

EPPO data sheet on Invasive Alien Plants
Fiches informatives sur les plantes exotiques envahissantes

Heracleum mantegazzianum*, *Heracleum sosnowskyi* and *Heracleum persicum

Identity of *Heracleum mantegazzianum*

Scientific name: *Heracleum mantegazzianum* Sommier & Levier

Synonyms: *Heracleum circassicum* Mandenova, *Heracleum grossheimii* Mandenova, *Heracleum giganteum* Hornemann.

Taxonomic position: Apiaceae.

Common names: giant hogweed, giant cow parsnip, cartwheel flower (English), kæmpe-bjørneklo (Danish), berce du caucase, berce de Mantegazzi (French), Herkulesstaude, Riesenbärenklau, kaukasischer Bärenklau (German), kaukasianjätiputki (Finnish), kjempebjørnnkjeks (Norwegian), barszcz mantegazyjski (Polish), kaukasisk jättefloka (Swedish), hiid-karuputk (Estonian), tröllahvönn, bjarnarkló (Icelandic), mantegaca latvnis (Latvian), mantegaco barštis (Lithuanian), reuzenberenklauw (Dutch) (Klingenstein, 2006), bolševník velkolepý (Czech).

EPPO code: HERMZ.

Notes on taxonomy and nomenclature

Nomenclature is difficult due to unclear taxonomy. *Heracleum mantegazzianum* and related tall *Heracleum* spp. originate from the Caucasus region (one of two centres of diversity for *Heracleum* spp., the other being China), and synonymy therefore depends on botanical explorations in that region. The main sources of synonymy are: (i) historical – before the taxonomic description of a full range of *Heracleum* spp., plants were referred to as those described first (beginning of the 19th century); (ii) modern – due to intensive taxonomic work by Russian botanists (in the 20th century), who generally accept a narrower species concept. Historical synonyms include: *Heracleum speciosum* Weinmann, *Spondylium pubescens* Hoffmann and *Pastinaca pubescens* (Hoffmann) Calestani. These were early names that are no longer in taxonomic use and cannot be regarded as true synonyms. *Heracleum pubescens* (Hoffmann) Marschall von Bieberstein (now considered an endemic of Crimea, Ukraine) was the first tall *Heracleum* sp. to be described (in 1819), and many plants were later referred to as this species. Modern synonyms are quoted above (see

‘synonyms’). Other historical synonyms include *Heracleum asperum* Marschall von Bieberstein, *Heracleum caucasicum* Steven, *Heracleum lehmannianum* Bunge, *Heracleum panaces* Steven, *Heracleum stevenii* Mandenova, *Heracleum tauricum* Steven and *Heracleum villosum* Sprengel. The names of two other species now naturalized in Europe (*Heracleum persicum* Fischer and *H. sosnowskyi* Mandenova) are also historical synonyms of *H. mantegazzianum*. The name *Heracleum trachyloma* Fischer & C.A. Meyer has recently been used for the most widespread *Heracleum* sp. naturalized in the UK (Sell & Murrell, 2009).

Phytosanitary categorization: EPPO List of invasive alien plants.

Identity of *Heracleum sosnowskyi*

Scientific name: *Heracleum sosnowskyi* Mandenova

Taxonomic position: Apiaceae.

Common names: Sosnowskyi’s hogweed (English), ope Cococoo (Russian), sosnovska latvānis (Latvian), sosnovskio barštis (Lithuanian), sosnovski karuputk (Estonian), barszcz Sosnowskiego (Polish), Sosnowsky’s Bärenklau (German), bolševník Sosnowského (Czech).

EPPO code: HERSO.

Notes on taxonomy and nomenclature

Heracleum sosnowskyi was only described in 1944, so, until then, plants of this species were recorded as some of the previously described *Heracleum* spp. These include *H. pubescens* (described in 1819 from Crimea and Eastern Greater Caucasus, now considered as endemic of Crimea, Ukraine), *H. wilhelmsii* (described in 1841 from Georgia) or *H. mantegazzianum* (described in 1895 from Western Greater Caucasus) (Jahodová *et al.*, 2007). The plants naturalized in the Western European countries have generally been known as *H. mantegazzianum*, without consideration of the possibility that *H. sosnowskyi* or another invasive *Heracleum* sp. (e.g. *H. persicum* Fischer) might also be present.

Phytosanitary categorization: EPPO A2 list of pests recommended for regulation.

Identity of *Heracleum persicum*

Scientific name: *Heracleum persicum* Fischer

Synonyms: *Heracleum laciniatum* auct. scand., non Hornem, *H. tromsoensis*, *H. Cf. pubescens* Marschall von Bieberstein.

Taxonomic position: Apiaceae.

Common names: persischer Bärenklau (German), perzische bereklauw (Dutch), Tromsøpalme (Norwegian), persianjäätputki (Finnish).

Eppo code: HERPO.

