become fewer and less diverse as a result of invasion and any associated valued by-products would be lost too though none have been identified specifically. The species has an impact on cultural services, as valued native habitats are invaded and transformed and ultimately degraded thereby making these habitats less attractive for e.g. leisure and recreation activities (CABI 2024ab). IUCN (2019) and

Nunes et al. (2024) details modified ecosystems by outcompeting native flora and leading to a decrease in pollinator food sources as the main impact by *S. canadensis*, *S. gigantea* and *S. altissima* on pollination as a ecosystem service. All the mentioned ecosystem services impacts are significant and measurable and a moderate score is given with medium confidence.

Qu. 4.8. How important is the impact of the organism on provisioning, regulating, and cultural services likely to be in the different biogeographic regions or marine sub-regions where the species can establish in the risk assessment area in the future?

- See guidance to Qu. 4.6.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: No information has been found on the issue but as above, an expert judgment suggests that a moderate score with medium confidence would remain in the timescale considered and the precautionary principle dictates that the score should not reduce. With increased climatic suitability over a greater area, it could even be expected for an increasing impact. The confidence remains medium based upon the published evidence (see Qu. 4.7.).

Economic impacts

Qu. 4.9. How great is the overall economic cost caused by the organism within its current area of distribution (excluding the risk assessment area), including both costs of / loss due to damage and the cost of current management.

- Where economic costs of / loss due to the organism have been quantified for a species anywhere in the world these should be reported here. The assessment of the potential costs of / loss due to damage shall describe those costs quantitatively and/or qualitatively depending on what information is available. Cost of / loss due to damage within different economic sectors can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage. As far as possible, it would be useful to separate costs of / loss due to the organism from costs of current management.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: Nunes et al. (2024) describe management measures for both *Solidago* species. The species thrive under irregular management practices, such as mowing followed by several years of no intervention. Recommended measures to control the spread of these species include repeated mowing (for several years). Small, localised populations of *Solidago* spp. can be uprooted by hand pulling; however, the risks of disturbing the vegetation should be considered. In the case of persistent populations that do not respond adequately to mechanical management, herbicide application (foliar spraying) can be considered according to national legislation. Ploughing the sites invaded by *Solidago* spp. is not recommended, as it stimulates regeneration, fragments the rhizomes, disturbs the soil and allows its colonisation by seeds. Mowing or grazing are mechanical methods that can reduce the seed set.

CABI (2024a) details that *S. canadensis* is rarely a weed of annual crops, but it has been recorded causing significant losses to wheat yields in China (Gu et al., 2006). It is also an alternative host of insects that can be vectors of crop pathogens. Poisoning of horses has been caused by large proportions of *S. canadensis* in hay feed in Germany (Chizzola & Brandstätter, 2006). *S. canadensis* possibly exhibits allelopathic properties, as aqueous leaf and rhizome extracts affected seed germination and root growth of radish and lettuce (Butcko & Jensen, 2002). Similarly, Sawabe et al. (2000) demonstrated germination inhibition activity of acetylenes and terpenoids against lettuce in bioassays.

S. gigantea is an alternative host of insects that can be vectors of plant pathogens. In infested areas, litter accumulation makes the field restoration difficult. According to Bérés & Kazinczi (2000), residues of *S. gigantea* reduced germination of test crops but fresh weight of crop seedlings was stimulated. Shoot extracts of *S. gigantea* reduced germination of wheat by 7.6% and germination of barley by 9.8% (CABI 2024b).

However, hardly any quantitative studies on the economic impact are available for the current area of distribution (excluding the risk assessment area) (Diagne et al. 2020). For China, Lu (2007) estimates costs of ~ 1.864.778 USD (exchange rate CNY to USD 2017) for management, though no information about the area, where management is applied, is given. An expert judgment suggests a major score with low confidence without available quantitative data.

Qu. 4.10. How great is the economic cost of / loss due to damage (excluding costs of management) of the organism currently in the risk assessment area (include any past costs in your response)?

