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and eradication**

DELIVERABLE 3.5

Guidelines for sustainable IPM control of weeds

- 1. Ailanthus altissima*
- 2. Ambrosia artemisiifolia*
- 3. Heracleum spp.*

TABLE OF CONTENTS

Document information	3
1. <i>Ailanthus altissima</i>	4
1.1. Introduction	4
1.2. Species description	4
1.3. Biology and ecology	5
1.4. Impacts.....	5
1.5. Management of <i>Ailanthus altissima</i>	5
1.6. Conclusions	10
1.7. References	10
2. <i>Ambrosia artemisiifolia</i>	12
1.1. Introduction	12
2.2. Species description	12
2.3. Biology and ecology	13
2.4. Impacts.....	13
2.5. Management of <i>Ambrosia artemisiifolia</i>	15
2.6. Conclusions	18
2.7. References	18
3. <i>Heracleum spp.</i>	20
3.2. Introduction	20
3.3. Summary of the project work	21
3.4. Distribution, Biology and life cycle of <i>Heracleum spp.</i>	22
3.5. Analyses of existing methods used for hogweed eradication	23
3.6. IPM Methodology for effective hogweed eradication.....	29
3.6.1. IPM development for practical solutions	29
3.6.2. Main aspects for effective IPM hogweed eradication.....	35
3.6.3. Field on-farm experiments for hogweed IPM	36
3.7. Trial places, location of field on - farm experiments	39
3.8. Recommendations and Quality requirements for hogweed IPM control	40
3.9. Dissemination, Training and Stakeholders for hogweed containment with IPM.....	47
3.10. Conclusions and Discussions.....	51
3.11. Acknowledgements for hogweed containment with IPM	51
3.12. References	52
Annex 1. On - farm experiment results (2015 – 2017) for <i>Heracleum spp.</i> containment with IPM.....	55

DOCUMENT INFORMATION

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1. AILANTHUS ALTISSIMA

Guidelines for sustainable IPM control of *Ailanthus altissima*

1.1. INTRODUCTION

Ailanthus altissima (tree of heaven) is native from China, has spread over a large part of Europe, and it mostly invades forests via roads or trails. As a fast growing tree, it tends to create dense pure stands that may have a strong impact on natural biodiversity. It can also be found in agricultural (including horticultural) and domestic habitats. This tree can also invade urban areas, where it can cause damage to buildings and other structures as well as transport networks, including roads, railways, and other constructed hard-surfaced areas. Control of this invasive species is particularly difficult as any disturbance to above ground structures, including cutting, chopping or girdling, promotes production of sprouts that may emerge from the root, the root crown and the stem (Hu, Shiu-ying. 1979).

1.2. SPECIES DESCRIPTION

Habitus: *A. altissima* is a deciduous tree, 5-30 m tall.

Stem: erect, with smooth and light brown/gray bark in the young plants that becomes slightly darker, rough and fissured when adult.

Roots: superficial roots with rhizomes able to produce numerous sprouts.

Leaves: dark green, alternate, compound with a single leaflet at the tip and with entire margin, with 1-4 teeth at the base and with a strong smell. Leaves of young seedlings are reddish-brown in colour.

Flowers: panicle inflorescence at the tip of the branches, 10-20 cm long. Separate male and female flowers are produced on different plants. Flowers are numerous, small, white or yellow greenish in colour with reddish shades. Male flowers have strong smell, while female flowers are odourless.

Fruits: winged fruits grouped in clusters with one seed centred in the middle of the fruit. Fruits are persistent on the tree during winter. Fruit clusters are reddish in colour when newly formed. They become brownish/reddish yellow at maturity.



Fig. 1.1 *Ailanthus altissima*

1.3. BIOLOGY AND ECOLOGY

Ecological requirements: *A. altissima* is a pioneer species, highly adaptable to different soil types. It can survive in different environmental conditions, such as saline, poor and compacted soils and in dry, heat and polluted environments. As it grows fast, it can rapidly colonize disturbed and unmanaged areas.

Pollination: small flies, beetles and honeybees have been recorded as pollinator of *A. altissima*.

Seed production and dispersal: the species produces up to 325,000 seeds grouped in several hundred clusters per plant. Seeds are dispersed by wind; however, they can also be dispersed by water, birds and machinery.

Plant propagation: *A. altissima* can sprout from roots and from the stump. Sprouts are produced up to 15 m from mother plant and have a rapid growth, till 3-4 m in a single season; seedlings have slower growth, about 1-2 m per year. Root sprouting is stimulated by plant cutting and root damages.

Flowering period: occurs from May to July (Northern Italy).

Environment: *A. altissima* can grow in different environments: natural, urban, and industrial areas including roadside and railways. It infests forests, meadows, riparian zones, uncultivated or abandoned areas. The species has been reported to infest mainly plain areas but it can grow up to about 1000 m a.s.l.

1.4. IMPACTS

Ecosystems: *A. altissima* is a short-lived species (30-50 years) but its ability to sprout constituting pure areas of infestation, that hampers the growth of other species, permits to dominate the infested sites indefinitely. The reduction of biodiversity caused by this species is also due to its allelopathic potential: bark and leaves can release allelopathic compounds that inhibit or affect the germination and the growth of other plants.

Agriculture: leaves are toxic for animals, but because of the bitter taste are relatively unpalatable compared to other species.

Human health: bark, leaf and root saps can cause skin irritation to some people due to the alkaloid ailanthin. Pollen may cause allergy reactions.

Buildings: the fast-growing root system can damage buildings, foundations, sidewalk, roads, archaeological sites, roofs and cracked walls of unmanaged buildings.

1.5. MANAGEMENT OF AILANTHUS ALTISSIMA

Preventive methods

- Avoid selling or planting the species as ornamental or for restoration/reforestation interventions.

- Remove female individuals, as they are source of seeds to prevent new infestations and to avoid spreading the existing ones.
- Preserve natural vegetation with closed canopy to avoid *A. altissima* establishment, as it is shade intolerant.
- Minimize bare soil conditions in construction sites and re-establish the vegetation with native species. Avoid use of soil coming from areas external to the site that can contain propagules of the species. Identify areas in the construction sites where equipment and vehicles can be cleaned to avoid spreading seeds inside and outside the sites.
- Map infestations, inspect disturbed areas, or areas in which the species has already been controlled to early detect new infestations and suppress root sprouts and seedlings.

Control methods

Agricultural areas

A. altissima is not considered a crop weed. However, it can infest field margins, buffer strips and uncultivated areas close to the fields, areas in proximity to hedges, ditches and tree rows. To manage the species in these areas, refer to control measures given for natural and semi-natural areas.

Non-agricultural (urban, industrial areas) and natural and semi-natural areas

Mechanical and physical control

- **Hand pulling.** It can be adopted to remove only young seedlings, which are easy to pull out; be sure to remove the root system completely to prevent root sprouting. Seedlings can be distinguished from sprouts as they are slender, have trifoliate leaflets and sometimes cotyledons are still present. Start removing *A. altissima* seedlings from less infested areas as the native vegetation can quickly revegetate the area and hamper the returning of the invasive species (Fogliatto *et al.*, 2016).
- **Mowing.** Repeated mowing of seedlings and sprouts, applied at regular intervals during the growing season, can be effective in reducing the ability of plants to resprout as it favours the depletion of the root reserves. Infrequent mowing enhances root sprouting and allows the sprouts to become too tall to be mowed.
- **Cutting.** Bigger plants that cannot be mowed can be cut with different tools, such as loppers, machetes, brush cutters and chainsaws. Give priority in cutting female individuals prior flowering to avoid the infestation spreading by seeds. Cutting has to be done frequently as it stimulates root and basal sprouting, increasing the infestation density. Cutting alone is not recommended and it should be coupled with a chemical treatment.

- **Girdling.** It can be applied for adult plants and consists of removing a strip of bark and cambial tissues of at least 15 cm for the entire circumference of the trunk using different tools, such as knife, chisel, ax or hatchet. Girdling should be performed in spring when the liquid pressure inside the plant is maximum. As girdling reduces the downward translocation of photosynthates to the roots, it promotes leaf size and number, as well as sprouting (Merceron *et al.*, 2016). If the band of bark removed is too fine, the formation of wound tissue can bring to a reconnection of the sides of the girdle, repairing the damage and making useless this control technique. As this technique stimulates sprouting it should be repeated in time or herbicides should be applied on the girdling surface few minutes after girdling. Girdled plants die remaining standing for sometimes before falling to the ground; thus, the use of this technique is not advisable in areas used by the public.



a) Hand pulling

b) Cutting



c) Girdling

Fig. 1.2 Mechanical and physical control methods: a) hand pulling; b) cutting, c) girdling

Chemical control

Chemical treatments can be performed with wide-spectrum systemic herbicides, in areas in which it is allowed by regulations, in addition to mechanical control. Herbicides that proved to be effective on *A. altissima* are, for example, glyphosate, triclopyr, fluroxypyr, aminopyralid and their mixtures (Dufour-Dror, 2013; USDA, 2014).

Particular attention should be given to verify if further restrictions exist for herbicides applied in areas used by general public or vulnerable groups as established by the National Action Plans for the Sustainable Use of Pesticides (Directive 2009/128/EC). In natural and semi-natural areas, chemical control is not advisable. However, some herbicide applications, such as stem injection, cut stump, etc., are performed using a very small amount of product and the risk of harming the environment because of spray drift is almost nil (Milan *et al.*, 2018).

In general, herbicide application is the most effective method to devitalize *A. altissima* plants, including root system and sprouts. To obtain the best result, attention should be paid to choose the correct herbicides, the appropriate time of application and the correct application dose (Vidotto *et al.*, 2015).

Herbicide label should be read carefully to individuate the allowed uses of the products as well as the allowed application methods and all the use instructions.

Herbicide should be used when vegetation is active growing from spring until autumn. Treatments applied to eliminate sprouts should be performed in late summer or autumn as it is the period in which the plants translocate the photosynthates to the roots.

Herbicides can be applied using different methods:

- **Cut stump application.** This technique consists of cutting the adult plants close to the soil, usually with chainsaw or by mowing, and applying systemic herbicides with hand-bottle or by using a paintbrush (Di Tomaso and Kyser, 2007; Burch *et al.*, 2003). The herbicide should be applied on the cut surface within few minutes after cutting. For large stumps, the herbicide application can be limited to the cambial layer inside the bark rings. When many stumps need to be treated, an indicator dye could be added to the herbicide solution to show the treated stumps. The efficacy of this method could be high, depending on the herbicide molecule used and on the correct application of the technique. However, it is not infrequent that even treated plants may produce sprouts, especially from roots. In this case, follow up foliar treatments should be performed.
- **Foliar treatment.** These treatments are suitable mainly to control young and isolated plants with moderate height (<150 cm), or as follow up treatment to other applications, by using back sprayers or tractor-mounted sprayers with anti-drift nozzles or other equipment to avoid spraying the nearby vegetation. Systemic herbicides should be used from the full-developed canopy stage (late spring) to autumn.
- **Basal bark application.** It consists of spraying the bark on the basal part of the plant, up to 40-50 cm from the base, with systemic herbicides. The efficacy is low if the plants

are adults with woody bark, while better results are given if the plants are young with an herbaceous bark. It is often used as follow up treatment after a foliar application in case of small plants with moderate infestations. This treatment similarly to girdling left the tree to die standing, thus care should be taken in deciding the place in which this technique could be applied without causing risks for the public.

- **Stem injection.** It consists of applying a small amount of concentrated systemic herbicide in injection holes drilled into the trunk (Badalamenti and La Mantia, 2013; Lewis *et al.*, 2008). The holes should be drilled angled downward in the trunk and spaced some centimeters around the trunk. Herbicides can be injected with a spray bottle or a syringe, and then the holes should be closed with mud, mastic or piece of wood to prevent herbicide evaporation. The number of holes will depend on the trunk diameter, however generally one hole every 8 cm of stem diameter. This treatment left the plant to die standing, similarly to basal bark application.



a) Cut stump application



b) Basal bark application



c) Stem injection



Fig. 1.3 Chemical control methods: a) cut stump application; b) basal bark application; c) stem injection

1.6. CONCLUSIONS

Control techniques based on the herbicide use provided better efficacy in the *A. altissima* containment compared to mechanical interventions. In general, plant cutting without herbicide application always stimulated the emission of sprouts from the stump or roots. Girdling never resulted in plant death and caused emergence of shoots below the cut area. The efficacy of a single application of herbicides always declined along the time, suggesting that complete eradication of this species from an infested area should require multiple interventions in consecutive growing seasons.

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2. AMBROSIA ARTEMISIIFOLIA

Guidelines for sustainable IPM control of *Ambrosia artemisiifolia*.

1.1. INTRODUCTION

Ambrosia artemisiifolia (common ragweed) is an invasive weed in Europe, native from North America. Its presence is actually increasing in all the European countries, in both agricultural and non-agricultural areas, in particular along roadsides and in riverbanks (Chauvel *et al.*, 2006; Müller-Schärer *et al.*, 2014; Gentili *et al.*, 2015). It is considered an important, noxious weed because of its allergenic properties and its competitiveness with crops (Buttenschøn *et al.*, 2010; Makra *et al.*, 2015; Milakovic *et al.*, 2014). Pollen of flowering plants may cause allergenic reactions (rhinitis) to humans. Common ragweed has become a dominant weed in many arable and vegetable crops, especially in spring-sown crops such as maize and sunflowers for which there are currently very few effective control methods (Essl *et al.*, 2015). In this regard, an important role has been played by the continuous mono-cropping, or short rotations, and by the frequent application of weed control strategies (mainly herbicides).

2.2. SPECIES DESCRIPTION

Habitus: herbaceous, annual, aromatic, 20-100 cm high.

Stem: upright and very branched; hairless or pubescent, reddish green.

Roots: taproot.

Leaves: green on both pages, petiolate, deeply incised lamina with lateral laciniae often incised or toothed, pubescent lamina on the upper page.

Flowers: small, unisexual, green, inconspicuous. Male flower heads in terminal racemes are numerous, pendulous, small (0.3-0.5cm diameter). Female flower heads, in the axils of the upper leaves, are few and sessile.

Fruits: fusiform obovoid achenes (containing only one seed each), 0.2-0.3cm long, with 4-5 erect spiny teeth.



Fig. 2.1 *Ambrosia artemisiifolia*

2.3. BIOLOGY AND ECOLOGY

Ecological requirements: thermophilus and heliophilous pioneer species, commonly present in areas disturbed by human activities like soil movement and agricultural practices, or in riparian areas by flooding activity. Prefers sandy soils, rich in nutrients, with neutral to acid pH. Tolerates aridity, high summer temperatures and a moderate salinity of the soil. Fertilizations with N, P, Ca and K increase fruit production.

Pollination: anemophilous, male flowers begin to produce pollen in August and constantly increase up to be maximum in September. Pollen can be transported more than 40km away from the plant that produced it.

Seed production and dispersal: produce a large amount of seeds, more than 3000 each plant, which accumulate in the soil forming a considerably seed bank. Seeds maintain their viability for at least 20 years. Seed dormancy can be broken by following a period of low temperatures and rains. Natural seed dispersion is mainly barochory, but also zoochory (birds) or hydrochory. However, involuntary transport due to anthropogenic activities is one of the main causes of diffusion, especially over long distances.

Propagation: high resprouting ability and flowering after cutting, even with small plants.

Flowering: between July and October (Northern Italy).

Environment: commonly present in disturbed ruderal areas such as roads, railways, gravel pits, urban construction sites, gardens, uncultivated areas, field margins and sandy river banks. It is considered a weed of many crops like sunflower, sugar beet, wheat and other cereals.