Notes on taxonomy and nomenclature

This plant was described in 1829 and some of the subsequent identifications of the plant as *Heracleum persicum* were probably mistaken with *H. mantegazzianum* and *H. sosnowskyi* (Nielsen *et al.*, 2005). In Norwegian, Danish and Swedish floras, the plant has been called *H. laciniatum*, but recent morphological and genetic analyses have shown that it is synonymous with *H. persicum* (Jahodová *et al.*, 2007; Lars Fröberg, unpublished data).

Phytosanitary categorization: EPPO A2 list of pests recommended for regulation.

Geographical distribution of *Heracleum mantegazzianum*

Eppo region: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Georgia (native), Germany, Hungary, Iceland, Ireland, Italy, Liechtenstein, Netherlands, Norway, Poland, Russia (Southern Russia) (native), Slovakia, Sweden, Switzerland, United Kingdom.

Asia: Georgia (native).

North America: Canada (British Columbia, Ontario, Newfoundland), USA (Connecticut, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, New York, Oregon, Pennsylvania, Vermont, Washington).

Oceania: Australia, New Zealand.

Note: the plant is listed as a noxious weed not occurring in North Carolina and Florida.

History of introduction and spread

Heracleum mantegazzianum is native to the Western Greater Caucasus (Russia, Georgia). It is now becoming widely naturalized throughout Western Europe with a continuing increase in its distribution. It is considered invasive in most of the countries where it has repeatedly been introduced as a garden ornamental from the 1800s, after which there has been natural spread along rivers. The first known record in Europe came from the Royal Botanic Garden, Kew (UK) in 1817. Details on the spread of *H. mantegazzianum* across Europe are summarized by Jahodová *et al.* (2007). It was introduced as early as 1917 into North America as a garden curiosity. In Canada, the first record of *H. mantegazzianum* comes from a herbarium specimen collected in Ontario in 1949, although it may have been present in British Columbia in the 1920s or 1930s. Further spread has recently been observed in the USA, with

new state records from Vermont in 2002, Maryland and Michigan in 2003 and Indiana in 2004 (NAPIS, 2004).

In the Czech Republic, a front of populations of *H. mantegazzianum* has been observed advancing at an average rate of about 10 m per year, the total area increasing by some 1200 m² each year. The number of host localities has doubled every 14 years during the phase of rapid invasion (Pyšek *et al.*, 2007).

Geographical distribution of *Heracleum sosnowskyi*

Eppo region: Armenia (native), Azerbaijan, Belarus, Estonia, Georgia (native), Germany, Hungary, Latvia, Lithuania, Poland, Russia (Karachay-Cherkessia, Kabardino-Balkaria, North Ossetia, Ingushetia, Chechnya, Dagestan and possibly Black Sea coast) (native) Central and Northern Russia (introduced), Turkey (introduced), Ukraine (introduced).

History of introduction and spread

Heracleum sosnowskyi is native to the Eastern and Central Caucasus (first described from Georgia), Central, Eastern and South-Western Transcaucasia and N.E. Anatolia in Turkey. It was introduced into North-West Russia at the end of the 1940s, for evaluation in experimental farms as a potential forage crop. From the 1960s, it was cultivated for forage over wider areas in Russia, Belarus, Ukraine and the Baltic States. It was also tested in the former German Democratic Republic, Hungary and Poland. *Heracleum sosnowskyi* started to spread very rapidly at the end of the 1980s as agricultural production systems and markets changed. In Russia, *H. sosnowskyi* has been hybridized in breeding programmes, with various other *Heracleum* spp. from different parts of the former USSR. Such hybrids may also have been naturalized. In 2008, the Latvian NPPO detected 7956 ha of territories invaded by *H. sosnowskyi*.

Geographical distribution of *Heracleum persicum*

Eppo region: Denmark, Finland, Norway, Sweden.

Asia (native): Iran, Iraq, Turkey.

Note: Possible occurrence in Hungary and in the UK.

History of introduction and spread

The earliest record for introduction originates from the seed list at the Royal Botanic Garden, Kew (UK), where the plant was received in 1819. Seeds from London populations of a similar plant were taken by English horticulturalists and planted in northern Norway as early as 1836 (Nielsen *et al.*, 2005). The species may have been sent to botanical gardens around Europe, but surprisingly, naturalized populations are only reported from Scandinavia, principally from Norway.

Heracleum persicum is known as the Tromsøpalm as it is the most common of the *Heracleum* sp. in Northern Norway. *Heracleum persicum* is in a stage of rapid expansion in the North and

East of Norway especially in the region around Trondheim (Fremstad & Elven, 2006; Fremstad, 2007).

In Finland, *H. persicum* is established but rare in the South of Finland and found occasionally in the North. *Heracleum persicum* has been established in Northern Sweden since the 1940s with seeds originating from Norway. It is found locally in Northern Sweden around settlements and towns (Oftén & Ericsson, 1996).

Morphology

Plant type

Heracleum mantegazzianum and *H. sosnowskyi* are herbaceous, monocarpic, perennial, seed-propagated plants (Tkachenko, 1989). *Heracleum persicum* is a herbaceous, polycarpic (flowering several times) perennial seed-propagated plant.

