# Invasive Alien Species and their Management

## A TRAINING COURSE MANUAL

Interreg
Danube Transnational Programme
Sava TIES

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Written by Jana Kus Veenvliet

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# Preface

When preparing this manual, I often thought about the beginnings of the awareness-raising actions on alien species in Slovenia. Back in 2008, we launched the first project on alien species in Slovenia, called Thuja. At that time, alien species were a new topic in Slovenia, an environmental issue about which only a few experts were concerned. We did not have an easy task, as we had to break new ground. When publishing the first popular publication on alien species, we had to decide how we would translate many alien-species terms to the Slovenian language, as many of them have not been used previously in our language. At the same time, we were spreading the word about alien species to various target groups.

Many years later, and with several more projects in-between, I was fortunate to become an external expert in the Sava TIES project (Preserving Sava River Basin Habitats through Transnational Management of Invasive Alien Species). The project consisted of many actions to improve the management of invasive alien plants in the Sava River basin. As alien species know no borders, transboundary cooperation is essential for their effective management.

One of the important pillars of effective alien species management is also cross-sectoral cooperation. Alien species are not only a nature conservation issue. With massive impacts on natural resources, economy and human health, they should concern all sectors. However, cooperation requires dialogue, and that requires that we all have a common baseline knowledge and understanding of terms. That we all speak "the same language". With that in mind, we've decided to prepare this training course manual to accompany online courses "*Invasive alien Species and their Management*". The courses were organised in all countries of the Sava TIES project Croatia, Bosnia and Herzegovina, Slovenia and Serbia. While the webinars were one-time events, this manual will hopefully provide a helpful reference to the attendees and other interested audience.

Invasive alien species can have very different impacts on the environment and economy. Only in the last decades, with an increasing number of studies on invasion biology, we start to understand the true extent of their impacts. However, for some species, the window of opportunity for eradication has been missed, and some invasive species have become very widespread. Management practices used before the encroachment of invasive species might not be appropriate anymore. Sectors have to adapt, but these adaptations should be made in such a way that they don't contribute to the further spread of invasive alien species.

Management of invasive alien species also requires public support. People are intentionally or unintentionally always involved in the introduction and spread of alien species. But, if properly informed, people can also be part of a solution. Managers of protected areas and natural resources can play an important role in how the public perceives management actions. They can also help private landowners in understanding issues of invasive alien species and in adapting land-use practices.

Alien species are now part of our everyday life. Many invasive plants are so widespread that it is not easy to walk along a stream and not see at least some of them. But this should not be a reason for despair. It should be taken as a warning of the immense invasion potential of some of the species. And we should use that and our improved understanding of the invasion processes to prevent new introductions. The capacities and funds for alien species management will never be sufficient to deal with all alien species. So we will also have to learn to choose our battles wisely and cooperate with all sectors to achieve the best possible results.

*Jana Kus Veenvliet*
*March 2021*

# 1 Invasive Species Terms and Concepts

## 1.1 What is an alien species?

Throughout the history of humankind, people have been travelling and trading with 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 export[1].

One of the major environmental concerns of globalisation is the movement and translocation of live organisms to new environments. In biology, species introduced to new environments with direct or indirect assistance of humans, are called **alien species**. They may belong to any group of organisms – viruses, fungi, plants, animals, and the pathways of their introduction vary greatly.

The ***Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species*** contains the following definition:

Alien species means any live specimen of a species, subspecies or lower taxon of animals, plants, fungi or micro organisms introduced outside its natural range; it includes any part, gametes, seeds, eggs or propagules of such species, as well as any hybrids, varieties or breeds that might survive and subsequently reproduce[2].

The term "native species" is defined by the *International Union for Conservation of Nature* (IUCN):

**Native species** is a species, subspecies or a lower taxa, 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 the natural range expansion, either by walking, flying, transport by water or wind or any other ways of dispersal.[3]

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 interspecific competition with the native species due to similar ecological requirements. 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 the native species (see **Box 1**).

Invasive alien species are a subset of alien species, for which there is a notable environmental impact. Also this term is clearly defined by the EU IAS Regulation 1143/2014:

**Invasive alien species** means an alien species whose introduction or spread has been found to threaten or adversely impact upon biodiversity and related ecosystem services[4].

With modification of habitats by humans, some native species may, within their existing range, increase their populations 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[4].

Studies have shown that climate change facilitates the spread and establishment of many alien species and creates new opportunities for them to become invasive. At the same time, climate change reduces the resilience of habitats to biological invasions. But as a consequence of climate change, more and more native species are shifting their range towards the north and into higher altitudes. This sometimes blurs the line between native and alien species. Recently, a new term "neonative" was proposed for this subset of species, with the following definition:

**Neonatives** are those taxa that have expanded geographically beyond their native range and that now have established populations whose presence is due to human-induced changes of the biophysical environment but not as a result of direct movement by human agency, intentional or unintentional, or due to the creation of dispersal corridors such as canals, roads, pipelines or tunnels. The latitudinal range expansion should be in order of at least 100 km, and for altitudinal expansion a few 100 m, after the year 1950[5] .

