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NEXT Poland – Ukraine

RECOMMENDATIONS ON A COMMON METHODOLOGY FOR CONTROL OF HOGWEED POPULATIONS IN VARIOUS CROSS-BORDER LANDSCAPE AREAS OF UKRAINE AND POLAND

These recommendations were developed based on existing methods for controlling Sosnowsky's hogweed in Poland and Ukraine (Part 1) and selected laboratory and field research methods planned in the ZeroHeracleum project (Part 2) in the field of controlling the hogweed population in various landscape areas of the Polish-Ukrainian border as part of the international conference "Applied application of methods of influence on the hogweed population in order to restore the biodiversity of the transboundary territories of Ukraine and Poland", which was held on October 16-17, 2025 as part of the project "Protecting the biodiversity of cross-border territories of Ukraine and Poland from invasive hogweed (Heracleum) populations" no. PLUA.01.03-IP.01-0008/23, financed by the European Union under the Interreg NEXT Poland-Ukraine Programme 2021-2027.

PART 1. EXISTING METHODS FOR HOGWEED CONTROL IN POLAND AND UKRAINE – RECOMMENDATIONS FOR TARGET COMMUNES

Recommendations will be implemented in several stages: Recommendations will be implemented from several stages, namely:

1. Detection and mapping of hogweed (March 2026 – December 2026 / January 2027).

Tools and applications: satellite images, mobile application, drones, GPS, and experts monitoring the state of invasive plant populations.

Actions: Survey all 1,000 ha in 9 target communes in Ukraine and 7 communes in Poland (905 km²), focusing on roadsides, riverbanks, and forest belts.

Interactive map: Create an interactive GIS map at the beginning of 2027 presenting the results of remote sensing analyses.

At the first stage, the main goal is the complete and detailed identification of Sosnowsky's hogweed population. Work begins with collecting available data, including local observations on plant distribution. For systematic surveying, the territory is divided into several-hectare plots to allow thorough inspection of each site.

Field surveys will be conducted using drones for aerial photography of hard-to-reach areas, GPS devices for precise geolocation, and satellite images to detect early stages of flowering. Hogweed populations will be analyzed across all habitat types.

During the survey, the frequency, distribution, and developmental stage of plants (from rosette to budding, flowering, and seed maturation) will be recorded to plan optimal timing for subsequent control measures. All detected locations will be entered into the GIS database, including geocoordinates, drone photos, and records of mechanical or chemical treatment.

Local residents will also use the interactive mobile application to photograph and report hogweed occurrences, supporting population mapping. Data collected will inform analysis of plant distribution and population characteristics, enabling evidence-based recommendations for control measures and effective planning of the next stages.

2. Planning and preparation (April 2026 – November 2026)

Formation of a mobile team at the commune enterprises of the territorial community.

- The team consists of two trained operators with tractor licenses and skills in operating tractors, as well as experience using GIS-based interactive maps.
- Staff should be familiar with invasive plant control methods at different growth stages, from rosette to flowering and seed maturation.
- The team ensures timely operations in all infested areas, particularly roadsides, riverbanks, and forested regions.

Procurement of equipment: Tractors and tractor attachments, manual tools, and personal protective equipment.

- **Personal Protective Equipment (December 2025):**

- Protective suits — 9 pcs. per community;

- Sprayers for washing suits — 2 pcs. per community;

- Chemically resistant gloves — 9 pcs.;

- Special shoes — 9 pairs;

- Respirators and filters — 9 pcs. Each;

- Safety glasses and visors — 9 pcs. Each.

These items ensure safe mechanical and chemical treatment of plants, prevent contact of skin and respiratory tract with toxic substances, and allow proper cleaning and disinfection after work.

Mechanization

- **Manual equipment (December 2025):** professional manual gasoline mowers — 2 pcs. per community, Battery sprayers — 2 pcs. per community. They are used for treatment of small and hard-to-reach areas.
- **Tractors (December 2025 – March 2026):** tractor SPIKE TK 904, 90 hp, four-wheel drive, turbo-diesel engine Sealed cabin with improved sound insulation and air conditioning for work under all weather conditions Open-type hydraulic system with three pairs of rear hydraulic outlets Equipped with GPS navigators capable of exporting data to the monitoring system

Additional tractor equipment (December 2025 – March 2026): plows with a skimmer for soil preparation and road mowers with a working width of 1.8 m, adjustable cutting height, floating structure and hydraulic tilt adjustment. Such equipment allows you to work on slopes, roadsides and at an angle of up to 60 degrees, providing effective plant control over large areas.

