Interreg
EUROPEAN UNION
Danube Transnational Programme
Sava TIES

BEAUTY OR THE BEAST

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Preserving Sava River Basin Habitats through Transnational Management of Invasive Alien Species

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BEAUTY OR THE BEAST

SavaParks Network

The Sava river represents one of Europe´s most interesting lifelines in terms of ecology and culture. It originates in the Slovenian mountains and flows into the Danube in Belgrade. Large sections of the Sava river are still free flowing, and frequently flooded areas and alluvial forests have been preserved until the present day. The annual cycles of temporal flooding in winter and spring have shaped the face of this region and created rich cultural landscapes and strong traditions of the people living in harmony with their river. In order to be preserved, this heritage needs not only protection, but also an overarching, transboundary cooperation.

This was the purpose behind the establishment of the SavaParks Network of protected area managers on the World Wetlands day 2015 (2nd February).

Currently, the network consists of 22 members committed to advancing the ecological, cultural and economic future of the Sava river and its tributaries.

The Sava river in Croatia
Goran Šafarek

The Network consists of institutions and organizations ranging from ministerial levels, state institutions, public and private bodies from environmental and cultural sectors. At the heart of the network is the responsibility for the ecological corridor and protected areas of the Sava river basin, from its source in the Slovenian Alps, to its confluence with the Danube river in Belgrade.

Our mission is to protect the ecological and cultural heritage of the Sava river basin through cross-sectoral and transboundary cooperation.

Our vision is a long-lasting harmony between preserved nature and human societies in the Sava river basin.

The strength of the network lies in its constant efforts to not only protect individual stands of ecological value, but also to foster the communication among members, and encourage them to join forces and create new visions together, to address the need for the transboundary-water catchment, managed sustainably and by taking up a multi-sectoral approach.

This partnership has led to international projects, dealing with common nature conservation targets such as river-floodplain restoration and invasive alien species management. The INTERREG DTP funded project "Sava TIES" is an extraordinary example of potential all-encompassing benefits of basin wide management of invasive alien plants. It not only proved advantageous for each project partner and the respective protected areas, but it also increased institutional and public interest in this topic.

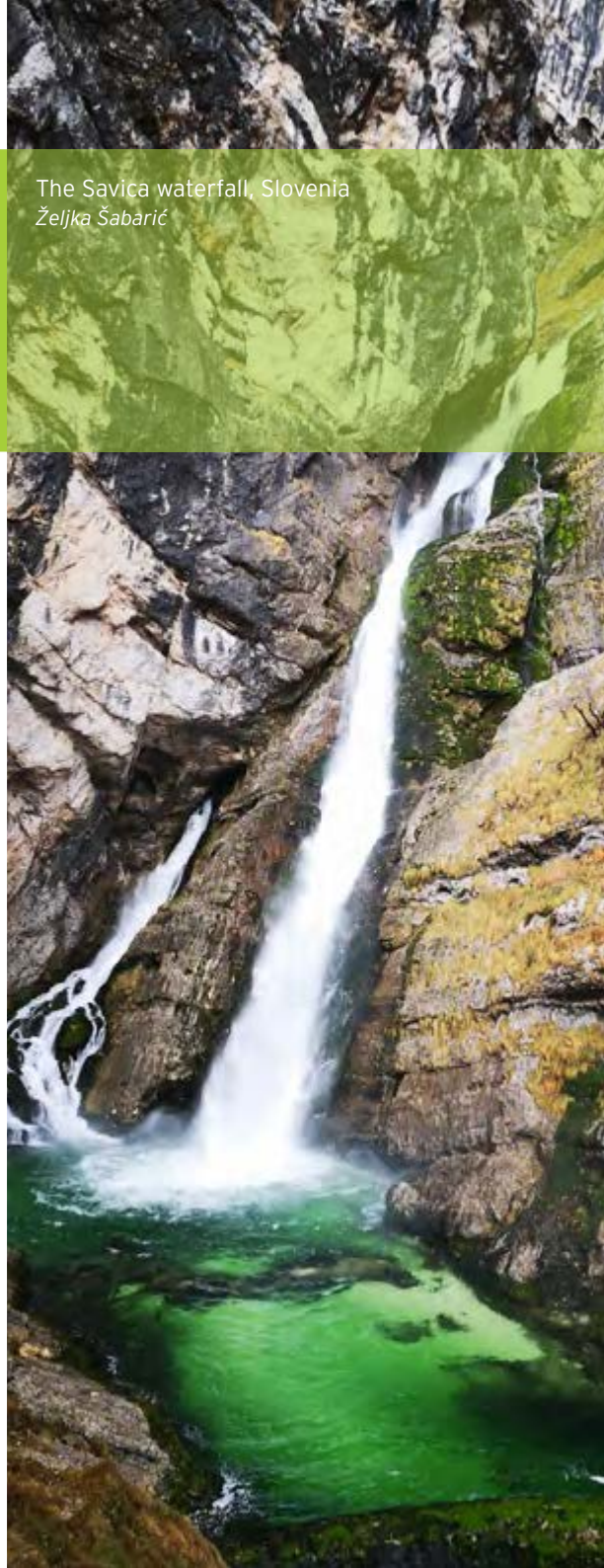
If you have any questions or suggestions, please feel free to contact us!

www.savaparks.eu

SavaTIES.project

savaties

info@savaparks.eu



The Savica waterfall, Slovenia
Željka Šabarić

IDENTITY CARD OF PROJECT SAVA TIES

PARTNERS

- EuroNatur Foundation
- Lonjsko polje Nature Park Public Institution
- Zeleni prsten Public Institution of Zagreb County
- Public Institution Ljubljansko barje Nature Park
- Public Company Una National Park Ltd. Bihać
- Center for Environment
- Institute for Nature Conservation of Vojvodina Province
- Public enterprise "Vojvodinašume"
- Nature Conservation Movement Sremska Mitrovica

MAIN GOALS

1. Find an effective solution for permanent eradication of IAS
2. Reduce habitat fragmentation
3. Improve the connectivity of the transnational ecological corridor

2018

BUDGET

1.604.137 €

MAIN RESULTS

1. Increased public awareness on negative effects of invasive alien plants
2. Best methods for controlling invasive alien plants identified
3. Invasive alien plants removed from 77 ha in protected areas
4. Recommendations for improvement of invasive alien species legislation prepared based on analysis of 4 countries and EU invasive alien species
5. Strategic Framework for Cross-Sectoral invasive alien species Management in Sava river basin prepared

AREA OF IMPLEMENTATION

Slovenia
Croatia
Bosnia and Herzegovina
Serbia

2021

What are invasive alien species?

Throughout the history of humankind, people have been travelling and trading goods. In the last century, with the development of sophisticated means of transport, international trade has transformed the global economy. In the last hundred years, there was at least a 40-fold increase in global trade.

AN ALIEN SPECIES is any live specimen of a species, subspecies or lower taxon of animals, plants, fungi or microorganisms introduced outside its natural environment that might survive and subsequently reproduce.

One of the major environmental concerns of globalisation is the movement and translocation of living organisms to new environments. In biology, species introduced to new environments with direct or indirect assistance of humans are called alien species.

A native species is a species, subspecies or a lower taxon, which lives on the territory of its usual (past or present) natural distribution, even if it is present only sporadically. This also applies to the areas which the species could have reached by natural range expansion, either by walking, flying, transport by water or wind or any other way of dispersal.

It should be noted that a species can be native in one part of the country but alien in another. The introduction of a closely related alien species is more likely to lead to competition for the same type of food and space due to their similarity. Furthermore, alien species are more likely to hybridise with closely related native species, which can alter the gene pool and lead to a permanent loss of the genetic identity of a native species.

Biodiversity means the variability among living organisms including diversity within species, between species and of ecosystems.

AN INVASIVE ALIEN SPECIES is an alien species whose introduction or spread has been found to threaten or adversely impact biodiversity and related ecosystem services.

Measuring the growth of invasive alien plants
Ljubljansko barje, Slovenia
Jasna Tarman

Ecosystem services are the conditions and processes through which natural ecosystems and the species that comprise those ecosystems sustain and fulfil human life.

This implies that any alien species which have negative impacts on native species, habitats, or ecosystems, or are disrupting any ecosystem processes on which humans depend on, should be considered an invasive alien species.