Sometimes, the origin of a species may be unclear, but the species population dynamics resemble those of alien species. This is especially common with smaller organisms, like viruses, bacteria or fungi. The definition is as follows:

**Cryptogenic species** is a species, which cannot be reliably demonstrated as being either alien or native[6].

**Figure 1.** Three species from genus *Impatiens*, but with different statuses. Western Touch-me-not (*Impatiens noli-tangere*) is native to most of Europe and Northern America, Garden Balsam (*Impatiens balsamina*) is non-native to Europe but so far not spreading. Himalayan Balsam (*Impatiens glandulifera*) is invasive alien species in many temperate parts of Europe. Photos: Institute Symbiosis.

## Box 1. Translocation of fish leading to loss of diversity

Historically, many freshwater fish were translocated out of their natural range, mostly for sports fishing purposes. Sometimes fish were introduced even to a nearby river system. However, when this river belongs to another river catchment, this can have major impacts on native fish species. In the distant past, river catchments might have been connected in a different way, and species were co-evolving. Due to some tectonic shifts, the catchments were split, thus isolating the populations of fish. Their evolution continued independently and gradually led to forming genetically distinct populations, which are often considered separate species. However, the sibling species from the nearby catchments are still closely related and can easily hybridise. When humans have translocated species to a nearby catchment, this often led to hybridisation and irreversible alteration of the gene pool of native species. In some cases, the alien fish or the hybrids became dominant over the native species, causing a significant decline in populations or even extinction.

A well-documented an example of decline of Marble trout (*Salmo marmoratus*), a large trout, native to the rivers flowing into the Adriatic Sea. It is one of the most endangered freshwater species in Europe. When trout from other European catchments were introduced, the species started to hybridise. Within some decades, the alien Brown trout and its hybrids became dominant in most of the Adriatic rivers in Slovenia.

A conservation project was initiated at the end of the last century, leading to a discovery of eight pure populations of Marble Trout in the upper parts of small tributaries, which were with waterfalls physically isolated from the downstream hybridisation zones. Through a restoration project, stocks of genetically pure Marble Trout were raised and used for restocking in the Soča River. At the same time, the introduction of Brown trout was ceased as it is since 2006 also prohibited by law in the whole territory of Slovenia.

A genetic study has shown that the genes of the alien Brown trout are slowly being replaced with the genes of the native Marble trout, indicating that this conservation project had succeeded to save the species from the brink of extinction. [7,8]

**Figure 2.** Due to hybridization with alien Brown trout, Marble trout (*Salmo marmoratus*) in Soča River in Slovenia was on the brink of extinction. The native trout were saved through a restoration project by restocking the river with hatchery -bread pure Marble trout, raised from the last genetically pure populations. Photo: Lorenzo Piovesan CC BY SA 3.0.

## 1.2. Pathways of introductions

In invasion biology the term introduction has the following meaning:

**Introduction** means the movement, as a consequence of human intervention, of a species outside its natural range[4].

Alien species can be introduced in many different ways or pathways. Understanding the pathways of introduction of alien species is one most relevant information in developing management strategies. With large-scale international trade, it is not possible to tackle every pathway. Management efforts need to focus on the most important ways alien species are introduced - i. e. the **priority pathways**. To determine the priority pathways, alien species have to be accurately assigned to clearly defined categories.

The most recent definition of a pathway is provided by the EU IAS Regulation and is as follows:

**Pathways** means the routes and mechanisms of the introduction and spread of invasive alien species.

Realising the importance of understanding the pathways of invasive species introductions, several classification frameworks were developed. This classification was later further developed under the **Convention of Biological Diversity (CBD)**, and is since 2014 considered a global standard. The CBD framework divides pathways to 6 main categories (Figure 3) with altogether 44 subcategories (Table 1). A more detailed guidance with the expanded description of all categories and subcategories was provided by a team of experts of IUCN[9]. With the adoption of the ***Commission Implementing Regulation (EU) 2017/1454***[10], this classification framework is now also used by the European Member states in reporting on the implementation of the EU IAS Regulation.

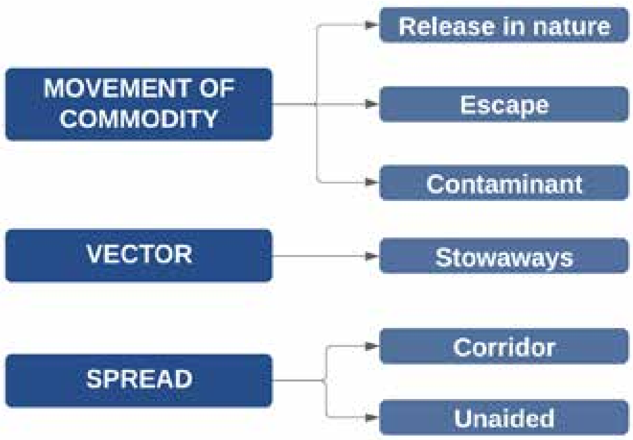


**Figure 3.** According to Hulme et al. 2008[11], there are three basic mechanisms of introductions which are further divided into six main categories of pathways

**Figure 4.** One of the most common pathways of introduction of alien plants is horticulture, with numerous plants imported as ornamental garden plants. Alien plants are also often spread to new areas by transportation of sand or soil. Photos show Giant hogweed (*Heracleum mantegazzianum*) and Japanese knotweed (*Reynoutria japonica*). Photos: Institute Symbiosis.