Description of *Heracleum mantegazzianum*

Heracleum mantegazzianum grows from a yellow branched root system 40–60 cm deep, which reaches 15 cm in diameter at the crown when mature. The species persists in the form of a vegetative rosette for several years, and then flowers (after the plant has accumulated enough resources for reproduction). Perglová *et al.* (2007) report that *H. mantegazzianum* is strictly monocarpic and dies after flowering, but there are some reports of polycarpy. The flowering stem can reach 5 m in height and 10 cm in diameter at the base. The stem is ridged, with purple blotches, and covered with pustulate bristles. Leaves are alternate, up to 3 m long and 1.7 m wide, ternately or pinnately lobed and coarsely toothed; upper leaves are progressively smaller, with the upper leaf surface glabrous and the underside pubescent, as is the petiole. The inflorescences are compound umbels of four orders. The main inflorescence (first-order) is a terminal compound umbel up to 80 cm in diameter with about 100 unequal hairy rays, each 10–40 cm long. There are also up to 8 satellite umbels which usually overtop the main one, and others developing on branches below. The main umbel is hermaphrodite; the umbels of higher orders, maturing later, may be only male. Flowers, on pedicels 10–20 mm long are white or pinkish with petals up to 12 mm long. Fruits are flattened and elliptical; 6–18 mm long by 4–10 mm wide; narrowly winged; with the larger fruits occurring on the main inflorescence and the smaller on satellites and branches, glabrous to villous; splitting into two mericarps; each with 3–5 elongated oil canals.

Description of *Heracleum sosnowskyi*

Heracleum sosnowskyi is closely related to *H. mantegazzianum* and can easily be confused with it. Plants have a thick taproot and are usually smaller than those of *H. mantegazzianum* since they are up to 3 m tall instead of 5 (Nielsen *et al.*, 2005). *Heracleum sosnowskyi* is distinguishable by having less divided leaves, the leaves of mature plants being divided to a varying extent, either into three approximately equal parts, which may themselves be similarly divided, or into more than three leaflets arranged in rows along the central rachis (pinnate). Outer petals

are radiate, 9–10 mm long, while those of *H. mantegazzianum* are 12 mm long. The fine hirsute indumentum of the rays of the umbel is also characteristic of this species. Each compound umbel has 30–150 rays (Nielsen *et al.*, 2005) and only short hairs. Fruits are oval to elliptical, broadly winged and comprise a pair of mericarps, which separate from each other before being shed, each containing a seed. Fruits from the terminal umbels tend to be smaller: some 10.5–16.5 mm long and 5.3–8.7 mm wide (Moravcová *et al.*, 2007). Mature fruits are brown with swollen brown oil canals $\frac{3}{4}$ of the length of the fruits. This is a distinctive character of the species.

Description of *Heracleum persicum*

Heracleum persicum is closely related to *H. mantegazzianum* and can easily be confused with it.

Plants are most often 1–2 m in height, especially for newly established plants, but can reach 3–4 m. Each plant often has more than one stem. Each stem is purple, 1.5 to 2 cm thick, with large even areas of purple to purple-red colour at the base. Leaves are more divided than for *H. mantegazzianum*. They may be up to 2 m in length and deeply incised with very sharp points, with 2–3 pairs of lateral leaf segments and less deeply serrate. The whole plant smells of aniseed.

Umbels of *H. persicum* are more convex than those of *H. mantegazzianum*, which has flat umbels. Whereas *H. mantegazzianum* has especially large umbels with side umbels as well developed as the main umbel, and all umbels develop fruit, the side umbels of *H. persicum* are rather small compared with the main umbel and often do not develop fruit. According to Lars Fröberg (Fremstad & Elven, 2006), another characteristic which may be used in distinguishing the two species is the shape and placement of hairs on the two plants. *Heracleum mantegazzianum* has transparent, very curly hairs which stand out at 45

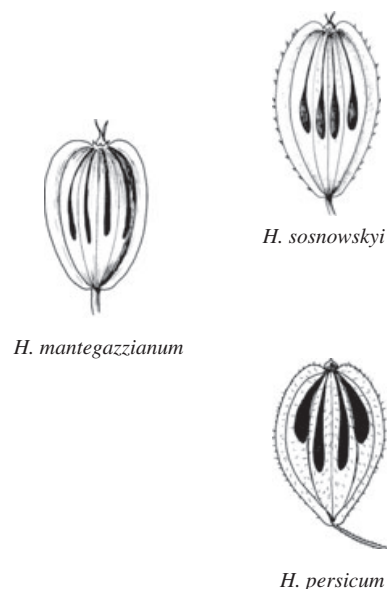


Fig. 1 Drawings of *H. mantegazzianum*, *H. sosnowskyi* and *H. persicum* seeds by J. C. Schou (in Nielsen *et al.*, 2005).

degrees from the stem. *Heracleum persicum* has somewhat stiffer and whiter hairs, which stand straight out from the stem.