2.4. IMPACTS

Ecosystems: may be occasionally observed on grassland or forest margins, but it is not usually able to establish permanently. In riparian areas, action of floods allows to create substrates particularly suitable for plant growth. It spreads very quickly along riparian areas due to the transport of seeds by the water stream. It is one of the most frequent species of stream biotic

community and may locally assume character of dominant specie (Brandes and Nitzsche, 2007).

Agriculture: present in many areas as weed of spring/summer crops, particularly in sunflower, maize and sorghum in which may cause yield losses. High infestation of *A. artemisiifolia* on winter cereals stubble may contribute to increase the soil seed bank, although it does not represent a direct damage to the crops (Buttenschøn *et al.*, 2009).

Human health: causes allergic reactions for both pollen and direct contact with the inflorescence. In terms of allergenic power, the pollen of *A. artemisiifolia* is more powerful than that of gramineae species and causes symptoms of inhalation and contact dermatitis/skin rash in allergic subjects, as rhinitis, conjunctivitis, asthma. The late flowering, usually from July to October, extends the seasonal allergic manifestations due to pollens in susceptible individuals (Taramarcaz *et al.*, 2005; Kazinczi *et al.*, 2008).

2.5. MANAGEMENT OF *AMBROSIA ARTEMISIIFOLIA*

Preventive methods

- In areas close to infested areas, avoid bare soil and maintain spontaneous vegetation covering.
- In construction areas with soil movements, design excavation and carryover interventions lot by lot in order to limit the presence of bare soil surface; provide the sowing of indigenous species on bare soils; avoid, if possible, the use of soil coming from other sites; providing a tire washing area for vehicles entering and leaving the construction site.
- In agricultural areas, adopt crop rotations and avoid uncultivated soils; sowing cover crops after winter cereals harvesting; provide, if possible, cleaning of farm machinery when they work in different areas, to avoid weed seeds contamination; use forage and feed coming from non-infested areas; use certified compost because domestic composting does not guarantee an adequate devitalization of the seeds.
- In non-agricultural areas, clean carefully the mowing machines.
- In urban areas, take care of cleaning and maintenance of the road surface to limit its spread.

Control methods

Different methods can be adopted to limit *A. artemisiifolia* infestation according to the application context: mechanical, physical and chemical control methods (Essl *et al.*, 2015).

Agricultural areas

Integrated management of *A. artemisiifolia* in agricultural areas needs to be set up according to the criteria and methods already adopted for the other weeds, taking into account the regulations in force.

Mechanical control

Mechanical control can be performed, in summer crops like maize and sunflower, with inter-row hoeing alone or in combination with ridging. These interventions are able to limit the growth of all weeds in general, in particular with young weed seedlings and early treatments. Good results may be also obtained by performing double mechanical interventions, or by using pre-emergence herbicide treatment followed by a mechanical intervention like the previous one. In addition, the false seedbed strategy may be adopted on early spring before the sowing of the crop.

In winter cereals, a 10cm deep soil tillage immediately after the harvesting of the crop may be very useful to limit the emergence of the weed. Cover crops may be a good opportunity to limit the growth of the weed in low infested areas.

Repeated mowing performed before flowering of the weed is a valid strategy to reduce the pollen diffusion but has low efficacy in reducing plant growth because of *A. artemisiifolia* re-

sprouting ability. For example, mowing performed at 5cm during the vegetative phase is not able to control the plants effectively, as they may rapidly regrow and bloom. Key factor is to mow plants before they set mature seeds. Combination of mowing of *A. artemisiifolia* before flowering followed by herbicide application on re-sprouts may allow a high control of the infestation.



Fig. 2.2 Infestation of *A. artemisiifolia* in winter wheat stubbles.

Chemical control

In general, chemical control strategies are quite effective in controlling *A. artemisiifolia*, in particular on summer crops. The efficacy of pre, post and pre+post emergence herbicide treatments is similar among them, but application timing is crucial as the plant susceptibility varies according to the phenological plant stages.

Some actions are required to limit diffusion of the weed:

- in sowed fields, use selective herbicides which include *A. artemisiifolia* as target weed on the product label;
- on bare soil, use non-selective broad-spectrum herbicides (e.g. glyphosate on winter stubble, flazasulfuron in vineyard sub-rows);
- in areas not yet infested, carry out continuous monitoring and act immediately in case of infestation.



Fig. 2.3 a) Infestation of *A. artemisiifolia* in sunflower.



Fig. 2.3 b) Infestation of *A. artemisiifolia* in maize.

Non-agricultural areas: urban, industrial, construction sites and buildings

Mechanical and physical control

- perform manual uprooting on low infestation areas of small size.
- use flame weeding on paved surfaces, by treating the young plants.
- perform repeated mowing before flowering. At least two cuttings are needed during the vegetative season. The number of cuttings may be variable, depending on the seasonal trend. Monitoring of plant growth stage are needed to plan treatments.
- prevent the weeds germination by adopting mulching.



Fig. 2.4 Infestation of *A. artemisiifolia* along roads.

Chemical control

Herbicide application should be carried out with non-selective broad-spectrum products, applying them by using equipment suitable for reducing spray drift as much as possible (e.g. screened nozzles, controlled flow equipment, equipment with lambent organs). Chemical control may also be carried out by using alternatives plant protection products, like pelargonic acid, a non-selective herbicide extracted from plants, which acts by contact. Before the treatment, checking for use restrictions of herbicides in areas used by general public or vulnerable groups as established by the National Action Plans for the Sustainable Use of Pesticides (Directive 2009/128/EC).



Fig. 2.5 *A. artemisiifolia* 7 days after treatment with pelargonic acid.

Natural and semi-natural areas

Mechanical and physical control

Uprooting, mowing and flame weeding are alternative options for *A. artemisiifolia* control:

- manual uprooting: useful only on small areas recently infested;
- mowing need to be carried out close to the soil as much as possible, and require at least twice interventions during the vegetative season, better if before flowering in order to avoid dispersion of pollen. However, mowing in later growth stages, but before seed production, may reduce inputs to the soil seed bank. The number of mowing treatments may be variable, depending on the seasonal trend. Monitoring of plant's growth stage are needed to plan treatments;
- flame weeding: useful on small infestation areas and young plants.

Chemical control

Use of herbicides in natural areas is not recommended.

Specific precautions for the operator

Allergic people should not manipulate the flowered plant; garden and green areas operators.

2.6. CONCLUSIONS

In maize, selective herbicides allowed, in general, a good control, both with pre-emergence and post-emergence treatments. In sunflower, pre-emergence herbicides often needed to be integrated with mechanical interventions at different leaf stage of the crop to get satisfactory control. Efficacy of non-systemic herbicides, applied as alternative to glyphosate, are strongly influenced by the coverage obtain during the treatment, which is in turn influenced by the presence of a dense canopy and overlapping leaves. High treatment volumes are always needed to achieve acceptable efficacy levels. The use of cover crops as soil covering resulted to be a good practice to limit *A. artemisiifolia* presence in low density infestation areas.

Correct management of *Ambrosia artemisiifolia* consists of limiting further spread in not-infested areas, reducing its abundance in the infested ones and adopting crop rotations. Early diagnosis of its presence and rapid eradication of all plant parts represent a very efficient way to control this species.

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3. HERACLEUM SPP.

Guidelines for sustainable IPM control of *Heracleum* spp.

3.2. INTRODUCTION

Following the proposal of the Latvia's State Forests (LVM) in 2012 Integrētās Audzēšanas Skola (IAS) started and after invitation from University of Turin (UNITO) within the framework of the EMPHASIS project continues to develop a new Integrated Pest Management (IPM) method to eradicate hogweed in EU countries effectively.

Heracleum spp. in non-agricultural areas is one of the 13 pathosystems researched by EMPHASIS project (2015-2019) www.emphasisproject.eu

Worldwide, hogweed species - *Heracleum sosnowskyi*, *H. mantegazzianum* and *H. persicum* – are invasive plant species with wide geographical distribution (EPPO, 2009). From last century, hogweed represents a serious threat for Europe and other parts of the world. A lot of effort and monetary incentives have been put in the last decades in order to tackle the problem, but the issue has remained unsolved. To-date, the containment and management methods used for these species have not achieved adequate control in non-agricultural area.

Toxicity and economic significance. Hogweed troubles the use of infested areas, because hogweed sap in contact with skin in presence of ultraviolet rays, results with serious burns of skin. Each year there are new cases of people in EU with serious burns. Photodynamic active substances - furanocoumarins are activated, which break the DNA protein and kill the skin cells.

Hogweed takes over the entire territory, becoming the monoculture of the site. Hogweed displaces not only the plant biodiversity, but also animals, humans and creates damage to the infrastructure. In the last decades, EU countries have spent millions of euros to control hogweed¹. Losses are not only economical, but also related with human health, nature biodiversity, road and railway management, municipal management etc. (Barkavas pag. teritorijas plānojums, 2007)

Three year field on-farm experiments in Latvia, Lithuania for *Heracleum sosnowskyi* and knowledge transfer to *Heracleum mantegazzianum* - main EU hogweed species (please see page 22) with trials in Czech Republic confirm the high efficacy of the new IPM method - practical solution developed in the frame of the EMPHASIS project.



Fig. 3.1 *Heracleum* spp.

¹ German study that assessed the economic impact of the closely related *H. mantegazzianum* shows that the costs are more than 12 million euros annually in the country (Reinhardt et al., 2003).

3.3. SUMMARY OF THE PROJECT WORK

Within the framework of the EMPHASIS study these guidelines summarize the work of “Integrētās Audzēšanas Skola” (IAS) on establishing and developing a new sustainable IPM method for hogweed eradication in non-agricultural area within the EMPHASIS project WP1, WP3, WP4, WP5 for task 3.4.5 “*Heracleum spp.* effective IPM in non-agricultural area”.

The proposed approach integrates into practical integrated pest management (IPM) solution combining mechanical methods, use of selective herbicides (active ingredients listed in Annex 1, but never used in combination for *Heracleum spp.* control) and site-specific plant species (biodiversity) as a biological method. In 2014, when preparing EMPHASIS project proposal, three active ingredients listed in EU Annex 1 were proposed in two combinations to control hogweed. The EU decision for these three active ingredients' future was not known at the start of EMPHASIS, on March 2015. After the EMPHASIS project 2nd year (30.09.2016), the EU decision to cancel registration of one active ingredient (triasulfuron) was adopted. Two active ingredients (tribenuron-methyl and metsulfuron-methyl) based on substitution of herbicides will be allowed in EU until 2024. This is an opportunity to EU countries to get down hogweed area with new IPM method.

The objective of the project is to develop an effective IPM method to eradicate hogweed in non-agricultural area (roadsides, river sites, forest edges etc.) within a 2-3 year period.

Field experiments were conducted between 2015-2017 on hogweed containment using IPM methods at 21 sites across Latvia, 2016/2017 in Lithuania by (IAS)) and in the Czech Republic by Mendelova Univerzita/Brno (MENDELU). The efficacy of selective herbicides, 3 months after their application (2015 – 2017) in field on-farm experiments was between 60% and 99%, depending on the level of *Heracleum spp.* infestation (cover and abundance) before treatment. In most of the trial plots, the hogweed reduction is > 90 % up to full control after a few years. Effective eradication is possible even in a location where hogweed grows as a monoculture for many years.

The mechanical method is developed as part of the IPM method, in cases where the chemical methods are not applicable or not desired by people. Selective herbicides for hogweed eradication are tested with precision application timing and in different soil types / locations. This combination does not influence the main species that compete with hogweed: grasses, dicotyledons, trees, shrubs. Restoration of biodiversity in a particular area as a biological method is a key tool for effective control of hogweed.

Thanks to the cooperation with Latvia's State Forests (LVM) and Latvian State Plant Protection Service (SPPS) the minor use of herbicides for hogweed containment is registered in Latvia. This practical hogweed eradication solution with IPM method has been adopted also by the Ministry of Environment of Republic of Lithuania in 2017.

The new hogweed IPM eradication method is now widely used in Latvia by municipalities, private landowners, foresters, service providers as well as state organizations. These guidelines give an overview for possible IPM method implementation in other countries.

3.4. DISTRIBUTION, BIOLOGY AND LIFE CYCLE OF *HERACLEUM* SPP.

Invasive hogweeds in Europe according to EPPO A1/A2 Lists are pests recommended for regulation as quarantine pests and have a wide geographical distribution https://www.eppo.int/ACTIVITIES/invasive_alien_plants/iap_lists#A1A2Lists:

Heracleum mantegazzianum: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Ireland, Italy, Liechtenstein, Netherlands, Norway, Poland, Slovakia, Sweden, Switzerland, United Kingdom.

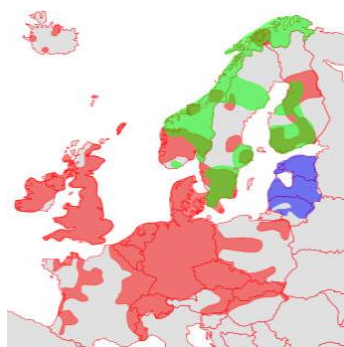
Heracleum sosnowskyi: Estonia, Germany, Hungary, Latvia, Lithuania, Poland.

Heracleum persicum: Denmark, Finland, Norway, Sweden.

All *Heracleum spp.* species are comparable as far as life cycle and biology are concerned. Developed eradication method for one hogweed species can be transferred (with some corrections) to other *Heracleum* species according to country specific flora/fauna and local climate conditions.

According to the State Plant Protection Service (SPPS) data (www.vaad.gov.lv, 2016) in Latvia 10,801 ha are invaded with hogweed. In Lithuania, hogweed now occupies around 15,000 ha, in Estonia around 2,000 ha, in Poland around 8,000 ha, and it is well known in Scandinavia, Germany etc. Huge areas are invaded in Russia and Belarus. Hogweed can also be found in USA, Canada and elsewhere in the world.

Hogweeds are from the family Apiaceae or Umbelliferae - aromatic flowering plants and commonly known as the celery, carrot or parsley family (Michael Davis et al., 2002). It also includes such well-known and economically important plants such as anise, caraway, carrot, celery, chervil, coriander, cumin, dill, fennel, hemlock, cow parsley, parsley, parsnip and many others (Priedītis, 2012). Hogweeds grow up to 2-5 m tall (Bērziņš et al., 2007). Stems at the base are usually 5-10 cm Ø. White or rarely pinkish flowers are clustered in an umbrella-shaped head (umbel) that can be up to 80 cm across. Flowering typically lasts from June to August. Depending on the species, environmental factors, hogweed can flower from the 2nd-3rd year. One hogweed on average forms around 3 – 20 thousand seeds. The life cycle ends with ripening of seeds and finally the plant dies – its mission is over. Distribution of hogweed is only by seeds. Mowing of hogweed prolongs the life cycle and flowering occurs later in the season or in the next year, it can be even delayed up to 10 years or more from germination until flowering. The green oval (elliptic) fruits form by July then turn dry and brown with swollen brown oil canals. All hogweeds contain phototoxic sap. Characters for each species are in http://www.ibot.cas.cz/personal/pysek/pdf/Giant_alien_uk.pdf. (Nielsen et al., 2005)



In Latvia *H. sosnowskyi* vegetation begins in the early spring – end of March/beginning of April, when the overwintering hogweeds start to grow. Sometimes after the winter there are more than 2,000 seeds/m² germinating in the early spring and from overwintered roots (2-10 year old plants) as well. Later in summer, most of young hogweed seedlings die because they are competing between each other.