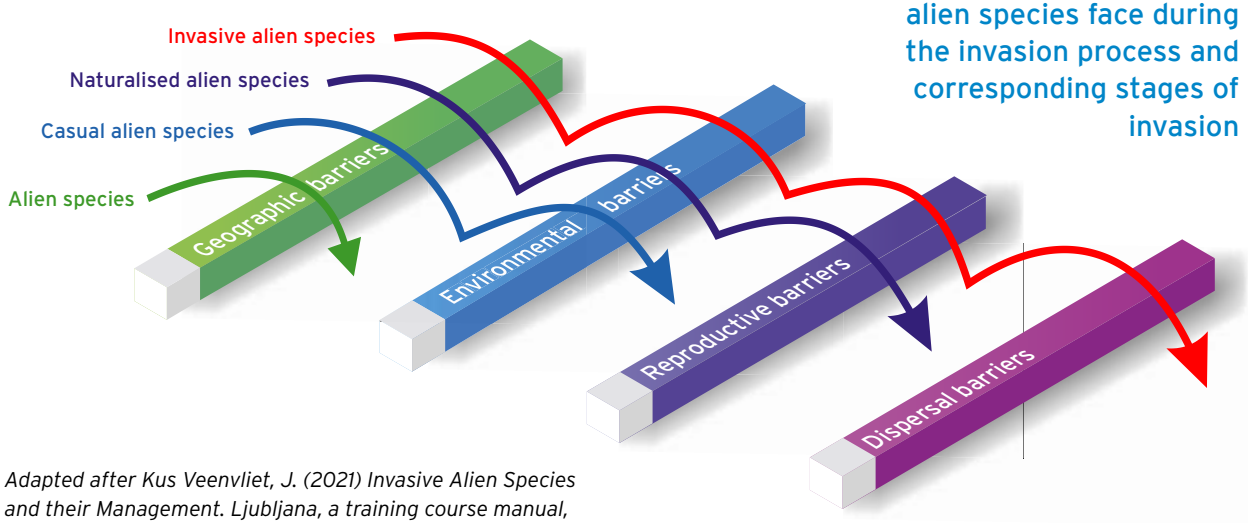
With modification of habitats by humans, some native species may increase their populations within their native area of distribution and cause environmental or economic damage. These species are not considered alien, but some methods used for alien species may be appropriate to manage their populations as well.

With the current dimensions of the global trade, thousands of species are brought to new areas each year. The outcome of each introduction is difficult to predict.

After crossing the geographical barrier, either with intentional or unintentional assistance of humans, alien species end up in a new environment. For an alien species to survive, the ecological conditions must be similar enough to those in the native range, or the species has to be able to adapt (acclimatise).

To successfully establish permanent populations, alien species have to overcome reproductive barriers. The success often depends on the number of individuals in the new environment, reproduction strategies and the mobility of species. However, even when alien species successfully form permanent populations, these may stay small, and such species do not cause noticeable changes in the environment. Only some alien species expand quickly and cause negative impacts to the environment.

The different barriers which alien species face during the invasion process and corresponding stages of invasion



Adapted after Kus Veenvliet, J. (2021) Invasive Alien Species and their Management. Ljubljana, a training course manual, EuroNatur Foundation and Institute Symbiosis.

In invasion biology, most attention is given to the invasive alien species. This is a relatively small subset of all the alien species which are transported to the new areas. However, with the scale of the global trade, the number of invasive alien species is rapidly increasing.

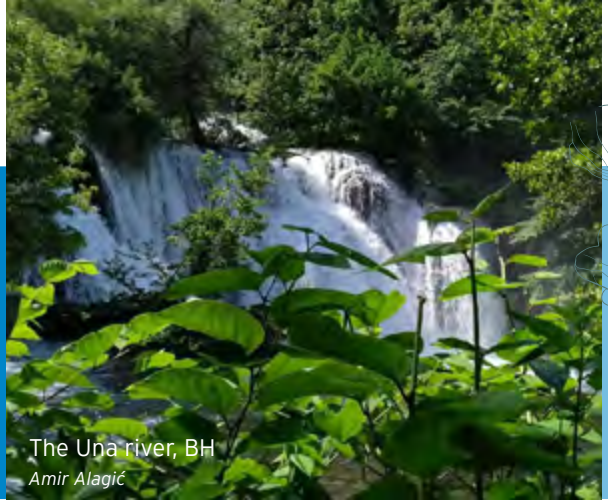
Why are they spreading?

The main driver of biological invasions is, of course, the transport of goods connected with the global trade. In 2019, shipping accounted for more than 90% of global trade. In the last 70 years, we have witnessed an evolution of container ships. The shift to transporting cargo in closed containers had already increased the chances of alien species reaching new continents alive.

Furthermore, the size of container ships has increased substantially. While the first container ships were able to carry from 500 to 800 containers, nowadays they often carry over 5 000, and some even more than 20 000 containers.

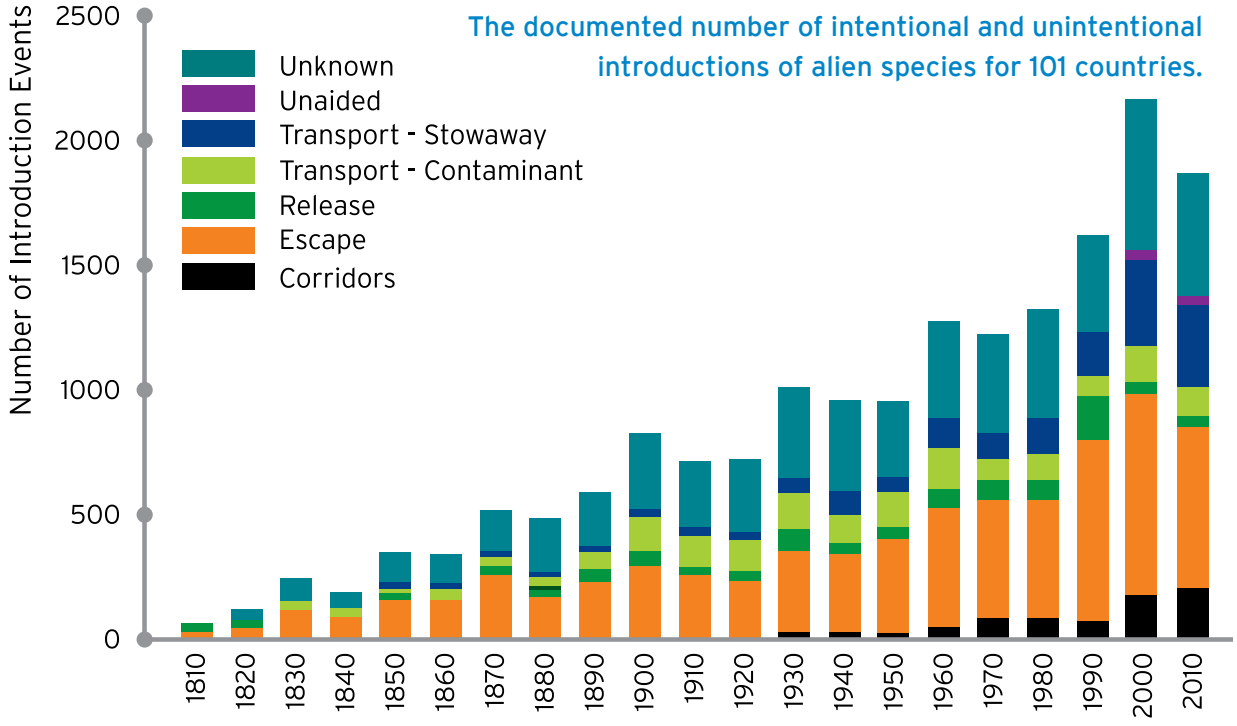
Air transport is less often used for transport of goods, but it is important for transport of time-sensitive, valuable or perishable goods. This can also include live plants and animals which can be contaminated with alien species.

Alien species reach new areas mostly by escaping from confinements, through intentional releases into nature, as stowaways in vehicles, contaminants in plant or animal material and expansion through corridors like roads and rivers.



The Una river, BH
Amir Alagić

The documented number of intentional and unintentional introductions of alien species for 101 countries.



Adapted after McGrannachan CM, Pagad S, McGeoch MA (2021) A multiregional assessment of transnational pathways of introduction. NeoBiota 64: 43-67. https://doi.org/10.3897/neobiota.64.60642.

The biggest problem of the 21st century?

Nowadays, invasive alien species are increasingly becoming a problem for nature, people, and the world economy. You may wonder how and when it all started. It is a consequence of the accelerated growth and expansion of trade, transport and travel, as many species were spread across the planet.

What do they do to nature?

Invasive alien species are the 2nd most significant cause of biodiversity loss in the world. It is quite important to understand that the introduction of an invasive alien species to new regions leads to a disturbance of the natural balance in many ecosystems. Consequently, many species end up in danger of extinction. Here are some examples of how that happens: by occupying the space of an autochtonous species and using its water and nutrients, they are changing the habitat conditions as well as the structure; by releasing substances that negatively affect the growth and development of other plants; by interbreeding with native species and changing their genetics.