The morphological characteristics of *H. persicum* vary according to the environmental conditions in which it grows, which makes identification difficult.

Similarities to other species

Heracleum spp. hybridize easily, thus causing confusion in identification. The common *Heracleum* spp. in Europe, *H. sphondylium*, *H. sibiricum* and the correspondingly common species in the USA, *H. montanum* Bartr. (= *H. lanatum* Michx.) are not easily confused with *H. mantegazzianum*, being much smaller, rarely over 2 m high, with grey-green, pubescent and less acutely toothed leaves.

Biology and ecology

Heracleum mantegazzianum

Seeds germinate in early spring after dormancy is broken by the cold and wet conditions of autumn and winter, by temperatures within the range of 1–6°C (Moravcová *et al.*, 2007). Germination then occurs from January to March in the United Kingdom. Drying tends to delay eventual germination or results in a requirement for additional or longer stratification. Exposure to light is apparently not required for germination. After germination, a strong tap-root is formed which soon contracts to pull the crown downwards. In the Czech Republic, the first leaves of the rosette are usually visible at the end of February or in March (they often start growth under the snow cover). Stem elongation is apparent at the end of May and the peak of flowering occurs at the end of June and beginning of July. The first true leaf develops in April, small and almost round, replaced in succession by steadily larger leaves, the fifth or sixth taking the adult form. The established vegetative plant has 3–4 functional leaves at any time.

Flowering occurs mainly in the third year of growth but under unfavourable conditions such as grazing, cutting or nutrient deficiency, flowering is postponed until sufficient reserves have been accumulated. In pastures, flowering may be delayed up to 7 years, which appears to be driven by the size of the crown and reserves in the root system. Individuals 12 years old have been reported from extremely dry sites (Pergl *et al.*, 2006).

The flowers of *H. mantegazzianum* are insect-pollinated and self-compatible (Perglová *et al.*, 2007). Self-pollination has been identified as advantageous in some colonizing species (Rejmánek *et al.*, 2005) and may lead to accelerated spread (Daehler, 1998). *Heracleum mantegazzianum* has unspecialized flowers which are pollinated by unspecialized insects; Coleoptera, Diptera, Hemiptera and Hymenoptera are the most frequent visitors (Grace & Nelson, 1981).

Most fruits ripen in the second half of July and start to be released (Perglová *et al.*, 2007). Propagation is exclusively by seeds, which are produced in very large numbers. Some 10 000 to 20 000 fruits are produced per plant in Europe, the maximum reaching some 50 000 fruits (Perglová *et al.*, 2007). Each mericarp contains one seed (Moravcová *et al.*, 2007). Seeds may

remain viable for up to 15 years when stored dry, but in the field this period is apparently much shorter – only 8.8% of seeds buried in the soil survived 1 year, 2.7% lasted 2 years and 1.2% remained viable and dormant after 3 years (Moravcová *et al.*, 2007). Correspondingly, no viable seeds were found in a *Heracleum* site after 7 years of sheep grazing (Andersen & Calov, 1996). The vertical distribution of seeds in the soil seed bank shows that 94% of the total seeds, including dead seeds, are in the upper 0.5 cm of the soil layer, with few in the deeper layers of 6–10 cm and 11–15 cm (Moravcová *et al.*, 2007). In the United Kingdom, the above ground parts of the vegetative plants senesce and die back in late September/October.

The chromosome number of *H. mantegazzianum* is $2n = 22$, as in most, if not all *Heracleum* sp. Hybridization is recorded with *H. sphondylium* in Germany and the United Kingdom (Ochsmann, 1996; Tiley *et al.*, 1996), but this is relatively infrequent even where the two species occur together, perhaps because of the lack of common insect visitors for pollination. The hybrids are virtually sterile.

Heracleum sosnowskyi

Seeds germinate in early spring after morphophysiological dormancy is broken by the cold and wet conditions of autumn and winter. Autumn germination under favourable conditions may also be possible (though not observed), as seeds of *H. sosnowskyi* require a shorter period of cold stratification to break dormancy (2 months or less) than those of *H. mantegazzianum* (Moravcová *et al.*, 2007). Experiments in the Czech Republic have shown that the seed bank is very quickly depleted by rapid germination in spring and seeds do not survive for more than one season. However, experiments in regions where *H. sosnowskyi* is invasive are needed to verify this. Germination of *H. sosnowskyi* seeds under laboratory conditions is very high (71–94% in different temperature regimes) (Moravcová *et al.*, 2007).

Flowering occurs from June to August. As with *H. mantegazzianum*, the flowers of *H. sosnowskyi* are insect pollinated, visited by a wide range of insects, including a number of Hymenoptera, Diptera and Coleoptera. The plant is reported to live up to 6 years when planted for biomass and silage production (Satsyperova, 1984). Propagation is exclusively by seeds. An average plant of *H. sosnowskyi* is reported to have produced 8836 fruits in the Leningrad area, Russia (Tkachenko, 1989). The majority of seeds (98.2%) are distributed in the upper soil layer of 0–5 cm, with little in the deeper layers of 6–10 cm and 11–15 cm (Moravcová *et al.*, 2007). Seeds are dispersed locally near the parent plants over longer distances by watercourses. When the plant is established, its huge size, fast growth and voluminous green mass suppress companion plant species, so that it forms a single-species stand.