Figure3.2 . Hogweeds in Europe: red - *H. mantegazzianum*; green - *H. persicum*; blue - *H. sosnowskyi*, [www. wikipedia.org](http://www.wikipedia.org)

3.5. ANALYSES OF EXISTING METHODS USED FOR HOGWEED ERADICATION

Heracleum spp. is not considered as crop weed in intensive (cultivated) agriculture land. The problem appears in non-agriculture areas: field margins, buffer strips, uncultivated areas close to the field, areas in proximity to hedges, ditches and riverbanks, roadsides, forest edges, new forest plantations, bushy areas, abandoned household, railways, industrial sites and extensively worked agriculture fields (Bērziņš *et al.*, 2003). Hogweed eradication methods applied worldwide for the last 20-30 years did not meet the desired results (LETA, 2012; Autoceļu avīze, 2006; Orupe, 2012).

Mowing of hogweed.

Mowing is the most common physical/mechanical hogweed eradication method in all countries. However, even after several mowings during the season, hogweed is still able to flower, develop viable seeds, and spread them (Lejiņš *et al.*, 2004).

Mown hogweed is able to flower until the first frosts in the autumn (October / November).

After each mowing, the plants form a larger green mass and a uniform, dense hogweed stand and it contributes to an increase of hogweed area. Vegetation period of these hogweeds will be much longer than for those growing naturally and it will restrain the growth of other plant species.

Mowing of hogweed limits the development of hogweed competing plant species and thus the hogweed becomes the dominant plant species in the habitat. If other hogweed eradication methods are not applied, the mowing operations in these areas will be carried out repeatedly.

In areas where attempts have been made to eradicate hogweed by mowing it regularly, the number and density of hogweeds is higher than in the unmowed areas!



Fig.3.3 a) Non mowed and regularly mowed hogweed. *Ķekava / in August.*

Fig. 3.3 b) Non mowed and regularly mowed hogweed. *Ķekava / in September.*

Mowing for a very short period improves the landscape value of the site (as a cosmetic effect), however, it is not an effective hogweed eradication method. Already a week or two after the mowing some plants may bloom and the mowed hogweed continue vegetation.

Without developing of leaves mowed hogweeds can form side shoots at the bottom of the plant. Flowers can grow from such side shoots and develop seeds. (Oļukalns, 2003)

Consequently, the seed dispersal is not limited. **Mowed hogweed is able to bloom very low and late in season - only few centimetres from the ground (2-5 cm),** which is practically invisible and mowed areas will be infested with new hogweed seeds.



Fig. 3.4 . Mowed hogweed flower very low and later

Leaves and stems of mowed hogweed form mulch on the soil, which limits or destroys the development of other native plant species and promotes rapid regrowth of hogweed.



Fig. 3.5. Mowed hogweed form mulch and flower later

At the end of August / early September, hogweed, whose development is not delayed due to human activity (anthropogenic), is naturally aging - the plants have ripened seeds and the plants are naturally dying. Hogweed leaves turn yellow and dry up. Grasses and other wintering weeds continue to grow under the hogweed. In contrast, in the mowed areas, the

hogweed is much "healthier and greener" than undisturbed plants. They continue to grow and accumulate nutrients to a temperature of +3° ... + 4°C, reaching a height of 150 cm. This kind of hogweed in a warm autumn can bloom in October and November.

In autumn, after frosts, when the hogweed leaves die off, we can observe how many seeds have ripened under the leaves.



Fig. 3.6 . Mowed hogweed is able to bloom very late in October and ripen seeds later

Regular mowing makes hogweed only shorter, but not less aggressive and does not exclude the blooming and ripening of the seeds.



Fig. 3.7. After mowing larger and denser hogweed stands

Hogweed mowing is effective only when the hogweed is mowed with regularity as a lawn during all vegetation period (from May to October) once a week. Such mowing can completely eradicate hogweed in 2 - 3 years. If there are 3-week intervals between mowing, the whole process will be extended or it may be considered that the work must be started from the beginning, because some hogweed can already flower and have seeds.



Fig.3.8. Hogweed in year 2002, Amatas region



Fig. 3.9. 13 years non mowed grass and hogweed, 2015

Self-spread of hogweed within the time period 2002-2015 was 2.65 m downhill (Amatas region), grass area around house was not mowed 13 years. Biological diversity of not mowed grass is the main method to stop expansion of hogweed, when seeds are not in contact with soil. Therefore, in the areas that are not highly important for use it is better to leave hogweed untouched. Man with mowing spreads hogweed faster than hogweed spreads itself, «Doing nothing is better».

Grazing of hogweed - alternative to use infested areas.

According to more than 20 year experience of farms in Latvia using the hogweed areas for grazing – this method will reduce the maximum height of hogweed, but will not eradicate the site (Greiškalne, 2012). From livestock goats and sheep are better than cows for grazing. Grazing is the cheapest hogweed elimination method, **but this is not eradication method.**



Fig. 3.10. Hogweed grazing by sheep and cattle

It is an alternative for using infested hogweed areas in a practical way - for animal feeding, The effect of grazing is equal to irregular mowing - the height of the hogweed is lower, but hogweed is not eradicated. Biodiversity in these areas is very low. As soon as grazing is stopped for some reason, the pastures and meadows are taken over again by the hogweed. Animals are not able to eat all the hogweed and the roots (Andersen *et al.*, 1996). As pasture always has a period of about a month, when animals are not grazing or grass is too short. During this time, the hogweed will recover, flower very low and ripen the seeds. Consequently, grazed area will remain as an infested area creating risk to surrounding territories.

Glyphosate and other herbicide use for hogweed eradication.

Glyphosate application is the **most common chemical method** for hogweed eradication (Domaradzki *et al.*, 2010).

All EU countries have a long list of different registered trademark products with content of the same active ingredient. Glyphosate is a systemic herbicide taken up by the green parts of plants (leaves, foliage, green stems). On annual weeds, the efficacy can be obtained after 3-7 days, on perennial after 14-21 days.



Fig. 3.11. After glyphosate treatment

Glyphosate is not selective. It is a misguided belief that hogweed is eradicated more efficiently when using a higher dosage of glyphosate solutions. Dose rate for monocot weeds (grasses) is 2 – 3 l/ha, but for perennial dicots 4 - 6 l/ha (Bērziņš *et al.*, 2007). Using a higher dose rate of glyphosate for hogweeds, we also destroy native plants of this area – plants that compete with the hogweed.

Heracleum spp. grow faster and better than other weeds and is more resistant to glyphosate. Application of glyphosates in non-agricultural areas decreases biological diversity. After a few treatments with glyphosate, native plants are represented much less or not at all anymore. Within a few years, hogweed in these sites becomes the dominant weed species - forming denser stands than before treatment. There is nothing wrong with glyphosate, apart from the way we use it.



Fig 3.12 a) Before treatment, May 2016



Fig 3.12 b) After treatment with glyphosate + phenoxy herbicide, September 2016

Other selective herbicides have been used for hogweed eradication in the last years. However, the problem remains unsolved: **efficacy level of hogweed control and safety to biodiversity**. If the used herbicides have efficacy level below 80 % after the 1st season - the problem remains unsolved and in the worst case has a negative side effect to native biodiversity.



Fig. 3.13 After glyphosate treatment, in August.



Fig. 31.4. After glyphosate + phenoxy herbicide, in September

3.6. IPM METHODOLOGY FOR EFFECTIVE HOGWEED ERADICATION

3.6.1. IPM development for practical solutions

The methodology guidelines below are used by Integrētās Audzēšanas Skola and confirm the results reached in EMPHASIS project task "*Heracleum spp.* effective IPM in non-agricultural area" as practical solution.

This IPM methodology can be used to find practical solutions for other pathosystems with invasive or native pests.

Integrētās Audzēšanas Skola (IAS) developed practical solutions for agriculture and forestry based on Mr. Jānis Āboliņš (SPPS) method created in LATVIA over many years. Penn State University IPM method was found and adapted by Integrētās Audzēšanas Skola and this has helped to discover practical solutions faster and confirmed the methodology.

The Pennsylvania Integrated Pest Management method (PA IPM) is a collaboration between the PA Department of Agriculture and the Penn State College of Agricultural Sciences (USA). **The PA Department of Agriculture and the Penn State College of Agricultural Sciences wrote IPM 6 steps & 6 tactics** (Pennsylvania State University, 2011). **IPM 6 experiences** are written by Integrētās Audzēšanas Skola based on the accumulated experience and results reached in field of practical solutions. **IPM 6 steps & 6 tactics & 6 experiences** has been widely used by Integrētās Audzēšanas Skola for decision making and discovery of effective practical IPM solutions for agriculture and forestry.

According to DIRECTIVE 2009/128/EC Article 3. Definitions 6: integrated pest management (IPM) means careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimise risks to human health and the environment. 'Integrated pest management' emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

IPM definition of Penn State University is shorter with the same meaning but understandable for everyone:

Integrated Pest Management (IPM) is an approach to controlling pests in a safer, more effective, and longer-lasting way.

IPM is an approach to pest control that focuses on pest prevention by eliminating the root causes of pest problems. When infestations are present and require immediate intervention, the safest, most effective methods available for the situation are chosen (<https://extension.psu.edu/what-is-integrated-pest-management>)

Integrētās Audzēšanas Skola used combination of these IPM definitions as a basis for thoughtful development of IPM strategy for eradication of hogweed and other practical solutions in the EMPHASIS project.

Cost-benefit analysis and multi-criteria analysis. How will you know if IPM is succeeding?

The advantages of IPM—efficacy, cost and safety. Build measurable objectives for each of those goals into your practical solution plan from the beginning.

Efficacy: since IPM is better for controlling pests, you should see a measurable reduction of pests.

Cost: set specific money parameters for your IPM costs to measure against them later.

Safety: IPM's ability to create a safer environment is predicated in large part on reducing plant protection product use. By reducing pesticide use, IPM helps to reduce the potential for negative impacts on human health and the environment.

In real life, Integrated Pest Management (IPM) will reduce the quantity of chemical pesticides entering the environment and will save money. IPM is based on taking preventive measures, monitoring the crop, assessing the pest damage, and choosing appropriate actions.

When you use IPM, you

- understand a pest's identity and habits so non-toxic, preventative measures can be used first
- use a combination of different tactics for better effectiveness
- use least-toxic chemicals, if any of course, any control tactic chosen must be used at the right time and place

Benefits of Integrated Pest Management

- Promotes soil structure & healthy plants, which better withstand damage from pests
- Reduces the need for pesticides by using several pest management methods
- Reduces excessive or unnecessary plant protection product applications
- Typically provides long-term control of pests, as opposed to more conventional short-term treatments
- Costs in long term are less to use IPM control methods

Six Steps of IPM

1. Proper identification of damage and responsible "pest"
2. Pest life cycle and biology
3. Monitor or sample environment for pest population
4. Establish threshold
5. Choose appropriate combination of management tactics*
6. Evaluate results

1. Proper identification of damage and responsible "pest".

The first step in solving any pest problem effectively and safely is the correct identification of the pest. It is critical to find out what kind of pests you have and where they are coming from. Since each pest has different habits, biology and life cycles, its positive identification will lead to control that is more effective.

2. Learn pest and host life cycle and biology

At the time you see a pest, it may be too late to do much about it except maybe spray with plant protection products. **Another life cycle stage is often susceptible to preventative actions.** For example, weeds in early spring after overwintering are much more sensitive to mechanical cultivation or to plant protection products than later in summer.

3. Monitor or sample environment for pest population

Preventative actions must be taken at the correct time if they are to be effective. For this reason, once you have correctly identified the pest, you begin monitoring BEFORE it becomes a problem. Monitor about pest populations include:

- pest present/absent?
- distribution - all over or only in certain spots?
- increasing or decreasing in numbers?

4. Establish threshold

In some cases, a certain number of pests can be tolerated. Conversely, there is a point at which you **MUST** do something. For the society, that point is the one at which the cost of damage by the pest is **MORE** than the cost of control.

This is an economic threshold.

5. Choose appropriate combination of management tactics*

For any pest situation, there will be several options to consider. **See Six Tactics of IPM.**

6. Evaluate results

Did your actions have the desired effect? **Was the pest prevented or managed to your satisfaction?** Was the method itself satisfactory? Were there any unintended side effects? What will you do in the future for this pest situation? If results were not good, it means that we missed something relevant and must start again with six steps.

Six Tactics / methods of IPM

1. Cultural methods
2. Physical methods
3. Genetic methods
4. Biological methods
5. Chemical methods
6. Regulatory methods

The goal of using multiple tactics/methods or "many small hammers" is to suppress pests effectively below injurious levels and avoiding outbreaks. Many tactics keep pest populations

off-balance and avoids development of resistance to pesticides. Whenever possible, least-toxic effective methods are used before those that are more toxic. It is always from 1 to 6 direction, beginning with less toxic.

The categories of tactics and specific actions included in each method are listed below:

1. Cultural methods

Suppress pest problems by minimizing the conditions they need to live (water, nutrients and etc.). Planting plants that are adapted to existing growing conditions, planting them in the right place, giving proper attention to their water and nutritional needs. Strong plants resist diseases, outgrow weeds and are less likely to succumb to insects.

2. Physical methods

Prevent pest access to the host or area, or, if the pests are already present, physically removing them by some means. In our case, this means green seed collection, digging techniques, depending upon the situation.

3. Genetic methods

Use pest-resistant plant varieties developed by classical plant breeding. Recently, this category has been expanded to include genetically engineered pest resistance.

4. Biological methods

Use predators, parasites and diseases of pests in a targeted way to suppress pest populations. Use of microbial diseases of pests have become part of the chemical pesticide registration process. Use of predators and parasites as biocontrol for pests are handled in one or more of the following three ways:

a) conservation and encouragement of naturally occurring biocontrol organisms by cultural techniques or at least avoidance of harming them (or biodiversity as crop protection instrument). **The conservation of natural enemies (plants) is one of the most important concepts in the practice of biological control of invasive species (e.g. hogweed).** It requires the comprehension of the biology of the natural enemies and willingness to modify our practices so that they would accommodate natural enemies (Conservation of Natural Enemies, <http://www.entomology.wisc.edu/mbcn/fea201.html>);

1. **b) augmentation** of naturally occurring species by purchasing and releasing more of the same; (<http://www.entomology.wisc.edu/mbcn/fea104.html>)

c) "classical" biological control in which new biocontrol species specific to pests are sought and introduced. (<http://www.entomology.wisc.edu/mbcn/fea103.html>)

5. Chemical methods

There are many "chemicals" that are used in pest management situations, but not all chemicals are alike from the standpoint of their range of action, toxicity, or persistence in the environment.

"Biorational" - chemicals are those that are less universally toxic and target a specific aspect of pest biology. There are some biorational chemical tactics that are hard to classify by toxicity or that are used together in innovative ways with other tactics.

"Conventional"- pesticides currently refers to synthetically produced compounds that act as direct toxins. There are many new classes of chemicals being added to the older conventional plant protection products.

6. Regulatory

Regulatory control refers to the role played by government agencies in trying to stop the entry or spread of pests into an area or into the country via inspection, quarantine, destruction of infested material, and other methods.

IPM follows a stepwise approach: always from 1st to 6th step. **IPM typically uses several tactics to deal with the pest to reach the best possible result.** Chemical method is used only after first four methods are considered and applied. Moreover, work related to chemical method should be done only by a licensed and experienced professional. Problems to find effective crop protection solutions often appear when regulatory method have been used first. (Invazīvo augu sugas – Sosnovska latvāņa – izplatības ierobežošanas noteikumi. MK Nr.559.; Latvāņu ierobežošanas programma 2006-2012)

Pests do not read and react to regulatory rules, we must think as pests, if we want to find solutions for them.