- Where economic costs of / loss due to the organism have been quantified for a species anywhere in the EU these should be reported here. Assessment of the potential costs of damage on human health, safety, and the economy, including the cost of non-action. A full economic assessment at EU scale might not be possible, but qualitative data or different case studies from across the EU (or third countries if relevant) may provide useful information to inform decision making. In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer “No information has been found on the issue”. This is necessary to avoid confusion between “no information found” and “no impact found”. In this case, no score and confidence should be given and the standardized “score” is N/A (not applicable). Cost of / loss due to damage within different economic sectors can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage.

RESPONSE	N/A minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: No information has been found on the issue.

Qu. 4.11. How great is the economic cost of / loss due to damage (excluding costs of management) of the organism likely to be in the future in the risk assessment area?

- See guidance to Qu. 4.10.

RESPONSE	N/A minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: No information has been found on the issue.

Qu. 4.12. How great are the economic costs / losses associated with managing this organism currently in the risk assessment area (include any past costs in your response)?

- In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer “No information has been found on the issue”. This is necessary to avoid confusion between “no information found” and “no impact found”. In this case, no score and confidence should be given and the standardized “score” is N/A (not applicable).

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: See answer to Qu. 4.9. regarding management of the *Solidago* species described by Nunes et al. (2024). CABI (2024b) adds the cultural control: The enormous infested grassland areas are

effects of the poor previous management practices, and in grasslands, continuous mowing or grazing is necessary every year to prevent establishment of *Solidago* species.

Hall et al. (2022) conducted a study in the protected area of the Donau-Auen National Park in Austria. The results of their study showed clearly that different management can contribute to effectively repress goldenrod stands in a nature conservation area. In particular, a short-term mowing treatment of three years can effectively reduce goldenrod density and simultaneously increase the establishment success of native species. Nevertheless, to improve species richness and community diversity a long-term approach is required as the management success of goldenrod in natural environments can be very sensitive to unpredictable factors like weather and wild animal disturbances. This is particularly true for nature conservation areas where management options are scarce due to legal regulations, strict planning schemes and restrictions in management guidelines. Therefore, they recommend a site-specific management plan which supports the effective reduction in abundance of goldenrod, but also has positive impact on species diversity, which contributes to the enhancement of community resistance against further invasions. To sum up, *Solidago* species management in nature conservation areas is a costly long-term task; though no cost figures are available.

Szymura et al. (2016) conducted a theoretical cost estimate study in south-western Poland (Silesia, with an area of ~30.000 km²). They assessed the area covered by stands of invasive *S. canadensis* / *S. gigantea* was 130.000 ha, which is ~ 4,5% of the total area of the studied region. The cost of removing stands of invasive *Solidago* species in this area of S-W Poland ranges from 123,24 to 266,17 million PLN (average exchange rate Polish Zloty (PLN) to Euro (EUR) in 2016: 0,2293 EUR; ~ 28.258.932 EUR to 61.032.781 EUR), depending on the method. The method they found that balances reasonable costs, low environmental impact and efficiency of grassland establishment costs 180,7 million PLN (41.434.510 EUR) for S-W Poland.

Table 15 Estimated costs of *Solidago* management in south-western Poland (Szymura et al. 2016); original costs in Polish Zloty, calculated to EUR by average exchange rate 2016

Method / treatment	Mowing with collection and transport	Mowing + mulching	Scalping (sod-cutting)	Tillage	Systemic herbicide	Selective herbicide	Direct seeding	Sowing	Mowing with collection and transport	Cost per hectare (EUR)	Total costs in regional scale (EUR)
1.	+						+		+	232,7	30 256 135
2.	+		+				+		+	318,7	41 434 510
3.		+		+				+	+	469,4	61 032 781
4.						+	+		+	225,2	29 274 731
5.					+		+		+	217,4	28 258 932

Qu. 4.13. How great are the economic costs / losses associated with managing this organism likely to be in the future in the risk assessment area?

