Ecological Questions 29 (2018) 4: 35–42 http://dx.doi.org/10.12775/EQ.2018.032

Risks posed by *Heracleum sosnowskyi* Manden in the Rivne region

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Received: 29 June 2018 / Accepted: 17 November 2018

Abstract. *Heracleum sosnowskyi* Manden of Caucasian origin is the most dangerous plant for the environment, geosystems, farming and public health. The sap of *H. sosnowskyi*, its pollen, scent and even dew are dangerous for human health and cause chemical burns, allergic reactions and even deaths. Works on the negative impact of the *H. sosnowskyi* spread have been published in Ukraine only recently. A more detailed study of *H. sosnowskyi* is possible only through inspections of each region in Ukraine, which would allow to predict the intensity, rate, frequency and area of phytocoenotic changes, as well as to provide data for cartograms. In the Rivne region, *H. sosnowskyi* overcomes geographical, ecological, reproductive and coenotic barriers, forms a large number of offspring, massively and rapidly spreads over considerable distances of the studied territory, establishing in anthropogenic and natural coenoses. The dense river network, sufficient moisture, mild climate and the decline of agriculture have created favourable conditions for the spread of *H. sosnowskyi*.

Populations of *H. sosnowskyi* in the Rivne region have an uneven distribution. The southern part of the oblast has the highest degree of weed infestation compared to other administrative settlements and covers 82.7% of the total area of the oblast. The species was not found in only three northern districts of the Rivne region. This can be explained by the poor quality of soil. In the central part of the region, the highest concentration of *H. sosnowskyi* populations was found in the southern and western parts of the city of Rivne. The presence of a large number of springs, rivers and the relief of the Rivne region does not allow the use of chemical plant control methods, as this can lead to significant contamination with herbicides. The most effective method is systematic cutting of shoots prior to flowering and trimming at the root collar.

Key words: invasive species; Rivne region; uncontrolled spread; quarantine status; safe methods of control.

1. Introduction

The rapid expansion and aggressive enrooting of alien species, leading to significant depletion of biodiversity and loss of ecosystem stability, is part of global natural change (European Commission, 2004). Therefore, the fight against invasive plant species was identified at the 17th International Botanical Congress (Vienna, Austria, 2005) as one of the main objectives The most dangerous for the environment, geosystems, farming and public health is *Heracleum sosnowskyi* Manden (Sosnowsky's hogweed) – a plant of Caucasian origin.

In numerous publications, the authors from other parts of the world have described their experience in monitoring of the *H. sosnowskyi* spread and modern methods of its control.

During research on alien flora in Europe, Lambdon et al. (2008) determined the specificity of the *H. sosnowskyi* distribution in Europe based on its Baltic distribution. Jahodová et al. (2007) described the history of *H. sosnowskyi* invasion in European countries. Bravo (2007) defined the conditions for the eradication of *H. sosnowskyi* in Pennsylvania, the USA, and neighbouring states.

Works on the negative impact of *H. sosnowskyi* have been published in Ukraine only recently, because previous papers considered only its beneficial properties and possible use in agriculture as fresh fodder. The decline of the livestock industry has provoked its uncontrolled spread over large areas.

Today, the problem of the *H. sosnowskyi* spread in Ukraine is extremely important and of interest to experts of various fields, e.g. medicine, biology, agronomy, geography. For example, Vihor and Proc (2012) investigated the territorial characteristics of the spread of weeds and methods of weed control in the Transcarpathian region (Marynich & Bazhan, 1993). Shuvar (2013) compiled detailed biological characteristics of *H. sosnowskyi*, its farming values, habitat distribution, control measures and warnings to the public. Considering the transboundary nature of the problem, Koynova (2013) emphasizes the need to develop and implement a joint Ukrainian-Polish programme to control dangerous weeds in the territory of the Lviv region. Moshkivska (2016) explores the biological characteristics of *H. sosnowskyi* growing in the Ukrainian forest-steppe.

A more detailed study of *H. sosnowskyi* is possible only through inspections of each region in Ukraine, which would allow to predict the intensity, rate, frequency and area of phytocoenotic changes, as well as to provide data for cartograms (Mosyakin & Fedoronchuk, 1999).

The distribution of *H. sosnowskyi* in the area of Western Polesie is not covered by any publications, therefore our study is relevant and necessary.

The objective of the work was to study the features of *H. sosnowskyi* distribution in the territory of the Rivne region and to identify its threats to phytodiversity and human health.