Fig. 3.15. Caricature of G. Šlūka on hogweed's victory over regulatory control (Latvian Avize, 2012)

Six experiences necessary for effective **IPM** development written by Integrētās Audzēšanas Skola based on the accumulated experience and results reached in field of practical solutions.

Six experiences for IPM

1. The systematics and life cycles of hosts and pests
2. Local climatic conditions and soil types
3. Organizing of agrotechnical measures in essence
4. Local and global plant protection legislation
5. Biological and chemical PPP (active ingredients) etc.
6. Interaction of 5 points mentioned above

One person or one organization cannot have all these abilities.

This is possible only through multidisciplinary interactions.

Effective IPM development and implementation - 3 Dimensional thinking.

Fig. 3.16. Effective IPM – 3 Dimensional thinking / © IAS

Base for successful IPM result in EU

The EU has excellent science, agriculture and forestry society compared with the rest of the world. Europe has developed high yield crop varieties and technologies for these crops. Practically all crops are growing there. There is a long history of farming. Europe has a high level of academic and applied science, many chemical and biological plant protection manufacturers, innovations in the field of plant protection and plant nutrition.

Knowledge is missing when facing a problem of new invasive or native pest species. There is lack of multidisciplinary interactions, when seeking for solutions. Projects like EMPHASIS bring expertise, experience and innovativeness together from different stakeholders for the creation of useful practical guidelines, which later are used by practitioners in the EU and beyond.

3.6.2. Main aspects for effective IPM hogweed eradication

The approach, i.e. by definition "Integrated Pest Management" is a combination of biological, biotechnological, chemical or plant breeding measures and the rational use of combinations in order to minimize the use of the plant protection product and maintain a population of harmful organisms at a level that does not result in economically significant damage or loss":

- 1) The efficacy level of method must be at least 85% of hogweed control at the end of season.
- 2) The eradication methods should be selective for native growing plant species, which are the main natural competitors of the hogweed.
- 3) Control methods must be different in order to replace each other, and the hogweed eradication could be performed for a longer period (e.g. from April until August), i.e. the possibility of replacing one method with another.
- 4) Method must be realizable in nature, taking into account the availability of workforce (qualification and competence) and the specificity of the hogweed eradication.
- 5) Develop IPM method for *Heracleum sosnowskyi* in Latvia and then transfer this knowledge to *H. mantegazzianum* and *H. persicum* - other hogweed species in EU.
- 6) The IPM process will never be completed. There will always be room for improvement in efficiency, reducing the use of plant protection products while at the same time avoiding economic losses.

3.6.3. Field on-farm experiments for hogweed IPM

Guidelines for field trials

Field experiments were conducted using the Integrated Pest Management IPM developed by IAS and the guidelines of the European and Mediterranean Plant Protection Organization (EPPO):

- PM 9/9 (1) *Heracleum mantegazzianum*, *H. sosnowskyi* and *H. persicum*. (Blackwell, 2009)
- PP 1/152 (3) Planning and analysis of tests for the evaluation of efficacy of plant protection products.
- PP 1/181 (3) Trial conduction on efficacy evaluation and preparation of reports.

Evaluation methods

In all field on-farm experiments where herbicides are used for hogweed eradication, the stages of development of both hogweed and competing plant species (biodiversity) are recorded also before spraying.

Four methods of assessment have been used to determine the effectiveness of a hogweed eradication method:

1) Assessment of biodiversity:

After any eradication method, the plant species found in each test plot are counted. *Conservation of natural enemies is arguably the most important concept in the practice of biological control and fortunately is one of the easiest to understand. That requires that we understand the biology of the natural enemies and are willing to modify our practices to accommodate them.*

2) Relative Evaluation:

Each treated plot is compared to the control (untreated) to evaluate efficiency of the herbicides. The hogweed amount, and projective cover reduction in area (%) is evaluated. In order to describe the effectiveness of the herbicide, an inverted scale of equivalent is used: 0% = no hogweed eradication, 100% = complete hogweed eradication.

3) Direct evaluation:

In each trial plot in June - August the flowering hogweed is counted.

4) Evaluation of damage characteristics of hogweed:

Delayed growth, flower, seed formation, chlorosis, deformation, etc.

At first, hogweed numbers are recorded before the treatment – early in the spring. In scientific trials, according to the guidelines, the effectiveness of herbicides is counted at weeks 4th and 8th. In order to better assess the effectiveness and development of biodiversity in treated areas, inventories were also carried out for 3 months, 5 months after the treatment and in the next season.

Applied Products, Methods and Technique

After careful analytical work, literature analysis (Tomlin, 1997) and plant protection products (PPP) description, selective herbicides were chosen, whose active substances are in the list of common European plant protection products and PPPs registered in the country, but have never been used for hogweed eradication anywhere. It was concluded that these herbicides meet the objectives of the study theoretically and practically: they are selective to native plant species with proper application timing (Prather *et al.*, 2011; Tu *et al.*, 2001).

Product mixture was developed based on point 3.6.2. Main aspects for effective hogweed eradication IPM development with selectivity to biodiversity. A combination of **selective herbicides mixture used early in spring (efficacy 8 weeks) and biodiversity of native plants and also insects (efficacy for 44 weeks)** covers one year and **creates unique combination of effective practical solutions. This is synergy of chemical and biological method.** The treatment should be carried out when hogweeds that are germinating from seeds are in cotyledons (most seeds germinate). Do not mow 2-3 months after treatment.

Method of selective herbicides was also used to choose products for Lithuania and Czech Republic - to get permission for trials and/or minor use registration.

Three herbicides (active ingredients) with registered dose rates for other crops in two combinations were used:

- Latvia: Nuance 75 WG (75% tribenuron-methyl) 15 gr /ha+ Accurate 200 WG (20% metsulfuron-methyl) 30 gr/ha + 100 ml Contact (surfactant)
- Lithuania: Nuance 75 WG (75% tribenuron-methyl) 10 gr /ha+ Accurate 200 WG (20 % metsulfuron-methyl) 20 gr/ha + 100 ml Contact (surfactant)
- Czech Republic: Nuance (75% tribenuron-methyl) 15 gr/ha + Logran 20 WG (20% triasulfuron) 37, 5 gr/ha + 200 ml/ha Contact (surfactant).

At the end of EMPHASIS 2nd year (30.09.2016) there was the EU decision to cancel registration of one active ingredient (triasulfuron). Two active ingredients (tribenuron-methyl and metsulfuron-methyl) based on substitution of herbicides will be allowed in EU until 2024. This is an opportunity for countries to get down hogweed area with new IPM method.



Fig. 3.17 a) After glyphosate treatment



Fig. 3.17 b) Eight weeks after treatment with selective herbicides according to IPM.

These combinations with selective herbicides can be used: as spraying; spot treatment; in bushy areas; new tree plantations. Application of one combination is done only once a year. Knapsack sprayer or motorised knapsack sprayer are more suitable for small invaded areas. For large-scale plots, tractor sprayer is recommended.

The use of selective herbicides does not influence the activity of different snails and insects.



Fig. 3.18 Different snail species (Gastropoda) attacking treated hogweed better than untreated ones.

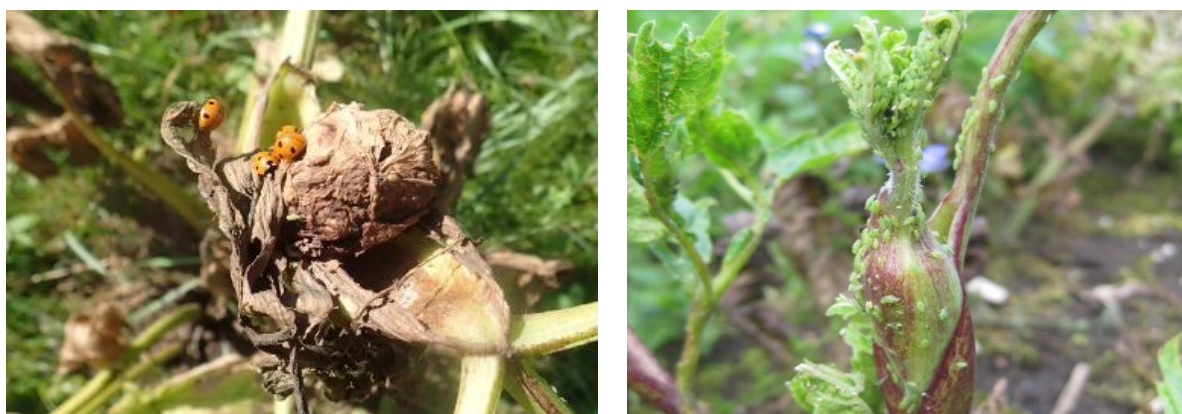


Fig. 3.19 Insect species (Coleoptera, Scarabaeidae, Aphidoidea, Diptera (Pitkin et al., 2016) and others) continue life cycle on treated hogweed.

The important part of this IPM method is for higher efficacy within one season to use also developed **physical/mechanical eradication methods** (see page 37-40). These methods are used for the containment of small hogweed stands, as well as in places where the spraying of selective herbicides cannot be used (for example along riversides and streams, etc., please see country specific regulations).

3.7. TRIAL PLACES, LOCATION OF FIELD ON - FARM EXPERIMENTS

(Please see Annex 1)

Locations of field on-farm experiments were selected in hogweed most invaded areas **for three years (2015-2017)** to test IPM practical solutions (Please see 3.6.3. Field on-farm experiments for hogweed IPM), according to distribution of *Heracleum sosnowskyi* in Latvia <http://www.vaad.gov.lv/> with an active participation of farms and landowners; and in Lithuania.

For *Heracleum mantegazzianum* trials was in Czech Republic for IPM eradication methods.

Field on-farm experiments in non-agricultural areas were carried out on: field margins, uncultivated areas close to the fields, ditches and riverbanks, roadsides, forest edges, new forest plantations, bushy areas, abandoned households, industrial sites and extensively worked agriculture fields.

The purpose of field on-farm experiments was to evaluate the response of hogweed population in relation to products, method application time and soil types.

- **21 trial plots in Latvia** (4 in 2015; 7 in 2016 and 10 in 2017), located in districts of Dekšāre, Priekuļi, Allaži, Lestene, Durbe, Zilupe, Amata, Augstkalne, Ķekava, Vaive, Dagda and Ezernieki.

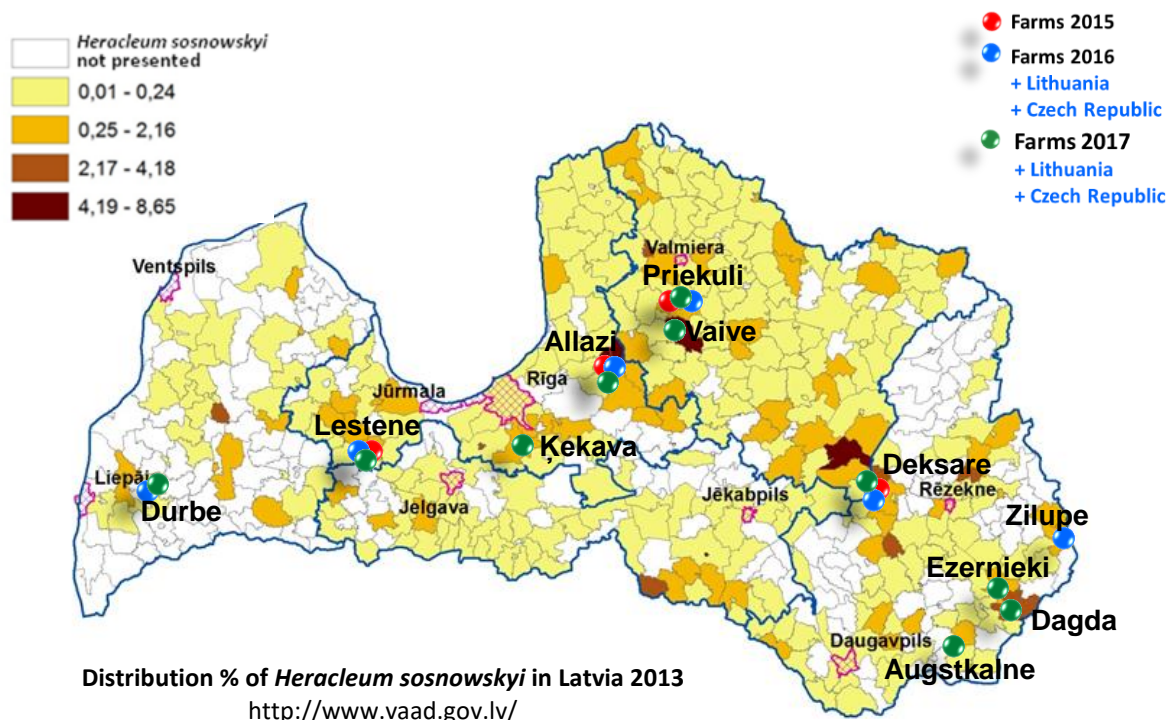


Fig 3.20. On - farm experiments/demonstrations for *Heracleum spp.* containment with IPM.

- **2 trial plots in Lithuania (2016-2017)** in cooperation with UAB "GRADERLITAS" Kėdainiai, Švenčionėliai.
- **3 trial plots in Czech Republic (2016-2017)** by Mendel University in Brno (MENDELU) in cooperation with (L.E.S. CR). Planá, Jíloviště, Osová Bitýška.

3.8. RECOMMENDATIONS AND QUALITY REQUIRMENTS FOR HOGWEED IPM CONTROL

Each of the IPM methods (root digging, collection of green seeds and cutting of side flowers, cutting of stems with flowering umbels, hogweed eradication by selective herbicides, etc.) must be done in the optimal hogweed development phase - specific for whichever method, which varies considerably between methods.

1) Hogweed eradication by root digging

Physical/mechanical eradication method of hogweed root digging is used for the elimination of individual plants or for the containment of small hogweed stands, as well as in places where the spraying of selective herbicides cannot be used (for example along riversides and streams, please check country specific regulations). This method is also recommended in cases if some hogweeds are left or not treated (spraying mistake) after application of selective herbicides

General requirements

1. The root digging to be carried out at an early stage of hogweed development (optimally in the rosette stage \varnothing 15-20 cm) – early in the spring (Klima *et al.*, 2016).
2. The root digging should be repeated 2-3 times during the vegetation season to eradicate all emerging hogweed plants.
3. The digging starts with biggest plants (rosettes). Digging should be done as deep as possible to reach all main roots or 2/3 from the top of hogweed root – carrot.
4. For small plants – all central root must be taken out from the soil.
5. Digging is carried out with a spade shovel (around 30cm)
6. The dug roots should be left upside down for drying out (with a root upwards).
7. Do not leave dug roots in contact with soil – they will recover and will continue to grow.
8. While digging, please always take care of biodiversity of other – native plant species, not to harm them.
9. While working in hogweed stands, personal protective equipment including eye protection and significant work safety requirements are mandatory, as hogweed sap causes chemical burns to exposed skin.