The impact of alien animal species is much more variable. The introduced animals can be predators

USFWS / Pixnio

A good example is the zebra mussel (*Dreissena polymorpha*) that accumulates on surfaces like pipelines, dams, ship walls and equipment. Three hydropower plants on the Drava river lost 200.000 EUR in 4 years due to the costs of removing this species and stagnation in electricity production.

or grazers. They cause various environmental and socio-economic effects. Many alien animals are pests of native plants and can cause a significant decline in populations of native species. Plants, algae, microorganisms, or small animals can also accumulate on unwanted surfaces.

Invasive alien species are the 2nd most significant cause of biodiversity loss in the world.

A simplified overview of diverse negative impacts of invasive alien species

Since the 17th century, invasive alien species have contributed to nearly 40% of all animal extinctions for which the cause is known.

Source: IUCN (2018), Invasive alien species and sustainable development. Issues Brief, July 2018.

Invasive plants can affect our health!

Many invasive alien species can also threaten human health. They affect the quality of life, work ability and associated costs.

This includes not only viruses and bacteria but also plants or animals which are poisonous to humans.

Maybe the best known of them all is the common ragweed (*Ambrosia artemisiifolia*). A highly allergenic plant species, its flowering causes severe allergic reactions in a certain part of the population every year.

For example, in Serbia 75% of people with polen allergy are sensitive to ragweed.

Common ragweed
Luka Basrek

Yevhenii Orlov/Shutterstock.com

Due to its extremely high reproductive power and good ability to adapt to new habitats, it spreads very quickly, especially on agricultural land and neglected arable land, where it causes great damage. The air concentrations of allergenic ragweed pollen could quadruple in Europe by 2050 due to climate change and the ongoing spread of this species.

South African ragwort
Giorgiamocilnik / iNaturalist

South African ragwort
botalu / iNaturalist

Bazwal/iNaturalist

We have to point out that many species that are potentially harmful to human health are spreading accross the globe. One example is the South African ragwort (*Senecio inaequidens*) that is spreading across Europe and has been recorded in countries of the Sava river basin. It contains toxins that might enter the food chain through honey or dairy products, thus making them unsuitable to be consumed by people.

In Europe, 28 introduced plants have been proved to have a negative impact on human health.

Giant Hogweed (*Heracleum mantegazzianum* **Sommier et Levier) causes 3rd-degree burns!**

Invasive plants deprive our economies!

Some alien species also have a significant socio-economic impact. This is particularly the case with pests or diseases of plants or animals, which can cause significant economic losses in agriculture and forestry. The most affected sectors are agriculture, fisheries and aquaculture, forestry, health sectors, and nature conservation.

It is estimated that such damages cost the world economy hundreds of billions of dollars every year, with the number climbing up to nearly 5% of the value of the global economy. Invasive alien species are estimated to have cost the EU at least €12 billion a year over the past 20 years, and the figure is growing over time. Once an invasive alien species escapes or is deliberately released from its contained environment, substantial human and financial resources are needed in order to repair the damage they cause and take measures to eradicate them, or at least stop them from spreading further. Reducing their impact to ecosystems is one of the main challenges for nature protection in Europe.

We can be sure that new invasive alien species are coming and that we need to build a more efficient system able to respond in time.

Many well-known invasive alien species are causing huge damages, and the new ones are either arriving or their effects have not been studied yet. One of them is the brown marmorated stink bug (*Halyomorpha halys*) that can cause huge damages to fruit and vegetable farming. It has been estimated that in 2019 this species caused € 500 million of damages in Italy alone.

Rivers are particularly vulnerable to invasions

Floodplain habitats are considered to be exceptionaly vulnerable to invasions of alien plants. The disturbances caused by regular flooding enhance the establishment of alien species in many ways. Part of the vegetation is very often destroyed by floods, creating space and light for the newcomers. The deposited sediment provides free space which in most cases is rich in nutrients. Rivers are natural ecological corridors characterised by narrow stretches of habitats which facilitate the migrations of animals and spread of plants. Plant propagules (spores, fruits, seeds, and parts of plants capable of developing into new individuals) could be transported by running water or by migrating animals along the river corridor. Sometimes a plant gradually spreads along the river, occupying suitable free surfaces created by floods.

The human influences before the industrial period had not altered the essential features of floodplains. Due to their high biomass production, the riparian habitats were used for livestock production. Not only the grasslands, but also the forests and wetlands were included into the complex grazing systems, adapted for the local

Traditional grazing of pigs in the Bosut forests, Serbia
Zsolt Molnar

conditions. After harvesting, the arable plots were regularly grazed, providing fodder for animals and controlling weed populations. In the early period of the industrialisation, poor rural families rented from local authorities common green surfaces (edges of roads and railways, canal banks, ditches etc.) and used them for haymaking.

Regulating the river flow enabled the conversion of wetland-grassland-forest mosaic into arable land and urbanised areas, decreasing the areas of wetlands and grasslands.

The modernisation in agriculture reduced the number of farmers willing to continue traditional breeding of animals on pastures or in the forests. There is a rapid growth of abandoned pastures, meadows and fallow land as their owners are growing too old to cultivate them. The lack of grazing or mowing enables the establishment of invasive species.

Most often the first invaders are goldenrods (*Solidago spp.*) and the common milkweed (*Asclepias syriaca*), followed by the false indigo-bush (*Amorpha fruticosa*) and the red ash (*Fraxinus pennsylvanica*). Depending on the vegetation of surrounding areas, after several years of neglect a thick shrubbery could contain 5-7 invasive alien species.

The common ragweed (*Ambrosia artemisiifolia*) appears first on abandoned arable plots, along with other weeds, gradually disappearing as more aggressive species move into the area.

The same dynamic can be observed in grassland habitats.

Cows grazing in Lonjsko polje, Croatia
Renato Bukvić

Transnational and cross-sectoral approach is crucial

It is already well known that invasive plant species easily spread across the landscapes, infesting different types of land and landowning categories. They infest both natural and man-made habitats such as forests, meadows, riverbanks, canals or hedgerows between arable plots.

The problem of invasive alien species is addressed differently in the Sava river basin countries. Some nations are already implementing international policies (EU strategy on invasive alien species, EU Regulation 1143/2014) or national action plans (transitional, non-EU countries).

The development of a common invasive alien species smart approach in land management practice is essential in responding to the emerging plant invasions.

The Sava river with its tributaries is recognized as part of the Blue Heart of Europe and referred to as one of the most preserved transnational European river systems. The river runs through both EU and non-EU countries with different national policies and land management systems.

Invasive alien species have become a serious threat to the productivity of forests and plantations. They also affect water supply, flood risk management, crop production, nature-based tourism and many other sectors.

There are few examples in all of the considered Sava river basin countries where land users have recognized the threat from some invasive alien species and are implementing eradication activities. In all of the examined countries, protected area managers are more proactive in invasive alien species management.

Both the causes and consequences of alien species introductions are transnational in character, calling for a cross-sectoral approach. When the target area is a transnational river corridor, a cross-border and cross-sectoral approach is a prerequisite for the effective invasive alien species management.

False indigo-bush
Amorpha fruticosa L.

The false indigo-bush is a deciduous shrub reaching the height of 5 m. It can be identified through its pinnate long leaves and its spike-like cone of dense flowers. In the Balkans, the main flowering season occurs in June and the fruits are ripe during the end of August.

The fruits can be found up to 15 m from the parent plant, and floods, animals and machines spread it over long distances. Older false indigo-bush stands build an almost continuous canopy by growing new shoots from the base to close the emerging gaps, leaving no space for other species. It releases substances into the soil that prevent the germination of seeds of other species.

Leaves
Simona Pavan/Shutterstock.com

The areas completely covered with false indigo-bush are symbolically called green deserts.

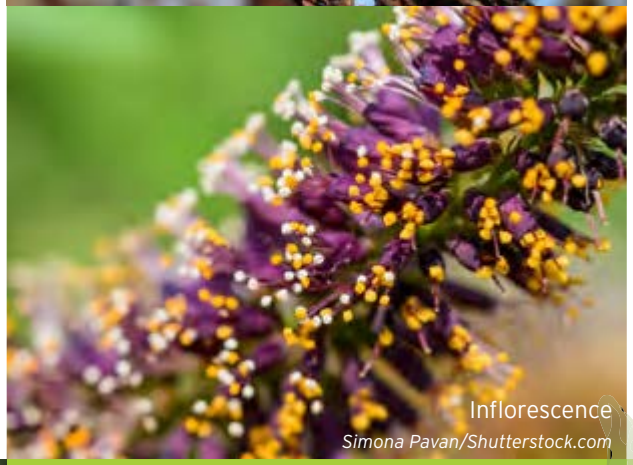
Area overgrown with false indigo-bush
SavaParks Network

The false indigo-bush invades a range of plant communities and has a strong negative effect on the structure and composition of grassland, forest and aquatic habitats. Its uncontrolled spreading can even prevent birds from nesting (e.g. corncrakes, birds of prey) and can lead to the formation of natural barriers which hinders free movement of wild animals such as deer and roe. It also inhibits forest regeneration.