- See guidance to Qu. 4.12.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: No quantitative information has been found on the issue, but as above, based upon an increased suitable area due to climate change an expert judgment suggests that a massive score with low confidence would remain in the timescale considered and the precautionary principle dictates that the score should not reduce.

Social and human health impacts

Qu. 4.14. How important is social, human health or other impact (not directly included in any earlier categories) caused by the organism for the risk assessment area and for third countries, if relevant (e.g. with similar eco-climatic conditions).

The description of the known impact and the assessment of potential future impact on human health, safety and the economy, shall, if relevant, include information on

- illnesses, allergies or other affections to humans that may derive directly or indirectly from a species;
- damages provoked directly or indirectly by a species with consequences for the safety of people, property or infrastructure;
- direct or indirect disruption of, or other consequences for, an economic or social activity due to the presence of a species.

Social and human health impacts can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: Although species of *Solidago* are suspected of causing hay fever only occasionally, in dry, very windy weather, sufficient pollen is blown into the air to affect sensitive individuals (CABI 2024a; Frankton 1963).

Qu. 4.15. How important is social, human health or other impact (not directly included in any earlier categories) caused by the organism in the future for the risk assessment area.

- In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer “No information has been found on the issue”. This is necessary to avoid confusion between “no information found” and “no impact found”. In this case, no score and confidence should be given and the standardized “score” is N/A (not applicable).

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: No information has been found on the issue, but as above, an expert judgment suggests that a minimal score with low confidence would remain in the timescale considered and the precautionary principle dictates that the score should not reduce.

Other impacts

Qu. 4.16. How important is the organism in facilitating other damaging organisms (e.g. diseases) as food source, a host, a symbiont or a vector etc.?

RESPONSE	N/A minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: No information has been found on the issue.

Qu. 4.17. How important might other impacts not already covered by previous questions be resulting from introduction of the organism?

RESPONSE	N/A minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: No information has been found on the issue.

Qu. 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 the risk assessment area?

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: *Solidago canadensis* and *S. gigantea* do not have any host specific natural enemies in the risk assessment area and there is no evidence that native organisms feed or infect the species in substantial levels to inflict any damage on the species. Given the impacts seen elsewhere in its alien range and also within the risk assessment area where the species are already established and invasive, the *Solidago* species can be assessed to have a major impact with a high confidence level.

Qu. 4.19. Estimate the overall impact in the risk assessment area under current climate conditions. In addition, details of overall impact in relevant biogeographical regions should be provided.

Thorough assessment of the overall impact on biodiversity and ecosystem services, with impacts on economy as well as social and human health as aggravating factors, in current conditions.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response: Both *Solidago* species are already established and invasive in biogeographical regions with more or less temperate climate conditions. The overall impact in the risk assessment area under current climate conditions can be scored as major with a high confidence. The impact of both species is major on various levels of community structure and ecosystem services. Protected areas for nature conservation with sensitive species and habitats are already affected.

Qu. 4.20. Estimate the overall impact in the risk assessment area in foreseeable climate change conditions. In addition, details of overall impact in relevant biogeographical regions should be provided.

Thorough assessment of the overall impact on biodiversity and ecosystem services, with impacts on economy as well as social and human health as aggravating factors, under future conditions.

- See also guidance to Qu. 4.3.

RESPONSE		CONFIDENCE	
	minimal		low
	minor		medium
	moderate		high
	major		
	massive		

Response: Both *Solidago* species are already established and invasive in biogeographical regions with more or less temperate climate conditions. Climate change may increase regions with temperate climate conditions, especially in the north and east. Though, the speed at which this will happen is unclear.