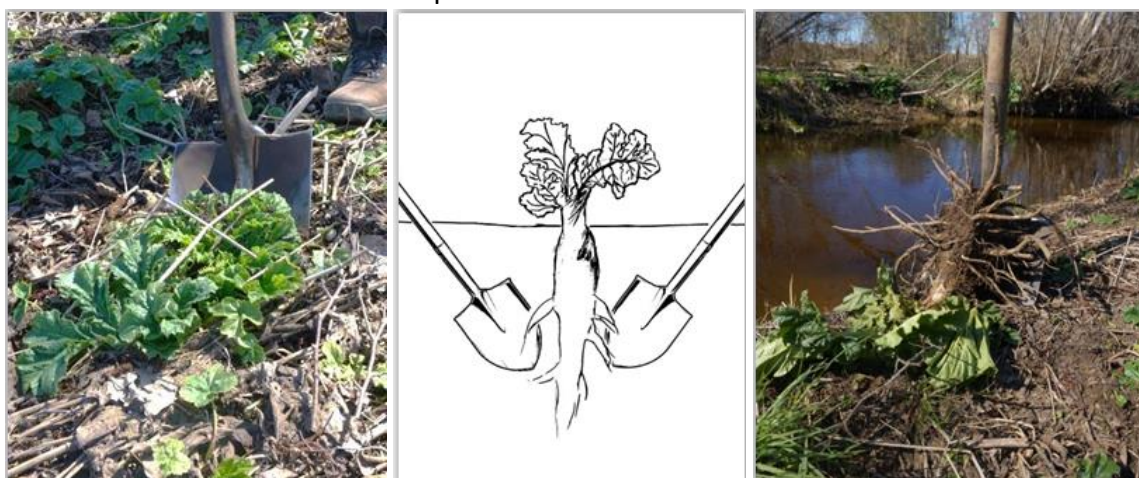


Fig. 3.21 Digging of hogweed roots.

2) Hogweed eradication by collection of green seeds and cutting of side flowers.

Physical/mechanical eradication method of hogweed green seed collection and cutting of flowers (without green seeds) is used for the elimination of individual plants or for the containment of small hogweed stands, as well as in places where the spraying of selective herbicides cannot be used (for example along river sides and streams, please check country specific regulations).

This method - green seed collection is also recommended in cases if some hogweeds are flowering after application of selective herbicides.

General requirements

1. Green seeds are present in the central shoot umbel of hogweed. Hogweed is in full size. Side shoots are flowering (figure). Method is used as long as hogweed seeds are green and not falling down. (July-August in Northern part of EU).
2. Full size hogweed stem (2-5 m) is cut down first to the ground. Collect the green seeds from one hogweed and then cut the next hogweed stem. Leave the cut off stems with removed green seed on the site – do not remove them.
3. Cutting and collection of green seeds and the collection of the side shoot green seeds and cutting of side flowers (without green seeds) should be done. If flowers have green seeds, collect them.
4. Collection of the green seeds should be carried out in durable bags (such as polypropylene or strong polyethylene), so that they do not break and the seeds do not get back into the environment. Alternatively, green seeds later can be composted in safe places from where seeds cannot be dispersed, invading new areas.
5. Close bags tightly with seeds and leave in hogweed stands, marking them. Seeds inside the bags will rot. When working in the same location in the next spring, check the bags first and if the seeds are already dead (as compost) empty the bags right there.
6. While working in hogweed stands, personal protective equipment and significant work safety requirements are mandatory, as hogweed sap causes chemical burns, when getting into contact with the skin (Boos *et al.*, 2010).



Fig. 3.22. Collection of the green seeds and cutting of side flowers (without green seeds).



Fig. 3.23. Cutting of hogweed umbels.



Fig. 3.24. Preparing durable plastic bags for collection of seeds and umbels



Fig. 3.25. Cutting of hogweed green seeds



Fig. 3.26. Collection of green seeds in plastic bags



Fig. 3.27. Green seeds must be composted in safe way

3) Hogweed eradication by cutting of stems with flowering umbels

Physical/mechanical eradication method. Cutting of hogweed stems with flowering umbels is a low-effective hogweed eradication method, carried out in specific areas in order to ensure compliance with the requirements, to prevent seed ripening and spread, as well as in places where the spraying of selective herbicides cannot be used (for example along river sides and streams, please check country specific regulations). Cutting of hogweed flowering umbels is safer to biodiversity (other – native plant species) than mowing.

This method can be used by a workforce in places where spraying is not possible, it is too late for digging and too early to collect the green seeds.

General requirements

1. Hogweed flower cutting need to be done at the beginning of hogweed flowering, when the green seeds are not visible yet.
2. Site check must be regular not to miss the right time for next flowers. Repeat cutting several times during the vegetation season; prevent green seed ripening in umbels.
3. Stems of hogweed after the cutting of umbels can be used as a landmark for checking the quality of work.
4. Cutting is carried out with a machete, a saw or other cutting tool.
5. While working in hogweed stands, personal protective equipment and significant work safety requirements are mandatory, as hogweed sap causes chemical burns, when getting into contact with the skin.

The two methods (2., 3.) mentioned above have a similar problem of having a need for educated and highly skilled workforce for a relatively short time of a year.

The methods of flower cutting and green seed collection can be efficiently used in small areas, in populated areas and water protection zones, which can be regularly observed and managed. In these places, the two described methods are equally effective.



Fig. 3.28. Hogweed eradication by flower cutting

4) Hogweed eradication by selective herbicides.

The optimal application time of selective herbicides (*please see page 33*), growth stages of hogweeds early in the spring.

According to growths stage of hogweed BBCH scale of umbelliferous crops (Strauss et al., 1994)

Hogweed germination in spring from seeds:

AS 09 – Emergence cotyledon break through soil surface

AS 10 – Cotyledon visible as hook

Owerwintering plants

The biggest plant rosettes ~20 cm wide, do not elongate yet.

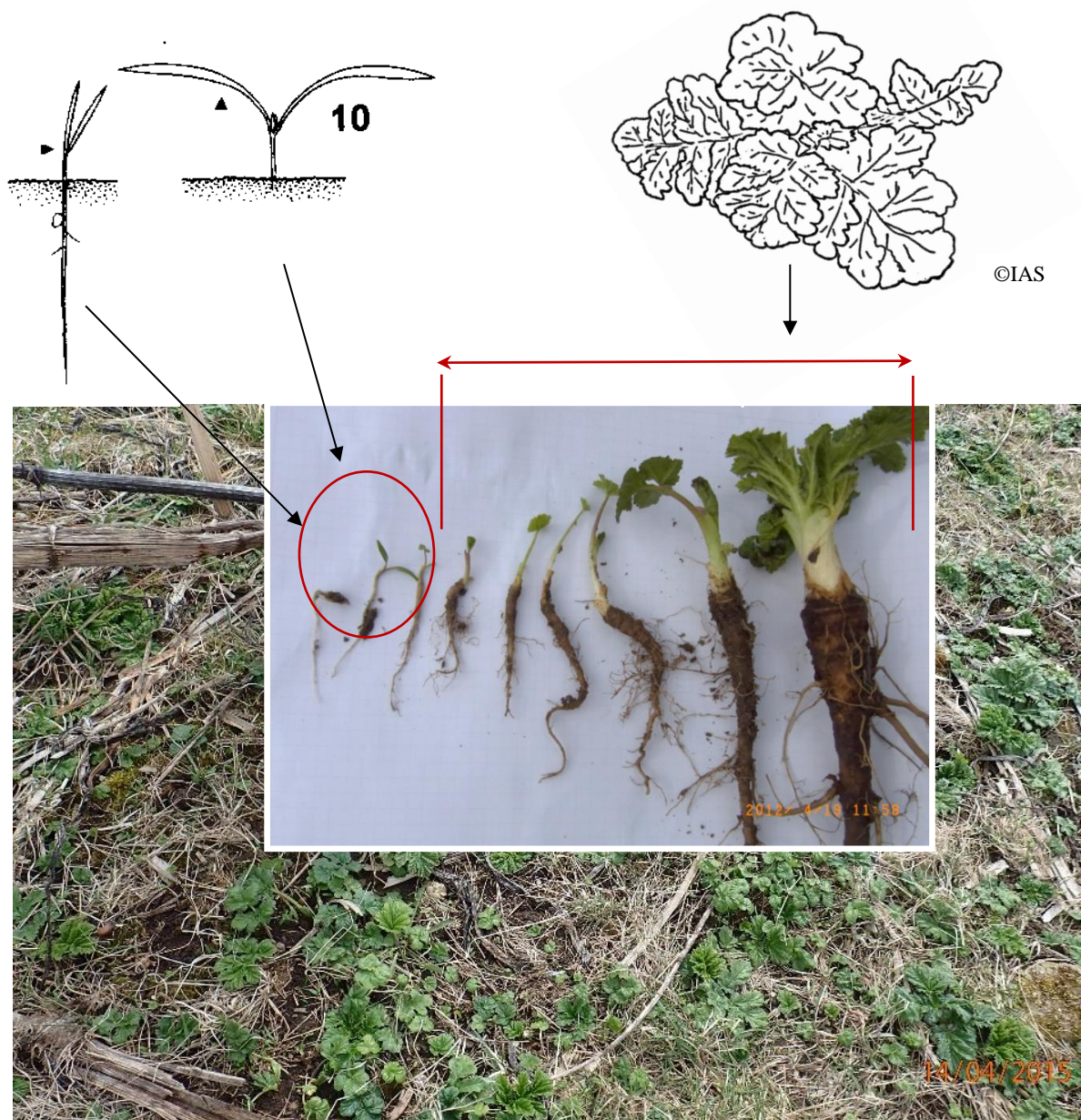


Fig. 3.29. Optimal application time of selective herbicides, growth stages of hogweeds early in the spring.

Application information

DO NOT contaminate water used for irrigation or domestic purposes and water areas, such as ponds, ditches, lakes, drainage systems etc. by disposal of product waste.

Selective herbicides combination must be used according to the Register of Plant Protection Products in the country (country specific).

Calculate carefully the required amount of spray mixture in order to prevent any leftover in the spray tank after treatment. Measure the spraying area. Always calculate carefully the product dose rates (for example with 5 L of clean water spray 250 m² area).

Tank mix preparation for (10 L sprayer) for 500 m² area.

- Fill 4 L clean water in sprayer;
- Add the measured 1st herbicide quantity provide agitation for 2 minutes.
- Add the measured 2nd herbicide quantity provide agitation for 2 minutes.
- Add surfactant 10 ml with syringe and add 3 L clean water in sprayer. Provide agitation for 30 seconds.
- Then add 3 L clean water in sprayer. Provide agitation for 10 seconds.

Use spray preparations immediately after mixing. Continue agitation during mixing and application to maintain a uniform spray mixture. Never leave crop protection products and equipment unattended.

Conditions for successful use

- Hogweed plants must be dry at the time of application.
- Minimum pre rain interval is 2 hours, better 3 hours.
- Best time for hogweed control with selective herbicides combination is early spring, (see page 54) when trees are without leaves and before green buds.
- Stop spraying if wind speed is higher than 4 m/s.
- Use clean water.

First results visible: 2 weeks after application - yellowing of hogweed leaves.

Efficacy evaluation – 4 weeks; 8 weeks, 3 months, 5 months after treatment.

If hogweed is higher than 40 cm, mow all hogweed; wait few weeks, when hogweeds reach 20 cm rosettes again - make application with selective herbicides mixture.

Recommendation: To carry out the work, ask for help from professionals, neighbourhood farmers with experience of professional use of plant protection products to save time and resources.

3.9. DISSEMINATION, TRAINING AND STAKEHOLDERS FOR HOGWEED CONTAINMENT WITH IPM

Dissemination and training activities for hogweed eradication with IPM (2015 – 2018).

In 2015 - 2018 within the framework of EMPHASIS, in 17 workshops organized by “Integrētās Audzēšanas Skola”, more than 1000 participants (landowners, foresters, service providers, state officers, etc.) and > 90 municipalities, received information about the new IPM method and results from the field on-farm experiments. After these workshops, many attendees started hogweed eradication with new IPM method. Following the recommendations of the IAS, together with partners experiments were held in Lithuania and the Czech Republic. Lithuanian authorities and stakeholders have followed the experience of Latvia. Latvia is the first and only country in the world, where it is clear how to eradicate hogweed effectively in a few years. Participants represented science, universities, landowners, foresters, farmers, cooperatives, ministries, state agencies, municipalities, service providers, small and large companies, etc.

First international workshop in Riga on hogweed eradication with Integrated Pest Management (IPM) methods. On November 29 (2016) in Latvia’s State Forest office (Riga) in collaboration with EMPHASIS partners (EPPO, UNITO, REC, UdL), Latvia’s State Forests, State Plant Protection Service and others, IAS organized the first scientific workshop for Baltic, Scandinavian and other EU countries: “Hogweed/*Heracleum spp.* containment with integrated pest management methods”. 76 participants from nine countries obtained information about application and practice of the new method as well as participated in active discussions.

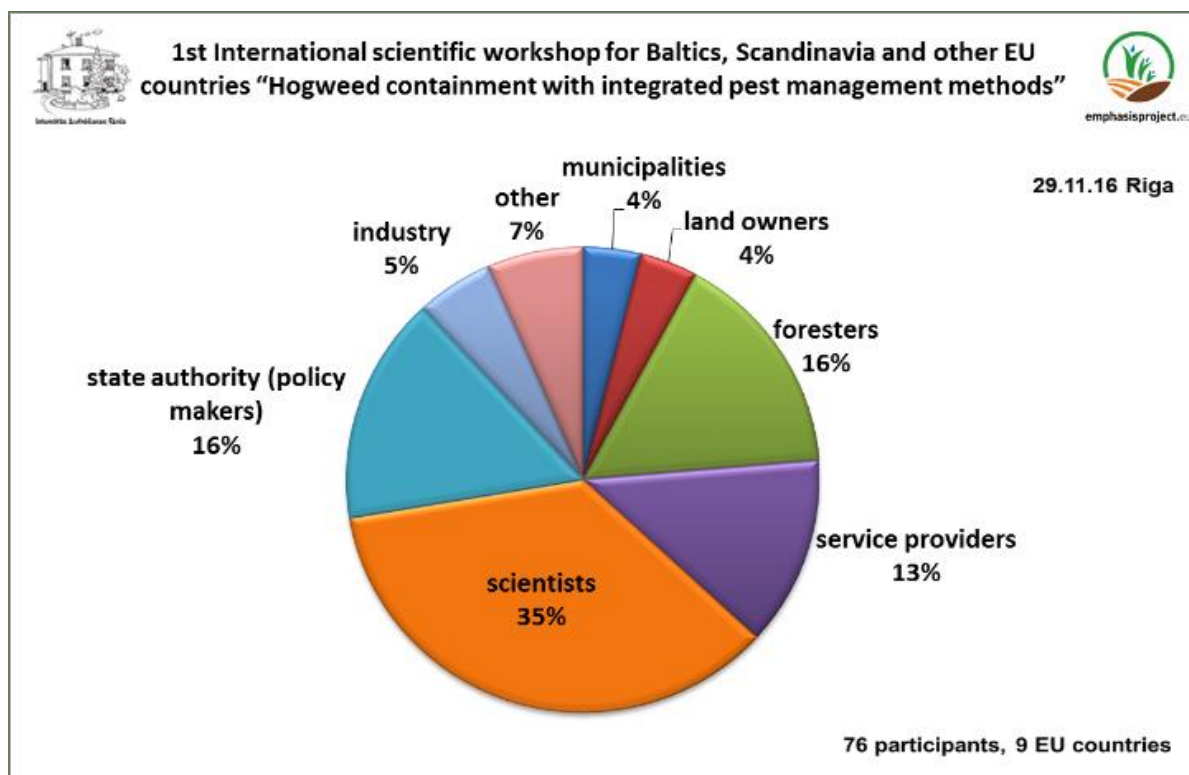


Fig 3.30. Stakeholders involved 29.11.2016.