It is able to overgrow canals in a very short amount of time and in this way it slows down the outflow of flood waters.

It is not easy to clear areas from this species once it has settled. A potential management strategy would include mulching and then introducing combined methods of grazing and mowing of the infested areas.

Fruits
Ivana Sučić



Inflorescence
Simona Pavan/Shutterstock.com

A flowering plant
Julian Popov / Dreamstime.com

In the 18th century, the false indigo-bush was brought to Central Europe from North America as an ornamental plant. It was introduced to the Sava floodplain during the 19th century to aid in maintenance of soil stability on railroad embankments. Today the plant is often used as a honey plant.

Common milkweed
Asclepias syriaca L.

Common milkweed is a perennial herb with long-spreading rhizomes (subterranean stem). In established stands, vertical roots may penetrate the soil to depths of 3.8 m. Stems are stout, erect, up to 2 m tall, with short downy hairs and milky sap which is released when the plants are injured.

The leaves are opposite, smooth margined, oblong, 10-20 cm long and 5-11 cm wide; upper surface is smooth, lower covered with short white hairs.

Flowers are sweet-smelling, pink to white, in large, many-flowered bell-like clusters. The flowering season of this plant is from June to August. The flowers produce copious amounts of nectar. Seeds are brown, flat, oval, 6 mm long, 5 mm wide, with a tuft of silky white hairs. The seeds are spread by wind, floating in clumps with their silky tufts of hairs like parachutes. Seeds germinate best when they are buried at 0.5 to 1 (5) cm

It propagates vegetatively by its rhizomes, and by seeds, which retain their germination ability in the soil for years. It contains several toxic substances known to be poisonous to sheep, cattle, and occasionally horses; therefore, it is avoided by grazers.

Flowering plants
Igor Čolak

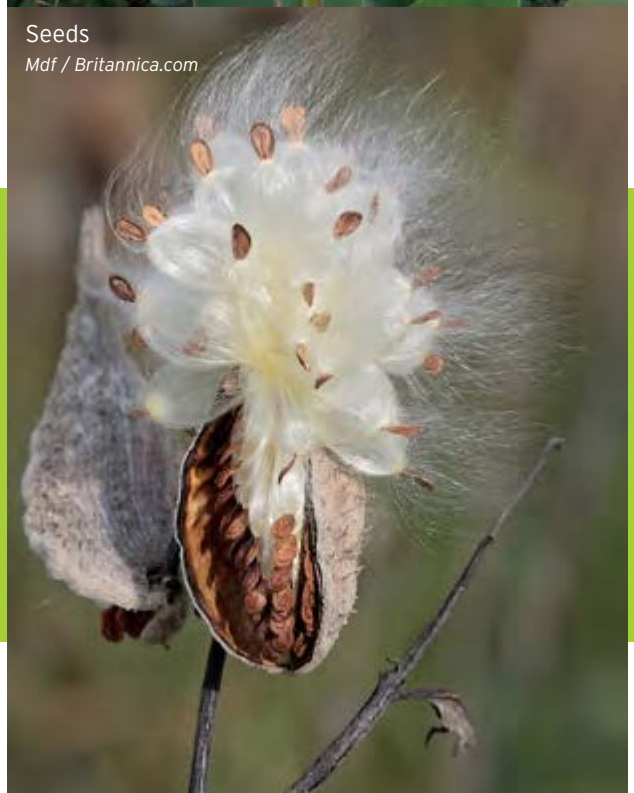
Inflorescence
nnattalli/Shutterstock.com

depth in the soil (e.g. along the public paths in the protected areas).

The common milkweed is found in semi-arid ecosystems, e.g. degraded forests and dry grasslands, where it is outcompeting native plant species and influencing the native fauna. It inhabits man-made or disturbed habitats - waste places, along roads and railways, canals, levees, at the forests edges and farmlands, with a wide range of soil conditions.

Eradication requires repetitive cutting, pulling or mowing during the vegetation season, before the flowering period, to exhaust in this way nutrition reserves in the underground parts. Translocated herbicides, destroying the roots and stems are also effective. On the invasiveness scale, it is classified as a highly invasive plant. The common milkweed is present in the Sava basin (banks, transportation network etc.) and is spreading in protected areas.

Fruits
Stefan Lefnaer



Seeds
Mdf / Britannica.com

The common milkweed originated from southern Canada, but is now widespread across southern Europe and Russia.

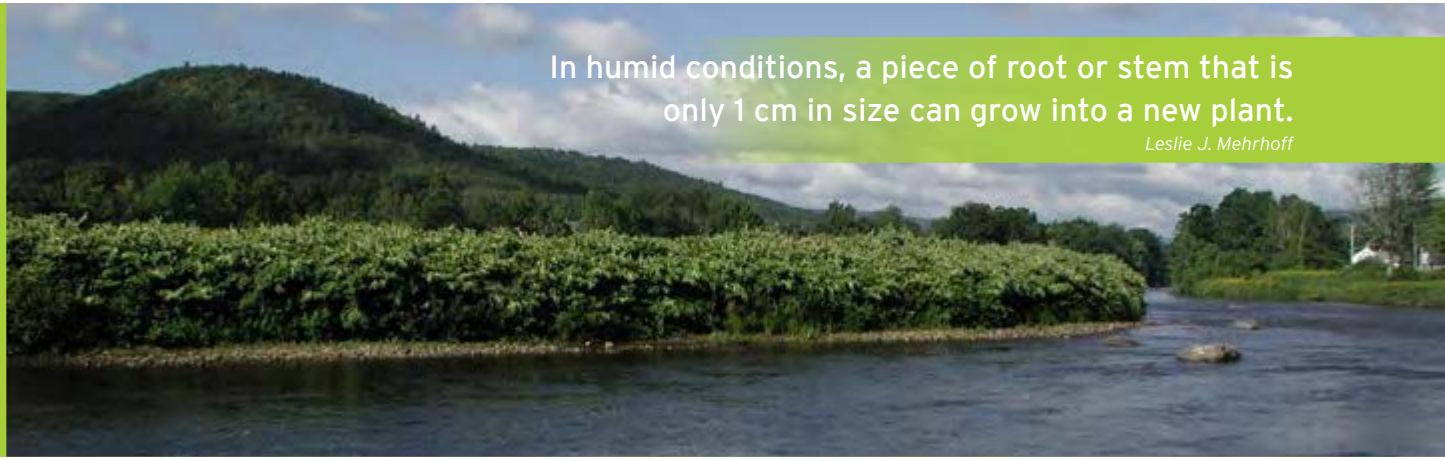
All parts of the plant contain milky juice, which is poisonous and causes diarrhoea, shortness of breath, cramps and balance problems.

Japanese knotweed
Reynoutria japonica Houtt.

The Japanese knotweed is a herbaceous perennial with a large underground network of roots or rhizomes which sends out above the ground stems reaching over 3 m in height, and 4 cm in thickness. The stems are upright, with hollow bottom portion, and leafless just above the ground level. Leaves are large and broad, lanceolate, with smooth margins.

The rhizome (the underground stem) is exceptionally well developed, extending up to 7 m horizontally, and up to 3 m in depth. The flowers are produced in erect racemes, 8 to 12 cm long. One plant can yield up to 200 000 flowers. This invasive species is a thermophilic plant which prefers moist soil and can tolerate a very wide range of pH value. It is not only capable of surviving higher concentrations of nitrogen and heavy metals, but also of changing the soil conditions so it would meet its needs. It frequently colonises riparian ecosystems, neglected land, roadsides, areas overgrown with bushes, as well as around populated areas.

The species is also known to destroy fundaments of buildings by breaking through the already existing cracks with its strong and long-reaching root system. Environmentally acceptable means of controlling Japanese knotweed is time-consuming and expensive (for example, years of consistent



In humid conditions, a piece of root or stem that is only 1 cm in size can grow into a new plant.

Leslie J. Mehrhoff

The Japanese knotweed was introduced to Europe during the 19th century as an ornamental plant. It is assumed that only one plant was introduced to Europe and it later, by means of vegetative propagation, spread to many European countries.

mulching and mowing). The most economical removal method is the application of herbicides, which also takes several years to take effect. In turn it causes soil contamination and limits remediation efficiency.