RISK SUMMARIES			
	RESPONSE	CONFIDENCE	COMMENT
Summarise Introduction and Entry*	very unlikely unlikely moderately likely likely very likely	low medium high	Both <i>Solidago</i> species have been introduced and entered the risk assessment area in the past. A number of active pathways of introduction exist and entry into the environment is very likely with high confidence.
Summarise Establishment*	very unlikely unlikely moderately likely likely very likely	low medium high	The species are already established in the risk assessment area and further establishment is very likely in both current and future climatic conditions. The species have a wide tolerance of habitats and abiotic parameters which promote their establishment.
Summarise Spread*	very slowly slowly moderately rapidly very rapidly	low medium high	<i>Solidago canadensis</i> and <i>S. gigantea</i> exhibit vegetative and sexual reproduction in the risk assessment area. The high propagule pressure (seeds) facilitates the colonization of new (disturbed) habitats. Small root/rhizome fragments can form viable plants and are spreading clonally, forming monodominant stands. Based upon the species' anemochory with tiny seeds, long-distance dispersal enables spread across landscapes to reach favourable and suitable habitats. Both <i>Solidago</i> species have spread across all climatically suitable biogeographical regions in Europe in about 175 years.
Summarise Impact*	minimal minor moderate major massive	low medium high	Both <i>Solidago</i> species have shown major impacts on biodiversity and ecosystem functioning and services through suppression of native species development and reducing species richness by forming dense monodominant stands.
Conclusion of the risk assessment (overall risk)	low moderate high	low medium high	<i>Solidago canadensis</i> and <i>Solidago gigantea</i> pose a high risk to the EU with high confidence. This overall risk conclusion score takes into account the major impact score already happening in several biogeographical regions, coupled

			with a rapid spread. The high confidence score incorporates the high amount of evidence and references for the risk assessment area.
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*in current climate conditions and in foreseeable future climate conditions

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Distribution Summary

Please answer as follows:

- Yes if recorded, established or invasive
- if not recorded, established or invasive
- ? Unknown; data deficient

The columns refer to the answers to Questions A5 to A12 under Section A.

For data on marine species at the Member State level, delete Member States that have no marine borders.

In all other cases, provide answers for all columns.

Member States

	Recorded	Established (currently)	Possible establishment (under current climate)	Possible establishment (under foreseeable climate)	Invasive (currently)
Austria	yes	yes	yes	yes	yes
Belgium	yes	yes	yes	yes	yes
Bulgaria	yes	yes	yes	yes	yes
Croatia	yes	yes	yes	yes	yes
Cyprus	no	no	no	no	no
Czech Republic	yes	yes	yes	yes	yes
Denmark	yes	yes	yes	yes	yes
Estonia	yes	yes	yes	yes	yes
Finland	yes	yes	yes	yes	yes
France	yes	yes	yes	yes	yes
Germany	yes	yes	yes	yes	yes
Greece	yes	yes	yes	yes	no
Hungary	yes	yes	yes	yes	yes
Ireland	yes	yes	yes	yes	yes
Italy	yes	yes	yes	yes	yes
Latvia	yes	yes	yes	yes	yes
Lithuania	yes	yes	yes	yes	yes
Luxembourg	yes	yes	yes	yes	yes
Malta	no	no	no	no	no
Netherlands	yes	yes	yes	yes	yes
Poland	yes	yes	yes	yes	yes
Portugal	yes	no	no	no	no
Romania	yes	yes	yes	yes	yes
Slovakia	yes	yes	yes	yes	yes
Slovenia	yes	yes	yes	yes	yes
Spain	yes	no	no	no	no
Sweden	yes	yes	yes	yes	yes

Biogeographical regions of the risk assessment area

	Recorded	Established (currently)	Possible establishment (under current climate)	Possible establishment (under foreseeable climate)	Invasive (currently)
Alpine	yes	yes	yes	yes	yes
Atlantic	yes	yes	yes	yes	yes
Black Sea	no	no	yes	yes	no
Boreal	yes	yes	yes	yes	yes
Continental	yes	yes	yes	yes	yes
Mediterranean	yes	no	yes	no	no
Pannonian	yes	yes	yes	yes	yes
Steppic	no	no	yes	yes	no

ANNEX I Scoring of Likelihoods of Events

(taken from UK Non-native Organism Risk Assessment Scheme User Manual, Version 3.3, 28.02.2005)