2nd CIRCULAR 11.11.2016

Hogweed/*Heracleum* spp. containment with Integrated Pest Management Methods

29th November 2016, Rīga 11.00-16.00

Valņodes iela 1, Rīga, LV 1004, Latvija. AS "LATVIJAS VALSTS MEŽI" www.vm.lv

The aim of scientific workshop is to share practical solutions and transfer knowledge developed by Integrētās Audzēšanas Skola / Latvia to Baltic countries, Scandinavia, and other EU countries stakeholders and project partners to control invasive alien species – hogweeds in non-agricultural areas by using new IPM methods (biological, chemical and mechanical). The results of two EMPHASIS www.emphasisproject.eu project cropping seasons, developed by WP3, will be presented, along with practical solutions and on-farm experiments (WP4) demonstrating the economic and environmental value of IPM to control alien and native pests.

PROGRAMME

10.00 Registration	13.00 Lunch
11.00 Opening	14.00 Part I
11.10 Part I	15.30 Final discussions

OPENING
Welcome / Integrētās Audzēšanas Skola / Latvia

PART I – STAKEHOLDERS AND MULTIDISCIPLINARY INTERACTIONS
Roberts Strīpnieks (President of JSC "Latvia's State Forests")
Research based forest management
Inga Gaile (Integrētās Audzēšanas Skola / Latvia) IPM vision and practical solutions
Ramón Albajes (EMPHASIS project WP3 leader / Professor University of Lleida / Spain)
EMPHASIS: an EU project to push the research and practical implementation of IPM
Indulis Brauner (Research Program Manager, JSC "Latvia's State Forests")
Hogweed Containment in JSC "Latvia's State Forests" lands
Venita Erzsts (Director of Plant Protection Department, State Plant Protection Service of Latvia)
Role of State Plant Protection Service in eradication of hogweed with new methods.
Eliza Ilze Malceniēce, Māris Malceniēks (farm "Brācas" / Latvia)
Hogweed containment practical experience in farm for many years and new IPM method.

PART II – PRACTICAL SOLUTIONS ON - FARM VALIDATION
Guntis Gulbis, Inga Gaile, Laura Kazāka, (Integrētās Audzēšanas Skola / Latvia)
New way to use biological and mechanical methods to control hogweeds.
Biodiversity as new crop protection instrument. Two years results of hogweed control with IPM method in different municipalities.
To ensure the IPM method efficiency. Equipment, Safety measures.
EMPHASIS: option for other EU countries to control of *Heracleum* spp.

Final discussions
Any questions please email: info@iaskola.lv, www.ias.lv

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 634179

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č.p. 215, 254 01 Okrouhlo
IČ:25657411, DIČ: CZ25657411

Lesnická a dřevařská fakulta Mendelova univerzita v Brně

POZVÁNKA

L.E.S. CR spol. s r.o. a Lesnická a dřevařská fakulta Mendelovy univerzity v Brně ve spolupráci s projektem EMPHASIS (financován z programu Horizont 2020) vás srdečně zvou na:

SOCIÁLNĚ-TECHNOLOGIČNÉ VÝZKUMNÉ LABORATOŘE (SLL) aneb setkání mezinárodní vědecké obce s odbornou lesnickou veřejností

SLL meeting je konán v návaznosti na nezbytnost předávání nejnovějších vědeckých poznatků týkajících se kontroly houbových patogenů a plevelů směrem do praxe a naopak získání zpětné vazby ze stran odborné lesnické veřejnosti k vědecké obci, tak aby byl další výzkum veden smysluplně a plně využitelně v praktickém lesnictví.

AKCE KONANÁ DNE: 17. 5. 2017 od 9.00 do cca 14.00 hod.

MÍSTO: Lesnická a dřevařská fakulta, Mendelova univerzita, Zemědělská 3, Brno, Zasedací místnost děkanátu, 1. patro

PŘEDBĚŽNÝ PROGRAM:

09.00-10.15	Boševník (I. Gaile, G. Gulbis, IAS) a jiné plevelné rostliny v lese (R. Krejčíř, L.E.S. CR) + diskuze
10.15-10.30	Přestávka
10.30-11.45	Chřadnutí jasanů (J. Hiemstra, DLO; J. Rozypálek, MENDELU) + diskuze
11.45-12.45	Léhký oběd
12.45-14.00	Kořenovník (P. Sedláč, MENDELU; L. Giordano, UNITO) + diskuze

REGISTRACE: Prosím, nahlaste svoji předpokládanou účast (nejlépe vyplněním formuláře na následující straně) Ing. Vendule Čermákové (organizátor za Mendelovu univerzitu) na e-mail Vendula.cermakova@mendelu.cz, nejpozději do 30. 4. 2017.

GARANTI AKCE: Ing. Roman Krejčíř, L.E.S. CR spol. s r.o.; tel. 603 434 959, e-mail: krejcir@lescr.cz
Prof. Dr. Ing. Libor Jankovský, Ústav ochrany lesů a myslivosti, Lesnická a dřevařská fakulta, e-mail: jankov@mendelu.cz

L.E.S. CR spol. s r.o., č.p. 215, 254 01 Okrouhlo, IČ: 25657411, DIČ: CZ25657411.
Společnost je zapsaná v Městském soudu v Praze, s.pis. číslo: C 16370.
bankovní spojení: GE Money Bank a.s.: IČ: 318250504/0600, web: www.lescr.cz, e-shop: www.e-lescr.cz, tel.: 313 033 310, fax: 313 033 311, ISIN: 603 474 299 e-mail: obchod@lescr.cz

Fig. 3.31. Programs from workshops

Workshop program / semināro programma

Hogweed/*Heracleum* spp. containment with Integrated Pest Management Methods for Lithuania/Barščių (*Heracleum*) genties augaļų integrūto naikinimo metodai Lietuvai

22nd February 2017, Vilnius 11.30- 14.00

Ministry of Environment of the Republic of Lithuania, Vilnius, A. Jakšto str. 4/9, hall No.508/ Lietuvos Respublikos aplinkos ministerija, Vilnius, A. Jakšto g. 4/9, 508 salė

REGISTRATION / REGISTRACIJA
From 11.00 / nuo 11 val.

OPENING / ATIDARYMAS
11.30 Welcome / Opening of EMPHASIS workshop / Sveikinimo žodis / EMPHASIS seminaro atidarymas.
Mr. Martynas Norbutas, Vice-minister of Ministry of Environment/ Aplinkos viceministras.

WORKSHOP / SEMINARO EIGA

11.35 – 11.50 *Heracleum* sosnoskyki situation in Lithuania / Sosnoskyki barščio (*Heracleum* sosnoskyki) populiacijos būklė Lietuvoje. (Dr. Zigmantas Gudžinskas, Junior Researcher Junior Researcher of Laboratory of Flora and Geobotany of Botany Institute of Nature Research Centre (presentation in Lithuanian. / Gamtos tyrimų centro Botanikos institutas (pranešimas lietuvių k.)

11.50 – 12.10 Integrated Pest Management (IPM) vision and practical solutions. EMPHASIS project./ Integruoto naikinimo metodo vizija ir praktiniai sprendiniai. EMPHASIS projektas. (Inga Gaile, Integrētās Audzēšanas Skola)

12.10 – 12.40 New way to use biological and mechanical methods to control hogweeds. Biodiversity as new crop protection instrument. / Nauji barščių (*Heracleum*) genties augaļų biologiņu ir mechaninių kontrolės metodų naudojimo būdai. Naujas biologinės įvairovės vaidmuo derliaus apsaugos požiūriu. (Inga Gaile, Guntis Gulbis, Integrētās Audzēšanas Skola)

12.40 – 13.10 Two years results of hogweed control by IPM methods in different municipalities Latvia, Lithuania./ Barščių (*Heracleum*) genties augaļų 2-ų metų integrūto naikinimo metodų rezultatai, vykdyti įvairiose Latvijos ir Lietuvos teritorijose. (Laura Kazāka, Guntis Gulbis, Integrētās Audzēšanas Skola)

13.10 – 13.35 To ensure the IPM method efficiency. Equipment. Safety measures. / Kaip užtikrinti integrūto naikinimo metodo efektyvumą. Prietaisai. Guntis Gulbis, Integrētās Audzēšanas Skola.

13.35 – 13.45 Professional use of products – efficiency. / Profesionalus apsaugos priemonių naudojimas ir efektyvumas. (Gražvydas Štukšcius, UAB Graderitas).

13.45 – 14.00 Legal regulation on *Heracleum* sosnoskyki in Lithuania. / Teisinis reglamentavimas dėl Sosnoskyki barščio (*Heracleum* sosnoskyki) kontrolės Lietuvoje. (Laura Janulaitienė, Ministry of Environment (presentation in Lithuanian)/ Aplinkos ministerija (pranešimas lietuvių k.)

FINAL DISCUSSIONS / DISKUSIJOS.

Semināra programma:

Latvāņu ierobežošana, izmantojot integrētās augu aizsardzības metodes”

Semināra norises vieta un laiks:

2017. gada 22. novembrī
Vaives pagasts, Cēsu novads, “Kaķukroga”.
Vidzemes sosaes malā, krustojumā Cēsis-Rāmiļi-Bānuži

Darba programma:

10.30 – 11.00 Reģistrācija un kafija

11.00 – 11.10 Semināra atklāšana. EMPHASIS projekts (Inga Gaile)

11.10 – 11.40 Integreto augu aizsardzības (IAA) metožu pielietojums latvāņu apkaresanā. Mehāniskās metodes. Bioloģiskā daudzveidība. (Inga Gaile)

11.40 – 12.10 Latvāņu apkaresanas rezultāti ar IAA metodi 2015.-2017.gadā. (Guntis Gulbis, Inga Gaile)

12.10 - 12.30 15 gadu praktiskā pieredze latvāņu apkaresanā un rezultāti ar IAA metodi (Mikus Bērziņš/MB Grimons)

12.30 – 12.50 IAA efektivitātes nodrošināšana. Inventārs, šķidumu sagatavošana, darba drošība (Guntis Gulbis)

12.50 – 13.00 Semināra noslēgums. Diskusijas

13.00 – 13.20 Kafijas pauze

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 634179

Main stakeholder activities 2015-2018:

Workshops				
Description of project activity: Introduction seminar; EMPHASIS project, IPM control of <i>Heracleum spp.</i>				
Stakeholders present: Scientists, state authorities, foresters, land owners, municipalities, service providers				
Objective of engagement: The control of <i>Heracleum spp.</i> with IPM methods				
Outcomes of engagement: Results 2015/2017 – confirm of awareness of IPM control methods; Implementation of IPM Hogweed control.				
Date	Place	Workshop	Nr. of Stakeholders	
15.04.2015	Riga, Latvia	Introduction. Hogweed containment with IPM methods	55	
01.12.2015	Stende, Latvia	Hogweed containment with IPM methods	55	http://ias.lv/lv/zinas/tris-seminari-pulce-ap-200-interesentus-par-latvanu-ierobezosanu
02.12.2015	Sigulda, Latvia	Hogweed containment with IPM methods	68	
03.12.2015	Kalsnava, Latvia	Hogweed containment with IPM methods	70	
09.02.2016	Vaive, Latvia	Hogweed containment with IPM methods	60	http://ias.lv/lv/zinas/seminari-par-latvanu-ierobezosanu
10.02.2016	Barkava, Latvia	Hogweed containment with IPM methods	43	
30.03.2016	Riga, Latvia	Hogweed containment with IPM methods	18	http://www.ias.lv/lv/zinas/seminari-par-latvanu-ierobezosanu-zemkopibas-ministrija
29.11.2016	Riga, Latvia	1 st international Scientific Workshop for Baltics, Scandinavia and other EU countries "Hogweed containment with integrated pest management methods"	76	http://ias.lv/en/news/international-workshop-hogweed-eradication-ipm-methods
06.12.2016	Jelgava, Latvia	Hogweed containment with IPM methods	55	http://ias.lv/en/news/workshop-jelgava-hogweed-ipm
12.01.2017	Mežciems, Latvia	Hogweed containment with IPM methods	24	
22.02.2017	Vilnius, Lithuania	Hogweed/Heracleum spp. containment with integrated pest management methods for Lithuania	56	http://www.am.lt/vl/index.php#a/18133
22.11.2017	Vaive, Latvia	Hogweed containment with IPM methods	90	http://ias.lv/en/news/workshop-vaive-attended-more-90-participants

On farm demonstration				
Date	Place	Project activity	Nr. of Stakeholders	
26.07.2016	Kedainiai, Lithuania	<i>Heracleum spp.</i> control with IPM demonstration on farm	6	
17.05.2017	Brno, Czech Republic	Soial-Tehnological Learning LAB "New technologies for forestry: Heterobasidion root rot, ASH dieback, Control of Heracleum"	27	http://files.lescr.webnode.cz/200001153-26ea427e44/pozv%C3%A1nka_SLLmeeting3VC_vypl%C5%88ovac%C3%AD.pdf
18.10.2017	Švenčionėliai, Vilnius, Kaunas, Lithuania	Innovative pest management strategy development framework for Lithuania	9	http://www.ias.lv/en/news/integrated-method-hogweed-eradication-lithuania

Participation with presentation in Workshop				
03.-04.03. 2016	Vantaa, Finland	8 th NORBARAG meeting	33	http://ias.lv/lv/zinas/daliba-8-norbarag-konference-hyvinka-somija
28.-29.09. 2016	Riga, Latvia	European Weed Research Society (EWRS) workshop	46	http://ewrs.org/doc/EWRS Biodiversity Riga Proceedings 2016.pdf
12.03.2017	Jelgava, Latvia	For the Study trip in the Euroforester master program SLU (Swedish University of Agricultural Sciences) Alnarp	27	http://ias.lv/en/news/emphasis-project-master-students-slu-alnarp-sweden
12.03.2018	Jelgava, Latvia	For the Study trip in the Euroforester master program SLU Swedish University of Agricultural Sciences) Alnarp	40	http://ias.lv/en/news/emphasis-project-students-swedish-university-agriculture
Participation with poster in Workshop				
09.11.2017	Daugavpils, Latvia	2 nd International Conference: "Sustainable Forest Management in the Baltics. Earth and man in the balanced interaction"	92	http://ias.lv/en/news/sustainable-forest-management-earth-and-man-balanced-interaction
12.02.2018	Brno, Czech Republic	Workshop "Likvidace invazních rostlin v krajine" (Control of invasive plants in countryside)	40	http://ias.lv/en/news/poster-and-presentation-workshop-brnoczech-republic
22.02.2018	Jelgava, Latvia	Conference "Balanced Agriculture"	103	http://ias.lv/en/news/participation-conference-balanced-agriculture
	TOTAL		1093	

3.10. CONCLUSIONS AND DISCUSSIONS

Natural biodiversity creates competition and this is one of the most important crop protection tools for effective control of hogweed. IPM ensure native plant species return to this site.

Each of the IPM methods (root digging, collection of green seeds and cutting of side flowers, cutting of stems with flowering umbels, hogweed eradication by selective herbicides, etc.) must be done in the optimal hogweed development phase - specific for whichever method, which varies considerably between methods.

A combination of selective herbicides mixture used early in spring (efficacy 8 weeks) and biodiversity of native plants and insects (efficacy for 44 weeks) covers one year and creates unique combination of effective practical solutions. This is synergy of chemical and biological method.

By applying IPM methods in hogweed eradication, procedure is relatively simple, effective and economically more beneficial. When combining IPM methods and good planning of the work, it is possible to eradicate hogweed effectively in 2-3 years.

28 On-farm experiments 2015-2017: LV, LT (IAS), CZ (by MENDEL) confirm efficacy of IPM – *Heracleum spp.* control by selective herbicides and biodiversity: 60 - 98% within 1st year.

(Please see 3.7 and Annex 1).

For regions and places where people had problems with hogweeds for decades this IPM experience is in high demand and very appreciated.

We should stop spreading myths about the hogweed.

Dissemination for stakeholders in face-to-face workshops is the most effective way to implement the IPM method. Implementation must be country specific and regionally adapted.