The knotweeds are widely dispersed along the Sava and its tributaries, but not so densely at the lower sections. Their invasive potential is high.

The Japanese knotweed is an ornamental honey plant which can improve the stability of riverbanks; however, it induces physical and chemical changes in the soil, inhibits the growth of other plants, competes for light, and is able to adapt to any given set of environmental conditions. Once it colonises a habitat, it depletes the soil and crowds out any other plant species.


Inflorescence
GlOGlOck/Shutterstock.com


Seeds
Greenseas/Shutterstock.com


Young shoots
Leslie J. Mehrhoff


Stems
Robert Vidéki

Green ash
Fraxinus pennsylvanica Marshall

The green ash is a medium tall tree (up to 25 m) that develops a wide irregular canopy and longitudinal bark cracks over time. It has hairy shoots and rusty brown buds. The leaves (5-9) are pinnate and single leaflets have pointed tips. The leaves are oblong, lustrous green on both sides or somewhat paler on the dorsal side of the leaf. The twigs are pale grey along with brown bark.

The female tree produces a large number of single-winged, dry, flattened fruits that can be transported over large distances by the wind.

It is a fast-growing tree that is popular in forestry due to the quality of its wood. In autumn, the canopy changes into attractive colours, from golden yellow to red. One of the main vectors of spreading is man, because green ash is often planted in gardens and parks from where it is able to invade the neighbouring areas (by wind, birds).

These trees demonstrate adaptability to a wide range of soils and growing conditions. This species prefers moist alluvial soils along streams in floodplain forests, but can also survive longer dry periods. The species looks very similar to the common European ash (*Fraxinus excelsior*) and the American ash (*Fraxinus americana*).

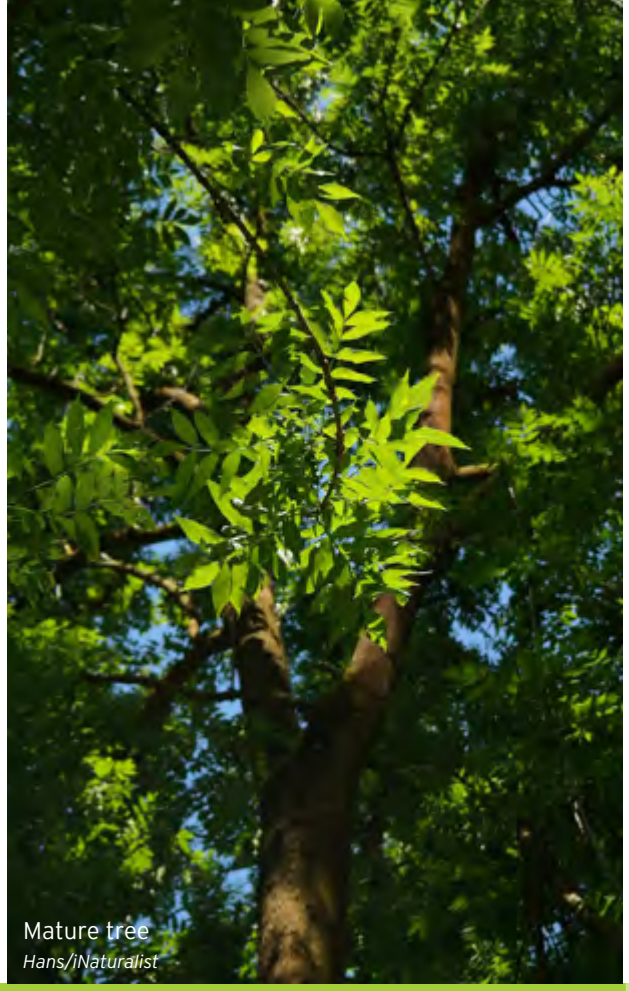
A high number of young shoots sprouting from the stub and roots of a tree after cutting makes the green ash difficult to eradicate. A

Leaves
Hans/iNaturalist

combination of different methods gives the best results in eradicating this species. This means the combination of cutting and chemical treatment(s).

In lowland habitats the species proved to be very aggressive and competitive with economically more important key native species such as pedunculate oak (*Quercus robur*) and narrow-leaved ash (*Fraxinus angustifolia*).

Green ash can survive in shade, in undergrowth of native oak-ash and willow-poplar forests in lowlands, waiting for the onset of forest regeneration (which happens spontaneously after natural hazards like storms or after the end of the rotation in forestry) to express its full invasive potential. The species is mostly present at the lower course of the Sava river.



Mature tree
Hans/iNaturalist

Tree bark
Alen Kiš

The green ash is a species of ash native to eastern and central North America. It has spread and become naturalized in much of the western United States and in Europe, from Spain to Russia. The species was introduced intentionally to Europe in 1783 and for a long time, it was planted in parks and gardens as an ornamental tree. Later it was used in wood industry and the formation of shelterbelts. It has been among the most rapidly spreading woody alien species in Central Europe in the past 25 years.

Tree of heaven

Ailanthus altissima (Mill.) Swingle

The tree of heaven is a tall, fast-growing tree with odd-pinnately compound leaves. It can be distinguished from a similar native species, *Fraxinus excelsior*, by the number of compounds in its leaves - *Fraxinus* rarely has more than 11, while *Ailanthus* commonly has more than 17. It can reproduce vegetatively as well, spreading profusely from suckers. If cut, it resprouts rapidly, and this is one of the reasons why it is extremely hard to eradicate.

It does not take long for a fast-growing tree such as this one to shade the ground beneath, inhibiting in this way the growth of other plant species.

Another characteristic that makes tree of heaven such a highly invasive species is a toxin called ailanthone, which also affects growth and competitive ability of other plants.

This is how it succeeds in forming dense forest stands where other species can no longer successfully compete.

A female tree can annually produce up to 300 000 winged seeds which are dispersed by wind.

Fruits

Dietmut Teijgeman-Hansen /iNaturalist

Inflorescence

Matthieu Gauvain /iNaturalist

The end result is a significantly negative impact on local biodiversity.

There are several methods that can be employed to control this species - biological, chemical, and physical.

The best results are achieved when a combination of several, mainly chemical-physical methods are employed, which includes treatment with herbicides to destroy existing trees and pulling shoots to stop further spreading.

In many countries it rapidly spread due to its resilience and pH- and drought-tolerance and can often be found in extremely poor, degraded habitats.

Leaves
Stinger /iNaturalist

Mature tree
Christopher Harasta /iNaturalist

The tree of heaven is native to northern and central China, and it was in fact one of the first species brought from China to the West. When it arrived in Europe in 1751, it very soon became a popular park tree and was used extensively as a street tree during much of the 19th century.

Canadian goldenrod and giant goldenrod

Solidago canadensis L. *and Solidago gigantea Aiton*

The Canadian goldenrod and the giant goldenrod are perennial plants that grow from 25 to 250 cm in height. Both are erected and have lanceolate leaves with serrated margins that are arranged alternately.

They spread quickly, with a single plant producing thousands of seeds that are carried by wind or animals.

They blossom from July till October when their large bright yellow inflorescences attract insects.

They also reproduce vegetatively with underground stems. Poorly cleaned machinery is often a dispersal vector for seeds, roots, and underground stems, which enables them to reach distant areas.

These invasive plant species significantly reduce species diversity by forming dense stands that prevent the growth of native plants.

Inflorescence
Ana Tratnik

Leaves
Ivana Sučić

The substances they produce also reduce soil fertility which makes it less suitable for farming.

Also, their roots produce substances that slow down the growth of other plants and decrease their successful development. This also makes the habitat inappropriate for many animal species and results in decreased biodiversity.

Different methods can be used to control invasive goldenrods. Small populations can be hand pulled. For control of large, infested areas, mowing at least two times per year a few years in a row proved effective. Grazing had the largest long-term positive effect. Herbicide application can effectively control invasive goldenrods, but it can also cause a decrease of native species populations.

Both species are native to North America. The Canadian goldenrod was one of the first decorative plants that were brought from North America to Europe and planted in botanical gardens, parks, and gardens from where it escaped into nature.

The species are unequally spread along rivers in the Sava basin. Species invasiveness is assessed to be high at the basin level.

Mature plant starts flowering
Ivana Sučić

Fruits
Ivana Sučić

Himalayan balsam
Impatiens glandulifera Royle

The Himalayan balsam is an annual plant that grows up to 250 cm tall. Its leaves are lanceolate to obovate and opposite. It flowers from June till October when it produces clusters of helmet-shaped flowers whose colour varies from white to pink and purple.