**Table 1.** An overview of the standardized categorisation of pathways of alien species

| | |
|---|---|
| **1. Release in nature** | 3.5 Parasites on animals (including species transported by host and vector) |
| 1.1 Biological control | 3.6 Contaminant on plants (except parasites, species transported by host/vector) |
| 1.2 Erosion control/dune stabilisation (windbreaks, hedges, …) | 3.7 Parasites on plants (including species transported by host and vector) |
| 1.3 Fishery in the wild (including game fishing) | 3.8 Seed contaminant |
| 1.4 Hunting | 3.9 Timber trade |
| 1.5 Landscape/flora/fauna 'improvement' in the wild | 3.10 Transportation of habitat material (soil, vegetation, …) |
| 1.6 Introduction for conservation purposes or wildlife management | **4. Transport — stowaway** |
| 1.7 Release in nature for use (other than above, e.g. fur, transport, medical use) | 4.1 Angling/fishing equipment |
| 1.8 Other intentional release | 4.2 Container/bulk |
| **2. Escape from confinement** | 4.3 Hitchhikers in or on airplane |
| 2.1 Agriculture (including biofuel feedstocks) | 4.4 Hitchhikers on ship/boat (excluding ballast water and hull fouling) |
| 2.2 Aquaculture/mariculture | 4.5 Machinery/equipment |
| 2.3 Botanical garden/zoo/aquaria (excluding domestic aquaria) | 4.6 People and their luggage/equipment (in particular tourism) |
| 2.4 Pet/aquarium/terrarium species (including live food for such species) | 4.7 Organic packing material, in particular wood packaging |
| 2.5 Farmed animals (including animals left under limited control) | 4.8 Ship/boat ballast water |
| 2.6 Forestry (including afforestation or reforestation) | 4.9 Ship/boat hull fouling |
| 2.7 Fur farms | 4.10 Vehicles (car, train, …) |
| 2.8 Horticulture | 4.11 Other means of transport |
| 2.9 Ornamental purpose other than horticulture | **5. Corridor** |
| 2.10 Research and ex situ breeding (in facilities) | 5.1 Interconnected waterways/basins/seas |
| 2.11 Live food and live bait | 5.2 Tunnels and land bridges |
| 2.12 Other escape from confinement | **6. Unaided** |
| **3. Transport — contaminant** | 6.1 Natural dispersal across borders of invasive alien species that have been introduced through pathways 1 to 5 |
| 3.1 Contaminant nursery material | |
| 3.2 Contaminated bait | |
| 3.3 Food contaminant (including of live food) | |
| 3.4 Contaminant on animals (except parasites, species transported by host/vector) | |

Source: Commission Implementing Regulation (EU) 2017/1454, See IUCN 2017 for detailed description of (sub)categories.

## 1.3. The invasion process

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. In order 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 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 terms used in this context are:

**Casual alien species** is alien species which only sporadically occurs in the new area. It may occasionally reproduce but does not form permanent populations and is only maintained through repeated introductions.

**Naturalised species** is an alien species which is regularly reproducing in the new environment and is maintaining its populations without human assistance or new introductions. Such species does not (yet) cause noticeable damage to the environment.

Some alien species are naturalised for decades before their evolutionary adaptation or some changes in the environment (e. g. climate change) trigger their expansion. It is therefore important to monitor these species and introduce management measures as soon as they start to show tendency to spread.

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. For clarity, we here once more repeat the definition of invasive alien species:

**Invasive alien species** means an alien species whose introduction or spread has been found to threaten or adversely impact upon biodiversity and related ecosystem services.

For a full understanding of this definition, we also need to look at the definition of terms biodiversity and ecosystem services:

**Biodiversity** means the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.[12]

**Ecosystem services** are the conditions and processes through which natural ecosystems, and the species that make them up, sustain, and fulfil human life.[13]

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

While these definitions are seemingly clear, it is in practice not so easy to draw a line, when a species is invasive. The fact is that the threat or adverse impact depend on our ability to detect these changes in the environment. The changes caused by alien species are gradual and might be difficult to detect when alien species are still in low numbers or only locally present. However, by the time we start to observe the impact of the invasive alien species, there is little information available of the pre-invasion situation and therefore the magnitude of changes, caused by alien species, is often difficult to determine.