2. Materials and methods

The following methods were used to survey the territory of the Rivne region: field (transect walk), laboratory (identification of plant species), biology (the number of *H. sosnowskyi* plants in a particular area), measurement, mapping, photography, sociometric research (surveys) and methods of system analysis that allowed us to obtain correct information on qualitative and quantitative parameters of the *H. sosnowskyi* spread in the investigated area. At the same time, such monitoring observations as description, mapping, photography and measurements of areas occupied by *H. sosnowskyi* were carried out. The main method of studying the spread of *H. sosnowskyi* was the transect walk in the territory of the Rivne region, carried out from May to October 2017. The presence of *H. sosnowskyi* was studied at different sites characterized by varying natural, climatic and economic conditions by the method of describing these areas. The age structure of *H. sosnowskyi* was visually determined by the following parameters: plant height, stem diameter and the presence of inflorescences. Therefore, after detection of more than two adult individuals of *H. sosnowskyi* at the flowering stage, the contamination of the area was noted. The invasiveness of this species is assessed using the Invasive Species Assessment Protocol. The degree of infestation of administrative districts was determined as follows: the total number of villages in a district was assumed to be 100% and the number of villages invaded by *H. sosnowskyi* accounted for a percentage of infestation of a given administrative district.

Laboratory methods consisted in identifying the species *H. sosnowskyi* using a botanical identification key. Plants were photographed in different positions during the day in accordance with the botanical requirements and principles using a SLR Canon EOS 1000D camera. The method of mapping consisted in mapping the distribution centres of *H. sosnowskyi* on the map of the Rivne region.

3. Results and discussion

Rivne Oblast is located in the northwestern part of Ukraine. It covers an area of 20,100 km^2, which constitutes 3.1% of the total territory of Ukraine. In the north, the Rivne region borders on the Brest and Gomel regions of Belarus, in the east – on the Zhytomyr region, in the southeast – on the Khmelnytskyi region, in the south-east – on the Ternopil region, in the southwest – on the Lviv region, and in the west – on the Volyn region (Gerenchuk, 1976; Dopovid pro stan navkolishn'ogo prirodnogo seredovishha v Rivnens'kij oblasti (1990-2013) [Report on the state of the environment in the Rivne region (1990-2013)], 2013; Harmful organisms that have quarantine significance for Europe, 1996).

Geomorphologically, it is divided into three parts: Polesie, Volyn Forest Plateau and Male Polesie. The region's rivers belong to the Pripyat River basin, the largest of them are the Goryn, the Styr and the tributary of the Horyn river – the Sluch, as well as Lake Nobel and Lake Bile. The soil cover of the region is heterogeneous. The most common are sod-podzolic black soil, ashed black soil, sod soil, turf soil and peat-marsh soil (Korotun & Korotun, 1996).

The Rivne region is unique because it covers several natural regions and lies on a peculiar border – the ecotone between Central and Eastern Europe, with a great variety

of flora. Many species of higher plants grow in many regions of the world. However, there are some species that occur in the described area on the edge of their distribution. The Rivne flora encompasses also relict species – remnants of the glacial period, i.e. glacial relicts (Gujdasha & Burkovs'ki, 2003).

The entire territory of the Rivne region lies in a forest area and owing to its vegetation cover it belongs to the East European province of the European broadleaf forest zone (region).

The formation of flora in the Rivne region took place in glacial and post-glacial periods. The vegetation composition was also influenced by the intermediate location of the studied area between West and East Europe. Therefore, the flora of the Rivne region includes both West and East European species. Boreal, nemoral, European, steppe and montane species grow here (Meremins'kij & Sacjuk, 2005). However, this diversity of flora can be destroyed for several decades by the invasive plant *H. sosnowskyi*.

The analysis of the potential invasiveness of *H. sosnowskyi* was carried out under the concept of "overcoming barriers" by Richardson et al. (2000) and approaches proposed by Burda and Ignatjuk (2011). It was found that this species has overcome geographical, ecological, reproductive and coenotic barriers in the Rivne region, generates a large number of offspring, massively and rapidly spreads over considerable distances of the studied territory, establishing in anthropogenic and natural coenoses (Stasjuk, 2016; Stasjuk & Ishhuk, 2017).

According to the Invasive Species Assessment Protocol (Randall et al., 2008), the invasive potential of *H. sosnowskyi* in the territory of the Rivne region is I-Rank = 92 points of negative impact on vegetation, coenosis, the environment and human health.