Staff training (January 2025 – March 2026)

- Training in occupational safety and methods of hogweed treatment at different growth stages (from rosette to flowering and seed maturation).·
- The training includes the practical use of hand equipment and tractors, the proper use of protective equipment, and compliance with the rules for handling chemicals.

Such training guarantees safe and efficient performance of work in all areas of the commune.

3. Spring Control (April – May 2026–2027)

Mechanical control:

- **Continuous mowing:** Up to three times per season for plants up to 1.5 m to limit early growth and reduce seed formation risk.
- **Root** cutting: Most effective in April; depth 12–15 cm to weaken or destroy the plant and prevent regrowth.
- **Plowing:** Mainly used in autumn, but also for spring preparation and root destruction, depth up to 25 cm to reduce population density next season.
- **Inflorescence cutting:** Mid-flowering to prevent seed formation and limit spread to new areas

Chemical control:

- **Spot spraying:** Performed during active growth using powerful cordless sprayers for precise application, minimizing contact with other crops and environment

Tank mixtures for Sosnowsky's hogweed

№	Tank mixture	Mechanism of action
1	*Potassium salt of glyphosate 625 g/L (5 L/ha) + Dicamba dimethylamine salt 480 g/L (0.5 L/ha) + MBSpH-corrector (50 mL/ha) + Urea (5 kg/ha) + Water (200 L/ha)*	**First treatment.** For young and medium plants; spot spraying. Rosette or early stem phase (spring–May – early summer)
2	*Potassium salt of glyphosate (5 L/ha) + Dicamba (0.5 L/ha) + MBSpH-corrector (50 mL/ha) + Urea (5 kg/ha) + Water (200 L/ha)*	**Second treatment** if needed (late summer). Systemic action; suitable for large plants, including root system.

- Processing time: early May – June, during active growth before flowering

- Temperature: +12–25°C
- Rain-free period: at least 4 hours after spraying
- Spraying: uniform leaf coverage, avoiding runoff
- Avoid spraying in windy conditions to prevent drift to crops
- Areas near rivers: mechanical treatment only to prevent water pollution

Personal protection: Due to the risk of burns from contact with Sosnowsky's hogweed, all work must be performed in full protective clothing (suits, gloves, respirators, visors, and boots).

Microwave method

Microwave radiation is considered a promising physical method for the eradication of Sosnowsky's hogweed. Research indicates that exposure to microwave radiation for 15 minutes ensures 100% plant mortality without causing ecotoxic damage to the soil. This method is environmentally safe and allows avoidance of chemical substances. However, its effectiveness requires further detailed research and confirmation of safety for human health. A перспективive approach is the application of microwave treatment using remotely controlled robotic systems, which would allow the treatment of hard-to-reach areas without direct human contact with the plant.

Biological control method

Sheep are immune to the toxic sap of Sosnowsky's hogweed and can consume the plant without harm to their health, while significantly reducing weed population density.This method is particularly effective on slopes, pastures, and areas along watercourses, where traditional mechanical or chemical control is limited or restricted.

4. Summer Control (June–August)

Re-treatment

- Mowing of mature plants before flowering is carried out to prevent seed formation, which significantly reduces further spread of hogweed. Mowing is repeated as necessary in areas with high plant density.
- Repeated herbicide spraying of new seedlings is carried out after the active growth phase of young plants. This enables control of the next generation of hogweed and prevents its mass spread in infested areas.

PART 2. LABORATORY AND FIELD METHODS PLANNED IN THE ZeroHeracleum PROJECT

Research methodology in WP2

The methodology for the tasks carried out within WP 2 includes six stages:

Stage 1 involves defining the precise boundaries of the analysis area in the communes of Poland and Ukraine and acquiring satellite remote sensing data for these territories. Multispectral images with a spatial resolution of less than 3 meters are planned for use. Additionally, preliminary field information will be collected in both countries through WebGIS regarding known hogweed locations, including GPS coordinates, photographic evidence, approximate population size, and landscape description. These data will serve as a reference base for subsequent classification.