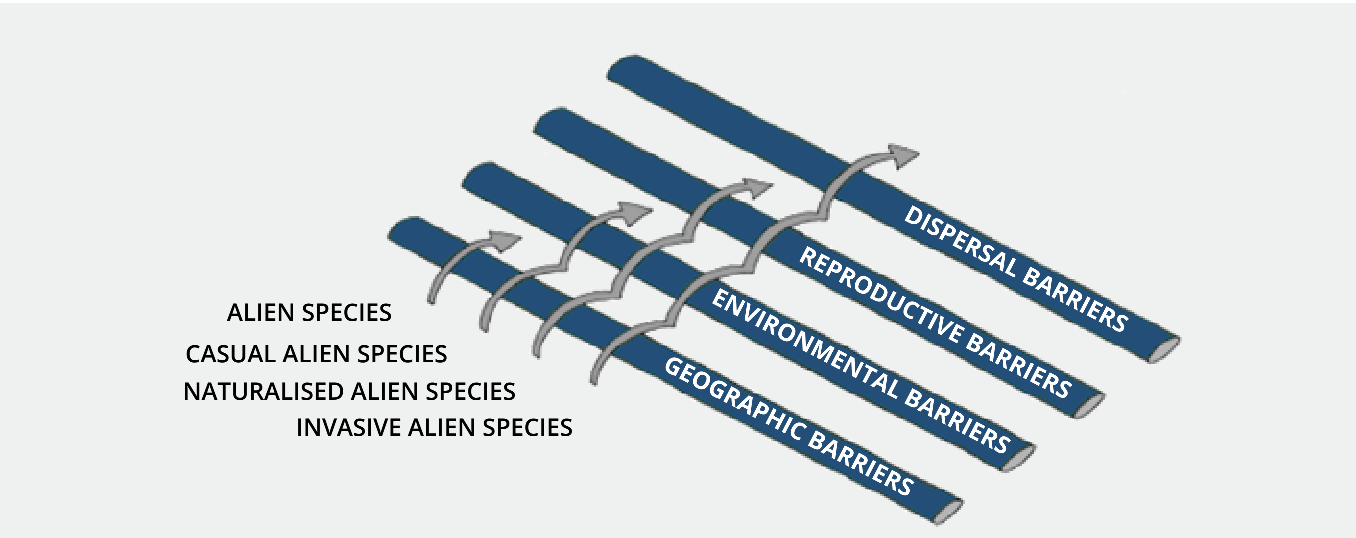


**Figure 5.** The different barriers which alien species face during the invasion process and corresponding stages of invasion (adapted after Richardson et al. 2000).

## 1.4 Drivers of biological invasions

The main driver of biological invasions is, of course, the transport of goods connected with the global trade. In 2019, over 90% of the world's trade was moved by shipping[14]. In the last 70 years we have witnessed an evolution of containership. Already the shift to transporting cargo in closed containers increased the chances of alien species to reach new continents alive. Furthermore, also the size of containership has increased substantially. While the first containership were able to carry from 500 to 800 containers, nowadays they often carry over 5000, some even more than 20.000 containers.[15]

Air transport is less often used for 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.

Even to a much larger extent, air transport is used for transport of passengers. Alien species can be moved with as contaminant on various goods or as a stowaways. Also humans can act as vector and can intentionally or unintentionally carry alien species. The extent of human movement with air transport was at least in the pre-pandemic time significant. In 2017, airlines flew approximately 4.3 billion passengers, which is in total volume 60 percent of the global population[16]. In 2020, we could witness the spread of SARS-CoV-2 virus, causing COVID-19 infection. The analysis of data has shown that already by the end of January 2020, passengers from China were likely exporting at least 1.5 cases of COVID-19 globally per day.[17]

Another important driver of biological invasions is climate change. Climate change is expected to increase melting of the Arctic ice-cap, which will open new shipping routes and open connectivity between different ports. The new climate conditions may trigger trends to growing new plants for agriculture or forestry. In areas of intensive agricultural production climate change could change the traditional trade routes.[18]

Climate change is also expected to result in changes of abiotic factors in the new environment. As a result of climate change, the performance and success of native and alien species could be affected. It is not yet clear weather alien species could be favoured due to changing abiotic conditions. It is however likely that higher winter temperatures could enable survival and naturalisation of alien species which are so far only casual alien species in the northern hemisphere. [17]

Land use and degradation in particularly contribute to invasion of alien plants. Many invasive plants are pioneering plants which can easily establish on soil where the primary vegetation was removed. Similarly also abandonment of arable land can lead to encroachment of alien plants (see **Box 5**).

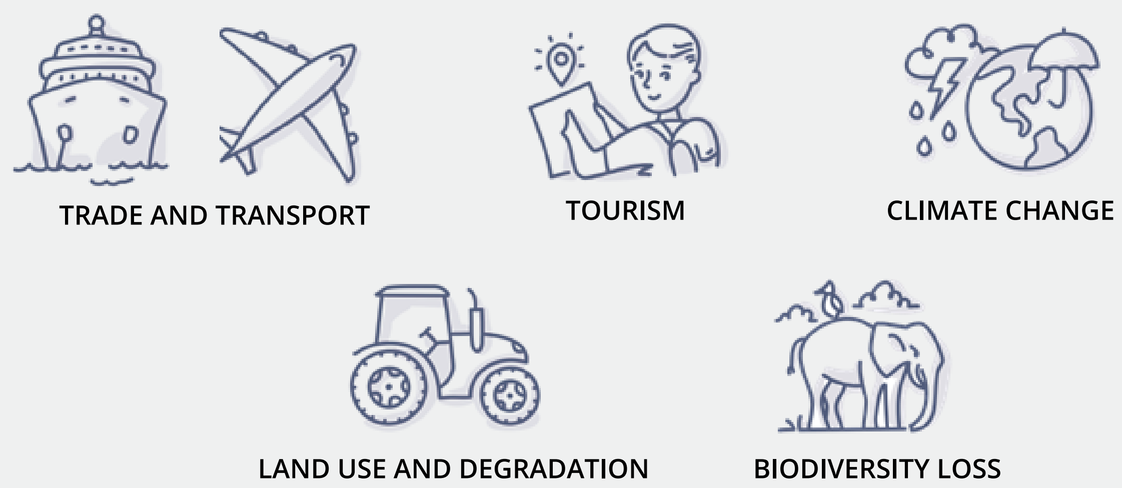


**Figure 6.** The main drivers of biological invasions which are expected to further increase in the future.

## 1.5 Can we predict the outcomes?

One of the biggest challenges in management of invasive alien species is the unpredictability. There are many factors which determine the survival and possible expansion of alien species in the new environment.

