Vectors of *Heracleum sosnowskyi* Manden. Invasion on the territory of Moscow region: history and modernity (as exemplified by the Shakhovskaya Urban District)

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Abstract. Sosnovsky’s hogweed (*Heracleum sosnowskyi* Manden.) was used as an ornamental plant since the middle of the 20th century, but has now become a dangerous invasive weed having invaded the ecosystems of Moscow region. Based on the literature and new original data obtained through observations on *H. sosnowskyi* dispersal across Moscow region, *H. sosnowskyi* pathways (dispersal vectors) that have existed since the culture was introduced in the 1960s until 2020 are being discussed now. Recently, a new dispersal vector that has important implications for the spread of *H. sosnowskyi* seeds is the use of lands infested with *H. sosnowskyi* as hayfields. As exemplified by the Shakhovskaya urban district, it is shown that the measures taken to provide chemical treatment of roadside areas and thickets accessible for transport have already yielded tangible results. The paper is concerned with the trends in *H. sosnowskyi* ranges changing as a result of dispersal into forests, hard-to-reach old-fallow meadows, and river floodplains, with areas that are unlikely to be cultivated and are a continuous source for further dispersal.

1. Introduction

Sosnovsky’s hogweed (*Heracleum sosnowskyi* Manden.) in the Umbelliferae or Apiaceae family comes under giant hogweeds distinguished by being rather high (up to 5 m). The native ranges of *Heracleum sosnowskyi* overlap in the Caucasus region. It is a subalpine meadow plant that was described as a new species by I.P. Mandenova in 1944 and named after D.I. Sosnovsky who explored the flora of the Caucasus. *H. sosnowskyi* is a monocarp perennial, i.e. dies off after flowering and fruiting. The fruit is a fractional two-seed that, when ripe, splits into two fruits, called seeds that give rise to a colony of new plants. A single flowering plant can produce between 3,000 and 20,000 seeds [1]. In the 20th century, *H. sosnowskyi* was used as an agricultural crop due to its high yield, cold resistance and ability to provide a large supply of silage for livestock [2]. By the beginning of the 21st century, the plant ceased to be cultivated and turned into a dangerous invasive weed that had grown roots in the ecosystems of Moscow region.

2. Materials and Methods

The paper relies on published data on *H. sosnowskyi*, including publicly available maps, materials from surveys by local residents – old-timers and natives of the villages of Burtsevo and Andreevskoye, as well as the results of private 25-year observations. The collected materials characterize the features
of *H. sosnowskyi* dispersal in the Shakhovskaya urban district between the 20th and early 21st centuries and complement the facts already gained in weed dispersal in central Russia.

3. **To the history of *H. sosnowskyi* introduction.**

The first global experiments on the use of hogweed as a silage crop started in 1942 in the USSR – in the Polar-Alpine Botanical Garden (Kirovsk, Murmansk region), i.e. before a new species was described. In this regard, until the beginning of the 1950s, scientists believed that they were investigating the nutritional benefits of another species – the fluffy hogweed (*Heracleum pubescens* (Hoffm.) Bieb.) [3].

Back in 1949, it was thought that the plant “when moved ... from south to north ... reduces its ability to accumulate essential oils. Apparently, this property varies greatly under the influence of climatic conditions” [3, sheet 33]. In 1951, *H. sosnowskyi* was included in the consolidated development plan to address the feeding problem in the Murmansk region for 1952-55 [4].

In 1953-55, led by V.S. Sokolov, Komarov Botanical Institute of the Russian Academy of Sciences (Leningrad) completed a series of studies towards *H. sosnowskyi*. Despite accumulating furanocoumarins that cause phytophotodermatitis in humans [5], in 1954 the plant was included in the action plan by the Institute for piloting and implementation. In 1955, extensive areas were planted under *H. sosnowskyi* in 17 collective and state farms in Leningrad region. Meanwhile, in 1953, *H. sosnowskyi* seeds were sent from Kirovsk to the Institute of Biology of the Komi Scientific Center of the Russian Academy of Sciences, where in 1953-1957 the plant was studied in the Laboratory of Plant Introduction headed by K.A. Moiseev [6].

Since 1957, experimental geographic crops of *H. sosnowskyi* were laid in all regions of the Komi ASSR. Since 1959, it spread from Inta to the southern borders of Komi, and in the 1960s-1980s – in the regions of the RSFSR from Kaliningrad to Kamchatka and the union republics (in Ukraine, Belarus, Moldova, the Baltic republics, Kyrgyzstan) [7].

