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Thesis

Invasive Alien Species in EU – Policy, legislation, practical implementation

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Contents

1 INTRODUCTION

Invasive alien species (IAS) are non-native species that under some circumstances got spread into another biodiversity and make a risk to a new biodiversity. Hazard that might be caused by IAS may ruin the hole ecosystem of the region and spread further to other regions and countries.

It may not seem to be so fatal, as most plants in their native environment are largely harmless, but after invading to another biodiversity, some critical features may emerge. So, we have a species that grows and spreads quickly, may be toxic to humans, cattle, and other inhabitants of the exposed area. Harmful alien species can expel other plants from occupied areas. This aspect can also affect crops, so it is a huge effect for agriculture in the region.

This thesis is related to the project Prevention and Utilization of Invasive Alien Species - PURE, implemented by the South-Eastern Finland University of Applied Sciences and ITMO University, as well as the Federal State Educational Institution of Higher Education Saint Petersburg State Forest Technical University. Natural Resources Institute Finland works as a partner in the project. The specific objective of the project is to raise awareness of safe prevention and elimination of hogweed among local communities in City of St. Petersburg, Leningrad Region and South-East Finland. Another objective is to raise awareness of prevention of IAS, among pupils in the schools and college students in the City of St. Petersburg, Leningrad Region and South-East Finland. Moreover, this work is applicable not only for Russia, Europe, especially Finland, but for Asia as well. Therefore, as an example this work either is overviewing China. The project also wants to develop and test new ways of handling, disposing of and potentially utilizing plants, common for all those regions.

The main IAS plant that is going to be highlighted in this work is Hogweed. Also, there are some other species worth paying attention to, that are common in both countries – Finland and Russia: Lupine and Himalaya balsam. Nevertheless, some of these plants are native for China, there for, this work also includes Jimsonweed and Ragweed.

The objective of this thesis is to describe properties of invasive alien spices, especially such plants as Himalaya balsam, Heracleum, Lupine, Ragweed, and Jimsonweed. To promote the eradication of plants, information is sought on the effective methods used to control spreading of these plants. This paper also reviews the current legislation related to IAS in Finland, Russia, and China.

2 LEGISLATION ABOUT IAS IN FINLAND, RUSSIA, AND CHINA

Invasive alien species can cause serious problems all over the world. They are considered to be one of the major drivers of biodiversity loss. They involve environmental, economic and health risks and of particular concern is the acceleration of plant spread because of climate change (Wenqin et al.2021). Therefore, some regulations and legislations has been applied. Below are the current legislative instruments used in the European Union (applicable to Finland), China and Russia.

2.1 Legislation (EU)

Regulation (EU) 1143/2014 on invasive alien species entered into force on January 1st, 2015, implementing the Action of the Biodiversity Strategy and the Strategic Plan for Biodiversity 2011-2020 under the Convention on Biological Diversity. The IAS regulation stipulates several measures to be taken throughout the EU in relation to invasive alien species included in the Union's list. There three different types of measures exist, all of them are approached to fight with IAS:

- **Prevention:** a series of strict measures aimed to prevent the intentional and unintentional importation of IAS into the EU.
- **Early detection and rapid eradication:** Member States should establish a surveillance system to detect the presence of IAS as early as possible and take prompt action to prevent their emergence and spread.
- **Management**: some Member States have already inadvertently allowed some IAS to be imported. Agreed management measures are needed to prevent their further spread and minimize the harm they cause.

October 13th, 2021: the Commission published the first report on the implementation of the Invasive IAS Regulation. The report concludes that the Invasive Alien Species Regulation is fulfilling its warrant because prevention and control measures, information and awareness of the issue have improved. However, the implementation is still problematic.

Relevant legislative acts:

- Commission Implementing Regulation (EU) 2019/1262 and Commission Implementing Regulation (EU) 2017/1263 updating the list of IAS

This commission is targeted to prevent and control the introduction and spread of IAS.

- Commission Delegated Regulation (EU) 2018/968 on risk assessment for IAS

Except main aim to prevent and control IAS, this commission is directed to apply for the inclusion of invasive alien species on the Union list. These requests must be accompanied by a risk assessment. Several methods and protocols for conducting risk assessment already exist and are used and respected in the biological invasion scientific community. The value and scientific reliability of such methods and protocols should be recognized.

- Commission Implementing Regulation (EU) 2018/1454 defining a technical format for Member States reports

The Commission should define a technical format for reporting and simplify and rationalize reporting obligations to Member States with respect to information. All actions provided for in this regulation are in accordance with the opinion of the IAS Committee.

- Commission Implementing Regulation (EU) 2016/1141 adopting a list of invasive alien species

It stipulates that due consideration must be given to implementation costs, inaction costs, cost-effectiveness and socio-economic aspects. In particular, some of these species have already settled in the Union or are widespread in some Member States, making it impossible to eradicate them in a cost-effective way. However, there are other cost-effective measures that can be implemented, so it is recommended to include these species on the federation list.

- Commission Implementing Regulation (EU) 2016/145 adoption of the format of the document serving as proof of authorization issued by the Member States competent authorities.

It appears as a regard to Regulation (EU) No 1143/2014 of the European Parliament and of the Council. This Regulation provides that the Commission

shall take the form of documents serving as evidence of permits issued by the competent authorities of Member States for the study or ex situ conservation of invasive alien species. Permissions may also be issued for subsequent use of these species for scientific production and medical purposes.

