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## SPREAD OF INVASIVE PLANT *HERACLEUM SOSNOWSKYI* IN SERBIA

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**Abstract:** *Heracleum sosnowskyi* is an invasive plant posing serious ecological and health risks in Europe. This study analyzes its biology, toxic properties, invasion history, and rapid spread at the Kovilovo site (Serbia) from 2017-2025. Field surveys and drone monitoring revealed a rapid expansion from a small population to several tens of hectares, highlighting high invasion potential and the urgent need for coordinated control measures.

**Keywords:** *Heracleum sosnowskyi*, Biodiversity impact, Phototoxicity, Seed dispersal, Serbia, Invasive plant management

### INTRODUCTION

*Heracleum sosnowskyi* is a weedy plant from the family *Apiaceae* (*Umbelliferae*). This is a large family comprising about 3.500 species, whose name stems from the characteristic umbrella-shaped inflorescences. The best-known plants of this family are carrot, celery, parsnip, fennel, anise, caraway, coriander, dill, etc. The medicinal plant angelica also belongs to this family, while the rest are mostly wild species. All species of this family are particularly rich in essential oils and aromatic secondary metabolites that are used in homeopathy, nutrition, folk medicine, and have pharmacological activity. Some plants also contain toxic substances, such as hemlock, wild parsnip, and others (Holub, 1997).

The genus *Heracleum*, as part of the *Apiaceae* family, includes about 400 species and subspecies, most of which live in Asia, where they originated (from the Caucasus Mountains in southwestern Asia and the Hengduan Mountains in southern China). About 20 species of *Heracleum* are present in Europe. From the perspective of their invasiveness and danger to humans (human health) and the environment, the most significant are the following three species: *Heracleum mantegazzianum* Somm. et Levier, *Heracleum sosnowskyi* Manden., and *Heracleum persicum* Desf. These species are classified as so-called "giant" species due to their height (3-5 m) and large leaves (up to 3 m in length, Figure 1), which is why they are often called "giant hogweeds". *Heracleum persicum* has a smaller habitus, while *H. sosnowskyi* and *H. mantegazzianum* are very similar and differ in specific characteristics of the stem and leaves (Jahodova et al., 1997; EPPO, 2020).



Figure 1. Large leaves of *H. sosnowskyi*



Figure 2. *Heracleum sosnowskyi*

Six species of the genus *Heracleum* are present in the flora of Serbia: *H. pallinianum*, *H. sibiricum*, *H. verticillatum*, *H. orphanidis*, and the most widespread *Heracleum sphondylium* subsp. *verticillatum*, commonly known as bear's paw, bear's hand, bear's palm, or bear's foot. This is a native European species used as a medicinal plant; animals readily eat it, it is not dangerous to human health, and it is not invasive. Field research conducted in Serbia in 2015 (Stojanovic et al., 2017) also recorded the presence of one of the three giant *Heracleum* species, a newly introduced invasive species, *H. sosnowskyi* (syn. *H. pubescens*). It is believed that it was brought by water, more precisely the Danube River, during the great floods of 2012, and thus appeared at the only known locality in Pančevački rit, on the left bank of the Danube, in the Kovilovo area (Stojanovic et al., 2017).

*Heracleum sosnowskyi* is a biennial or perennial herbaceous plant. It has a well-developed, strong, deep, and branched root system that firmly anchors this robust plant in the soil. The root is perennial, so the plant can develop from the same root as a biennial or perennial species. This strong root provides high resistance and could also regenerate even after repeated mechanical removal of the above-ground part of the plant by mulching or mowing. The root zone that is crucial for stem development lies 10-20 cm below the soil surface, so if the plant is cut at ground level, regeneration occurs after some time. The only way to prevent regeneration is to cut the root within this zone. The stem is sturdy, hollow, ridged, up to 5 cm thick, 1-3 m tall, sparsely hairy, and marked with purple spots. The leaves are very large (they can reach 2-3 m), lobed, with short, rounded teeth at the tips; they are hairless on the upper surface and slightly hairy on the underside. The flowers are white (pinkish), grouped in large compound umbels located at the top of the stem, 30-80 cm wide (Figure 2). The plant flowers and bears fruit only once during its life cycle (a monocarpic species), meaning it can spend several years in the vegetative phase (although it usually flowers in the second year), but after producing seeds the plant dies. Flowering usually begins in June and lasts until August. The fruit is a schizocarp of ovate to oval shape. According to literature data, a single large plant can produce up to 10.000 seeds (Figure 3, <https://inspection.canada.ca/>). The seeds do not disperse far from the parent plant, only a few meters, but they are light and float on the water surface (for up to three days before sinking), so they can easily be transported over longer distances by watercourses, as well as by various human activities (on the wheels of machinery and vehicles, on footwear), on