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ANNEX 1. ON - FARM EXPERIMENT RESULTS (2015 – 2017) FOR *HERACLEUM SPP.* CONTAINMENT WITH IPM

Table 1. On - farm experiments/demonstrations for *Heracleum spp.* containment with IPM. Trials and results in Latvia 2015

Trial ID	Place	Place description	Hogweed coverage at the beginning of trial (%)	Date of treatment	Efficacy (%)			
					2 nd week	More than 4 weeks	More than 8 weeks	More than 3 months
I-2015-04-20	Dekšāre	around building	65%	APRIL 20 th	Stop of growth, Leaf chlorosis	94%	95%	96% other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
II-2015-05-08	Priekuļi	roadside	40%	MAY 8 th	Stop of growth, leaf chlorosis	95%	98%	98% other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
III-2015-05-15	Allaži	around building	90%	MAY 15 th	Stop of growth, leaf chlorosis	80%	80%	80% other weed species cover soil
IV-2015-06-15	Lestene*	around building	55%	JUNE 15 th	<i>Heracleum</i> rosettes and leaf chlorosis	95%	96%	96% other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering

Table 2. On - farm experiments/demonstrations for *Heracleum spp.* containment with IPM. Assessments in Latvia 2015

Place	Assessment before treatment	Date of first treatment	Time of assessments										
			MAY		JUNE		JULY		AUGUST		SEPTEMBER	OCTOBER	
LATVIA													
Dekšāre	17.04.2015.	20.04.2015.	05.05.2015.	25.05.2015.	08.06.2015.	22.06.2015.	09.07.2015.	27.07.2015.	03.08.2015.	17.08.2015.	25.08.2015.	21.09.2015.	26.10.2015.
Priekuļi	24.04.2015.	08.05.2015.		29.05.2015.		26.06.2015.		22.07.2015.				17.09.2015.	
Allaži	27.04.2015.	15.05.2015.	29.05.2015.		26.06.2015.		22.07.2015.					17.09.2015.	01.10.2015. OLD/ another Field
Lestene*	15.06.2015.	15.06.2015.			17.06.2015. 2 days after treatment		21.07.2015.		10.08.2015			29.09.2015.	

*mechanical cutting of *Heracleum* (30.05.2015.)

	4 weeks
	8 weeks
	3 months
	5 months



Fig. 3.32. Trial place I-2015-04-20 in Dekšāre.
3 days before treatment (17.04.2015.) and 2 years after treatment (09.06.2017.)



Fig. 3.33. Trial place II-2015-05-08 in Priekuļi.
4 weeks after treatment (29.05.2015.) and 3 months after treatment (22.07.2015.)



Fig. 3.34. Trial place III-2015-05-15 in Allaži
Before treatment (27.04.2015.) and 2 weeks after treatment (29.05.2015.)



Fig. 3.35. Trial place IV-2015-06-15 in Lestene
8 weeks after treatment (10.08.2015.) and in next year (13.05.2016.)

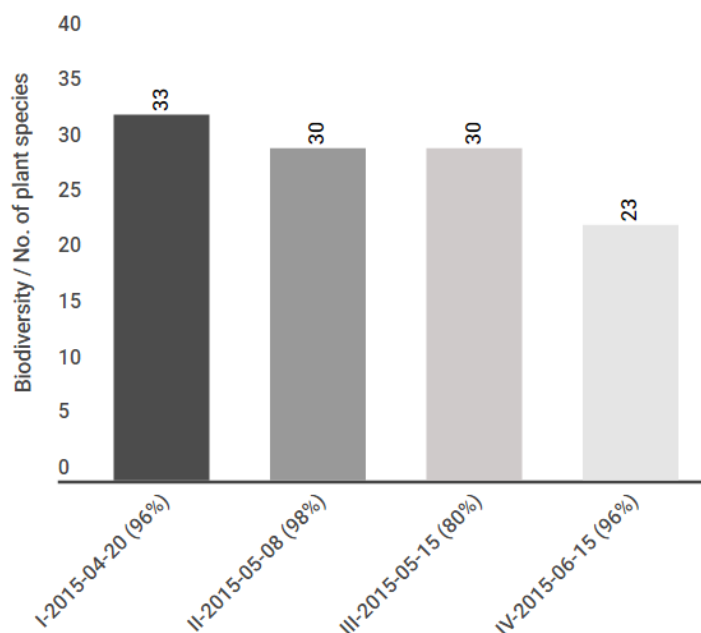


Fig 3.36. Biodiversity / No. of plant species replacing hogweeds in 4 trial places in Latvia 2015 (efficacy % level of hogweed control in the autumn)

Table 3. Plant biodiversity (native species replacing hogweed) in 4 trial plots/locations in Latvia 2015. (Bitckis, 1920; Bitckis, 1923)

Occurrence in No. Trial plots	Number of plant species	Latin names	English
4	6	<i>Cirsium arvense</i>	Creeping Thistle
		<i>Dactylis glomerata</i>	Cock's-foot
		<i>Equisetum pratense</i>	Shady Horsetail
		<i>Poa pratensis</i>	Smooth Meadow-grass
		<i>Veronica arvensis</i>	Wall Speedwell
		<i>Vicia cracca</i>	Tufted Vetch
3	12	<i>Achillea millefolium</i>	Yarrow
		<i>Artemisia vulgaris</i>	Mugwort
		<i>Convolvulus arvensis</i>	Field Bindweed
		<i>Deschampsia caespitosa</i>	Tufted Hair-grass
		<i>Elytrigia repens</i>	Common Couch
		<i>Galium album</i>	Upright Hedge-bedstraw
		<i>Galium aparine</i>	Cleavers
		<i>Hypericum perforatum</i>	Perforate St John's-wort
		<i>Poa trivialis</i>	Rough Meadow-grass
		<i>Sonchus arvensis</i>	Perennial Sow-thistle
		<i>Taraxacum officinale</i>	Common Dandelion
		<i>Urtica dioica</i>	Common Nettle
2	9	<i>Aegopodium podagraria</i>	Ground-elder
		<i>Agrostis tenuis</i>	Common Bent
		<i>Alopecurus pratensis</i>	Meadow Foxtail
		<i>Arctium tomentosum</i>	Cotton Burdock
		<i>Campanula patula</i>	Spreading Bellflower
		<i>Centaurea jacea</i>	Brown Knapweed

		<i>Plantago major</i>	Greater Plantain
		<i>Setaria viridis</i>	Green Bristle-grass
		<i>Veronica filiformis</i>	Slender Speedwell
1	38	<i>Acer platanoides</i>	Norway Maple
		<i>Anthoxanthum odoratum</i>	Sweet Vernal-grass
		<i>Apera spica-venti</i>	Loose Silky-bent
		<i>Atriplex patula</i>	Common Orache
		<i>Avena fatua</i>	Wild-oat
		<i>Barbarea vulgaris</i>	Yellow rocket
		<i>Bromus mollis</i>	Soft- Brome
		<i>Capsella bursa-pastoris</i>	Shepherd's-purse
		<i>Centaurea scabiosa</i>	Greater Knapweed
		<i>Chelidonium majus</i>	Greater Celandine
		<i>Chenopodium album</i>	Fat-hen
		<i>Clinopodium vulgare</i>	Wild Basil
		<i>Daucus carota</i>	Wild Carrot
		<i>Equisetum arvense</i>	Field Horsetail
		<i>Erigeron canadensis</i>	Canadian Fleabane
		<i>Erysimum cheiranthoides</i>	Treacle Mustard
		<i>Euphorbia helioscopia</i>	Sun Spurge
		<i>Festuca pratensis</i>	Meadow Fescue
		<i>Galeopsis tetrahit</i>	Common Hemp-nettle
		<i>Impatiens parviflora</i>	Small Balsam
		<i>Leucanthemum vulgare</i>	Oxeye Daisy
		<i>Lotus corniculatus</i>	Common Bird's-foot-trefoil
		<i>Lupinus polyphyllus</i>	Garden Lupin
		<i>Matricaria perforata</i>	Scentless Mayweed
		<i>Medicago sativa</i>	Lucerne
		<i>Phleum pratense</i>	Timothy
		<i>Picea abies</i>	Norway Spruce
		<i>Plantago lanceolata</i>	Ribwort Plantain
		<i>Poa annua</i>	Annual Meadow-grass
		<i>Populus tremula</i>	Aspen
		<i>Potentilla anserina</i>	Silverweed
		<i>Quercus robur</i>	Pedunculate Oak
		<i>Rubus caesius</i>	Dewberry
		<i>Rubus idaeus</i>	Raspberry
		<i>Salix cinerea</i>	Grey Willow
		<i>Senecio vulgaris</i>	Groundsel
		<i>Stellaria media</i>	Common Chickweed
		<i>Trifolium medium</i>	Zigzag Clover

Table 4. On - farm experiments/demonstrations for *Heracleum* spp. containment with IPM. Trials and results in Latvia, Lithuania, Czech Republic. 2016

Trial ID	Location	Place description	Hogweed coverage at the beginning of trial (%)	Date of treatment	Efficacy (%)			
					2 nd week	More than 4 weeks	More than 8 weeks	More than 3 months
I-2016-04-12	Durbe	in front of building	85%	APRIL 12 th	Stop of growth, Leaf chlorosis	90%	90%	98%, Other weed species cover soil, only some <i>Heracleum</i> spp., no flowering
II-2016-04-12	Lestene	edge of the forest	95%	APRIL 12 th	Stop of growth, Leaf chlorosis	80%	80%	80%, Only some weed species cover soil / no hogweed flowering
III-2016-04-22	Dekšāre	1 st around old building	75%	APRIL 22 nd	Stop of growth, Leaf chlorosis	85%	90%	95%, Other weed species cover soil/only some <i>Heracleum</i> spp. /no flowering
		2 nd edge of the forest	70%	APRIL 22 nd	Stop of growth, Leaf chlorosis	90%	95%	95%, Other weed species cover soil/only some <i>Heracleum</i> spp. /no flowering
		3 rd around building	95%	APRIL 22 nd	Stop of growth, Leaf chlorosis	70%	70%	75%, Only few weed species cover soil/ no hogweed flowering.
IV-2016-04-27	Priekuļi	1 st roadside	80%	APRIL 27 th	Stop of growth, Leaf chlorosis	85%	85 %	90%, Other weed species cover soil, some Hogweed flowering.
		2 nd roadside	80%	APRIL 27 th	Stop of growth, Leaf chlorosis	85%	90%	90%, Other weed species cover soil, some Hogweed flowering.
V-2016-04-28	Zilupe	roadside	75%	APRIL 28 th	Stop of growth, Leaf chlorosis	80%	90%	95%, Other weed species cover soil/only some <i>Heracleum</i> spp. /no flowering
VI-2016-05-05	Allaži	1 st valley ¹	25%	MAY 5 th	Stop of growth, Leaf chlorosis	80%	80%	85%, Other weed species cover soil, some Hogweed flowering.
		2 nd landfill	90%	MAY 5 th	Stop of growth, Leaf chlorosis	80%	70%	60%, Other weed species cover soil/ some <i>Heracleum</i> spp., no flowering, small weed species
		3 rd slope	95%	MAY 5 th	Stop of growth, Leaf chlorosis	85%	90%	98%, Other weed species cover soil.

¹trial in 2015



*Fig. 3.37. Trial place I-2016-04-12 in Durbe
Day of treatment with control plot (12.04.2016.) and 4 weeks after treatment with control plot (11.05.2016.)*



*Fig. 3.38. Trial place II-2016-04-12 in Lestene
Day of treatment (12.04.2016.) and 3 months after treatment (15.07.2016.)*



*Fig. 3.39. Trial place III-2016-04-22 in Dekšāre
4 weeks after treatment (23.05.2016.) and 5 months after treatment (19.09.2016.)*



*Fig. 3.40 Trial place IV-2016-04-27 in Priekulī
Before treatment (year 2015) and 3 months after treatment (28.07.2016.)*



Fig. 3.41. Trial place V-2016-04-28 in Zilupe
Day of treatment (28.04.2016.) and 5 months after treatment (29.09.2016.)



Fig. 3.42. Trial place VI-2016-05-05 in Allaži
Before treatment (year 2015.) and 3 months after treatment (28.07.2016.)



Fig 3.43. Trial place LT-2016-04-25 Lithuania, Kėdainiai
Day of treatment (25.04.2016.) and 4 weeks after treatment (23.05.2016.)



Fig. 3.44. Trial place CZR-2016-05-18 Czech Republic, Planá
Figures. Day of treatment (18.05.2016.) and 3 months after treatment (02.08.2016.) Czech Republic, Planá

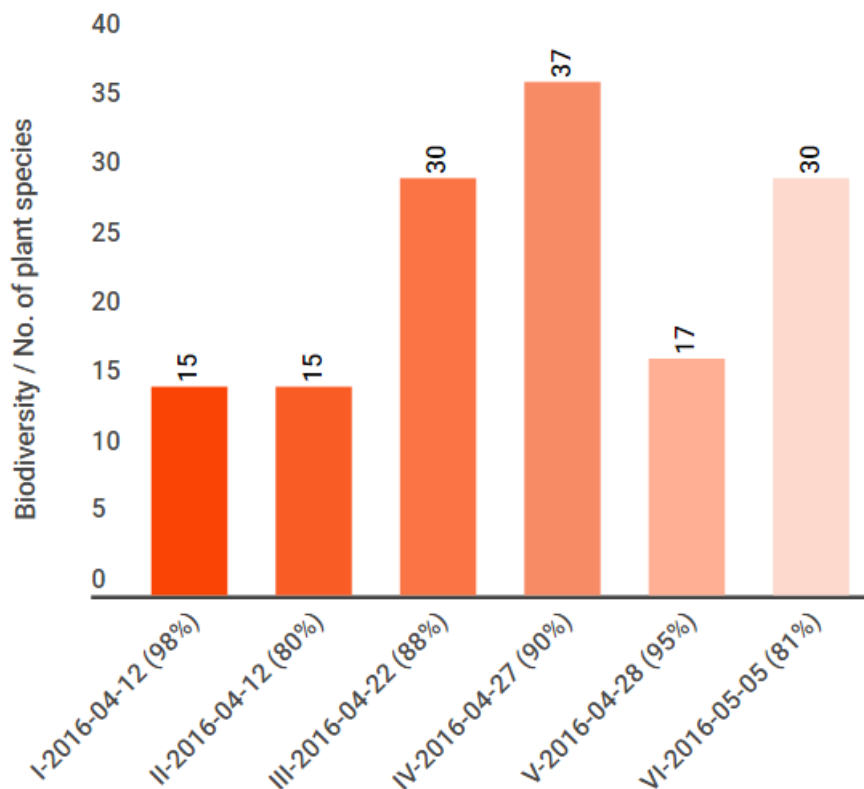


Fig. 3.45. Biodiversity / No. of plant species replacing hogweed in 6 trial plots in Latvia 2016 (efficacy % level of hogweed control in the autumn).