Score	Description	Frequency
Very unlikely	This sort of event is theoretically possible, but is never known to have occurred and is not expected to occur	1 in 10,000 years
Unlikely	This sort of event has occurred somewhere at least once in the last millenium	1 in 1,000 years
Moderately likely	This sort of event has occurred somewhere at least once in the last century	1 in 100 years
Likely	This sort of event has happened on several occasions elsewhere, or on at least once in the last decade	1 in 10 years
Very likely	This sort of event happens continually and would be expected to occur	Once a year

ANNEX II Scoring of Magnitude of Impacts

(modified from UK Non-native Organism Risk Assessment Scheme User Manual, Version 3.3, 28.02.2005)

Score	Biodiversity and ecosystem impact	Ecosystem Services impact	Economic impact (Monetary loss and response costs per year)	Social and human health impact, and other impacts
	<i>Question 4.1-5</i>	<i>Question 4.6-8</i>	<i>Question 4.9-13</i>	<i>Question 4.14-18</i>
Minimal	Local, short-term population decline, no significant ecosystem impact	No services affected ⁵	Up to 10,000 Euro	No social disruption. Local, mild, short-term reversible effects to individuals.
Minor	Local, short-term population loss, Localized reversible ecosystem impact	Local and temporary, reversible effects to one or few services	10,000-100,000 Euro	Significant concern expressed at local level. Mild short-term reversible effects to identifiable groups, localised.
Moderate	Local to regional long-term population decline/loss, Measureable reversible long-term damage to ecosystem, little spread, no extinction	Measureable, temporary, local and reversible effects on one or several services	100,000-1,000,000 Euro	Temporary changes to normal activities at local level. Minor irreversible effects and/or larger numbers covered by reversible effects, localised.
Major	Long-term irreversible ecosystem change, spreading beyond local area, population loss or extinction of single species	Local and irreversible or widespread and reversible effects on one / several services	1,000,000-10,000,000 Euro	Some permanent change of activity locally, concern expressed over wider area. Significant irreversible effects locally or reversible effects over large area.
Massive	Long-term irreversible ecosystem change, widespread, population loss or extinction of several species	Widespread and irreversible effects on one / several services	Above 10,000,000 Euro	Long-term social change, significant loss of employment, migration from affected area. Widespread, severe, long-term, irreversible health effects.

⁵ Not to be confused with “no impact”.

ANNEX III Scoring of Confidence Levels

(modified from Bacher et al. 2017)

Each answer provided in the risk assessment must include an assessment of the level of confidence attached to that answer, reflecting the possibility that information needed for the answer is not available or is insufficient or available but conflicting.

The responses in the risk assessment should clearly support the choice of the confidence level.

Confidence level	Description
Low	There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence <i>and/or</i> Impacts are recorded at a spatial scale which is unlikely to be relevant to the assessment area <i>and/or</i> Evidence is poor and difficult to interpret, e.g. because it is strongly ambiguous <i>and/or</i> The information sources are considered to be of low quality or contain information that is unreliable.
Medium	There is some direct observational evidence to support the assessment, but some information is inferred <i>and/or</i> Impacts are recorded at a small spatial scale, but rescaling of the data to relevant scales of the assessment area is considered reliable, or to embrace little uncertainty <i>and/or</i> The interpretation of the data is to some extent ambiguous or contradictory.
High	There is direct relevant observational evidence to support the assessment (including causality) <i>and</i> Impacts are recorded at a comparable scale <i>and/or</i> There are reliable/good quality data sources on impacts of the taxa <i>and</i> The interpretation of data/information is straightforward <i>and/or</i> Data/information are not controversial or contradictory.

ANNEX IV CBD pathway categorisation scheme

Overview of CBD pathway categorisation scheme showing how the 44 pathways relate to the six main pathway categories. All of the pathways can be broadly classified into 1) those that involve intentional transport (blue), 2) those in which the taxa are unintentionally transported (green) and 3) those where taxa moved between regions without direct transportation by humans and/or via artificial corridors (orange and yellow). **Note that the pathways in the category “Escape from confinement” can be considered intentional for the introduction into the risk assessment area and unintentional for the entry into the environment.**



ANNEX V Ecosystem services classification (CICES V5.1, simplified) and examples

For the purposes of this risk assessment, please feel free to use what seems as the most appropriate category / level / combination of impact (Section – Division – Group), reflecting information available.