Stage 2 involves developing two WebGIS applications for collecting field data on the distribution of Sosnowski's hogweed in Poland and Ukraine. The applications will be created in two versions with different levels of detail and adapted for specialists (researchers), non-specialists and volunteers, including local community employees familiar with local hogweed sites. The applications will operate using GNSS positioning of mobile devices and will allow users to collect coordinates, photos, estimates of infestation area, population density, and landscape type in communes in both Poland and Ukraine.

Based on the spatial data collected through WebGIS in Poland and Ukraine, a training dataset will be created for GeoAI and ML algorithms.

Stage 3. Within this stage, additional field verification will be carried out at: 50 additional locations in Poland and 50 additional locations in Ukraine. The purpose is to confirm the presence of hogweed, verify the accuracy of the initial model, and improve satellite image classification. All updated data will be synchronized with WebGIS to further enhance model accuracy.

Stage 4 covers the main remote sensing analyses. The OBIA method will be applied to multispectral satellite images for territories in Poland and Ukraine to automatically detect hogweed populations.Model accuracy will be assessed, and the results will be prepared as a GIS database and published as an interactive online map (WebGIS beta version) accessible for both countries. Field data from Ukraine and Poland will be used to improve classification accuracy and refine the identified population boundaries.

Stage 5 involves aerial imaging of hogweed-infested areas using multispectral sensors mounted on UAVs. Imaging will be carried out: in Poland on selected plots using a multispectral drone, in Ukraine covering at least 1,000 ha across designated communes. Based on the collected data, vegetation indices will be calculated to refine population boundaries, assess their condition, and monitor the effectiveness of control measures. Aerial surveys are planned multiple times during the vegetation season in both countries, enabling monitoring of plant regeneration, control effectiveness, and changes in the natural environment.

Stage 6 includes updating the WebGIS application to its final version and integrating all data obtained in Poland and Ukraine: satellite imagery, field points, aerial survey results, and verification.

The outcome will be the final WP2 report, which will include:

- a comprehensive map of hogweed distribution in the communes of both countries,

- results of remote sensing and UAV surveys,

- an integrated database for use in subsequent work packages.

Research methodology in WP3

Stage 1: Conducting field research over two growing seasons to collect data for a database containing a list of characteristics of the Sosnowski hogweed population in 30 municipalities in Poland and nine in Ukraine. The database will contain the following information:

- GPS coordinates and photographic documentation of the populations;

- name of the locality and site code;

- habitat type;

- population size (number of individuals or/and area of population per hectare);

- viability of population individuals (% share of individual developmental plant stages);

- biometrics of six scattered population individuals (leaf dimensions, plant height, number of umbels or absence thereof, density of hogweed);

- manner of clustering of hogweed individuals (sociability);

- list of accompanying species (phytosociological survey using the Braun-Blanquet method).

Any visible traces of control measures against the species under study will also be assessed. All field data will be entered into the application and onto standardised research forms.

Stage 2: While assessing the characteristics of the population in the field, biological samples (such as leaf fragments, whole leaf blades and seeds) will be collected for genetic and biochemical laboratory testing.

Stage 3: Soil condition (pH, organic matter content and nutrient content) will be assessed using a soil scanner.

Stage 4: The database of information obtained will form the basis for developing recommendations for combating hogweed in individual municipalities. The collected biological material will be used for biochemical and genetic laboratory analyses.

Research methodology in WP4

The aim of the research conducted within the WP4 package is to develop recommendations for combating hogweed based on biochemical genetic analyses of the populations being controlled.

Research on the genetic structure of the Sosnowski hogweed population

The first stage involves collecting samples in 30 municipalities in Poland and 9 in Ukraine and delivering them to the University of Life Sciences in Lublin and Maria Curie-Skłodowska University in Lublin as leaf fragments dried at room temperature, no later than by the end of August 2026. Within each location, fragments from at least five individuals from random but distant sites within that location should be collected separately in paper bags. GPS coordinates for each sample should be written on the respective bag. The youngest leaves should be collected from the plants to avoid excessive accumulation of secondary metabolites that hinder the isolation of pure nucleic acids.