In Moscow region, the first experimental crops of *H. sosnowskyi* were produced in 1959 at the All-Russian Williams Fodder Research Institute (Lobnya). A few years later, the plant became widespread in many farms throughout Moscow region. Thus, in 1963-1969 over 10 tons of seeds were grown in the Lidino state farm of the Ruzsky district, which were sent to 55 farms in Moscow region and to 67 farms in the regions of the RSFSR [7].

By the 1970s, it became obvious that the cultivation of *H. sosnowskyi* is dangerous, because the plant causes burns. This fact was mentioned in the publications devoted to new silage crops, although the authors tried not to attach much importance to this feature [8]. Nevertheless, the researchers started looking for a non-inflammatory, non-phototoxic form of *H. sosnowskyi*, which was not crowned with success [9]. Moreover, there were some self-seeding cases.

Cases of *H. sosnowskyi* self-seeding on the territory of the USSR were first analyzed in the Botanical Garden of the Academy of Sciences of the Moldavian SSR in 1970 [10]. It was found that it is substances contained in the essential oil channels of *H. sosnowskyi* seeds that have allelopathic and phototoxict effects on the seeds of other plants. They slow down the germination of seeds of other plant species and remain viable up to 6 months, showing a high percentage of survival in new habitats, provided that the hogweed exclusively propagates by seed [10, p. 75]. The authors believed that the phenomenon they described could be of great practical interest from the standpoint of successful naturalization of a new highly productive silage plant. Time has shown that a utilitarian view of the allelopathic properties of *H. sosnowskyi* seeds did not allow timely recognition and prevention of the danger posed by unwanted spread of this plant.

Obviously, cases of *H. sosnowskyi* self-seeding throughout Moscow region could have been observed soon after this plant was introduced into cultivation, but its spread in Soviet times was restrained by the intensive exploitation of agricultural land.

By the 1980s, a negative experience with the use of *H. sosnowskyi* had accumulated, which was confirmed by I.F. Satsyperova. It turned out that obtaining a form of *H. sosnowskyi* devoid of furocoumarins and not causing burns is impossible. Besides, furocoumarins were proved to remain in
silage, causing an unpleasant taste in the meat and milk of cows whose diet included *H. sosnowskyi* [9]. In the mid-1980s, the plant came under potential ergaziophytophyles (“escapees”) [11]. It was not until 2015 that the plant lost its status as an agricultural crop and was included in the industry classifier of weeds in Russia [12].

4. Sosnovsky hogweed in the Shakhovskaya urban district in the 1960s and early 1990s: a valuable silage culture.

The Shakhovskaya urban district is located on the northwestern outskirts of Moscow region. The agro-climatic conditions of this municipality, spanning the southern taiga zone, favorable for growing winter and spring crops, corn for silage [13], turned out to be suitable for the cultivation of *H. sosnowskyi* that from the middle of the 20th century was tested as a new silage crop in the Non-Black Earth Region [7].

*H. sosnowskyi* crops appeared on the territory of the Shakhovskaya urban district in 1962, when learners of the Seredinskaya secondary school (Sereda village) were instructed to plant *H. sosnowskyi* in a school experimental plot [14]. Over time, hogweed plantations appeared in many collective and state farms, where, as per the guidelines, the plant was grown outside the arable land – near silage pits and cattle farms.

Between the 1960s and 1980s, the attitude towards *H. sosnowskyi* as an agricultural crop changed dramatically. According to the indigenous inhabitants of the villages of Burtevo and Andreeskoye, at first collective farmers treated the plant with special trepidation, believing that it would help solve the growing scarcity of feed. Hogweed seeds were almost worth their weight in gold. However, when it turned out that in the conditions of Moscow region *H. sosnowskyi* was capable of causing painful burns, they began to be leery of it.

In the first years following the collapse of the USSR, in the conditions of a deep economic crisis and feed shortage, *H. sosnowskyi* helped farmers to save livestock from starvation, because in early spring, the plant is one of the first to start growing. By the early 1990s, after numerous incidents when cattle and shepherds were burned getting into the *H. sosnowskyi* thickets, the plant had a strong reputation as a harmful and dangerous weed. Collective farmers familiar with the hogweed tried to keep away from the plots of land overgrown with *H. sosnowskyi*.