Section	Division	Group	Examples (i.e. relevant CICES “classes”)
Provisioning	Biomass	Cultivated <i>terrestrial</i> plants	Cultivated terrestrial plants (including fungi, algae) grown for <u>nutritional purposes</u>; <u>Fibres and other materials</u> from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials); Cultivated plants (including fungi, algae) grown as a <u>source of energy</u> <i>Example: negative impacts of non-native organisms to crops, orchards, timber etc.</i>
		Cultivated <i>aquatic</i> plants	Plants cultivated by in- situ aquaculture grown for <u>nutritional purposes</u>; <u>Fibres and other materials</u> from in-situ aquaculture for direct use or processing (excluding genetic materials); Plants cultivated by in- situ aquaculture grown as an <u>energy source</u>. <i>Example: negative impacts of non-native organisms to aquatic plants cultivated for nutrition, gardening etc. purposes.</i>
		Reared animals	Animals reared for <u>nutritional purposes</u>; <u>Fibres and other materials</u> from reared animals for direct use or processing (excluding genetic materials); Animals reared to provide <u>energy</u> (including mechanical) <i>Example: negative impacts of non-native organisms to livestock</i>
		Reared <i>aquatic</i> animals	Animals reared by in-situ aquaculture for <u>nutritional purposes</u>; <u>Fibres and other materials</u> from animals grown by in-situ aquaculture for direct use or processing (excluding genetic materials); Animals reared by in-situ aquaculture as an <u>energy source</u> <i>Example: negative impacts of non-native organisms to fish farming</i>
		Wild plants (terrestrial and aquatic)	Wild plants (terrestrial and aquatic, including fungi, algae) used for <u>nutrition</u>; <u>Fibres and other materials</u> from wild plants for direct use or processing (excluding genetic materials); Wild plants (terrestrial and aquatic, including fungi, algae) used as a <u>source of energy</u> <i>Example: reduction in the availability of wild plants (e.g. wild berries, ornamentals) due to non-native organisms (competition, spread of disease etc.)</i>
		Wild animals (terrestrial and aquatic)	Wild animals (terrestrial and aquatic) used for <u>nutritional purposes</u>; <u>Fibres and other materials</u> from wild animals for direct use or processing (excluding genetic materials); Wild animals (terrestrial and aquatic) used as a <u>source of energy</u>

			<i>Example: reduction in the availability of wild animals (e.g. fish stocks, game) due to non-native organisms (competition, predations, spread of disease etc.)</i>
	Genetic material from all biota	Genetic material from plants, algae or fungi	<u>Seeds, spores and other plant materials</u> collected for maintaining or establishing a population; Higher and lower plants (whole organisms) used to <u>breed new strains or varieties</u> ; Individual genes extracted from higher and lower plants for the <u>design and construction of new biological entities</u> <i>Example: negative impacts of non-native organisms due to interbreeding</i>
		Genetic material from animals	Animal material collected for the purposes of maintaining or establishing a population; Wild animals (whole organisms) used to breed new strains or varieties; Individual genes extracted from organisms for the design and construction of new biological entities <i>Example: negative impacts of non-native organisms due to interbreeding</i>
	Water⁶	Surface water used for nutrition, materials or energy	Surface water for <u>drinking</u> ; Surface water used as a material (<u>non-drinking purposes</u>); Freshwater surface water, coastal and marine water used as an <u>energy source</u> <i>Example: loss of access to surface water due to spread of non-native organisms</i>
		Ground water for used for nutrition, materials or energy	Ground (and subsurface) water for <u>drinking</u> ; Ground water (and subsurface) used as a material (<u>non-drinking purposes</u>); Ground water (and subsurface) used as an <u>energy source</u> <i>Example: reduced availability of ground water due to spread of non-native organisms and associated increase of ground water consumption by vegetation.</i>
Regulation & Maintenance	Transformation of biochemical or physical inputs to ecosystems	Mediation of wastes or toxic substances of anthropogenic origin by living processes	<u>Bio-remediation</u> by micro-organisms, algae, plants, and animals; <u>Filtration/sequestration/storage/accumulation</u> by micro-organisms, algae, plants, and animals <i>Example: changes caused by non-native organisms to ecosystem functioning and ability to filtrate etc. waste or toxics</i>
		Mediation of nuisances of anthropogenic origin	<u>Smell reduction</u> ; <u>noise attenuation</u> ; <u>visual screening</u> (e.g. by means of green infrastructure) <i>Example: changes caused by non-native organisms to ecosystem structure, leading to reduced ability to mediate nuisances.</i>
	Regulation of physical, chemical, biological conditions	Baseline flows and extreme event regulation	Control of <u>erosion</u> rates; Buffering and attenuation of <u>mass movement</u> ; <u>Hydrological cycle and water flow regulation</u> (Including flood control, and coastal protection); <u>Wind</u> protection; <u>Fire</u> protection