2.2 Legislation in Russia

The first steps towards the elimination of hogweed by legislative means were taken by the government in 2011 but were not successful due to a lack of understanding of the scale of the ecological disaster. Moreover, most documents, that should appear to local governments of districts allover Russia as legislation and regulation are literally just “recommendations”. Speaking about the budget allocated by the state to municipalities for the fight against hogweed, it is worth noting that chemicals are considered the main method of control. The population of settlements closest to the territories treated with herbicides is mainly notified only through the press, less often through television advance to avoid poisoning people and livestock. Since spring 2019 roadsides are treated with herbicides against hogweed, with preparation that contains sulfometuron-methyl. 68 municipalities from 16 districts of the Leningrad region were selected to receive state support in 2020 for the eradication of hogweed. Regional authorities are trying to cope with a hogweed “attack” in different ways, sometimes quite original ones. In January 2019, amendments to the regional law "On Administrative Offenses" came into force, which allow local authorities to fine citizens for hogweed. Failure to take measures to combat weeds on the lands of settlements entails the imposition of an administrative fine on citizens in the amount of 2 thousand to 5 thousand rubles (20 - 60 €), on officials - from 5 thousand to 20 thousand rubles (60 - 200 €), on legal entities - from 20 thousand up to 50 thousand rubles (200 – 600€).

2.3 Legislation in China

Conservation of biodiversity in China through the joint efforts of the Wildlife Conservation Society and the Institute of Zoology. List of invasive alien species in China has been compiled. In 2002, the impact of IAS on biodiversity has become a more serious problem. IASs have seriously damaged China's biodiversity and ecology and caused enormous economic damage. Thus, in

subsequent years, China's State of the Environment Report included a section entitled “Prevention and Control of Alien Species Invasion”. In 2003, the Ministry of Agriculture performed "the Office for the Management of Invasive Alien Species" and "the Center for the Prevention and Control of Invasive Alien Species". Experimental projects were established in Liaoning Province, Kaiyuan City (Yunnan Province), Tengchun District (Yunnan Province), Xichang City (Sichuan Province), Ningnan City (Sichuan Province) and Renhe District of Panzhihua City (Sichuan Province) to eliminate IAS. In 2006, the Ministry of the Environment investigated the invasion of dangerous alien species in 26 national reserves in China. The data obtained show that such an invasion is observed in all 26 reserves, numbering 131 species. Low-latitude regions such as islands and tropical areas are subject to relatively severe threats with a large number of invasive species. While high latitude regions keep lighter threats with less invasive species (China’s Actions on IAS, 2009).

3 INVASIVE SPICIES/DEFINITIONS

” IAS have been recognized as the second most important threat to biodiversity at the global level (after direct habitat loss or destruction) and they represent a serious impediment to conservation and sustainable use of global, regional and local biodiversity.” (Technical Support to EU Strategy on Invasive Alien Species, 2009). Great efforts have been made to solve the problem caused by IAS. During years 2004-2008, EU introduced the DAISIE project, (Inventory of alien invasive species in Europe) which collected data of alien species in EU. Database contains records of 5789 alien plant species in Europe (Lamdon et al 2008, 110).

3.1 Characteristics of target plants

Himalayan Balsam (*Impatiens glandulifera*) is an annual herb (picture 1). The height of a plant is 1-2 meters. The plant also known as: Bobby tops, Copper tops, Gnome's hat stand, Indian balsam, Ornamental jewelweed, Policeman's helmet, Poor man's orchid.

Picture 1. Himalayan balsam (peiinvasives.com)

Flowers are rough (zygomorphic), 2.5-4 cm long. Petals 5, dark or light red or white, 4 lower ones fused in pairs. Sepals 3, lower saccular, narrow petal colors, with spurs bent down. 5 stamens, fused anthers. Gynoecium consists of 5 accrete carpels. The inflorescence in the axils is erect, a cluster of 5–12 flowers.

The lowest leaves are paired opposite, the upper leaves are usually in 3 whorls. Leaves are petiolate, with large secretory glands at the base. The blade is elliptical-ovoid, thick, fragile, with a densely serrated edge. Fetus of Himalaya balsam is 5-part capsule that swings open when finished, throwing seeds into the air.

Picture 2. Himalaya balsam (Illustration by Lizzie Harper)

Habitat of Himalaya balsam: yards, gardens, banks, forest edges, meadows, ditches, and wastelands. Also appears as an ornament. (Beerling, D. J., & Perrins, J. M. (1993))

Himalayan balsam appeared in Finland and Russia as a garden ornament. It is impressive and easy to care for, which has made it very popular. However, the garden hedges were ignored and began to spread ruthlessly. The species' club-like capsule of this species bursts at the slightest disturbance and carries ripe seeds quite far from the mother plant. The earliest information on distribution was recorded in the early 1970s, and in the 90s it began to be actively disseminated, so it still has some novelty value. Himalayan balsam is considered a nuisance in Central Europe, where it grows in wide dense thickets along riverbanks. The sensitivity of the annual plant to frost in early summer and autumn in Finland slows down the spread a little, at least in the north of the country. This plant might cause excess sediment which negatively affects fish reproduction, affects crops, causes bank erosion.