It is propagated by seeds, which are produced in large quantities. One plant can produce 700 to 800 seeds that retain their viability for 18 months or more.

Seeds are expelled from the seed capsule and dispersed to a distance of several meters, and then further transported by water currents. Human activities, such as processing and cleaning of areas where the species occurs, have an important role in the species distribution.

In Europe, the Himalayan balsam is predominantly a weed of riparian systems where it can form dense monocultures along riverbanks and reduce local diversity. It also attracts pollinators at the expense of native plants.

The Himalayan balsam can be controlled by hand pulling, grazing or mowing. Maintaining traditional

Inflorescence
Udo Schmidt

Flowers
Pandur/Shutterstock.com

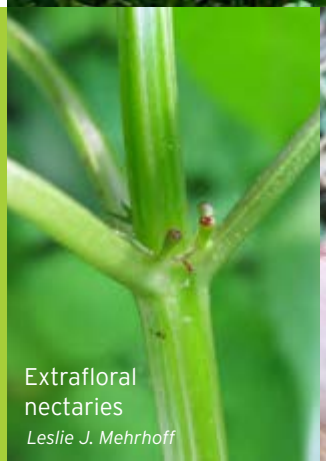
forms of land-use in grassland will prevent invasion into such vegetation. The removal must be continued until no more growth occurs for at least 2 to 3 years.

The species is so far present almost exclusively in the upper sections of the Sava river and some of the tributaries, but its invasiveness on floodplain habitats in the Sava river basin is high.

Fruits
I. Schmiegel

Mature plants can grow up to 2,5 meters
Jan Samanek

It is native to Himalaya and was introduced to Europe as a garden plant. It soon escaped gardens and colonised areas at riverbanks and ditches. It is considered invasive in almost all temperate European countries and parts of North America.



Extrafloral nectaries
Leslie J. Mehrhoff

Young plant
Robert Vidéki

Common ragweed
Ambrosia artemiisifolia L.

The common ragweed is an annual herbaceous plant that grows from 20 to more than 150 cm in height. Its stem is erect, with rough hairs. The 5 to 10 cm long and deeply feathered leaves are arranged opposite each other. Its wind-pollinated male flowers produce huge amounts of pollen. Its pollen is a strong allergenic agent and causes numerous symptomes.

Ragweed pollen is considered one of the strongest allergens, and one plant can drop over a million pollen grains a day.

One plant produces between 3 000 and 60 000 seeds a year, which are spread by wind over short distances, or through birds and mammals' fur over longer distances. Seeds may remain viable for 40 years in the soil seed banks, which is why it is extremely difficult to remove them from an area.

The common ragweed is typically found in neglected and disturbed habitats, mostly those under human influence. It can be found along settlements, roads, construction sites, railways, on agricultural land along the edges of crops, or on abandoned agricultural fields.

The common ragweed in blossom
Ivana Sučić

The common ragweed competes with native plant species for nutrients, light and space. Its massive growth leads to rapid exhaustion of nutrients and soil depletion. It significantly slows down the regeneration of natural habitats and threatens rare plant species and many natural plant communities that grow in the same habitat.

If it is found in small areas, it is most effective to pluck whole plants before they can produce seeds. If larger areas are colonised, mowing at a height of 2 cm from the soil is recommended. This cannot eradicate the common ragweed, but if this method is consistently used, it could reduce common ragweed population level over several years by decreasing seed production.

If herbicides are used, they prove most effective on plants in early developmental stages, and when their application is followed by mechanical methods.

Leaf
Mikhail Gnatkovskiy/Shutterstock.com

Ploughed land overgrown with the common ragweed
Luka Basrek

Mature plant
Ivana Sučić

The origins of the common ragweed are in North America and Mexico. It is believed to have been first introduced to Europe in the mid-19th century and has since been accidentally brought to various parts of Europe as an unintended component of cereal and grass seeds and bird feed.

Our accomplishments

As a part of the Sava TIES project, guidelines, studies, reports, and manuals have been prepared, as a "toolbox" for monitoring and management of invasive alien species. All these tools together provide the necessary support for protected area managers, ministries, scientists, and all other people interested in helping natural ecosystems overcome this serious threat. Find out more about each tool in the following sections.

How to remove them?

The review of best practices in invasive alien species management provides a list of eradication methods for the most common invasive plants in the Sava river basin, in addition to references to professional literature for further reading. The three types of eradication methods (mechanical, chemical, and biological) were described as they pertain to the key invasive species in Sava river basin.

Using extractigator for tree of heaven removal

Ana Tratnik

How to map them?

The Mapping and Monitoring Protocol for invasive alien species gives clear examples and instructions that together form the base ground for mapping and monitoring of invasive alien species plants in the Sava river basin. The Protocol is giving examples of four affirmed methods in invasive alien species mapping, adjusted to the scale of mapping, available time, and capacities. Combined together, these create a foundation for long-term monitoring and mapping the invasive alien species in the Sava river basin.

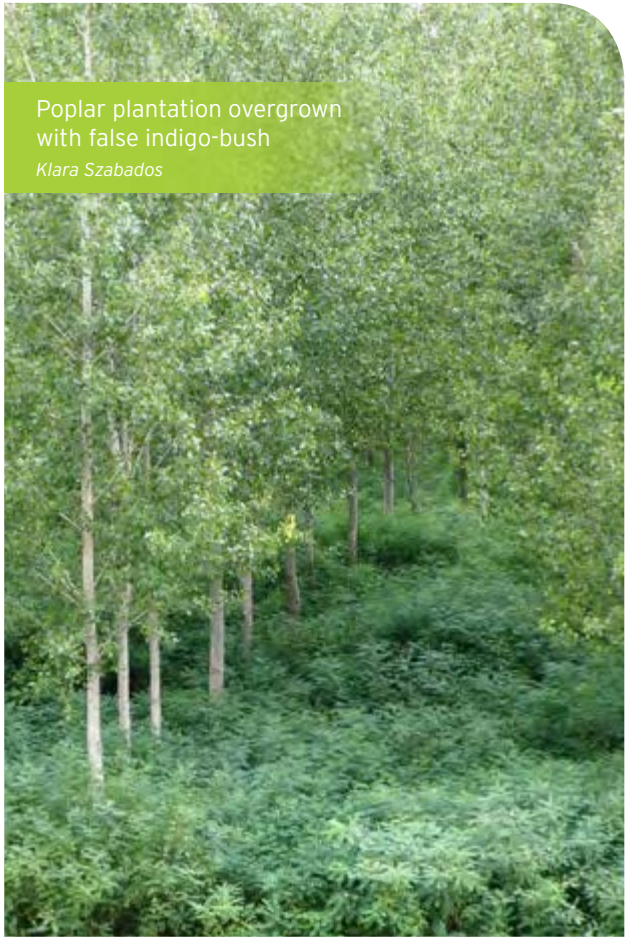
Find and report invasive alien species

Even though today there are many databases that collect data about the distribution of biodiversity, the project partners have identified the need for a common platform for collecting data about the distribution of invasive alien plants for the whole Sava river basin area. To assure long-term sustainability, the project partners have decided to use an existing database owned by the Joint Research Centre of the European Commission and managed by the European Alien Species Information Network (EASIN). One of the main advantages it provided was that already

Mobile app. for INVASIVE ALIEN SPECIES mapping

established Slovenian and Croatian official invasive alien species databases („Invazivke“ and „Invazivne vrste u Hrvatskoj“) automatically share all data with the EASIN. In addition, it already had a corresponding mobile application adapted for

use by amateurs, available for both Android and iOS. Based on the inputs and the needs of the project partners, EASIN experts have upgraded the app to collect data for 32 key invading plant species in the Sava river basin. Furthermore, the project partners initiated further upgrades to this application to enable the collection of more detailed data.



Poplar plantation overgrown with false indigo-bush
Klara Szabados

How dangerous are they?

The Risk Assessment Study for 6 selected invasive species in Sava river basin identifies, analyses, and evaluates possible adverse impacts of particular alien species on biodiversity, ecosystem services and human health. The results of the analysis revealed a high risk of invasiveness in connection with five species - the false indigo-bush, the Japanese knotweed, the Bohemian knotweed, the Canadian goldenrod and the giant goldenrod. Additionally, it is estimated that that above mentioned species have high probability of introduction and spreading as well as high impact on biodiversity. The giant knotweed is the only species for which a moderate risk of invasiveness was assessed on account of moderate probability of entry, moderate impact on biodiversity, and at the same time, low risk of spreading.

How to use your land to avoid invasive alien species?