The dynamic trends of *H. sosnowskyi* can be represented by two phases of invasion – the initial (1973–1999) and exponential (2000 to date) ones (Vihor & Proc, 2015). The initial phase is characterized by a slow invasion of new localities by the species, with gradually increasing area and adaptation of the species to climatic and territorial characteristics of the distribution area. These are usually single isolated localities with several individuals. The exponential phase is the rapid germination of seeds and the emergence of many new localities.

The study of conditions and specificity of the *H. sosnowskyi* distribution in the Rivne region made it possible to reveal the main factors that contribute to the conservation and further distribution of this plant. The main factors are as follows:

– the presence of *H. sosnowskyi* in the vast majority of areas of the region, different in terms of the area, quantitative and age composition of the plant growth sites;
– they occupy vast areas of anthropogenic and natural habitats that are gradually expanding, namely pastures, landfills, fallow land, adjacent areas, roadside paths, river banks, outskirts;
– favourable natural and climatic conditions for the distribution of this species, which have developed in the region;
– in the conditions of the Rivne region, *H. sosnowskyi* basically does not have any enemies and competitors;
– there are many sites that have long been extremely favourable for the species, due to the lack of economic activity, proper management of the land and its abandonment;
– poor awareness of local and state authorities regarding the features and threats caused by the spread of the *H. sosnowskyi* population.

As evidenced by the phytosanitary inspection and our own field research conducted in the Rivne region, the distribution of *H. sosnowskyi* is uneven (Fig. 1).

The largest area of *H. sosnowskyi* is located in the Radyvyliv district – 14.9% of the total area (t. (town) Radyvylov, v. (village) Stoyanivka, v. Kozyn, v. Pasiky, v. Balky, v. Stanislavy, v. Druzhby, v. Nemyrivka, v. Sestryatyn, v. Hotyn, v. Polunychne);

Rivne district – 14.9% (c. (city) Rivne, v. Malyi Zhytyn, v. Shpaniv, v. Veresneve, v. Omelyana, v. Kolodenka, v. Basiv Kut);

Demydiv district – 12.9% (v. Vovkovyyi, v. Zolochivka, v. Malev, v. Boremel);

Ostrog district – 12.7% (v. Mogilyane, v. Ozhenyno, v. Verhiv, v. Hrylyache, v. Melyaty, v. Kolodenka, v. Tesiv);

Zdolbuniv district – 9.3% (v. Bilyashiv, v. Hlyns'k, v. Derman 1, v. Derman 2, v. Mizochyk);

Rokytnivskyi district – 7.7% (t. Rokytno, v. Dert, v. Borove);

Goshchansky district – 6.3% (v. Pidlisky, v. Maykiv, v. Rusyliv, v. Fedorivka).

In the Mlyniv district (v. Bokiyma, v. Mykolaivka, v. Dobryatyn), Dubno district (t. Dubno, v. Ptycha, v. Tarakaniv, v. Semyduby), the Koretskiy district (v. Koryst), the Bereznivskyi district (v. Gorodyshche), the Kostopil district (v. Zlazne) and the Volodymyrets district (t. Volodymyrets), the area of infestation by *H. sosnowskyi* does not exceed 4%.

The species was not found in Zarichne, Dubrovytsya and Sarnenskyi districts. This can be explained by the poor quality of soil.

The characteristics of the *H. sosnowskyi* distribution in the city of Rivne, as the regional centre of the Rivne region, are presented in Figure 2.

Single specimens of *H. sosnowskyi* were recorded in the central streets, where mowing is performed regularly and in the backyards of the local population: Plastova street, Mitskevicha street, Shevchenko park, Kniahyni