In the 1990s, there was a popular invasion hypothesis called "tens rule". It was predicted that about 10 % of alien species would become established, and 10 % of those (or 1 % of all introduced alien species) would cause significant detrimental impacts. This hypothesis was, however, not empirically proven. Recent studies could not provide any support for this hypothesis. On the contrary, meta-analysis across many published records revealed that about 25% of alien plants and invertebrates and about 50% of alien vertebrates are on average successful in taking consecutive steps of the invasion process. It was not possible to establish and rule regarding their impacts.[19]

A strong tool for predicting the outcomes of invasions is risk assessments used to identify species for which there is a high likelihood of showing an invasive character in a particular area outside their natural range[20]. Risk assessment is obligatory in procedures for granting permits for the intentional introduction of alien species. However, a similar approach can also be used when a new, usually unintentionally introduced alien species is found. We need to estimate whether the species poses a threat and should be removed or it is likely to be harmless.

Risk assessments are often carried out using a standardised protocol (a comprehensive overview is provided on the homepage of Regional Euro-Asian Biological Invasions Centre (REABIC)[21], which is guiding experts through a series of questions regarding the characteristic and possible impacts of alien species. A decision is made based on expert knowledge, literature study and consultation with experts from other countries. If an alien species is invasive in a country with a similar climate and habitats, it should be treated as a potentially invasive species and its populations and impacts should be closely monitored. Sometimes these species are specially listed on the alert list, which provides a good basis for more focused work on alien species.

Risk assessment is also used in developing legal restriction on trade with alien species to prevent their introduction. Any legal measures that may affect free trade have to be justified so that the World Trade Organisation rules are not violated. Risk assessments in the EU for the purposes of legal ban have a prescribed methodology which is determined with a Commission Delegated Regulation (EU) 2018/968 of 30 April 2018 supplementing Regulation (EU) No 1095/2010, 1143/2014 of the European Parliament and of the Council with regard to risk assessments in relation to invasive alien species.

**Figure 7.** Annual fleabane (*Erigeron annuus*) was introduced to Slovenia in the middle of 19th century. For a long time it was considered a rare alien species, but in the last decades it started spreading in ruderal sites and meadows. It is now one of the most widespread alien plant in Slovenia. Photo: Institute Symbiosis.

## Box 2. Risk assessment as a tool to predict the spread of invasive plants

In the Sava TIES project, detailed risk assessments were performed for several alien plants which are at least locally already invasive in parts of the Sava River basin. Risk assessments were performed for the entire Sava River basin area, which expands over Slovenia, Croatia, Bosnia and Herzegovina and Serbia.

Risk assessments were performed for Indigo bush (*Amorpha fruticosa*), Japanese knotweed (*Reynoutria japonica*), Bohemian knotweed (*R. x bohemica*), Giant knotweed (*R. sachalinensis*), Canadian goldenrod (*S. canadensis*) and Giant goldenrod (*S. gigantea*).

Non-native Risk Assessment (NNRA) methodology[22,23]) was selected for performing the risk assessment. This methodology offers a precise assessment of all stages of invasion. The methodology is also detailed enough that it can be used in the processes of justification of legal restrictions and complies with the requirements set out in Annex to Commission Delegated Regulation (EU) 2018/968 of 30 April 2018 amending Regulation (EU) No 1095/2010. The study concluded that the species Indigo bush, Japanese knotweed, Bohemian knotweed, Canadian goldenrod and Giant goldenrod are highly invasive species in the Sava River Basin. It is estimated that there is a high likelihood of the introduction of these species. All of these alien plants have a high spread potential, and their environmental impact is estimated to be high.

Giant knotweed is so far considered moderately invasive in the Sava River Basin. There is a moderate likelihood of introducing this species and its establishment in the risk assessment area. The species has a moderate spread potential, and its impact is estimated to be moderate. The species is more significantly spread only in Slovenia, so it was estimated that the species is less invasive than the other assessed species.

Source: Authors, 2020[24]

**Figure 8.** Indigo bush (*Amorpha fruticosa*), Japanese and Bohemian knotweed (*Reynoutria japonica* and *Reynoutria* x *bohemica*), and Canadian and Giant Goldenrod (*Solidago canadensis* and *Solidago gigantea*) are already common in the Sava River basin. The risk assessment has confirmed their high invasion potential and measures should be taken to prevent their further spread. Photos: Institute Symbiosis

## 1.5 Impacts of invasive alien species

The impacts of invasive alien species can be very diverse and are often be blurred by many environmental variables. In particularly in the early invasion stages, impacts of alien species are often difficult to detect as they are often relatively small. However, by the time we notice the alien species spreading, the pre-invasion situation does not exist anymore. Complex ecological studies are needed to define the impacts of invasive alien species, often involving comparing different sites with and without certain alien species.