Table 5. Plant biodiversity (native species replacing hogweed) in 6 trial plots/ locations in Latvia 2016. (Bitckis, 1920; Bitckis, 1923)

Occurrence in No. Trial plots	Number of plant species	Latin names	English
6	7	<i>Dactylis glomerata</i>	Cock's-foot
		<i>Elytrigia repens</i>	Common Couch
		<i>Galium aparine</i>	Cleavers
		<i>Impatiens parviflora</i>	Small Balsam
		<i>Poa pratensis</i>	Smooth Meadow-grass
		<i>Urtica dioica</i>	Common Nettle
		<i>Veronica arvensis</i>	Wall Speedwell
4	6	<i>Arctium tomentosum</i>	Cotton Burdock
		<i>Chelidonium majus</i>	Greater Celandine
		<i>Equisetum pratense</i>	Shady Horsetail
		<i>Rubus idaeus</i>	Raspberry
		<i>Taraxacum officinale</i>	Common Dandelion
		<i>Vicia cracca</i>	Tufted Vetch
3	8	<i>Capsella bursa-pastoris</i>	Shepherd's-purse
		<i>Cirsium arvense</i>	Creeping Thistle
		<i>Daucus carota</i>	Wild Carrot
		<i>Phleum pratense</i>	Timothy
		<i>Plantago major</i>	Greater Plantain
		<i>Poa annua</i>	Annual Meadow-grass
		<i>Potentilla anserina</i>	Silverweed
<i>Sonchus arvensis</i>	Perennial Sow-thistle		

2	9	<i>Alopecurus pratensis</i>	Meadow Foxtail
		<i>Artemisia vulgaris</i>	Mugwort
		<i>Convolvulus arvensis</i>	Field Bindweed
		<i>Deschampsia caespitosa</i>	Tufted Hair-grass
		<i>Erysimum cheiranthoides</i>	Treacle Mustard
		<i>Galium album</i>	Upright Hedge-bedstraw
		<i>Sonchus asper</i>	Prickly Sow-thistle
		<i>Thlaspi arvense</i>	Field Penny-cress
		<i>Trifolium medium</i>	Zigzag Clover
1	36	<i>Acer platanoides</i>	Norway Maple
		<i>Aegopodium podagraria</i>	Ground-elder
		<i>Agrostis vulgaris</i>	Common Bent
		<i>Anemone nemorosa</i>	Wood Anemone
		<i>Artemisia absinthium</i>	Common wormwood
		<i>Athyrium filix-femina</i>	Lady-fern
		<i>Betula pendula</i>	Silver Birch
		<i>Calystegia sepium</i>	Hedge Bindweed
		<i>Campanula patula</i>	Spreading Bellflower
		<i>Carduus crispus</i>	Curled Thistle
		<i>Carex cespitosa</i>	Sedge
		<i>Centaurea scabiosa</i>	Greater Knapweed
		<i>Chenopodium album</i>	Fat-hen
		<i>Clinopodium vulgare</i>	Wild Basil
		<i>Corylus avellana</i>	Hazel
		<i>Crepis tectorum</i>	Narrow-leaved Hawk's-beard
		<i>Erigeron canadensis</i>	Canadian Fleabane
		<i>Euphorbia helioscopia</i>	Sun Spurge
		<i>Fumaria officinalis</i>	Common Fumitory
		<i>Galega orientalis</i>	Fodder Galega
		<i>Galeopsis tetrahit</i>	Common Hemp-nettle
		<i>Humulus lupulus</i>	Common Hop
		<i>Juncus bufonius</i>	Toad Rush
		<i>Leucanthemum vulgare</i>	Oxeye Daisy
		<i>Matricaria perforata</i>	Scentless Mayweed
		<i>Mentha arvensis</i>	Corn Mint
		<i>Papaver dubium</i>	Long-headed Poppy
		<i>Picea abies</i>	Norway Spruce
		<i>Pinus sylvestris</i>	Scots Pine
		<i>Polygonum persicaria</i>	Redshank
		<i>Rumex crispus</i>	Curled Dock
		<i>Sambucus nigra</i>	European elder
		<i>Sinapis arvensis</i>	Charlock
		<i>Stellaria media</i>	Common Chickweed
		<i>Ulmus laevis</i>	European white elm
		<i>Veronica filiformis</i>	Slender Speedwell

Table 6. On - farm experiments/demonstrations for *Heracleum spp.* containment with IPM. Trials and results in Latvia, Lithuania, Czech Republic. 2017

Trial ID	Location	Place description	Hogweed coverage at the beginning of trial (%)	Date of treatment	Efficacy (%)			
					2 nd week	More than 4 weeks	More than 8 weeks	More than 3 months
I-2017-04-12	Lestene	edge of the forest*	40%	APRIL 12 th	Stop of growth, Leaf chlorosis	85%	85%	85%, other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
I-2017-06-08		meadow	35%	JUNE 8 th	Stop of growth, Leaf chlorosis	98%	98%	99% other weed species cover soil / no hogweed flowering
II-2017-04-20	Priekulji	roadside*	25%	APRIL 20 th	Stop of growth, Leaf chlorosis	90%	90%	95%, other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
III-2017-04-21	Augstkalne	meadow	85%	APRIL 21 th	Stop of growth, Leaf chlorosis	85%	90%	95%, other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
IV-2017-04-24	Durbe	around building*	15%	APRIL 24 th	Stop of growth, Leaf chlorosis	95%	99%	99%, other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
V-2017-05-03	Ķekava	meadow	85%	MAY 3 rd	Stop of growth, Leaf chlorosis	90%	90%	92%, other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
VI-2017-05-05	Dekšāre	around building	98%	MAY 5 th	Stop of growth, Leaf chlorosis	90%	95%	99%, only some weed species cover soil / no hogweed flowering / small weed species
VII-2017-05-08	Vaive	roadside	75%	MAY 8 th	Stop of growth, Leaf chlorosis	90%	90%	90%, other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
VIII-2017-05-12	Dagda	roadside	80%	MAY 12 th	Stop of growth, Leaf chlorosis	90%	95%	95%, other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
IX-2017-05-12	Ezernieki	roadside	85%	MAY 12 th	Stop of growth, Leaf chlorosis	90%	95%	98%, other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
X-2017-07-03	Allaži	valley**	25%	JULY 3 rd	Stop of growth, Leaf chlorosis	85%	85%	90% other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
		landfill*	80%	JULY 3 rd	Stop of growth, Leaf chlorosis	80%	80%	85% other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering
		slope*	15%	JULY 3 rd	Stop of growth, Leaf chlorosis	95%	95%	97% other weed species cover soil/ only some <i>Heracleum spp.</i> / no flowering

*trial in 2015

**trial in 2016



Fig. 3.46. Trial place I-2017-04-12 in Lestene
4 weeks after treatment (23.05.2017.) and 8 weeks after treatment (14.06.2017.)



Fig. 3.47. Trial place II-2017-04-20 in Priekule
Before treatment (year 2016.) and 3 months after treatment (02.08.2017.)



Fig. 3.48. Trial place II-2017-04-21 in Augstkalne
2 weeks after treatment (05.05.2017.) and 8 weeks after treatment (12.06.2017.)



Fig. 3.49. Trial place IV-2017-04-24 in Durbe
Before treatment (year 2015.) and 8 weeks after treatment (08.06.2017.)



*Fig. 3.50. Trial place V-2017-05-03 in Ķekava
4 weeks after treatment (07.06.2017.) and 8 weeks after treatment (29.06.2017.)*



*Fig. 3.51. Trial place VI-2017-05-05 in Dekšāre
4 weeks after treatment (29.05.2017.) and 5 month after treatment (09.10.2017.)*



*Fig. 3.52. Trial place VII-2017-05-08 in Vaive
Before treatment (year 2015) and 5 month after treatment (17.10.2017.)*



*Fig. 3.53. Trial place VIII-2017-05-12 in Dagda
Before treatment (year 2015) and 5 month after treatment (12.10.2017.)*



Fig. 3.54. Trial place IX-2017-05-12 in Ezernieki
Day of treatment (12.05.2017.) and 8 weeks after treatment (07.07.2017.)



Fig. 3.55. Trial place X-2017-07-03 in Allaži
Day of treatment (03.07.2017.) and 3 months after treatment (10.10.2017.)

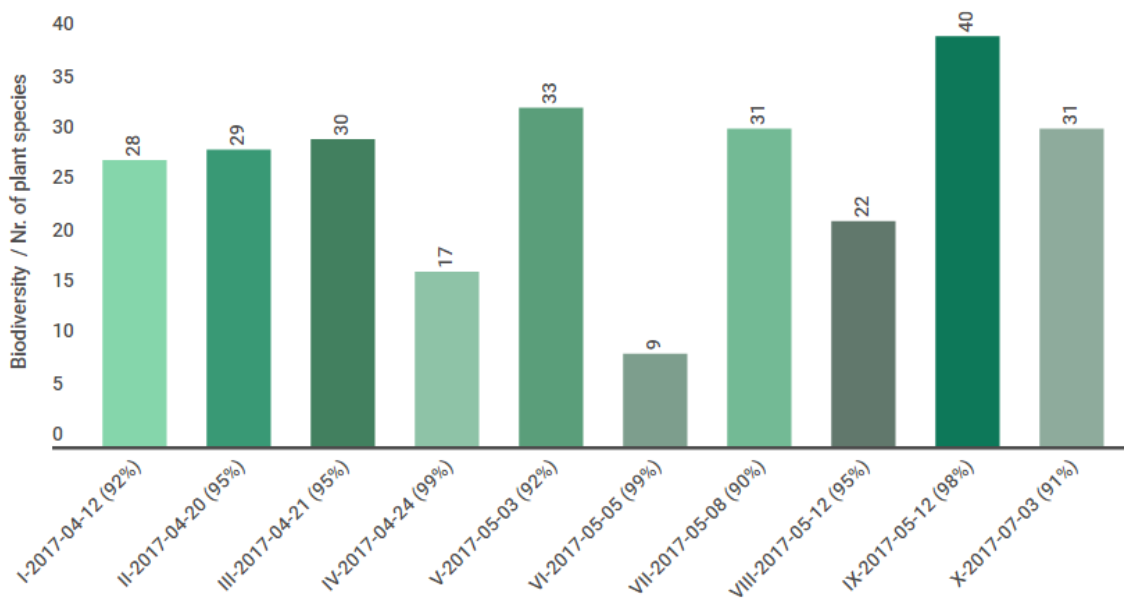


Fig. 3.56. Biodiversity / No. of plant species replacing hogweed in 10 trial plots in Latvia, 2017
(efficacy % level of hogweed control in the autumn).

Table 7. Plant biodiversity (native species replacing hogweed) in 10 trial plots/locations in Latvia, 2017 (Bitckis, 1920; Bitckis, 1923)

Occurrence in No. Trial plots	Number of plant species	Latin names	English
10	3	<i>Dactylis glomerata</i>	Cock's-foot
		<i>Elytrigia repens</i>	Common Couch
		<i>Galium aparine</i>	Cleavers
9	2	<i>Poa pratensis</i>	Smooth Meadow-grass
		<i>Veronica arvensis</i>	Wall Speedwell
8	2	<i>Artemisia vulgaris</i>	Mugwort
		<i>Urtica dioica</i>	Common Nettle
7	4	<i>Plantago major</i>	Greater Plantain
		<i>Sonchus arvensis</i>	Perennial Sow-thistle
		<i>Taraxacum officinale</i>	Common Dandelion
		<i>Vicia cracca</i>	Tufted Vetch
6	3	<i>Impatiens parviflora</i>	Small Balsam
		<i>Phleum pratense</i>	Timothy
		<i>Potentilla anserina</i>	Silverweed
5	4	<i>Agrostis tenuis</i>	Common Bent
		<i>Arctium tomentosum</i>	Cotton Burdock
		<i>Cirsium arvense</i>	Creeping Thistle
		<i>Geranium pusillum</i>	Small-flowered Crane's-bill
4	10	<i>Achillea millefolium</i>	Yarrow
		<i>Capsella bursa-pastoris</i>	Shepherd's-purse
		<i>Chelidonium majus</i>	Greater Celandine
		<i>Daucus carota</i>	Wild Carrot
		<i>Equisetum arvense</i>	Field Horsetail
		<i>Matricaria perforata</i>	Scentless Mayweed
		<i>Poa annua</i>	Annual Meadow-grass
		<i>Rubus idaeus</i>	Raspberry
		<i>Salix cinerea</i>	Grey Willow
<i>Trifolium medium</i>	Zigzag Clover		
3	12	<i>Barbarea vulgaris</i>	Yellow rocket
		<i>Betula pendula</i>	Silver Birch
		<i>Campanula patula</i>	Spreading Bellflower
		<i>Centaurea scabiosa</i>	Greater Knapweed
		<i>Chenopodium album</i>	Fat-hen
		<i>Convolvulus arvensis</i>	Field Bindweed
		<i>Equisetum pratense</i>	Shady Horsetail
		<i>Galium album</i>	Upright Hedge-bedstraw
		<i>Hypericum perforatum</i>	Perforate St John's-wort
		<i>Lathyrus pratensis</i>	Meadow Vetchling
		<i>Poa trivialis</i>	Rough Meadow-grass
<i>Rumex crispus</i>	Curled Dock		
2	15	<i>Alchemilla vulgaris</i>	Lady's-mantle
		<i>Bromopsis benekenii</i>	Lesser Hairy-brome
		<i>Canadian Fleabane</i>	Erigeron canadensis L.
		<i>Centaurea jacea</i>	Brown Knapweed
		<i>Corylus avellana</i>	Hazel
		<i>Crepis tectorum</i>	Narrow-leaved Hawk's-beard
		<i>Deschampsia caespitosa</i>	Tufted Hair-grass
		<i>Erysimum cheiranthoides</i>	Treacle Mustard
		<i>Filipendula ulmaria</i>	Meadowsweet

		<i>Galeopsis tetrahit</i>	Common Hemp-nettle
		<i>Galinsoga parviflora</i>	Gallant Soldier
		<i>Sonchus asper</i>	Prickly Sow-thistle
		<i>Stellaria media</i>	Common Chickweed
		<i>Thlaspi arvense</i>	Field Penny-cress
		<i>Trifolium aureum</i>	Large Trefoil
1	34	<i>Aegopodium podagraria</i>	Ground-elder
		<i>Anemone nemorosa</i>	Wood Anemone
		<i>Anthoxanthum odoratum</i>	Sweet vernal grass
		<i>Bromus arvensis</i>	Field Brome
		<i>Calystegia sepium</i>	Hedge Bindweed
		<i>Carduus crispus</i>	Curled Thistle
		<i>Cichorium intybus</i>	Chicory
		<i>Clinopodium vulgare</i>	Wild Basil
		<i>Dactylorhiza maculata</i>	Spotted-orchid
		<i>Echinochloa crusgalli</i>	Cockspur
		<i>Erigeron canadensis</i>	Canadian Fleabane
		<i>Euphorbia helioscopia</i>	Sun Spurge
		<i>Galega orientalis</i>	Fodder Galega
		<i>Galium elongatum</i>	Great Marsh-bedstraw
		<i>Lamium purpureum</i>	Red Dead-nettle
		<i>Leucanthemum vulgare</i>	Oxeye Daisy
		<i>Lycopsis arvensis</i>	Bugloss
		<i>Melilotus albus</i>	White Melilot
		<i>Oenothera biennis</i>	Common Evening-primrose
		<i>Picea abies</i>	Norway Spruce
		<i>Pinus sylvestris</i>	Scots Pine
		<i>Plantago lanceolata</i>	Ribwort Plantain
		<i>Polygonum lapathifolium</i>	Pale Persicaria
		<i>Prunus padus</i>	Bird Cherry
		<i>Rubus caesius</i>	Dewberry
		<i>Rumex acetosa</i>	Common Sorrel
		<i>Solanum dulcamara</i>	Bittersweet
		<i>Solidago virgaurea</i>	Goldenrod
		<i>Trifolium repens</i>	White Clover
		<i>Tussilago farfara</i>	Colt's-foot
		<i>Ulmus laevis</i>	European white elm
		<i>Verbascum thapsus</i>	Great Mullein
		<i>Veronica filiformis</i>	Slender Speedwell
		<i>Viola arvensis</i>	Field Pansy