5. Unverified spread of Sosnovsky hogweed in the 1990-2010s.

Mass *H. sosnowskyi* dispersal over the Shakhovskaya urban district occurred in the late 1990s – early 2000s. By this time, most of the collective and state farms that produced *H. sosnowskyi* went bankrupt. The plant was left on its own. A rapid seizure of new territories was facilitated by the established reputation of a harmful and dangerous plant, as well as almost complete absence of animals that could feed on *H. sosnowskyi*.

Admittedly, at the initial stage of invasion, a man-made burden was decisive. For example, in the mid-1990s, soon after the collective farm had collapsed, the inhabitants of the village of Burtevo decided to enrich their gardens with spoiled hogweed silage. As a result, whole weed plantations took rise around the village from surviving seeds that served as a source for further dispersal. From the former vegetable gardens, the plant was moved to the floodplain of the Costinka River, having spread under the canopy of *Alnus incana* (L.) Moench. downstream and producing impassable thickets in the river valley. Together with manure from a private farm, next to which there are still thickets of hogweed, the seeds of the plant were dispersed across several horticultural associations.

Since the 2000s, in the urban district of Shakhovskaya, hay harvesting in *H. sosnowskyi*-infested meadows has been crucial in the spread of weeds. A high rate of *H. sosnowskyi* spread on this kind of land is caused by the fact that haymaking activities are commonly scheduled from July to September, when the seeds have already formed and are almost ripe, or are fully ripe and began to crumble. Unripe seeds on cut peduncles ripen in a few days and fall off in the process of tedding hay, being dispersed by haymaking machinery. The very next year, the number of *H. sosnowskyi* seedlings increases by an order of magnitude. Long-term observations in the Shakhovskaya urban district show
that even a single plant in haymaking leads to the fact that within 10 years this land will be heavily weedy, and in 15 years – will actually turn into an *H. sosnowskyi* plantation.

The seeds of the plant were successfully spread not only by agricultural machinery, but also on the tires of vehicles, the soles of shoes, and by pets, being several kilometers away from the parent plant and forming stable populations. As a result, by 2020, vast thickets of hogweed can be found in hard-to-reach places far from settlements, for example, in a young small-leaved deciduous forest that has grown on the site of haymaking. Such places can be found throughout the city district.

However, outside the hayfields, where the impact of technology is excluded, the dispersal rate of the weed is quite high – about 5 m per year, which corresponds to the range of seeds being dispersed by the wind from the parent plant [15]. Thus, in the photo taken in 2006, a relatively small clump of *H. sosnowskyi* (approximately 5x5 m) can be seen outside the Kostinka River dam. In 2012, the size of the clump was already 35x30 m, i.e. increased by 6-7 times (Fig. 1). At present, the entire lowland near the dam is occupied by *H. sosnowskyi* that has spread into the forest from *Alnus incana* along the banks of the Kostinka River several tens of meters downstream.

![Figure 1. *H. sosnowskyi* outside the dam on the Kostinka River: in 2006 (photo by A.L. Ozerov and N.A. Ozerova) and in 2012 (Yandex maps).](image)

In the Shakhovskaya urban district, *H. sosnowskyi* has formed thickets on the sides of highways and railways, because the seeds are blown along the roads by the wind currents amplified by transport.

6. **Changes in habitat as a result of measures to combat hogweed in 2016-2020**

The Shakhovskaya urban district is one of the first in Moscow region, where a municipal program to combat hogweed was initiated. The respective activities have been under way since 2015 [16]. In the fall of 2017, a large-scale campaign to combat the weed was launched throughout Moscow region, and the Shakhovskaya urban district turned out to be one of the areas most susceptible to invasion (Fig. 2).
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Figure 2. *H. sosnowskyi* spread in Moscow region in 2016 [17].

By the beginning of 2018, by voting on the Dobrodel portal [18], the areas were determined that should first be cleared of the plant, and an action plan was developed [19]. Information on the areas where *H. sosnowskyi* was fought against in 2016-2021 is presented in Table 1.

**Table 1.** Information about the areas treated from *H. sosnowskyi* in the Shakhovskaya district and in Moscow region in 2016-2021 [16, 20, 21].

| Year | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 (plan) |
|------|------|------|------|------|------|-------------|
| Area of treated municipal land in Shakhovskaya district, ha | 30 | 800* | 446 | 650 | 768 | 930 |
| Funds allocated to stop the spread of hogweed in Shakhovskaya district, ₽ | 500 000, 00 | 681 333,00 | 8 967 954,00 | 12 598 656,00 | 15 194 211,00 | 11 277 417,00 |
| Area of treated municipal land in Moscow region, ha | 16 033,5 | 17 000* | 18 000 | 15 000 | 18 000 | 16 000 |
| Funds allocated to stop the spread of hogweed in Moscow region, ₽ | — | — | 300 000 000,00 | 321 000 000,00 | 350 000 000,00 | — |

Note: * all the land overgrown with *H. sosnowskyi*; no data available on the area of processed land; — no data available.