⁶ Note: in the CICES classification provisioning of water is considered as an abiotic service whereas the rest of ecosystem services listed here are considered biotic.

			Example: changes caused by non-native organisms to ecosystem functioning or structure leading to, for example, destabilisation of soil, increased risk or intensity of wild fires etc.
		Lifecycle maintenance , habitat and gene pool protection	Pollination (or 'gamete' dispersal in a marine context); <u>Seed dispersal</u> ; Maintaining <u>nursery populations and habitats</u> (Including gene pool protection) Example: changes caused by non-native organisms to the abundance and/or distribution of wild pollinators; changes to the availability / quality of nursery habitats for fisheries
		Pest and disease control	Pest control; Disease control Example: changes caused by non-native organisms to the abundance and/or distribution of pests
		Soil quality regulation	<u>Weathering processes</u> and their effect on soil quality; <u>Decomposition and fixing processes</u> and their effect on soil quality Example: changes caused by non-native organisms to vegetation structure and/or soil fauna leading to reduced soil quality
		Water conditions	Regulation of the <u>chemical condition</u> of freshwaters by living processes; Regulation of the chemical condition of salt waters by living processes Example: changes caused by non-native organisms to buffer strips along water courses that remove nutrients in runoff and/or fish communities that regulate the resilience and resistance of water bodies to eutrophication
		Atmospheric composition and conditions	Regulation of <u>chemical composition</u> of atmosphere and oceans; Regulation of <u>temperature and humidity</u> , including ventilation and transpiration Example: changes caused by non-native organisms to ecosystems' ability to sequester carbon and/or evaporative cooling (e.g. by urban trees)
Cultural	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through <u>active or immersive interactions</u> ; Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through <u>passive or observational interactions</u> Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that make it attractive for recreation, wild life watching etc.
		Intellectual and representative interactions with natural environment	Characteristics of living systems that enable <u>scientific investigation</u> or the creation of traditional ecological knowledge; Characteristics of living systems that enable <u>education and training</u> ; Characteristics of living systems that are resonant in terms of <u>culture or heritage</u> ; Characteristics of living systems that enable <u>aesthetic experiences</u>