Invasive alien species have various impacts on native species, habitats and ecosystems. Alien plants often form dense stands and outcompete native plants, by reducing the availability of light or/and with allelopatic substances (biochemicals that have inhibitory effects on other organisms). Many alien plants also increase flammability and greatly increase the risk of fires, leading to the loss of habitats.

The impacts of alien animals are much more variable. The introduced animals can be predators or grazers and reduce the number of native species. They can also directly compete with native species for resources or space. Many alien animals are pests of native plants and can cause a significant decline in populations of native species. Similar negative impacts on native plants are also observed from many alien fungi. Plants, algae, microorganisms or small animals can also accumulate on unwanted surfaces - the process is known as biofouling.

While invasive alien species, by definition, always have negative impacts on biodiversity, their impact goes far beyond that. When their populations increase, they may, for example, degrade habitats, alter hydrology, cause soil erosion. They can lead to or contribute to the decline of native species or change patterns of primary production. Some alien species also have significant socio-economic impacts. This is particularly the case with pests or diseases of plants or animals, which can cause significant economic loss in agriculture and forestry. Many invasive alien species can also threaten human health. This includes not only viruses and bacteria but also plants or animals which are poisonous to humans.

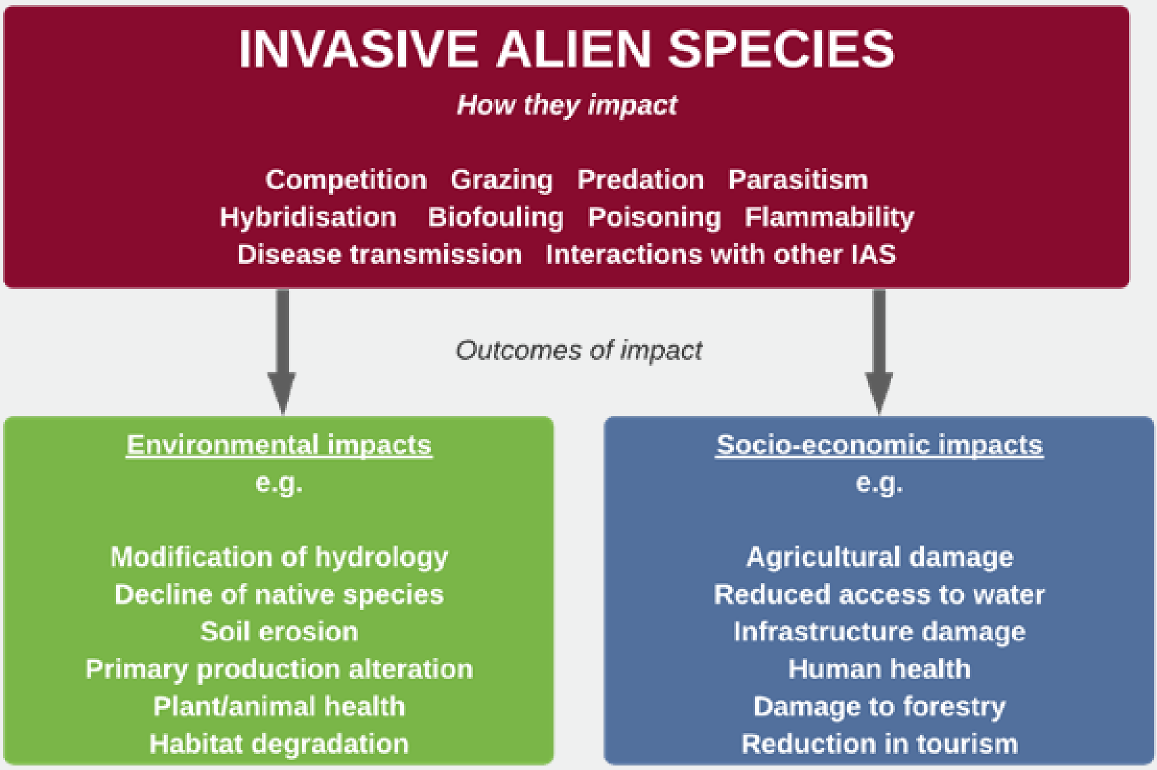


**Figure 9.** A simplified overview of diverse impacts of invasive alien species. With their direct impact on native species and habitats, they cause various environmental and socio-economic impacts. Source: IUCN, Invasive alien species and sustainable development[25]

## 1.6 The scale of threat of alien species

With the increasing trade and movement of people, the number of species introduced to new areas is constantly rising. Analysis of large datasets performed in 2017 has shown that the annual rate of first records of alien species worldwide has increased during the last 200 years. More than one-third of all first records were reported from 1970–2014 [26]. With the rising number of alien species, there are also more invasive species that negatively impact biodiversity. Invasive alien species are therefore considered as one of the largest environmental issues and substantially contribute to the loss of biodiversity.