Heracleum persicum

The plant has a growth and development similar to those of *H. mantegazzianum*. Pollination by insects is common, but self-pollination also occurs. The species is spread by seeds and does not reproduce vegetatively. Because the side umbels of the plant are

often poorly developed and do not always produce ripe fruits, the potential of *H. persicum* for seed production is thought to be inferior to that of *H. mantegazzianum*. The leaves of *H. persicum* wilt in the autumn, but the plant over winters with buds below the soil surface. Nutrients are stored in the root system and the size and development of the root system determine the time for flowering.

The plant needs one or more years to build up a nutrient reserve in its root system to be able to flower.

Habitat

Heracleum mantegazzianum in its native range is a plant of forest edges and glades, often alongside streams, in mountain areas with annual rainfall of 1000–2000 mm, characterized by temperate, continental climates of hot summers and cold winters. The species is a good colonizer of open and bare ground, and benefits from man-induced habitat disturbances (i.e. a pioneer species). Both in the native and introduced range it can be found forming dense populations in man-made stands. In the introduced range, a high proportion of stands include rivers, roads, railway banks, damp places, rubbish dumps and waste ground (Pyšek & Prach, 1993; Pyšek & Pyšek, 1995; Tiley *et al.*, 1996). In addition to rural habitats, the plant occurs in urban areas, gardens and parks (Pyšek & Pyšek, 1995). Although it is generally a plant of open ground, it can establish and grow successfully in woodland, the edges of clearings, and partially shaded habitats.

According to a German study (Thiele *et al.*, 2007), the most common habitat types are linear structures along traffic routes (roadsides, railway margins) and flowing waters. These habitats can be completely open or partly shaded by tree lines, single trees or shrubs. *Heracleum mantegazzianum* can often be found at fringes and margins of woodlands and grasslands. In terms of area covered by stands of *H. mantegazzianum*, abandoned grasslands are the most represented habitat types, followed by tall-herb stands which can be found at long-abandoned former grassland sites or at other disused sites. Ruderal places (i. e. site that recently have been severely disturbed by human activities) are suitable habitats (e. g. sand pit, building sites, rubbish dumps). Managed grasslands are marginal habitats, as the plant is not invasive as long as regular management is applied. Moreover, Thiele *et al.* (2007) found out according to their study in Germany that sites invaded by *H. mantegazzianum* are not subject to regular land use except for marginal occurrences in managed grasslands. Indeed, 71% of plots examined were disused, 17% were maintained by rather irregular mowing or removal of shrubs and trees, and only 12% of sites were under agricultural land use.

The native range of *H. sosnowskyi* is in the Caucasus where it grows in mountain areas alongside streams, in forests or in alpine meadows. The climate in the natural habitat is continental, with hot summers and cold winters. In other areas, *H. sosnowskyi* has been introduced as an agricultural crop and has spread rapidly, infesting grasslands, forests, wetlands, riverbanks/canal sides, rail/roadsides, urban areas, as well as abandoned agricultural land, particularly in Latvia (Thiele *et al.*, 2007).

Heracleum persicum colonizes the same habitats as *H. mantegazzianum*: cultural landscapes, areas strongly influenced by

anthropogenic factors, urban areas (along roadsides and railroads), grasslands and wetlands (Klingenstein, 2006). It is common in meadows, pasturelands or agricultural fields that are no longer in use and in ruderal areas or wastelands, as well as in riparian habitats, growing along streams and rivers. It has been reported growing on mountainsides and on mountain slopes and in cracks where the soil layer is quite thin, but it is not known whether it will flower in this habitat. It has also been found in coastal habitats (beaches) where *H. mantegazzianum* has not been found. In Tromsø, *H. persicum* has been found growing among the seaweed vegetation on beaches. Its presence on unpopulated islands indicates that it may be spread with sea water (Alm, 1988; Alm & Jensen, 1993). In Norway it is becoming more common growing at the edge of forests and has been reported as growing in the birch forest (*Betula* spp.) probably because of the high light conditions of this ecosystem (Fremstad & Elven, 2006). It does not flower in the forest, but survives for a long time in the shade under the trees.

Environmental requirements

Climatic preferences include temperate (no dry season), and cold (no dry season) climatic regions, with reasonable moisture and cold winters. Cold winters are required to ensure germination. Moist conditions are favoured for much of the year, but moderate summer droughts can be tolerated (Tiley *et al.*, 1996). *Heracleum mantegazzianum* tends to be associated with lowland sites in the United Kingdom, mainly due to the sources of infestation being originally associated with gardens in the lowlands, and not due to a climatic limitation (Willis & Hulme, 2002). The seeds are shown to germinate at all elevations up to 600 m in North-East England. In the Czech Republic the plants occur in a wide range of altitudes from 154 to 1249 m. In the native distribution range it grows in the altitudes up to 2200 m (Otte & Thiele, 2007).