The data in Table 1 indicate significant areas overgrown by hogweed in Shakhovskaya urban district and Moscow region. In fact, these territories are even larger, since only those plots brought to the attention by the residents or detected by the Moscow Land Committee are included on the public
map. These figures also signify enormous damage associated with a need to take measures to combat the plant due to its unwanted spread. Since the Law of the Moscow Region of August 27, 2018 N 139/2018-OZ [22] obliges legal entities and individuals to carry out activities to remove *H. sosnowskyi* on land plots owned, controlled or used by them, with the costs to be borne not only by municipalities, but also individuals on whose land this weed was identified. The amount incurred by private landowners to combat the plant is not known. Fines issued to individuals and legal entities in Moscow region in 2019 amounted to ₽39.1 million, and in 2020 – ₽45.8 million [20].

By 2020, resulting from anti-*H. sosnowskyi* measures in the urban district, land plots that can be easily accessed by transport were treated (fig. 3). Far from roads, agricultural lands, represented by old-fallow meadows and overgrown with forests, have turned into foci of invasion, serving as a further source of hogweed dispersal into hard-to-reach areas where they are hard to stop. Not all of them are shown on the public map. An example of such territories is the former hayfields northeast of the village of Berezenki and southwest of the village of Burtsevo. Here, the hogweed can be found under the canopy of a small-leaved forest, where it produces the second layer. It is extremely difficult to fight it in such conditions.

Hogweed dispersal in forests, floodplains of small rivers and specially protected natural areas is a major concern, because herbicide treatment is prohibited there. These territories are almost missing on the public map.

![Map of Shakhovskaya urban district](image_url)

**Figure 3.** Public map of Shakhovskaya urban district with the areas where *H. sosnowskyi* is being fought [18]
7. Conclusions
Currently \textit{H. sosnowskyi} is a serious concern for the Shakhovskaya urban district. The efforts to stop the weed have been going on for several years, but the problem has not yet been completely solved. For the period 2016-2020 the areas nearby settlements and roads were treated. In 2021, it is planned to treat the areas with herbicides near villages and roads, many of which have already been treated before. \textit{H. sosnowskyi} is likely to disappear in these areas soon. However, given that the seeds of the plant can remain viable for several years, even these areas will need to be monitored annually for at least a decade.

In the Shakhovskaya urban district, the weed control has not currently affected hard-to-reach areas, including floodplains of small rivers, ravines, forest edges, former hayfields that have turned into old-fallow meadows with access overgrown with forest. Hence, the hogweed in these places continues to spread, invading natural ecosystems. However, the municipal authorities may not know anything about these sites, since not every resident visits such places. To better inform the owners and users of land plots, it would be useful to create a map based on the analysis of the latest satellite images of the territory, since they show thickets of hogweed perfectly distinguishable. Yet, this work requires funding necessary to purchase space images, experts concerned, high-quality equipment, software for data processing, etc. If such a map existed, were publicly available and updated annually, it would help to combat \textit{H. sosnowskyi} more effectively.