The aim of Study of land use practices enhancing or preventing the invasions was to determine which changes in land use triggered the spread of

invasive species, which current land use practices in protected areas prevent or promote invasive species, and to find possible common ground in invasive alien species management with other sectors.

The analyses considered land use management operations which can promote or prevent both the introduction and the spreading of invasive alien species, such as: mowing and grazing, mulching, spraying herbicides, afforestation and forest regeneration, soil excavation and transportation.

Some of the practices that prevent invasive alien species spread are grazing and mowing for haymaking or forest grazing. Forest grazing has been banned in many countries due to the intensification of wood production and is rarely practiced even in the countries where it is still allowed. Some practices that help invasive alien species to spread are soil excavation and transport, as well as the maintenance of transportation network edges with machinery that can carry seeds and propagules to new areas.

Removing invasive alien species from the meadow in Fruška gora National Park
SavaParks Network

Beside the neglected industrial sites, certain types of amenity areas (some suburban parks, zones of weekend cottages with gardens and temporarily abandoned properties) offer ideal conditions for the development of invasive plants, often imported, and planted as ornamental plants in the gardens.

How to protect natural habitats, our health, and the economy?

Invasive alien species are referred to as a "cross-cutting issue" because they are affecting many sectors, at governmental and NGO level, causing environmental, social and health related issues. Invasive alien species have become a serious threat to the productivity of forests and plantations, and also affect water supply, flood risk management, crop production, nature-based tourism, and many others.

The national commitments on invasive alien species control and eradication across the Sava river basin are at different stages and still in progress. The experience of the Sava TIES partners in protected area management combined with stakeholder survey confirmed that soil excavation, selective trimming, and biomass transport remain common practices, in addition to other activities which can promote introduction and spreading of invasive alien species.

The Cross-sectoral guidelines for joint management, control and eradication of invasive alien species help us identify the best practices that can be adopted by various sectors.

Recommendations for sectorial policies to tackle plant invasions

The policy review concludes that in the project countries, the legal frameworks for invasive alien species management are underdeveloped.

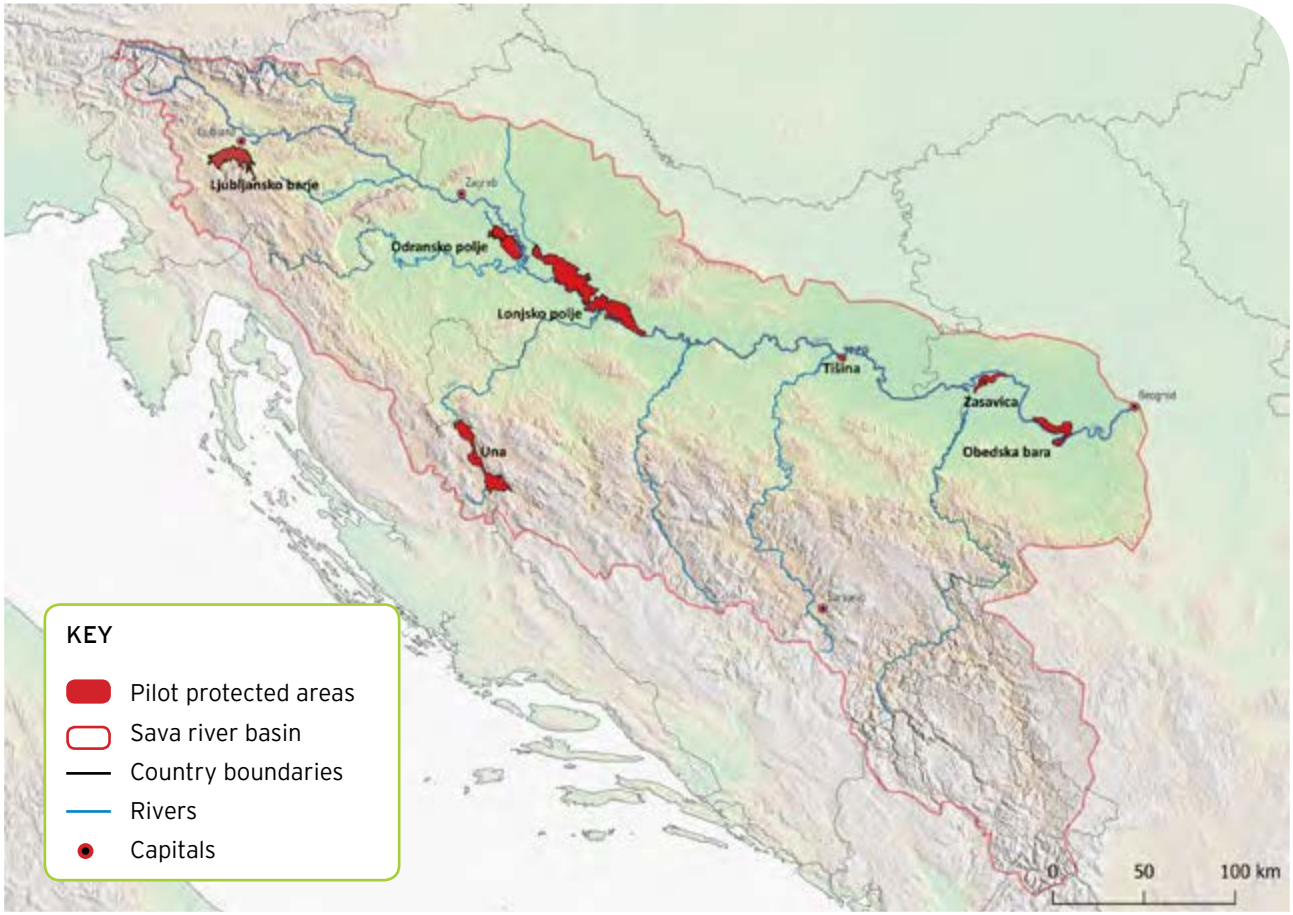
Some provisions are established within the environmental sector, but other sectors do not have at their disposal anything more than few invasive alien species related rules, and no systematic framework whatsoever to handle all aspects of invasions. In particular, there is a gap in the management of unintentional introductions and management of high-risk pathways.

Due to insufficiently developed institutional frameworks, the management of alien species is mainly dealt with on a case-by-case basis. There is an evident lack of sustainable funding for invasive alien species activities, and many activities are financed on a project basis only.

In all countries, invasive alien species are primarily dealt within the environmental sector and only some fragmented rules to prevent or control invasive alien species are included in the legislation of other sectors. Efforts should be made to make sure that invasive alien species are addressed on the principles of ecosystem approach and are tackled by all sectors.

Searching for the most effective methods

Special attention within the Sava TIES project was given to the practical side of invasive alien species management. Seven protected area managers in the four Sava river basin countries have implemented pilot actions in invasive species control and eradication, aiming to increase joint capacities of the SavaParks Network, to plan and successfully implement eradication activities. The selected sites infested by invasive alien species are highly important in the context of nature protection and nature-based tourism: Ljubljansko Barje Nature Park (Slovenia), a Natura 2000 site



Odransko polje (Croatia), Lonjsko Polje Nature Park (Croatia), Una National Park (Bosnia and Herzegovina), Tišina Protected habitat (Bosnia and Herzegovina), Zasavica Special Nature Reserve (Serbia) and Obedska Bara Special Nature Reserve (Serbia).

The pilot actions have been selected to manage some of the worst invasive plants, on typical and threatened habitats in the Sava river basin.

For more details on the implemented pilots and methods refer to the Joint Pilot Report and Transferability Plan of the Sava TIES pilot activities in invasive alien species management.

Three categories of invasive alien species management methods (mechanical, chemical, and biological) were carried out, including their combination, for example, mowing with cattle grazing.

The intention was to test the effectiveness of various methods against target invasive alien species. The eradication activities were carried out in the course of two subsequent years.

On larger infested sites the invasive alien species removal was conducted with the use of heavy machinery (such as mechanical shovels and rotary hoes), while on infested spots it was done mostly by hand tools (pulasks, spades, scythes and herbicide-injections or wiping).

The target invasive alien plants were the Himalayan balsam, the tree of heaven, the giant goldenrod,

Mulching of goldenrods on pilot plots
Petra Hladnik

Tree of heaven
Haris Hadžihajdarević

Testing the effectiveness of mechanical removal of Japanese knotweed followed by covering the infested plot with black plastic sheet.

Haris Hadžihajdarević

Amir Alagić

the Canadian goldenrod, the false indigo-bush, the box elder (*Acer negundo*), the wild cucumber (*Echinocystis lobata*), the Bohemian knotweed (*Reynoutria bohemica*) and the common milkweed.

Sharing the experience gathered from different environmental, economic and policy frameworks in the Sava river basin countries will help other land managers to control the invasive species without trial-and-error approach.