A study by Thiele *et al.* (2007) in Germany showed that *H. mantegazzianum* needs fairly high nutrient rich soils and moisture levels for optimal growth. With respect to pH values, *H. mantegazzianum* was found in a wide range of conditions from acidic to alkaline. Extreme values were 4.0 and 8.5. In its native distribution range, it was found growing on soils of pH ranging from 5.34 to 6.68 (Pergl *et al.*, unpublished data). Occurrence along riverbanks is usually associated with sandy or silty soils, but a wide range of soil textures are also tolerated from gravels to clay and highly organic or waterlogged soils. It is occasionally found close to the sea and apparently has some tolerance of salt spray. Growth of the species in semi-shade is fairly good, but it cannot grow in full shade (Thiele *et al.*, 2007).

Heracleum sosnowskyi develops in fresh and slightly moist, neutral soils, rich in nutrients, in the pH range 6.3–7.0. *Heracleum sosnowskyi* communities have developed in artificial and seminatural habitats over the last 20 years. They are nitrophilous and their expansion is stimulated by eutrophication of the environment (Laivins & Gavrilova, 2003). *Heracleum sosnowskyi* is a light demanding plant which cannot tolerate shade in the first growth stages (Obolviča, 2001). Nevertheless, it is considered more shade-tolerant than *H. mantegazzianum* (Nielsen *et al.*, 2005).

Climatic and vegetational categorization

Heracleum mantegazzianum is associated with areas with warm to hot summers and cool winters. It is not favoured by drier conditions. Hardiness is not specified, but the plant is probably hardy to zone 6 (−23 to −18°C). It is associated with the vegetation zones: temperate deciduous forests and mixed conifer forests.

A study of climatic effects on *H. mantegazzianum* in its invaded range in the Czech Republic conducted by Pyšek *et al.* (1998) showed that the distribution of the species was significantly affected by January isotherm; the species was less represented in areas with warmer January isotherm.

Heracleum sosnowskyi, like *H. mantegazzianum*, is associated with areas with warm to hot wet summers and cool wet winters. It is considered to be more suited to continental climates and is not adapted to drier conditions. It is winter hardy down to −25°C. The new shoots of *H. sosnowskyi* are rather cold-resistant and can survive −4 to −7°C. It is found that starting from the second year, they can survive up to −25°C, and under a snow cover, even down to −45°C (Oboloviča, 2001). Seeds germinate in early spring (but not during summer) and require a period of cold stratification for breaking dormancy (<2 months).

Natural enemies

Surveys for natural enemies in the native area of the Caucasus were conducted in 2002 with the aim of identifying potential biological control agents (Seier *et al.*, 2003). Many fungi were found associated with *H. mantegazzianum*, most species being new records for this host. However, none of the pests assessed, either insects or fungal pathogens, exhibited sufficient specificity to be considered safe for introduction into Europe (Cock & Seier, 2007).

Uses and benefits

Heracleum mantegazzianum has been widely grown as an ornamental plant in Europe, because of its striking appearance and usefulness in flower arranging. It is reported to be widely sown in Switzerland by bee-keepers to increase food resources for bees (Westbrooks, 1991).

Heracleum sosnowskyi has been cultivated for silage and honey production in Russia and the Baltic States. Average yield of green matter reached 50–100 t ha^{−1} in the third year of growing. Honey yield per plant was theoretically 12.7 g from one plant or 270 kg ha^{−1}. In Russia, two cultivars were grown, ‘Uspek’ and ‘Severzhanin’.

Heracleum persicum has also been used as an ornamental.

Pathways of movements

Natural dispersal

Propagation is exclusively by seeds, which are produced in very large numbers (on average 20 000 seeds per plant, occasionally reaching 50 000 according to Perglová *et al.*, 2007).

The majority of seeds are released into a short-term seed bank in close vicinity to the parent plant. In individuals of about 2 m tall, 60–90% of seeds fall to the ground within a radius of 4 m of the parent plant (Nielsen *et al.*, 2005). Short-distance dispersal (2–10 m) is by wind, while longer-distance dispersal is achieved by water, the seeds being able to float for at least 3 days (Pyšek, 1994). No dispersal by birds has been observed (Neiland, 1986).

Accidental transport

Transport is also assisted by human activity: collection of ornamental seed-heads followed by disposal on rubbish heaps; movement of soil during building and excavation; movement along roads or railways by attachment to vehicles or by air currents; movement by agricultural and forest tractors, which carry seed on radiators and roofs. The seed can also be transported attached to clothes or animal hides (e.g. sheep and cattle) (Nielsen *et al.*, 2005).

Agricultural practices

Bee-keepers have played a significant role in spreading *H. mantegazzianum*, as it is a preferred food plant for honeybees (Reinhardt *et al.*, 2003). *Heracleum sosnowskyi* was widely planted as a forage crop (see *History of introduction and spread*).