Lupine (*Lupinus polyphyllus) is* a perennial herb (Picture 3). The height of a plant is 60-100 cm. Other names of the plant: Bigleaf lupin, Big-leaved lupine, Blue-pod lupine, Bog lupine, Common lupine, Garden lupin, Largeleaf lupin, Large-leaved lupine, Meadow lupine, Russel lupin.

Picture 3. Lupine (Freepik.com)

Lupines flowers are corolla zygomorphic, blue purple, sometimes pink, white, or multi-colored, 12-14 mm in length. There are five petals; standing "standard", two side "wings", the two lower ones are connected in a "keel", the general shape of the rim resembles a butterfly. The calyx is two-lipped, the upper lip is clearly shorter than the lower one. 10 stamens, threads with fused bases. The only carpel. The inflorescence is a long, dense raceme ending in a stem.

Leaves are alternate, long-stalked, stipulate. Palmate leaves with 9–15 leaflets, tapered, with entire margins. Fetus is 2.5–4 cm long, sparsely hairy, brown, 5–9-seeded pod.

Picture 4. Illustration of Lupine (weekly-sketch.blog.com)

Places of habitat: Gardens, roadsides, railway embankments, wasteland. Also, an ornamental.

It arrived in Finland as an ornamental plant in the 19th century. Many would prefer that it never appeared: garden lupine has spread along the embankments of the highway and along the fallow so that it has already covered the whole country. As a large plant, it leaves a few of our smaller “natives” in the shade, weaves rings around other plants that often accompany it when it comes to prolonged dry periods, and its root nodules fix nitrogen in the soil for its own use. Its excessive spread already poses a threat to the natives of Finland. When the naturally varied flower field turns into a sea of violet-blue lupines, you start to tire of the plant's beautiful conical inflorescences. This uniformity of color is a genetic issue: the genes for blue are dominant. Lupine is Toxic for animals, seeds are toxic for human as well, affects crops, because of excessive spread is posing a threat to smaller natives.

Hogweed (*Heracleum*) is a biennial or short-lived, usually once-flowering perennial herb (Picture 5). The height of a plant is 150-420 cm. Also called Cartwheel-flower, Giant cow parsley, Giant cow parsnip, Parsnip tree, Wild parsnip, Wild rhubarb.

Picture 5. Hogweed. Picture by Roel Meijer

Flower of Hogweed consists of corollas. Corolla is regular, white, 12–25 mm wide; petals 5, deeply notched. Sepals 5. Stamens 5. Pistil of two accrete carpels, styles 2. Inflorescence compound umbel, secondary umbels 50–120. The bracts of the primary umbel quickly fade, 10–18 bracts of the secondary umbel are preserved. Leaves are alternating, petiolar, vaginal at the base. The stem is up to 1 meter long, usually maximum as long as broad is, underside densely haired–glabrous, glabrous top, pinnate, 3-5 leaflets. Leaflets are large, with long narrow lobes, dentate. Fetus is elliptical, two-section, rather shallow crest, schizocarp 9–11 mm long, oil ducts distinctly clavate

Picture 6. Illustration of Hogweed by Lizzie Harper

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Can be found on roadsides, yards, parks, wasteland, forest margins and riverbanks.

This impressive species was introduced to later exposed countries as a decorative element, but unfortunately it was problematic from the beginning, as the furanocoumarins in its coarse hairs combined with sunlight cause skin burns that are difficult and slow to heal. Doctors call this chemical irritation to the skin, which has light phototoxicity. Even the special smell of giant hogweed is enough to cause allergic symptoms in sensitive people, so protective clothing, masks and goggles should be worn when working with the plant.

A large individual can produce up to 50,000 seeds, so if even a small fraction of these seeds germinate, hundreds of millions of seeds will be produced within a few years. The plant usually dies after flowering, so it will die if it cannot sow seeds. It is advisable to destroy wild plantations as soon as possible, although the seed stock will remain in the soil for many years, so getting rid of established populations is often difficult and very time-consuming work. The giant hogweed has become so unpleasant in many places that the question of banning the sale of its seeds and shoots is being seriously considered (Thiele et al., 2008).

Jimsonweed (*Datura Stramonium)* is an erect, annual, freely branching herb (Picture 7). The height of a plant is 60-150 cm. Also known as Thorn apple, Jimson weed, Devil's snare, or Devil's trumpet.

Picture 7. Jimsonweed. Photo by Wendy R. Fredricks

The flowers are tubular, white to cream or purple in color, 6 to 9 cm long; and grow on short stems either from the axils of the leaves or from the branches of the branches. The calyx is long and tubular, swollen at the bottom and acute-angled, topped with five sharp teeth. Corolla folded, only partially open, white, funnel-shaped, with protruding ribs. Flowers open at night.

Leaves 8 to 20 cm long, smooth, toothed, soft and unevenly wavy. The upper surface of the leaves is darker green and the lower one is light green. The seed capsule is ovoid and has a diameter of 3-8 cm and is either spiked or bald. As it ripens, it divides into four chambers, each of which contains many small black seeds.

Picture 8. Illustration from book “Köhler's Medizinal-Pflanzen”

Appears on roadsides, railways, disturbed lands, wastelands, fallow lands, crops, managed grazing lands, drainage ditches, forest edges / abysses, lowlands, ravines, and dry riverbeds.