In the second stage, the obtained samples will be disintegrated to destroy the tissue structure and cell walls. After obtaining cell lysates, nucleic acids will be isolated using silica membranes. The quantitative and qualitative parameters of the isolated preparations will be determined by spectrophotometric, electrophoretic, and fluorimetric methods.

In the third stage, DNA preparations with the best quantitative and qualitative parameters will be selected. To verify the suitability of nucleic acids for genomic analysis, test reactions will be performed using the real-time PCR method. Samples that do not contain reaction inhibitors and show high amplification efficiency (within the range of 90-110%) will be used for reduced representation genome sequencing using the DArTseq method. After being adjusted to the same concentration, the DNA samples will be sent to the sole supplier of the patented technology for analysis. As a result, sequence data covering tens of thousands of restriction fragments in each sample will be obtained. These data will be converted into binary matrices for bioinformatic analysis.

In the fourth stage, bioinformatic analyses of the genetic data will be carried out to determine the genetic similarity of the studied objects and to characterize the population structure. The following parameters will be determined: (I) three types of

genetic populations - G1a-G1c: homogeneous, medium diversity, and high diversity, respectively; (II) four levels of similarity - G2a-G2d: low (up to 50%), medium (50-75%), high (75-90%), and very high (>90%), respectively; and biochemical parameters: (III) number of identified compounds - B1a-B1c: low, medium, high, respectively; (IV) concentration of compounds - B2a-B2c: low, medium, high, respectively. Genetic data will be compiled and compared with other traits identified for the studied populations, such as biochemical, morphological, and phenological characteristics.

In the fifth stage, based on the obtained results, recommendations for control methods tailored to individual genetic groups will be developed.

Qualitative and quantitative studies of secondary metabolites in the Sosnowski hogweed population (Faculty of Biology and Biotechnology, Maria Curie-Skłodowska University, Lublin).

The study will examine the quality and quantity of secondary metabolites, paying particular attention to furanocoumarins, which irritate the human body and cause photodermatosis. This assessment will inform the selection of an optimal method for combating hogweed and protecting human and animal health in a given population. Level of bioactive compounds – biochemical parameters: (III) number of recognized compounds, B1a-B1c – low, medium, high, respectively; (IV) concentration of compounds, B2a-B2c – low, medium, high, respectively.

Stage 1: Preparation of extracts for secondary metabolite analysis from plant samples collected in the field. Multiple extraction to obtain a concentrated solution. Preparation of dilutions for detailed analyses.

Stage 2: Biochemical analysis using high-performance liquid chromatography (HPLC), mass spectrometry (MS) and UV/VIS spectroscopy to qualitatively and quantitatively assess the active substances contained in the samples (e.g. furanocoumarins, flavonoids and anthocyanins).

Stage 3: identification of the substances detected using standards and databases (MS libraries).

Stage 4: imaging of the identified substances in leaf tissues using an HTX MALDI M3+TM Sprayer.

Stage 5: supplementing the database with data obtained from genetic and biochemical tests. Incorporating the results into recommendations for municipalities.

Research methodology in WP5

The first stage of the task will be to select sites for the control of Sosnowski's hogweed. This species will be controlled in the municipalities of Końskowola and Werbkowice.

Two methods will be tested there: a mechanical-chemical method and a cryogenic method. 9 test plots of 1 hectare each will be selected in Ukrainian communes, including Korostiv, Zhupany, Spas, Dovhe, Tukhlya, Lybohora, Pidhorodtsi, Smerechka, and Yasenytcia.

The mechanical-chemical method of controlling hogweed involves the mechanical removal of the above-ground parts of the plant using a specialised mower, combined with the use of herbicides (flazasulfuron and glyphosate). In this method, the above-ground parts of the plant will be removed using specialised hand or mechanical equipment. Next, the herbicide mixture will be applied to the root collar or inside the stem using a herbicide sprayer with specialised nozzles. To achieve the desired effect, herbicide spraying will be applied throughout the area to young regrowing plants. After the herbicide treatments, plant health will be monitored using a non-contact chlorophyll meter. At the end of the growing season, a visual assessment of the effectiveness of the method will be carried out and soil samples will be taken to determine the residues of active herbicide substances. The same mechanical-chemical method will be applied on all Ukrainian test plots, following population characteristics identified in WP3 and genetic/biochemical recommendations from WP4.