Movement in trade

The deliberate introduction of *H. mantegazzianum* (as well as *H. persicum*) is likely, since it is used as an ornamental plant. Seeds are available from commercial nurseries via mail order catalogues and from websites in, for example, Canada, Netherlands and the United Kingdom. Seeds can also be a contaminant of food products in international trade, and Fowler (1998) notes that *H. mantegazzianum* is one of the three most common regulated species to be detected at entry points to USA, comprising 14% of all such detections, one pathway being the accidental contamination of cumin seeds (*Carum carvi*) (Westbrooks, 1991).

The key pathway for *H. sosnowskyi* is intentional introduction as a feed plant and a melliferous plant for bees.

Impact

Heracleum mantegazzianum, *H. sosnowskyi* and *H. persicum* have negative impacts on biodiversity and on the environment in general, on human health and tourism.

Effects on plants

There are no records of direct impact on crops. *Heracleum mantegazzianum* is not normally a weed of crops but there are reports of its encroachment into crop fields, for example in potatoes in Sweden, and it has also been seen invading pastures. In Latvia alone, the total cost of the 2006–2012 control program of this

species was estimated at 12 million EUR (Cabinet of Ministers Order No. 426, 2006).

Heracleum persicum, as well as the two other *Heracleum* spp., block sunlight from penetrating to the undergrowth and suppress other vegetation. The leaves of *H. persicum* contain allelopathic substances which may act as growth inhibitors on other plants as the leaves decompose (Myrás, 1978).

For these species, significant costs are incurred by the measures taken to control the weed in amenity and other areas and to turn the land back to agriculture, and this activity is also likely to increase soil erosion along stream banks where they occur.

Heracleum spp. can create stands that may range in extent from square metres to hectares; small patches, linear stands or fringes can be found. The density of populations may also vary: in large stands, it ranges from sparse growth (1–3 adult individuals/10 m²) to almost entire ground cover (more than 20 adult individuals/10 m²) (Nielsen *et al.*, 2005). Cover of *H. mantegazzianum* in the vegetation sampled in a German study varied between 1% and 95% (Thiele & Otte, 2007). In 31% of sampled plots, it was dominant, with cover exceeding 50%. The enormous height and leaf area of *H. mantegazzianum* is assumed to overgrow most (indigenous) plant species and hence to be in competition with them for light, absorbing up to 80% of incoming light in dense stands. A strong decline in species richness has been observed in abandoned grasslands and ruderal habitats in Latvia due to the presence of *H. sosnowskyi* (Nielsen *et al.*, 2005). In amenity areas, established colonies compete strongly with, and rapidly replace most other plants except trees. Along riverbanks, it can almost totally replace the natural vegetation and threaten biodiversity, including fauna associated with (native) plants, building a 'giant hogweed landscape' (Nielsen *et al.*, 2005).

Nevertheless, since many stands of the species are linear, the biodiversity effects are often overestimated, as light can filter in from the sides (Starfinger & Kowarik, 2003). According to the study made in Germany by Thiele & Otte (2007), observed impacts on plant communities and local plant species richness are largely driven by successional changes following abandonment of land use or after large-scale disturbance. In the course of succession, competitive native tall herbs, such as *Urtica dioica*, have similar impacts on resident vegetation. Therefore, these impacts could be seen as symptoms of human-driven changes rather than a particular effect of *H. mantegazzianum*. Moreover, although *H. mantegazzianum* affects up to 10% of the area of suitable habitats in the study area, it appears that regional populations of native plant species have not been endangered until now as these co-occurring species are very common.

Heracleum mantegazzianum can lead to riverbank erosion through the suppression or exclusion of native species, which play an important role in riverbank stabilization. When *H. mantegazzianum* plants in dense stands die off in winter, they leave bare soil that can be eroded by rainfall or winter floods. Deposition of eroded silt can alter substrate characteristics in rivers, and, for example, render gravel substrates unsuitable for salmonid spawning (Thiele & Otte, 2007).

Environmental and social impact

Hybrids are possible in the genus *Heracleum* (Gavrilova, 2003). Hybrids between *H. mantegazzianum* and native *H. sphondylium* are reported from Great Britain (McClintock, 1975) and Germany (Ochsmann, 1996). They are found in sites where the two species grow together, although they are not numerous (Grace & Nelson, 1981; Stewart & Grace, 1984). Hybridization of both *H. mantegazzianum* and *H. sosnowskyi* with the native *Heracleum sibiricum* is expected in Lithuania (pers. comm. Z. Gudžinskas). Hybridization seems possible between *H. sphondylium* and *H. mantegazzianum* (Perrier, 2001) but occurs very rarely. Hybridization between *H. mantegazzianum* and *H. sosnowskyi* is possible (Klingenstein, 2006).

Heracleum mantegazzianum, *H. sosnowskyi* and *H. persicum* contain photosensitizing furanocoumarins. In contact with the human skin and in combination with ultraviolet radiation, a toxic reaction can occur 15 min after contact, with a sensitivity peak between 30 min and 2 h causing burnings of the skin.