Datura stramonium probably originated in the tropical regions of Central and South America and has become a cosmopolitan weed in the warmer regions of North, Central and South America, Europe, Asia, Africa and New Zealand. It was registered in Virginia, USA by 1676, where its seeds were used as a drug by British soldiers. Jimsonweed appeared in Finland as an ornament and accidentally as a contaminant. Aggressively competes with local plants and crops, forming dense monospecific plantations. This plant has an allelopathic effect. It is also an alternative host for some pests and pathogens on nightshade crops. The plant is toxic to humans, horses, cattle, sheep, pigs, and chickens. Jimsonweed has gained fame as a plant that humans use to commit suicide. The plant may cause dry mouth and extreme thirst, vision problems, nausea and vomiting, fast heart rate, hallucinations, high temperature, seizures, confusion, loss of consciousness, breathing problems, and death.

Ragweed (*Ambrosia Stramonium)* is an upright annual herb with fine roots (Picture 9). Plant height 50-350 cm. Most often 50-200 cm. Other names of this plant: bursages, burrobrushes, common ragweed, annual ragweed, and low ragweed.

Picture 9. Jimsonweed (nazinvasiveplants.org)

Flowers of Ragweed are cream or pale green, of two types: male forest tubular, in groups of 10-100 or more in small drooping hemispherical heads, between which are cupped wraps of growths, located along the bare spiny racemes, ending in stems and branches; female flowers without petals in L-shaped heads, singly or in groups along the upper axis of the leaf, wrapper length 3-5 mm, saucer-shaped, with a jagged edge.

Leaves are green, short-stemmed, opposite below, alternating above; 2-3 cm long, deeply dissected into many small narrow lobules; the uppermost leaves are sometimes without lobes.

Fetus is light brown, vermiform, 3-5 mm long, 2-3 mm in diameter, woody; with a subulate beak, 1-2 mm long, surrounded by a ring of 4-7 spines, about 1 mm long.

Picture 10. Illustration of Jimsonweed (Biodiversity Heritage Library)

Arise as weed in cultivated land; disturbed open areas, stubble, old pastures, wastelands, roadsides, railroad reserves and wastelands.

Ragweed is a native of North America. It has been introduced to Europe, Russia, Asia, and Australia as an accident contaminant. Seeds might be spread

by water, during floods, in woolpacks, bags, clothing, furred animals, in agricultural seeds. Also, one of the most common ways of spreading is contaminated gravel and soil moved for road construction or garden topdressing. Ambrosia is a serious competitor to vegetables, cereals, soybeans, and maize; inhibits germination of oats and onion. Mostly cattle eat young shoots of ragweed, but it is unpalatable for horses. There for, it usually grows intact in stables. Ambrosia produces highly allergenic pollen. It can provoke an allergic reaction after inhalation, contact with mucous membranes, and even just skin. Moreover, it might cause itching, burning, and swelling of the mouth and throat, runny eyes and nose, hives, and, less commonly vomiting, diarrhea, asthma, and anaphylaxis.

3.2 Elimination

In this part of work known methods of elimination of target plants are described, including chemical, physical and cultivation methods of removal.

Himalaya balsam

Himalaya balsam is week against mowing and grazing. The best results are obtained when mechanical control is applied at the end of the season, that is, when the plants are in bloom or are starting to bloom. Early pruning of plants below the first node can control populations, although it is labor intensive.
In areas with moist and soft soil, heavy machinery will damage the soil and provide open spaces ideal for restoration. In small stands, manual brush cutters can be used; it is also possible to pull out plants by hand. In such case, care should be taken to ensure that the plucked plants cannot grow back where they were laid. For long-term success, the area of re-growth should be monitored.

Selective herbicides such as 2,4-D and triclopyr and non-selective herbicides such as glyphosate have been shown to be suitable for controlling Himalayan balsam. Even though, according to local legislation usage of herbicides might be prohibited. Moreover, rivers and streams are the most effective way of

Himalaya balsam seeds distribution. Therefore, seeding should be controlled starting with the upper part of the river, moving downstream.

Lupine

Small stands of Lupine can be mowed by hands at the early beginning of flowering, before fetuses starts to appear. Also, smaller amount of stands can be cut or removed as whole plant, not just flowering part. For more plants technical supply is recommended. This method of mowing or grazing reduces number of plants in future. Control should be based on two mows in mid and late summer to prevent re-flowering, with cuttings removed regularly. Even though, Lupine is still very popular among gardeners as an ornamental plant. Therefore, distribution of seeds should be controlled more seriously. The main reason, why Lupine should not be eliminated with chemicals, is possibility to affect crops as well. Even though, still one of herbicides useful against this plant is glyphosate, but not applicable in all countries because of local legislation.

Hogweed

Removing whole plant by hand (with gloves) can be effective for young seedlings, but not practical for larger plants. Mechanical pruning is often used to clean riverbanks but does not provide long-term control as it re-grows rapidly from underground, and this can help preserve perennial flowering shoots that would otherwise die after flowering. Pruning in May and June is slightly more effective at reducing seed yields and / or regrowth than pruning in March, but one should not rely on pruning alone to prevent possible seeding. In case of removing whole plant in right period to prevent re-cultivation, soil should be covered with black plastic firm for two years. This method will give more chances to stop growth of new Hogweed plants. Correct crop rotations and intensive land use (The neglect of the fields over the past 15-20 years gave the hogweed an incredible chance to develop arable land).