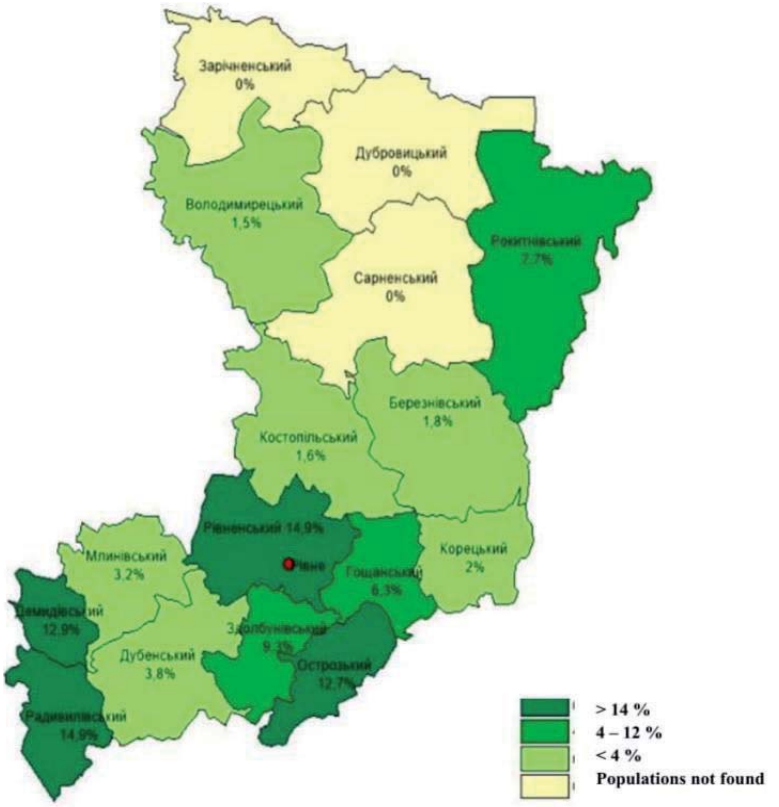

Figure 1. Distribution *Heracleum sosnowskyi* in the Rivne region, %

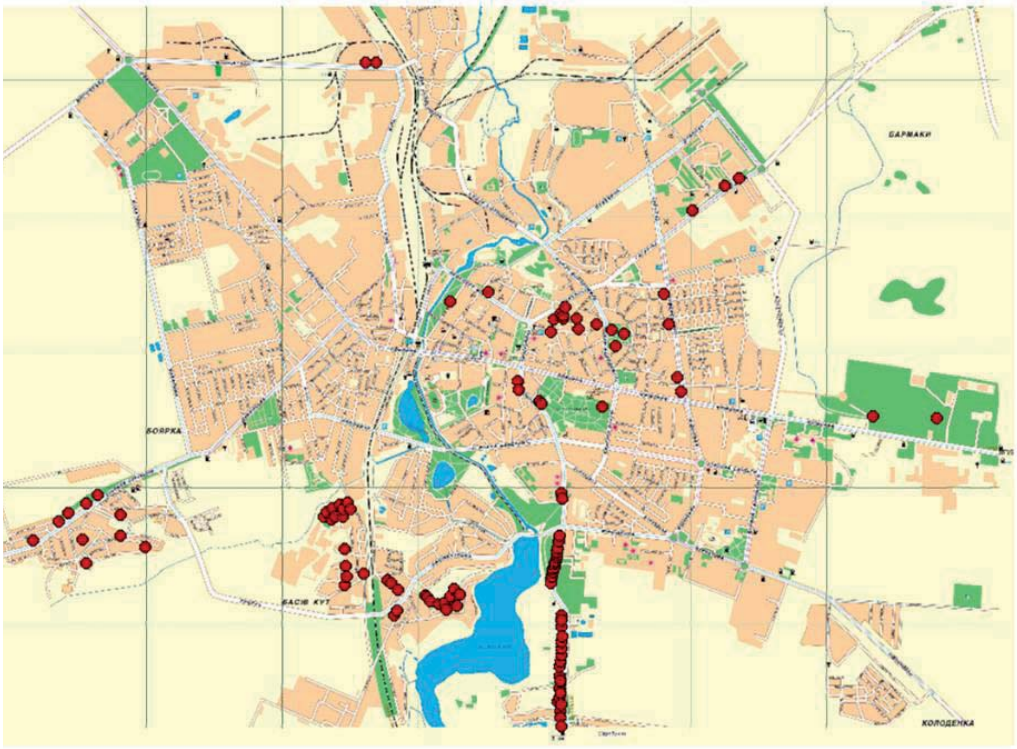

Figure 2. Distribution of *Heracleum sosnowskyi* in Rivne

Olhy street, Chornovola street, Naberezhna street, Soborna street, Strutynskogo street.

Some specimens with flower peduncles, which produce large amounts of seeds can be found on the outskirts of the city: in Barmaky; Kyivska street, close to the zoo; Kurchatova street; in Boyarka near gardens; Mlynivska street; in the direction of the Lutsk city; Soborna street.