After about 24 h, flushing or reddening of the skin (erythema) and excessive accumulation of fluid in the skin (edema) appear, followed by an inflammatory reaction after three days. Approximately one week later a hyper-pigmentation (usually darkening the skin) occurs which can last for months. The affected skin may remain sensitive to ultraviolet for years. Although such photosensitized toxic activity is known in other European plants, it is particularly dangerous in these *Heracleum* sp. because of its high intensity and the large size of the plants. The European public is not generally aware that such risks exist, so these plants present a real hazard, especially to children.

Dense infestations can seriously interfere with access to amenity areas, riverbanks, etc., and along roadsides, large stands can reduce visibility and result in road safety hazards. Obstruction of lake shores and riverbanks by stands of *H. mantegazzianum* affects anglers, water sports enthusiasts, swimmers, bird watchers, hikers and those working along river systems (Thiele & Otte, 2007). The costs of maintenance of roads may increase due to *H. sosnowskyi* (A. Garkaje, pers., com., 2008).

Cultivation of *H. sosnowskyi* as a forage plant was eventually abandoned in the Baltic States at the end of the 1980s as agricultural production systems and markets changed, partly because the aniseed scented plants affected the flavour of the meat and milk of the animals to which it was fed, and partly because of the health risk to humans and cattle (Nielsen *et al.*, 2005).

A German study assessed the economic impact of *H. mantegazzianum* to be more than 12 million EUR annually in the country, distributed among the health system (1 050 000 EUR), nature reserves (1 170 000 EUR), road management (2 340 000 EUR), municipal management (2 100 000 EUR) and district management (5 600 000 EUR) (Reinhardt *et al.*, 2003).

Summary of invasiveness

Heracleum mantegazzianum has spread rapidly in a number of European countries after introduction as an ornamental plant

from its native area in Russia and Georgia. It continues to be available as an ornamental species, and seeds may be a contaminant of food products so it is likely to spread further. It is an undesirable invader on account of its large size, prolific seed production and vigorous growth leading to gross changes in vegetation, obstruction of access to riverbanks, and soil erosion. However, the health hazards of this species via serious dermatological effects on skin contact are the main reasons for concern over its spread.

Heracleum sosnowskyi spread rapidly in the Baltic States and Russia after its introduction as a fodder plant. It is an undesirable invader on account of its large size, prolific seed production and vigorous growth leading to gross changes in vegetation, obstruction of access to riverbanks, and soil erosion.

Heracleum persicum invaded Scandinavia after its introduction as an ornamental plant. It seems as invasive as the other two *Heracleum* spp., and seems to be able to colonize additional habitats having an environmental value (such as beaches).

Control

See Eppo PM9 on *Heracleum* spp.

Regulatory status

In the United Kingdom, legislation requires that landowners should control the plant and prevent further spread (Willoughby, 1996). *Heracleum sosnowskyi* is regulated in Estonia, Latvia and Lithuania. In Latvia, the legislation requires that landowners should control the plant and prevent further spread. In Sweden, there is a control legislation for *H. mantegazzianum* based on the Plant Protection Act.

In the USA, *H. mantegazzianum* is declared a noxious weed and is specifically regulated in 13 states (Alabama, California, Connecticut, Florida, Massachusetts, Minnesota, New Hampshire, North Carolina, Oregon, Pennsylvania, South Carolina, Vermont, Washington). In State legislation, it is categorized under various terms: Class A noxious weed, pest plant, under quarantine, prohibited invasive species, etc. (USDA-ARS, 2005; USDA-NRCS, 2005).

Heracleum mantegazzianum is on the Eppo list of invasive alien plants. *Heracleum sosnowskyi* and *H. persicum* are registered on the Eppo A2 list of pests recommended for regulation.

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Appendix

Geographical distribution of *Heracleum mantegazzianum*

Global Invasive Species database (2007) *Heracleum mantegazzianum*
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Australia

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Canada (British Columbia, Ontario)

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France

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Iceland

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Ireland

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Indiana

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Vermont, Illinois

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[searchName=Heracleum+mantegazzianum](http://www.natureserve.org/explorer/servlet/NatureServe?searchName=Heracleum+mantegazzianum)

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New Zealand

Manaaki Whenua – Landcare research Databases (2007) *Heracleum mantegazzianum* Sommier & Levier

[http://nzflora.landcareresearch.co.nz/](http://nzflora.landcareresearch.co.nz/default.aspx?selected=NameDetails&NameId=A86B08DE-B872-48AD-AC1A-B461B1A1078C&StateId=&Sort=&TabNum=0)

[default.aspx?selected=NameDetails&NameId=A86B08DE-B872-48AD-AC1A-B461B1A1078C&StateId=&Sort=&TabNum=0](http://nzflora.landcareresearch.co.nz/default.aspx?selected=NameDetails&NameId=A86B08DE-B872-48AD-AC1A-B461B1A1078C&StateId=&Sort=&TabNum=0)

Geographical distribution of *Heracleum sosnowskyi*

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Lithuania

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Poland

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