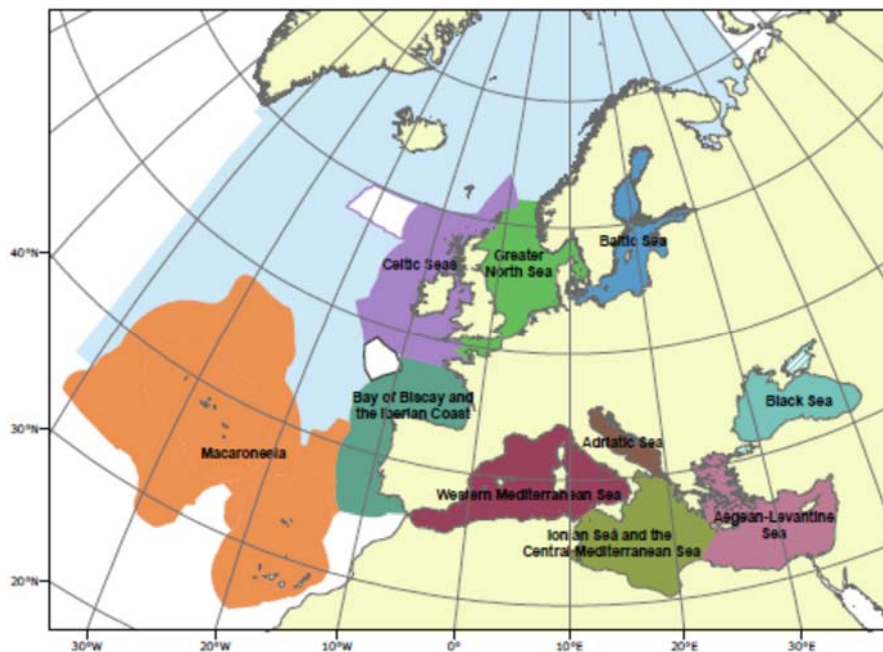
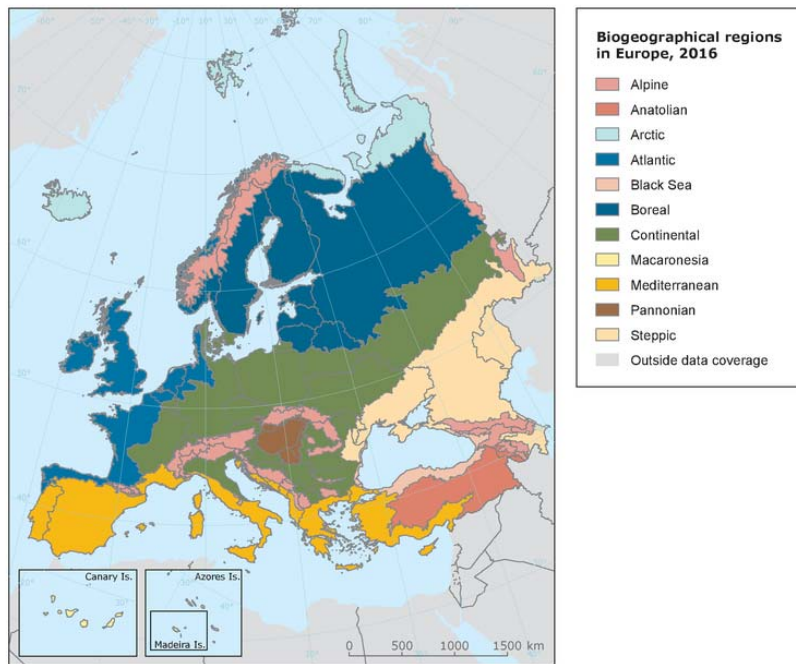
			<i>Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that have cultural importance</i>
	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems that have <u>symbolic meaning</u>; Elements of living systems that have <u>sacred or religious meaning</u>; Elements of living systems used for <u>entertainment or representation</u> <i>Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that have sacred or religious meaning</i>
		Other biotic characteristics that have a non-use value	Characteristics or features of living systems that have an <u>existence value</u>; Characteristics or features of living systems that have an <u>option or bequest value</u> <i>Example: changes caused by non-native organisms to ecosystems designated as wilderness areas, habitats of endangered species etc.</i>

ANNEX VI EU Biogeographic Regions and MSFD Subregions

See <https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2> ,
http://ec.europa.eu/environment/nature/natura2000/biogeog_regions/

and

<https://www.eea.europa.eu/data-and-maps/data/msfd-regions-and-subregions-1/technical-document/pdf>



ANNEX VII Delegated Regulation (EU) 2018/968 of 30 April 2018

see <https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32018R0968>

ANNEX VIII Projection of environmental suitability for establishment in Europe

See separate files.