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References
[1] Panasenko N N 2017 On certain issues of biology and ecology of Sosnowsky’s hogweed \textit{(Heracleum sosnowskyi Manden)} \textit{Russ. J. Biol. Invasions} 8 272–281
[2] Kabuce N and Priede N 2017 NOBANIS—Invasive Alien Species Fact Sheet — \textit{Heracleum sosnowskyi}, 2010. Retrieved from: \url{https://www.nobanis.org/globalassets/speciesinfo/h/heracleum-sosnowskyi/heracleum-sosnowskyi.pdf}. Accessed November 3.
[3] Archive RAS 188 1 (1949) 19
[4] Archive RAS 534 1 (1945-1954) 201 and 202
[5] Sokolov V S, Medvedev P F and Marchenko A A 1955 \textit{Silage plants and their culture in the non-chernozem zone} (Moscow-Leningrad) pp 1-195 (In Russian)
[6] Mironova N P and Koroleva V I 2017 Research on the introduction of forage plants by the agrobiologist K.A. Moiseev in the 1950-1980s in the Komi branch of the USSR Academy of Sciences \textit{History journal: Research} 6 178-191 (In Russian). DOI 10.7256/2454-0609.2017.6.24447
[7] Ozerova N A and Krivosheina M G 2018 Patterns of Secondary Range Formation for \textit{Heracleum sosnowskyi} and \textit{H. mantegazzianum} on the Territory of Russia \textit{Russian Journal of Biological Invasions} 9(2) 155–162. DOI: 10.1134/S2075111718020091
[8] Smolskiy N V 1965 On the problem of the introduction of new silage plants for agriculture in Belarus \textit{New fodder and silage plants: Proceedings of the 2nd All-Union Meeting-Seminar on New Silage Plants} (Minsk) pp 17–32 (In Russian)
[9] Satsyperova I F 1984 \textit{Hogweeds of the USSR are new fodder plants} (Lenindrad: Nauka) pp 1-224 (In Russian)
[10] Zhamba G E 1970 Allelopathic properties of Sosnowsky hogweed and cordifolia \textit{The Fifth Symposium on New Silage Plants. Materials of scientific reports} 2 75-76 (In Russian)
[11] Budarin S N 2015 \textit{Morphological and physiological relationships of \textit{Heracleum sosnowskyi} (Manden.) with cultivated and weed plants}, Extended Abstract of Candidate Dissertation (Moscow) pp 1-24 (In Russian)
[12] Luneva N N, Konechnaya G I, Smekalova T N, Chukhina I G 2018 On the status of the species Sosnovsky hogweed Heracleum sosnowskyi Manden. on the territory of the Russian Federation *Plant Protection Bulletin* 3(97) 10-15 (In Russian)

[13] Chirkov V I, Sennikov V A and Ogorodnikov B I 1976 Agroclimatic resources of the Shakhovsky district of the Moscow region (Moscow) pp 1-33 (In Russian)

[14] Krivosheina M G, Ozerova N A and Petrosyan V G 2020 Distribution of Seeds of the Giant Hogweed (Heracleum sosnowskyi Manden.) in the Winter Period *Russian Journal of Biological Invasions* 11(4) 318–325. DOI: 10.1134/S2075111720040049

[15] In the urban district of Shakhovskaya, they are fighting with a hogweed 2016 *Shakhovskie vesti* 07 July, 12(53). Retrieved from: [http://inshahovskoe.ru/novosti/ekologiya/v-gorokruge-shahovskaya-boryutsya-s-borshchevikom](http://inshahovskoe.ru/novosti/ekologiya/v-gorokruge-shahovskaya-boryutsya-s-borshchevikom) (In Russian)

[16] Destruction of Sosnovsky hogweed in the Moscow region (In Russian). Retrieved from: [http://proborshevik.ru/wp-content/uploads/2017/10/Antiborsh_Moscow_region_2017.pdf](http://proborshevik.ru/wp-content/uploads/2017/10/Antiborsh_Moscow_region_2017.pdf)

[17] Dudin V N 2013 *Age-old fields of Shakhovskaya* (Moscow) pp 1-320 (In Russian)

[18] Geoportal of the Moscow Region. Retrieved from: [https://rgis.mosreg.ru](https://rgis.mosreg.ru)

[19] Dalke I V, Chadin I F and Zakhozhiy I G 2018 Control of Sosnowskyi’s Hogweed (Heracleum sosnowskyi Manden.) Invasion on the Territory of the Russian Federation *Russian Journal of Biological Invasions* 9(4) 331–344. DOI: 10.1134/S2075111718040045

[20] Internet portal of the Shakhovskaya urban district. Retrieved from: [https://uax-fo.pdj/](https://uax-fo.pdj/)

[21] Tenders: destruction of hogweed. Select region: Selected regions: 1 (Moscow region) Retrieved from: [https://rostender.info/category/tendery-unichtojenie-borshchevika?active_filter=1&kladr52=on&page=1](https://rostender.info/category/tendery-unichtojenie-borshchevika?active_filter=1&kladr52=on&page=1)

[22] Law of the Moscow Region of August 27, 2018 N 139/2018-OZ "On Amendments to the Law of the Moscow Region” On Improvement in the Moscow Region ”and the Law of the Moscow Region” Code of the Moscow Region on Administrative Offenses ”(adopted by a resolution of the Moscow Regional Duma of 16 August 2018 N 13/59-II. Retrieved from: [https://base.garant.ru/43240660/](https://base.garant.ru/43240660/)