The areas on Basiv Kut, Dvoretska street, Chornovola street towards the city of Zdolbuniv are particularly dangerous for human health, where 8–10 plants of *H. sosnowskyi* can be found within 1 m^2, including 2–3 individuals with flower peduncles. These areas are favourable for the growth and spread of *H. sosnowskyi* due to good soil moisture and the content of nutrients (river-valley area of Lake Basivkut with a significant human impact). Most individuals of this species were found among semi-natural vegetation, somewhat less among natural plant communities and in urban areas (roadsides, landfills, construction zones).

The lack of awareness of the population about the risks posed by *H. sosnowskyi* leads to an annual increase in the number of victims. Plant sap, pollen, aroma (smell) and even dew are dangerous.

Transparent watery sap of the plant is rich in furanocoumarins, which become toxic when exposed to solar radiation. Even one touch of *H. sosnowskyi* leads to burns of 1–3 degrees, which in the first few days are similar to thermal burns. The particular danger is that touching the plant for the first time does not give any unpleasant sensations and this can simply be overlooked. Redness, watery blisters do not appear in affected areas of the body immediately after the contact, but after one or two days, under the influence of the sun, they turn into chemical burns. Places of lesions are difficult to heal, symptoms of other skin diseases become more acute. This situation is extremely dangerous for children. If the burns are severe, the temperature rises, fever begins, ulcers appear. Dark spots remain in places of burns after the treatment. *H. sosnowskyi* is also a contact and respiratory allergen and has a strong odour, which is felt even five meters from the plant. This causes severe effects on the body and the pollen of *H. sosnowskyi* is able to penetrate even through clothes. If the sap or pollen gets into the eye, it can lead to blindness. Inhalation of *H. sosnowskyi* pollen or essential oils can significantly harm the respiratory system and even lead to death. The consequences of toxic effects include swelling of the larynx and asthma.

The dew of *H. sosnowskyi* is also dangerous. Even touching a grass near the plant can cause severe burns. Such injuries take a long time to heal and can leave scars.

It is impossible to determine the number of burn victims of *H. sosnowskyi*, due to the lack of any register of lesions caused by *H. sosnowskyi* in medical institutions. Therefore, it is necessary to include information work with the population in the methods of controlling the plant.

In Ukraine, despite the apparent threat to human health from *H. sosnowskyi*, this species is not officially included in the quarantine group of plants (Sitnik, 2005).

In order to qualify for quarantine status, the species should be included on the "List of regulated pests" (Sikalo & Chernega, 2015).

In accordance with the International Plant Protection Convention (IPPC) and regulations of the European Plant Protection Organization (EPPO), a quarantine pest must meet all of the following requirements (Convention on Biological Diversity, 1995):

1. To be absent or have limited distribution in a country.
2. May be brought with products imported into the country, with cargoes and vehicles.
3. To be able to acclimatise in the territory of a given country.
4. To cause considerable damage to crops produced.
5. To be regulated by quarantine phytosanitary measures.

It is necessary that all the above criteria are met simultaneously. Therefore, even a very harmful indigenous or adventive form that has covered its full potential range in the territory of Ukraine (not corresponding to item 1) cannot have the quarantine status.

Today, due to the rate of spread and the damage that *H. sosnowskyi* causes to people in direct contact, it certainly must be destroyed.

Measures to control weeds, including *H. sosnowskyi* fall under the administrative responsibility under Article 52 of the Code of Ukraine "On Administrative Offenses". In case of non-application of measures by landowners and land users, a fine of 50 to 100 non-taxable minimum income of citizens is imposed. The Land Resources Inspectorate also has all the necessary powers to impose fines for improper use of land.

Given the physical-geographical features of the Rivne region, the chemical control method cannot be applied, because of the large number of springs and rivers as well as the relief, which can result in significant contamination with herbicides.

The systematic cutting of shoots before flowering and cutting the roots at a depth of 10 cm (2–3 times a year) will be most effective on the river banks and on agricultural rivers. This method prevents the reproductive maturity of the plant, leading to its gradual elimination from natural vegetation. In areas where heavy equipment is used, harrowing can be carried out 1–2 times a year, for example along roads and agricultural fields with continuous thickets of weeds.

Heracleum sosnowskyi and *H. mantegazzianum* are found in other countries too. For example, they belong to the most dangerous plant species in Poland. Their toxic

properties pose a serious threat to the health and life of humans (Sosnowsky's hogweed can cause dermatitis in all three degrees, respiratory ailments, and even anaphylactic shock). Such damage can occur even without direct contact with the plant. *H. sosnowskyi* rapidly spreads (one plant can produce approx. 100,000 seeds) and is very difficult to control (Klima, 2014; Bochniarz & Bochniarz, 1986; Badowski, 2014; Sachajdakiewicz & Mędrzycki, 2014; Tokarska-Guzik et al., 2014).