The cryogenic method will involve the use of extremely low temperatures (-196oC) to eliminate both young and adult plants. This method will use a specialised device for the precise application of liquid nitrogen. Before the gas is applied, the above-ground parts of mature plants will be mechanically removed (mowed). In the case of seedlings and young plants that have reached a maximum height of 30 cm, the gas will be applied to the surface of the entire plant. In the case of mature plants, the liquefied gas will be administered (injected) directly into the stem and/or roots of the plants using an applicator. The treatments will be repeated twice during the growing season. After the second series of treatments, plant residues will be destroyed using a rotary tiller. After cryotherapy treatments and at the end of the growing season, a visual assessment of the effectiveness of the method will be carried out. Note: Cryogenic method will only be applied in Poland due to logistical constraints, while Ukrainian plots will use mechanical-chemical, mulching, and grazing methods.

In addition, biological tests will be carried out under controlled laboratory conditions. The effectiveness of selected herbicide mixtures, used alone or with an adjuvant, on seedlings and young plants of Sosnowski's hogweed will be assessed. The herbicides will be precisely applied in a laboratory spray chamber. The experiments will be conducted in a climate chamber with adjustable temperature, lighting and air humidity. Ukrainian Partners will participate in laboratory trials at partner facilities in Poland for training and methodology standardization.

The latest tested methods for controlling Sosnowsky's hogweed include grazing livestock on pastures in the Werbkowice commune. The project included testing various variants: animal species (cattle, sheep), livestock density (LSU/ha), different development stages of Sosnowsky's hogweed, and different months of the growing

season (August-September 2025 and April-September 2026). In Ukraine, grazing experiments will also be conducted on selected plots with livestock, complemented by manual mowing and overseeding with grasses and legumes, adapted to local conditions. Ukrainian Partners will monitor livestock density, plant regrowth, and habitat restoration success over the same periods.

Research methodology in WP6

Stage 1: Selection of areas for the control of HS and provision of communal enterprises with necessary equipment. In the 9 target communes of Ukraine, tractors, ploughs, mowers, dump trucks, and personal protective equipment will be purchased and transferred to the ownership of communal enterprises, enabling them to conduct systematic hogweed eradication. For hard-to-reach and hazardous areas with steep slopes, a remotely controlled robot equipped with a rotary tiller and a transport platform will be acquired and deployed across all nine communes. Agreements will be concluded with the enterprises to ensure the implementation of the measures and define further actions of the communes in eliminating hogweed.

Stage 2: Mechanical destruction of HS over an area of 1000 hectares during two years in the nine target communes of Ukraine. The work will be carried out by personnel of the communal enterprises using the purchased tractors, ploughs, mowers, dump trucks, protective equipment, and the remotely controlled robot. Simultaneously, progress monitoring, control over the implementation of the measures, and collection of data on vegetation condition and effectiveness of mechanical removal will be conducted.

Stage 3: Renaturalisation of 10 hectares of land after hogweed removal in the Strilky commune (Lopushanka-Khomyna village). The area will be prepared for grass restoration through mowing, rototilling, herbicide application, fertilization and liming if necessary, followed by harrowing, sowing of recommended grass mixtures, and rolling of the seeded area. Once the grass cover is established, the land will be used for livestock grazing by local community members, with monitoring of pasture condition and evaluation of the effectiveness of the renaturalisation.

Stage 4: Monitoring of pastures and assessment of the effectiveness of the measures. Grass cover condition, effectiveness of applied herbicides and fertilizers, compliance with agronomic procedures, as well as indicators of milk production and livestock numbers will be tracked to determine the feasibility of establishing public pastures in other communes, restoring biodiversity, and maintaining sustainable control of hogweed after the project’s completion.

Practical recommendations were jointly prepared by the Lviv Agrarian Chamber, the Stepan Gzhytskyi Lviv National University of Veterinary Medicine and Biotechnologies, the University of Life Sciences in Lublin, the Maria Curie-Skłodowska University, and the Lublin Agrarian Chamber, with the aim of protecting biodiversity in the cross-border territories of Ukraine and Poland from invasive populations of Sosnowsky's hogweed, within the framework of the Interreg NEXT Poland–Ukraine Programme 2021–2027, financed by the European Union.

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