There are some biological methods to eradicate Hogweed: *Micromycetes* (microscopic fungi) infecting weeds of the genus *Heracleum. Phoma Complanata* fungus strain with mycoherbicidal activity against *Sosnovsky* hogweed). Insect

pests (Stalked weevil, Euleia heracleid, hogweed phytomisa, Depressaria pastinacella. Glyphosate is often applied in April or May. As it was noticed before – usage of herbicides should be applicable only according to local legislation. In some cases, sowing land with fast-growing and highly productive cereals or legumes (Closed grass stand forming dense turf: *Galega*, *Festuca pratensis*, *Dactylis glomerata*, *Phleum pratense*, *Taraxacum*, also *Jerusalem artichoke*) might be effective.

Jimsonweed

Isolated Jimsonweed plants should be hand-plucked before sowing the seeds, whereas large areas of infestation are easily controlled by tillage when the weeds are in the germination stage. As the plants mature, cultivation becomes less efficient because the stems become woody, and the roots cannot be completely cut off. Seedlings take a long time to germinate, so re-cultivation may be necessary to reduce infestation (Parsons and Cuthbertson, 1992). Post-harvest tillage can promote seed survival because seed degrades more quickly at the soil surface than when buried (Stoller and Wax, 1974) and seed loss with no till is greater than with traditional tillage systems (Brust and House, 1988).

Jimsonweed is weak against variety of soil and leaf herbicides commonly used to selectively control annual broadleaf weeds. These include: acifluorfen in soybeans and peanuts; bentazone in soybeans, peanuts, and certain types of beans; metolachlor in corn and sorghum (combined with an antidote); atrazine, cyanizing, simazine, bromoxanil, or dicamba; and 2,4-D, which is effective at the seedling and young stage. Herbicide-tolerant varieties offer the opportunity to increase the flexibility of chemical control. Jimsonweed can be effectively controlled by applying imazethapyr before emergence of imidazolinone tolerant maize.

Ragweed

Ragweed survives trampling, grazing, mowing, and cultivation. The only plants ragweed can’t compete with are legumes and grass. Also planting meadow

clover (*Trifolium pretense*) as a cover crop for established winter wheat reduced the biomass of Ragweed. Mechanical pruning can reduce the seed yield of Ragweed by up to 74%, depending on the number and timing of cuttings (Guan et al., 1991). Hand-mowing is also successful, but this method is too expensive.

Table 1. Comparison of seed production between 3 times and single leaf hand-cutting ("Effect of defoliation on growth and fruiting of ragweed" by Guan, G. Q.; Li, S.; Gao, D. C.; Zhai, Q.; Wan, F. H.; Wang, R.; Liu, W. Q)

Cutting period (Physiological Days)	**32-67**		**50-78**		**67-93**		**78-109**	
Cutting level	1/3	2/3	1/3	2/3	1/3	2/3	1/3	2/3
Single cutting (cm)	1187,3	1094,4	1276,1	1060,9	1380,2	1089,5	1618,6	1297,8
3 times cutting (cm)	1010,7	550,0	866,9	613,3	702,7	646,3	1413,9	885,9
Reduction (%)	14,9	49,7	32,1	42,2	49,1	40,6	12,6	26,7
Compensative capacity ratio	0,85	0,50	0,68	0,58	0,51	0,59	0,87	0,73

Cutting reduced seed production from 12,6 to 49,7 %. The best result was achieved when the cutting period was in the middle of the physiological days.

Annual ragweed is week against most current herbicides, like 2,4-D, bentazone, bromoxynil, diuron, glyphosate, imazaquin, MCPA, flurochloride, glufosinate, linuron, simazine, and Lenacil (Parsons and Cuthbertson, 1992).

3.3 Flowering/Seeding period, occurrence

The sprouting period of the plants varies from March to June. The flowering may start in May and it lasts until October with these plants. Seeding period varies from July to October (table 2).

Table 2. Sprouting, flowering and seeding periods of plants

	Himalayan balsam	**Lupine**	**Hogweed**	**Jimsonweed**	**Ragweed**
Sprouting	March - April	March - April	April - July	May - June	March - May
Flowering	June - September	May - August	August - September	July – October	August - September
Seeding	July - October	July – September	September - October	August – October	September - October

4 MATERIALS AND METHODS

This work is a review of the available literature, including scientific articles, botanical encyclopedias, bachelor's, master's, and doctoral dissertations. Most of the information on which this dissertation is based is taken from resources with reliable information. The main tools providing research have been used, such as: sciencedirect.com, researchgate.com, dx.doi.org. While the most useful resources about current legislation in Europe, Russia and Chine are ec.europa.eucabi.org, cbd.int, and docs.cntd.ru, mosreg.ru. Also, important online databases of information about IAS and its distribution that should be mentioned: gfib.org, neobiota.pensoft.net, iucn.org, nobanis.org, and cabi.org. These resources are capable of providing reliable information necessary for research. After a careful study of the data provided by these resources, an analysis was carried out, highlighting the necessary information to obtain subsequent results aimed at solving the question posed.