A serious challenge in determining the scale of the threat of alien species is the lack of quality data. In countries of the Sava River basin, monitoring of biodiversity is poorly developed. Even less attention was given to surveying alien species, but there are more and more studies focusing on alien species in the last years. Existing data on alien species were collected under the Global Biodiversity Information Facility (GBIF), which in 2020 published and updated Global Register of Introduced and Invasive Species. Data from GIBF datasets of the countries of the Sava River Basin are shown in **Table 1**.

**Table 1.** Overview of alien species in countries of the Sava River basin as listed in the datasets of the Global Biodiversity Information Facility (GBIF) in 2020.

| Taxonomic group \ Country | Bosnia and Herzegovina | Croatia | Slovenia | Serbia |
|---|---|---|---|---|
| Bacteria | no data | no data | no data | 8 |
| Chromista | no data | 47 | 50 | no data |
| Fungi | 8 | no data | 341 | 8 |
| Plantae | 375 | 822 | 437 | 256 |
| Animalia | 82 | 461 | 426 | 146 |

Sources: Maslo et al., 2020[27]; Boršić et al., 2020[28]; De Groot et al., 2020[29]; Rat et al., 2020[30]

In all countries of the Sava River basin, there is still a lack of data on the distribution of alien species and their impacts. In the Sava TIES project, important steps were taken to make available advanced tools for collecting data in the field (See **Box 4**).

With the lack of historical data from the Balkans, trends on the number of alien species can only be observed from the datasets from 11 Northern European countries. These data show a continuous increase in the number of alien species. Also in this case, most alien species are plants. The number of alien invertebrates started increasing after 1950 with the advances of means of transport and expansion of trade over the entire world.[31]

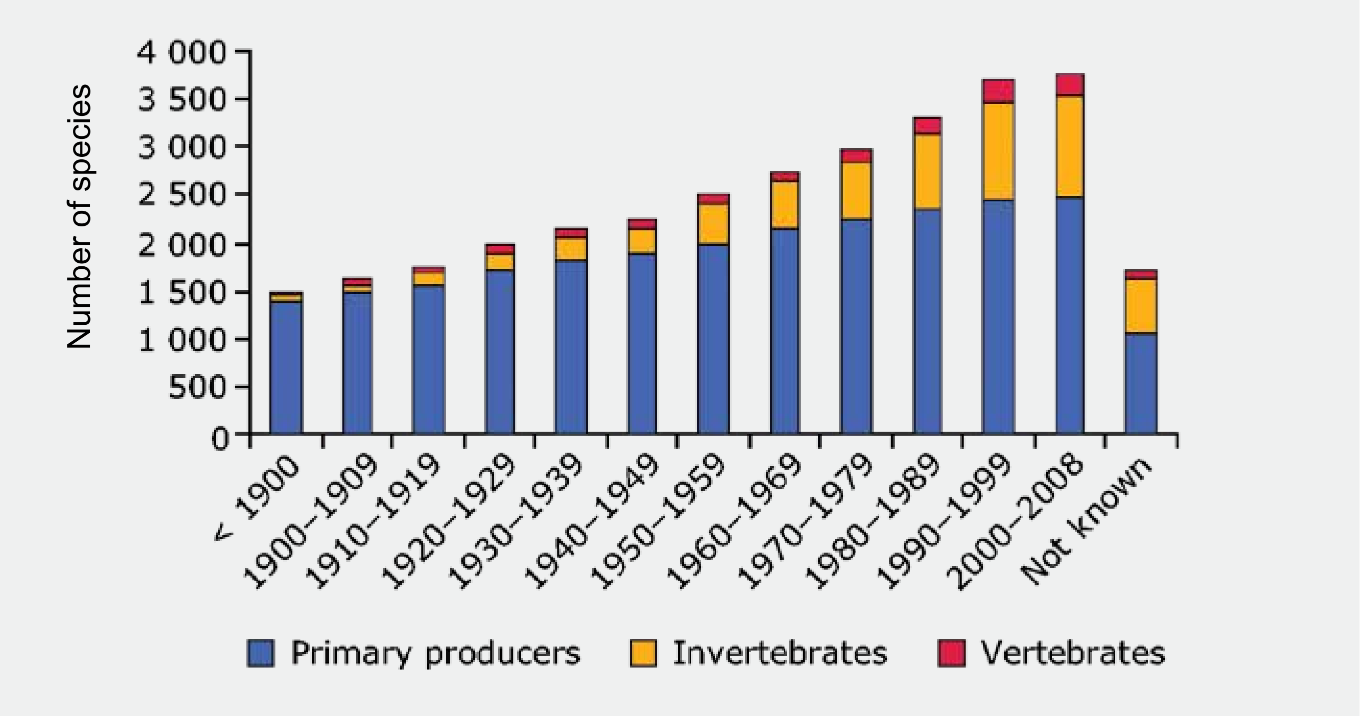


**Figure 10.** Cumulative numbers of alien species in 11 European countries show that their number is steadily increasing. The majority of alien species are primary producers, i. e. plants, where most of alien species are imported via horticultural trade. The number of invertebrates increased significantly with the technical advances and speed of transport. Source: European Environmental Agency, indicator last updated in 2017.

reference to the app will be changed depenting on the country

## Box 3. Mapping of invasive alien species

Accurately mapped data are crucial for planning management activities. These are the baseline data on which we can estimate the spatial extend of alien species and later also monitor the effectiveness of eradication or control measures.