Monitoring invasive alien plants

Haris Hadžihajdarević

After removing invasive alien plants from 77 ha of protected areas, the presence of native plants and animal species has been monitored to assess biophysical effectiveness, while cost-efficiency of the implemented methods was evaluated by comparing the costs and the level of engagement per unit area.

Field experience with applied methods

Due to the habitat diversity of the Sava river basin, the gained experience is, to some extent, site-specific, but most of the gathered data is considered valid within the broader region. The most important conclusions drawn after testing invasive alien species eradication/control methods are presented in the following chapters.

Note: in places managed by forestry companies, mowing/mulching works are subject to national forestry legislation and need prior approval by forest managing authorities.

Haris Hadžihajdarević

Mowing/Mulching

For best results, mowing herbaceous invasive alien species should be done before fructification (if possible, before blooming, so as to hamper the development of underground parts as well). Extraction of woody invasive alien species must be carried out before its seeds are mature. In order to lower their survival rate or the risk of their reemergence after mulching, it is recommended that remaining plants, those inaccessible to heavy equipment, are hand-pulled.

Also strongly advised is the combination of mowing/mulching and grazing. Combined eradication practices should be applied at least twice a year.

Common milweed and goldenrods are noxious invasive alien species removed on the two pilot sites in Serbia

Ana Tratnik

The method employed in Croatia to control the spread of the false indigo is the combination of mulching/mowing followed by grazing

Renato Bukvić

Experiences with particular invasive alien species:

- **Himalayan balsam:** Potential risks include possible harm for vegetation and erosion of stream bank caused by mulching and pulling out invasive plant individuals.

  These risks appear to be less pronounced at habitats with trees cover where not much sensitive vegetation grows.

  Also, some plants that were merely damaged during mulching tend to regrow or even bloom so these should be hand pulled. It also recommended to continue monitoring the mulched area.

- **Goldenrods:** Mowing and mulching are recommended to prevent growth of goldenrods on meadows or where plants are present in lower numbers.

  With these methods eradication of goldenrods is slower but less harmful for native plants. This method proved to be highly effective on lowland meadows in Odransko polje (Croatia) where the giant goldenrod significantly decreased in number.

- **False indigo-bush:** Mowing/mulching alone has proved to promote aggressive regrowth of new plants across newly opened areas from their remains in the ground or near the ground as well as from seed bank. Also, some

other invasive alien plants (e.g. the common beggarticks, the annual fleabane, the giant goldenrod) started to grow after the shading tree and bush species were removed. On the one hand, this created low dense shrub which could be controlled with much lighter machinery at five times lower costs. On the other hand, quick resprouting from remaining plant parts and a lot of remaining biomass can impede later mowing efforts.

Consecutive mulching is possible, but it is too expensive and not effective.

Common milkweed: A month after mulching, the first young plants emerged (occasionally 1-2 stems from one root), but their total number was low.

This method appears to be the fastest and most economical in large areas, but it usually removes only the aboveground plant parts, while its thick rhizomes, containing nutrient reserves, remain more or less intact under ground, so young plants quickly resprout.

Heavy machines are needed to remove even young false indigo-bush stands

Luka Basrek

Hand pulling

This method is particularly recommended on sites with greater number of native species and where invasive species are in its initial stages of invasion or in places inaccessible to removal by heavy machinery.

Experiences with particular invasive alien species:

- **Himalayan balsam:** hand pulling can be made difficult or impossible because of the position of target plants (e. g. within the stream). Many small plant parts (shoots, young stems on the ground etc.) remain hidden within dense vegetation and later start growing. When it comes to hand pulling, it has to be repeated more than once during a single season and a combination with mulching (mulching followed by hand-pulling) is highly recommended. Potential risks include erosion caused by pulling out invasive plant individuals.
- **Common milkweed:** It is very difficult to completely remove by hand pulling the well developed tuberous rhizomes from which new plants quickly resprout to form new colonies. After only a month and a half after the initial removal of the aboveground plant parts, even the smallest remaining parts of rhizomes start to emit new offshoots and new plants quickly recolonise the area. Also, it is difficult to apply this method on larger areas, and because it needs to be repeated many times, it is economically not sustainable in the case of this species.

Hand pulling of the common milkweed
Igor Čolak

Hand pulling of the common milkweed
Igor Čolak

Milling by rotary hoe/ cutter

This method destroys the whole vegetation, leaving an open soil surface that needs further management actions. It is only moderately successful when applied to invasive plants which are able to regenerate from very small (less than 5 cm long) underground shoots.

Experiences with particular invasive alien species:

- **Goldenrods:** It is most effective when applied to dense stands where few native species are present. After milling, sowing of native plants seeds is recommended to prevent the colonisation of the area with other invasive alien plants.

False-indigo bush
Goran Šafarek

Mechanical pulling

Experiences with particular invasive alien species:

- **Tree of heaven:** The method can be effective while trees are still young and have not yet developed an extensive root system. This method is recommended for elimination of a smaller number of young trees.

This method implies using the extractor or some other heavy equipment to pull out bigger plants like trees.

Removing common milkweed
Igor Čolak

Herbicide treatment

Herbicides are among the most effective and resource-efficient tools to treat invasive species but it is necessary to follow all safety measures and to respect the local legislation. Also, its application should not be considered in places close to water bodies (e.g. ponds, lakes, rivers, flood reservoirs).

The herbicides can be applied by means of heavy equipment or manually. The main disadvantage of the latter is that it is time-consuming, it requires a considerable amount of human labour and its efficiency depends on how well and thoroughly the surfaces of leaves and stems are painted.

This method is not feasible on large areas but can be applied with small groups of people on smaller areas inaccessible to heavy machinery. On the other hand, application by tractor sprayers provides cost-efficiency but excludes the possibility of selective treatment of invasive species which could be very harmful to the habitat.

Also, herbicide treatment can be obstructed by local public opinion which is shaped differently in highly invaded sites than in those with preserved nature, where local people have not faced the loss caused by the invasive species („do nothing and nature will take care of itself").

Selective treatment of the common milkweed with herbicide
Igor Čolak

The use of herbicides should be carefully considered and it should generally be seen as the "last resort" in invasive alien species eradication.

Experiences with particular invasive alien species:

- **Goldenrods:** The best results are achieved on homogenous goldenrod stands without much native plant species present, where this method proved to be most effective in combination with mulching.
- **Common milkweed:** Herbicide painting has proved to be quite an effective method of elimination with success rate of 40-60% and no new plants emerging after treatment. However, this method should be applied with exceptional care (only manual treatment, limited to the invasive alien species specimens) in areas along the water bodies and in initial stages of invasion i. e. in habitats with more or less developed natural vegetation.

Grazing/Browsing

Experiences with particular invasive alien species:

- **False indigo-bush:** Eradication of the false indigo-bush is cost effective only when grazing can be ensured. Pasturing method gave the best results in cotrolling the false indigo-bush but other fast-growing invasive or pioneer species which are avoided by cattle like the common beggarticks, the annual fleabane and the pale persicaria can create significant problems in the revitalisation of grasslands. It is strongly recommended to combine pasturing with mowing/mulching after mid-August. In other cases, it will resprout up to two meters high after only four months forfeiting entire investment.
- **Common milkweed:** Cattle grazing is not an option since the common milkweed is not edible.
- **Bohemian knotweed:** The experience gained through the project has shown that goat grazing does not always lead to the eradication of knotweed, as not all goat breeds eat the plant. Effects of grazing in invasive alien species control, by the same grazing species, can be different and shaped by local environment and previous grazing habits of the utilised cattle.

Sharing the lessons learned can help other stakeholders to successfully manage invasive species without trial-and-error approach. This is the essential purpose behind these pilot activities, in addition to the fact they are designed with the intention to be transferred and replicated in different areas of the basin, in the environmental and legislative framework of the Sava river basin.

Cattle grazing in Lonjsko polje
Renato Bukvić

Invasive (plant) species remain one of the biggest challenges of the 21st century. They are the second major driver of biodiversity loss in the world and their threat is becoming increasingly larger and more immediate. They cause damages not only to our health and environment, but also to our economy. In the last 20 years on the territory of the EU, invasive species have caused damages of at least € 12 billion annually, with the costs expected to grow.

Our efforts in fighting invasive alien species will not stop with the completion of the Sava TIES project. Owing to new insights and strengthened by new partnerships, we continue our work on protecting the nature, human health, and sustainable development. The Sava river basin is an area of extraordinary biodiversity containing invaluable natural resources. Join us in our efforts to map invasive alien species and prevent their spread. Only by working together can we preserve the immense value of this area for future generations.

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