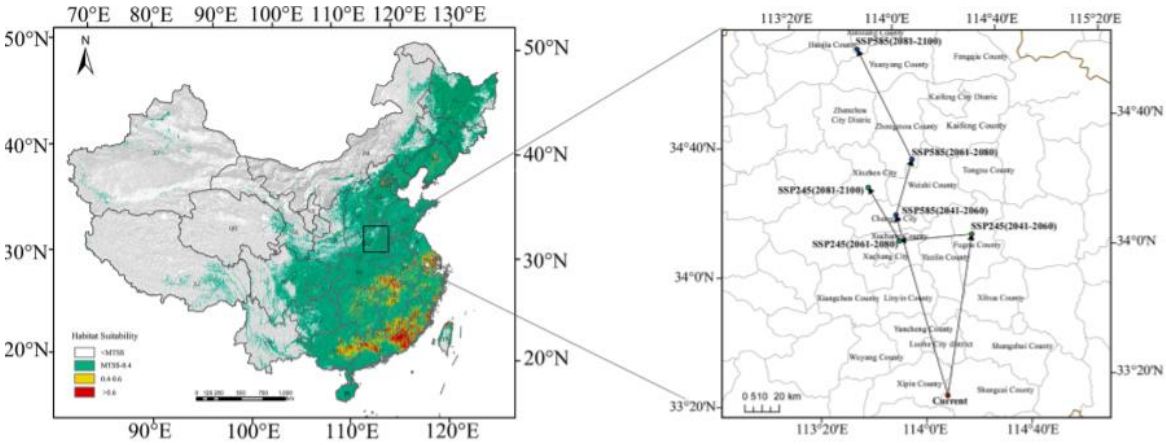
5 DYNAMICS OF DISTRIBUTION

Nowadays World is suffering with a problem of climate change. Global warming is also a power driving distribution of species (Dyderski et al., 2018; Xiong et al., 2019; Li et al., 2020). Most plants listed in this work grow in warm climate and have higher dynamics of offspring survival. Therefore, according to

climate change target plants will spread further to North, even if it takes decades. Because of this aspect dynamics of distribution should be considered.

5.1 Dynamics in China

The current total suitable habitat area of *Ambrosia artemisiifolia* in China, is about 3.50 × 106 km^2. The most suitable habitats are mainly located in the eastern part of Guangdong province and most of Fujian province. It is also likely that plants grow in four inter-provincial borders, that is, on the borders between the provinces of Guangdong and Fujian, Guangdong and Guangxi, Jiangxi, and Hubei, as well as the provinces of Zhejiang and Jiangsu. Suitable habitats for Ragweed plants will be significantly expanded in future climate scenarios (2041–2060, 2061–2080, 2081–2100) (Picture 11).



Picture 11. The current potential distribution (Left) and the centroid distribution transfer (Right) in three future periods (2041–2060, 2061–2080, 2081–2100) under SSP245 and SSP585 scenarios.

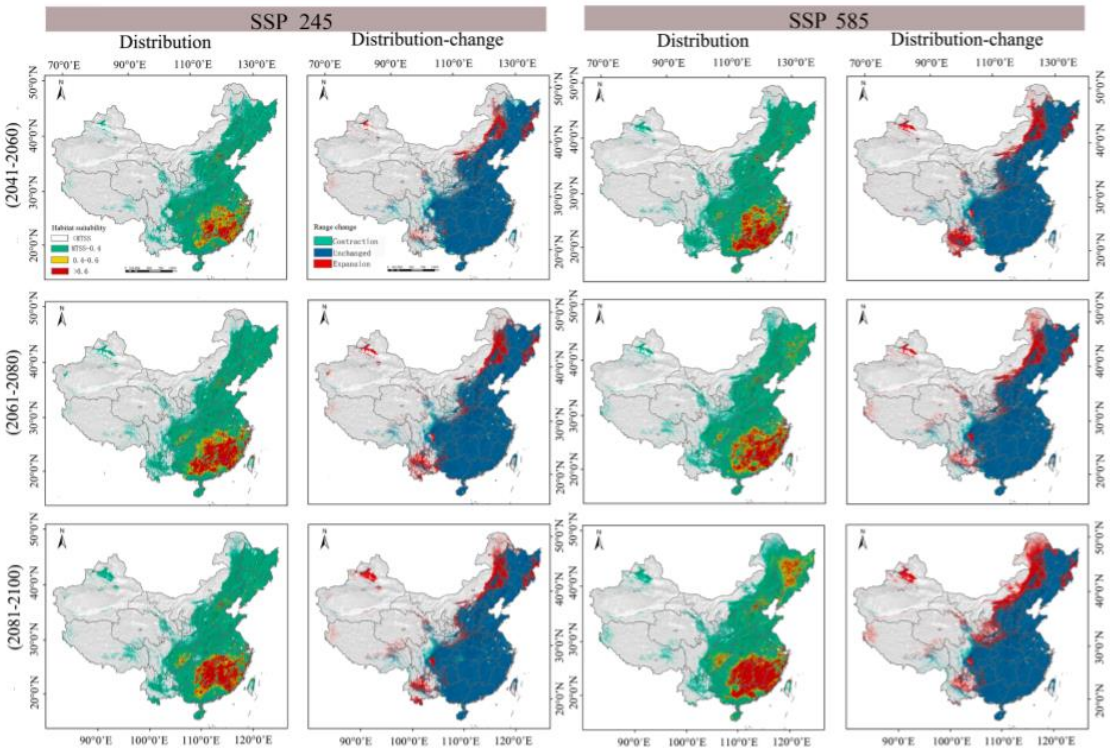
Through past few years energy systems modelers, climate scientists and economists have presented Shared Socioeconomic Pathways (SSP). These scenarios are based on current and modeled future climate change, possible social choices, and economic changes. So, it is possible to predict and model further distribution of IAS. Therefore, in two shared socio-economic pathways (SSPs: 245 and 585) of CMIP6 should be taken in account. The distribution habitat area of this plant in China will decrease by 8.15–17.96% under SSP 245, while under scenario SSP 585 it will be 16.77–26.59%. Therefore, under