the fur of wild and domestic animals, e.g. *H. sosnowskyi* reproduces exclusively by seed, which are dormant; dormancy is broken by cold and moist conditions during autumn and winter. Some of the seeds perish due to unfavorable conditions during winter, but most survive and remain in the surface soil layer (up to 5 cm), forming a large so-called “seed bank” (Nielsen et al., 2007; Šoštarčić, 2024). Data on seed viability varies, with some studies indicating that seeds do not persist for more than one year, while others suggest that seeds remain viable for about two years, meaning that most seeds perish after one year, but about 3% survive for two years (EPPO, 2020).



Figure 3. Seed of *Heracleum sosnowskyi*  
<https://inspection.canada.ca/>



Figure 4. Skin hyperpigmentation  
[www.istockphoto.com](http://www.istockphoto.com)

*Heracleum sosnowskyi* contains a high concentration of phototoxic substances, furanocoumarins (psoralen, xanthotoxin, bergapten, and isopimpinellin) in the sap of its stems and leaves, as well as in its fruits and seeds (EPPO, 2020). Under dry and warm weather conditions, the concentration of these compounds increases. If the stem is damaged and comes into direct contact with the skin, and the skin is then exposed to UVA radiation (sunny days), furanocoumarins become activated, bind to the DNA of skin cells, and cause skin inflammation, blistering, tissue damage, painful burns (often second-degree), and skin hyperpigmentation (Figure 4, [www.istockphoto.com](http://www.istockphoto.com)). In contact with the eyes, reactions in sensitive individuals may cause eye damage (Hoseini et al., 2019; Ušjak, 2019; Paramanova et al., 2024).

According to the International Agency for Research on Cancer (IARC), all three furanocoumarins contained in *H. sosnowskyi* are very dangerous: xanthotoxin in combination with UVA radiation is carcinogenic to humans, while bergapten in combination with UVA radiation is probably carcinogenic to humans. These effects result from the binding of photoactivated furanocoumarins to DNA, leading to various alterations of genetic material (Shtratnikova et al., 2025). They also interact with proteins, membrane lipids, and ribosomes, with psoralens being the most reactive (Hoseini et al., 2019). All individuals who stay or work in areas infested with *H. sosnowskyi* should be aware of the health risks posed by this plant. Skin injuries may occur during any activity that involves damaging, tearing, cutting, or touching the leaves, stems, or inflorescences, which leads to the release of toxic sap. All parts of the body must be covered with protective clothing; gloves with long sleeves should be worn, and protective glasses must be used when cutting

the plant to prevent sap from entering the eyes. Modern motorized equipment, such as trimmers, can disperse finely chopped plant material, making it necessary to wear additional eye protection and respiratory protection. In the event of contact with plant sap, the skin should be carefully washed with soap and water as soon as possible, and the affected area should then be kept out of sunlight for at least 48 hours. Early treatment with corticosteroid creams can reduce the severity of the reaction and relieve discomfort. In the following months, sunscreen should be applied to sensitive areas. If sap gets into the eyes, it should be rinsed with water and sunglasses should be worn. In cases of intense contact and severe reaction, medical attention must be sought.

In the 1940s, *H. sosnowskyi* began to be cultivated in northwestern Russia as an agricultural crop intended for silage production for feeding livestock. Cultivation of this species spread to Latvia, Estonia, Lithuania, Belarus, Ukraine, and the former German Democratic Republic. Although domestic animals readily consumed this plant, the practice was eventually abandoned, partly because plants with an anise-like odor affected the taste of meat and milk from animals that consumed them, and partly due to health risks to humans and livestock (which were later confirmed) (EPPO, 2009). There are reports that in some parts of northern Russia the plant is still cultivated for these purposes (Jahodová et al., 2007). Until the 1970s, *H. sosnowskyi* was a rare plant in natural ecosystems in Europe, but its spread has intensified since then. Particularly strong pressure has been observed in countries where it was cultivated, as plants that “escaped” into the wild rapidly became invasive. Today, this species is present in 12 European countries: Belarus, Bulgaria, Denmark, Estonia, Finland, Hungary, Latvia, Lithuania, Poland, Romania, Serbia, and Ukraine as well as in Russia (EPPO, 2020)

According to EU data ([www.seedidguide.idseed.org](http://www.seedidguide.idseed.org)), the main biological and ecological traits that make this species such a significant invasive organism can be summarized as follows:

- it germinates in early spring, before native vegetation emerges,
- low plant mortality once populations are established,
- very rapid growth of stems and leaf rosettes, allowing leaves to easily overtop local vegetation,
- a stable proportion of plants that flower and produce seeds,
- the ability of plants to delay flowering under unfavorable conditions until sufficient reserves are accumulated,
- early flowering during the growing season, enabling timely completion of seed development,
- the ability to self-pollinate, resulting in the production of fertile seeds,
- high fecundity even a single plant can initiate an invasion,
- high seed density in the soil seed bank, with some seeds surviving for at least two years,
- efficient breaking of seed dormancy due to low winter temperatures,
- exceptionally high germination rates,
- absence of natural enemies,
- very easy dispersal, both naturally and through human activities.

If suitable habitats are available, high rates of spread are possible at both local and regional levels, and data from countries where the invasion is present indicate that during the phase

of intensive invasion, the number of localities doubled approximately every 14 years (EPPO, 2020).

## MATERIAL AND METHODS

The objective of this study conducted in 2025 at the Kovilovo site was to determine how *H. sosnowskyi* behaved during the period from 2017 to 2025 under the influence of changes in the environment in which it grew.

In the area where the original *Heracleum* population is located, a survey of the current situation, i.e., plant presence, was carried out through ground-based inspections of the ruderal area around the canal and along its banks. Due to the inaccessibility of the terrain, additional surveying was conducted using drones (Figure 5). Through phytocenological surveys, the weed species accompanying *H. sosnowskyi* were identified.

## RESULTS AND DISCUSSION

The example of *Heracleum sosnowskyi* population in Kovilovo clearly demonstrates the spread capacity of this plant. In 2015, when it first appeared, the plant was present on both banks of the Grbavica Canal at the edge of a planted poplar forest, covering a total area of about 150 m<sup>2</sup>. The number of plants was relatively small, and within the same area *Heracleum* was “competing for space” with another invasive species, false indigo bush (*Amorpha fruticosa*).

Until 2021, this locality was monitored by associates of the Institute for Nature Conservation of the Republic of Serbia and the public enterprise “Srbijašume,” who successfully kept this population under control through mechanical and chemical control measures. When the forest was cut down in 2021 and monitoring ceased, the plant quickly “escaped” control and began to invade. On the cleared forest area, which was transformed into a ruderal habitat (Figure 6), open space, fertile soil, and favorable moisture conditions became available, all of which enabled its intensive spread.

The only obstacles were other invasive plants such as false indigo bush (*Amorpha fruticosa*), common milkweed (*Asclepias syriaca*), and many robust herbaceous, semi-woody, and woody native weed species, with which it competed quite successfully for space. Under such conditions, by 2025 the plant had spread over an area of several tens of hectares, with a tendency toward an even more aggressive expansion. Rapid spread was further facilitated by the neighboring canal, through which seeds were dispersed, so that plants can now be found up to 2 km from the original location.



Figure 6. Drone footage



Figure 5. Habitat of *H. sosnowskyi*

## CONCLUSION

It is only a matter of time before *Heracleum sosnowskyi* invades the surrounding agricultural land. Cultivated crops are weak competitors against such strong invaders, and control technologies are insufficiently known and very complex, so major problems can be expected.

The greatest problems with *H. sosnowskyi* are experienced in the Baltic countries and Russia (Sazonov, 2024), and their experience clearly shows the species' strong invasive potential and how difficult, long-term, and costly its control is. It is considered that individual plants can be eradicated relatively quickly, but once colonies are established, a minimum of seven years is required for their eradication.

*Heracleum sosnowskyi* is listed on the A2 list of quarantine organisms, indicating that the species is already present in the EPPO region and obliging countries to implement phytosanitary measures for its control, i.e., to prevent its further spread.

To ensure that this process is as effective as possible, multiple stakeholders need to be involved, and the measures can be grouped as follows:

- monitoring and rapid detection of new populations and their mapping, which should be carried out by qualified professionals to avoid misidentification or confusion with similar species (research institutes, universities, professional services, etc.),
- education of the public and relevant target groups (farmers, road and river managers, anglers, hikers, etc.),
- identification of seed dispersal pathways and vulnerable habitats,
- eradication campaigns in cases where preventive measures fail,
- continuous field monitoring,
- investigation of control and eradication options within research institutes and other relevant stakeholders, as well as through cooperation and exchange of experience with other countries facing the same problem.

Competent authorities must have the capacity for rapid response, including field inspections, confirmation of species identification, assessment of the level of invasion, and selection of appropriate control methods.

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