The national census of *H. sosnowskyi* and *H. mantegazzianum*, conducted in 2013 by Sachajdakiewicz I. and Mędrzycki P., is the first cyclic action in Poland and one of the first in Europe organized by PSER WSEiZ [the Laboratory of Applied Plant Ecology at the University of Ecology and Management in Warsaw], attended by all entities and individuals, including representatives of the government and institutions managing the areas covered by hogweed's invasion, who may have knowledge about the sites of *H. sosnowskyi* and *H. mantegazzianum* located in areas under their management (Sachajdakiewicz & Mędrzycki, 2014; Mędrzycki et al., 2017).

H. sosnowskyi or/and *H. mantegazzianum* can be found in all provinces of Poland. More than 1/4 (around 27%) of municipalities have populations of these species. The amount of information on the localities of the Caucasian hogweeds in Poland is more than 200% larger than that contained in the previous databases supervised by PSER WSEiZ. The high increase in the new information may result from the use of more efficient methods of data acquisition and the public involvement in the action following the rapid, exponential increase in the number of Caucasian hogweed sites in Poland.

The measures aimed at controlling *H. sosnowskyi* and *H. mantegazzianum* used by people and entities responsible for the invaded areas are largely ineffective. Many of those responsible for the areas where *H. sosnowskyi* and *H. mantegazzianum* occur report direct and indirect damage caused by these species. Most people who have shared information about the scale of *H. sosnowskyi* and *H. mantegazzianum* invasion in a specific area treat this issue as a major problem and need help in fighting it (Badowski, 2014; Klimaszyk et al., 2014; Sachajdakiewicz & Mędrzycki, 2014; Mędrzycki et al., 2017).

The serious risk posed by *H. sosnowskyi* is also observed in the USA. According to the state and federal law, it is prohibited to grow, distribute, sell, import, buy and transport the plant. The giant hogweed is an invasive species and therefore its distribution, sale or transportation is illegal in the United States (Kraus, 2017).

If the plants have already released their buds, it is too late to cut them. It is therefore necessary to cut the buds at the beginning of the flowering season. The collected removed buds need to be burned. The shoots of the plant contain large amounts of nutrients, sufficient for the seeds to ripen in the removed umbels. It is therefore important not to allow the new plants to produce flowers.

A regional programme and targeted funding and monitoring of its implementation are required to address this problem. A delay in this respect will lead to significant state damage and complications of the environmental situation in the region and the country as a whole, the deterioration of the investment climate and tourism attractiveness. Investors who invest in the development of agricultural production and tourism can also join this programme.

4. Conclusions

This article describes the features of the distribution and risks posed by *H. sosnowskyi* in the Rivne region.

1. The dense river network, sufficient moisture and mild climate on the one hand, and the decline of agriculture on the other, create favourable conditions for the spread of *H. sosnowskyi* in the Rivne region.
2. *H. sosnowskyi* has overcome geographical, ecological, reproductive and coenotic barriers; it forms offspring in large numbers, massively and rapidly spreads over considerable distances of the studied territory, establishing in anthropogenic and natural coenoses.
3. The populations of *H. sosnowskyi* in the Rivne region have an uneven distribution pattern.
4. The most effective method of controlling the plant is systematic cutting of shoots before flowering and trimming at the root base.
5. The largest concentration of *H. sosnowskyi* populations in the central part of the region is found in the southern and western parts of the city of Rivne.
6. The sap of *H. sosnowskyi*, its pollen, scent and even dew are very dangerous to human health and cause chemical burns, allergic reactions and even deaths.
7. In Ukraine, despite the obvious risks posed by *H. sosnowskyi* to human health, this plant has not been officially included in the quarantine group of plants.
8. In order to effectively eradicate *H. sosnowskyi,* it is necessary to conduct a detailed mapping of the region and to develop measures to destroy the stands of this species.

Availability of data and material

Authors are encouraged to/should make readily reproducible materials described in the manuscript, including new software, databases and all relevant raw data, freely available to any scientist wishing to use them, without breaching participant confidentiality. In any case, authors should

make their new software, databases, application/tool described in the manuscript available for testing by reviewers in a way that preserves the reviewers' anonymity.

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