SSP 245 (2041–2060) scenario habitat area of ragweed is 2.85 × 10^5; (2061-2080) 5.35 × 10^5; (2081-2100) 6.28 × 10^5. Also, if scenario SSP 585 would be counted dynamics of distribution of ragweed is: (2041-2060) 5.86 × 10^5; (2061-2080) 6.16 × 10^5; (2081-2100) 9.3 × 10^5. (table 3).

Table 3. Ragweed (distribution change %) Under SSP245 and SSP585 scenarios.

Under SSP 245			Under SSP 585		
2041-2060	2061-2080	2081-2100	2041-2060	2061-2080	2081-2100
8.15%	15.29%	17.96%	16.77%	17.62%	26.59%

To predict the most accurate distribution model of Ragweed d highly effective approach (Maxent) was combined with relatively high spatial accuracy and occurrence records by ArcGIS 10.3 (Picture 11).



Picture 12. Projected future distributions of periods (2041–2060, 2061–2080, 2081–2100) for Ragweed under SSP 245 and SSP 585 scenarios.

To prevent distribution of Ragweed in future actions should be taken as soon as possible, including not only elimination, but also monitoring and management for further scientific evidence (Tu, W., Xiong, Q., Qiu, X., & Zhang, Y. (2021)).

5.2 Dynamics in Europe

Dynamics of distribution in Europe is based on information from online database “GBIF” (gbif.org) and modeled in programs DIVA-GIS and MaxEnt. MaxEnt is an open software for modeling distribution of species and to predict their distribution. Bioclimate variables (table 4.) are derived from monthly temperature and rainfall values to provide more biologically meaningful variables and are often used to model the distribution of species and related ecological modeling techniques in this model as well. The three variables with highest contribution (in descending order) were: Temperature Annual Range (BIO7 (BIO5-BIO6)), Precipitation of Warmest Quarter (BIO18) and Mean Temperature of Warmest Quarter (BIO10) (P.Germann 2018).

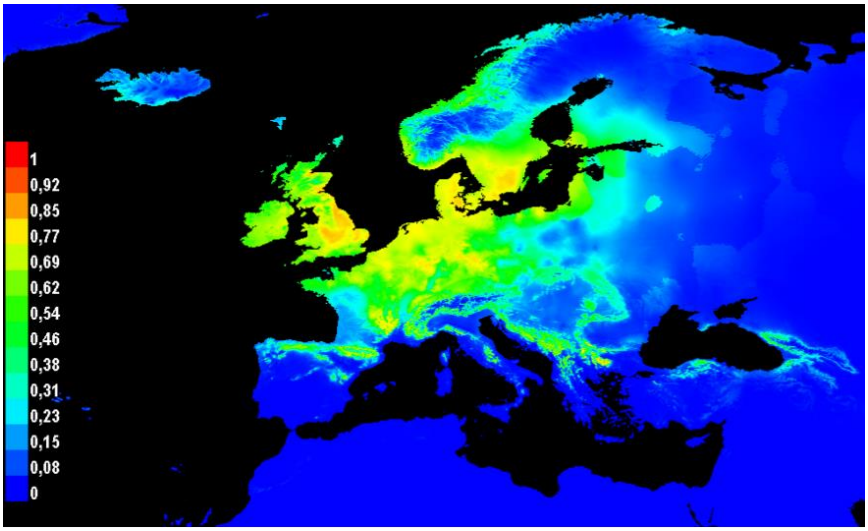
Table 4. Review of all available bioclimatic variables in DIVA-GIS(world-clim.org/bioclim)

BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp)
BIO3	Isothermality (BIO2/BIO7) (standard deviation ×100)
BIO4	Temperature Seasonality (standard deviation ×100)
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
BIO8	Mean Temperature of Wettest Quarter
BIO9	Mean Temperature of Driest Quarter
BIO10	Mean Temperature of Warmest Quarter
BIO11	Mean Temperature of Coldest Quarter
BIO12	Annual Precipitation
BIO13	Precipitation of Wettest Month
BIO14	Precipitation of Driest Month
BIO15	Precipitation Seasonality (Coefficient of Variation)

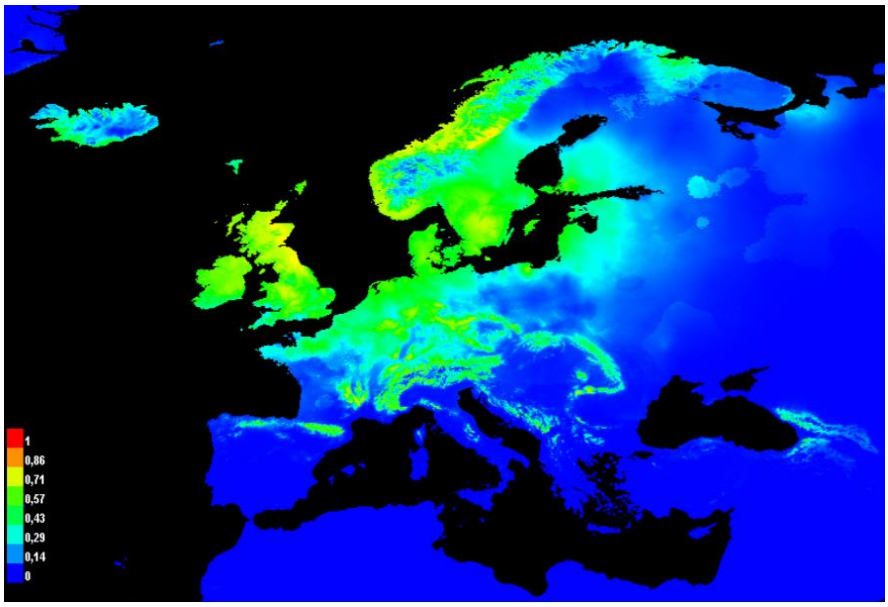
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BIO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter

Hogweed is a native plant of Caucasus, where temperature stays between -4(in winter) and +29(in summer). Also, the landscape of the Caucasus is dominated by mountains. Therefore, mountains of Europe (Pyrenees, Alps, etc.) are not a natural barrier preventing the spread of the plant. This model shows current climate run for Europe p=0,3071 with low standard deviation of only 0.0002 (Picture 12). Even though, the model of future climate run for Europe is p=0.3092, while the standard deviation is also 0.0002 (Figure 13.) (P.Germann 2018).

In addition to the probabilities calculated by the models, the relative values and contribution of each bioclimatic variable should also be considered. Moreover, this model doesn't provide enough information about Hogweed distribution from Russia and, especially, Karelia, because of lack of data about current number of plants on borders with European countries.



Picture 13. Predicted distribution under present climate conditions



Picture 14. Predicted distribution under future climate conditions

According to this model of Hogweed distribution for further 60 years, should be noticed that more strict measures must be introduced to control the spread and destruction of hogweed.

6 CONCLUSION

Most of these IAS plants need special mechanical treatment like mowing on right growth period. Moreover, some plants can't be properly removed by engineering because some plants are growing in hard-to-pass places for vehicles, while hand mowing is very productive, but expensive as well. Even though, chemical eradication is more productive, in some countries most of appliable chemicals are forbidden for usage, due to their toxicity for human, animals, crops, and cattle. Therefore, cultivation is the most beneficial method to eliminate IAS, but for some target species native enemies don't exist (Table 15).

Table 5. Table of comparison for removal of Lupin/Himalaya balsam/Hogweed/Jimsonweed/Ragweed.

	Chemical / Biological	Physical	Cultivation
Himalaya balsam	2,4-D and triclopyr and glyphosate	mowing and grazing	-
Lupin	Glyphosate	mowing and grazing	-
Hogweed	*Stalked weevil*, *Euleia heracleid, hogweed phytomisa*, *Depressaria pastinacella*, Glyphosat, Sulfometuron-methyl	To remove whole plant, when it just has sprouted, mowing (better to be repeated several times during season)	*Galega, Festuca pratensis, Dactylis glomerata, Phleum pratense*, *Taraxacum,* also *Jerusalem artichoke* [1]
Jimsonweed	Acifluorfen in soybeans and peanuts; bentazone in soybeans, peanuts, and certain types of beans; metolachlor in corn and sorghum (combined with an antidote); atrazine, cyanizing, simazine, bromoxanil, or dicamba; and 2,4-D	Mowing, grazing, post-harvest tillage	-
Ragweed	2,4-D, bentazone, bromoxynil, diuron, glyphosate, imazaquin, MCPA, flurochloride, glufosinate, linuron, simazine, and Lenacil	Mowing during certain period	Legumes, grass, meadow clover

[1] The Jerusalem artichoke grows quickly enough and displaces the hogweed from the occupied territories. At the same time, it is even more difficult to stop the growth of Jerusalem artichoke because of the powerful root system and the increased vitality of the plant, which is the main disadvantage of this method.
In some countries, for example in Switzerland, Jerusalem artichoke is included in the supervisory list of invasive plants and is also considered a potentially quarantine object in Europe. Jerusalem artichoke can be used in a variety of industries:

- Fodder crop (eaten both by humans and as fodder for livestock);
- In the hunt (Cultivation of Jerusalem artichoke for game in the form of forage strips along roads, glades, forest edges is an effective biotechnical measure);
- Industrially produce Jerusalem artichoke powder;
- Jerusalem artichoke fiber;
- Inulin (alcohol, fructose);
- Dietary substitute for coffee;
- Beekeeping (supports late honey harvest);
- Ornamental plant;
- Alcoholic beverages production (Brandy).

As a result, if Jerusalem artichoke is used as a cultivation method, it will vastly reduce growth of Hogweed, but it will cause a new problem of its own elimination as well. Biological and cultivation also require attention in the selection of suitable species and their control requires well timed and appropriate actions.

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