In Slovenia, an information system for mapping alien species was developed in 2017 in the LIFE ARTEMIS project. Desktop and mobile (Android) applications Invazivke became widely used. By the end of the project in October 2020, the database contained almost 75.000 records of alien species. Of those, over 18.000 were collected via the mobile Invazivke App

A similar tool has been developed in Croatia. It is based on the application developed by the Joint Research Centre of the European Commission, which runs the initiative European Alien Species Information Network (EASIN).

The other two countries of the Sava River basin were still without a proper mapping application. The consortium of the Sava TIES project made an agreement with EASIN, which added a new geographical layer of the Sava River basin and 32 key invasive plants that are particularly relevant for this area. The application was extended with new functionality to serve the needs of the protected area managers. They can in the field also note other attributes, for example, the habitat of the alien species, density, degree of degradation, pathways.

The app was translated to Serbian and ijekavica, one of the official languages in Bosnia in Herzegovina.

The desktop version of Invazivke is available on www.invazivke.si. The Android application can be downloaded from the GooglePlay: https://play.google.com/store/apps/details?id=si.gozdis.invazivke2&hl=en&gl=US

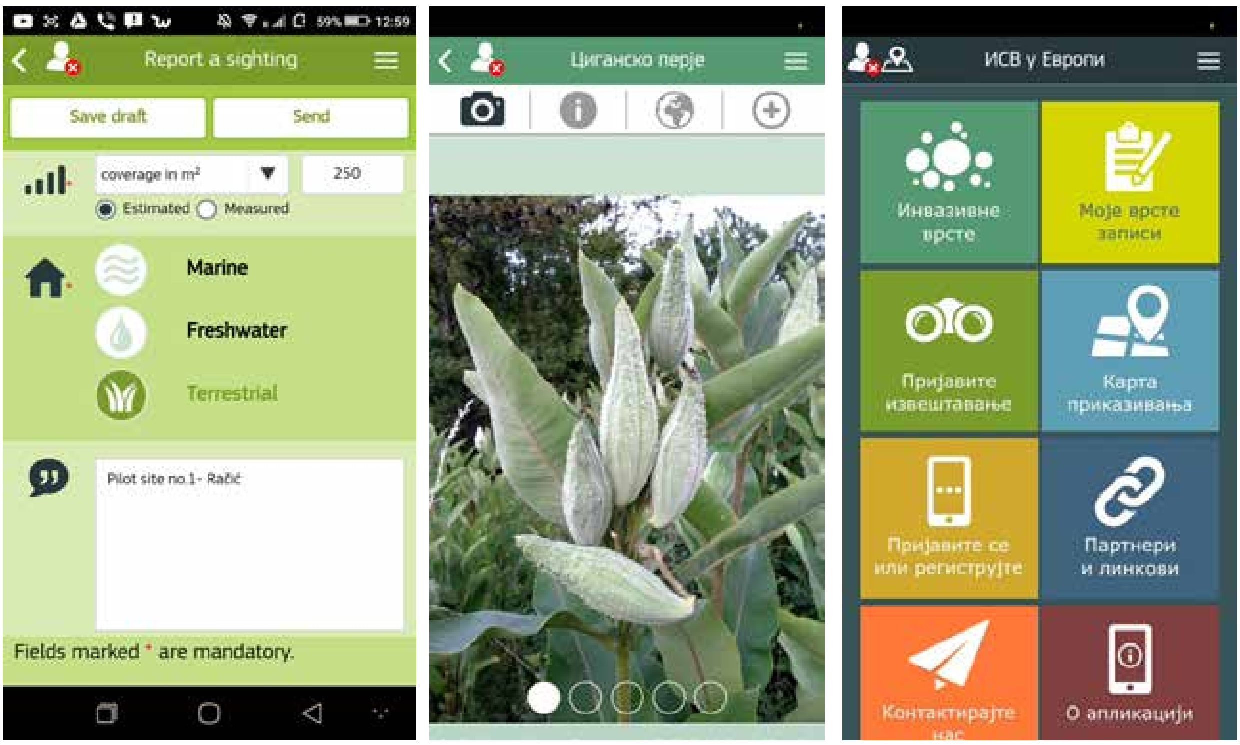


**Figure 11.** Screen shots of the EASIN application in English and with translation to Serbian. Source: EASIN

# 2 The Management of Invasive Alien Species

## 2.1 Responding to invasions

With increasing studies in invasion biology, there is a growing body of evidence that invasive alien species are one of the main and increasing threats to biodiversity, food security, and human and animal health. As the drivers of biological invasions will continue to contribute to the introduction and spread of alien species, countries have to develop more effective mechanisms to respond to these threats.

Management measures can be introduced in any invasion stage. However, the possibilities to effectively manage alien species decline when populations increase and spatially expand. As invasiveness is difficult to predict and is linked to many uncertainties, a precautionary approach should be applied to decisions regarding an authorised intentional introduction or when making decisions on the management of alien species which were already introduced.

Depending on the invasion stage, there are several management options: prevention, early warning and rapid response, eradication and control.

## 2.2. Prevention

The preferred management option is always prevention which is also the most cost-effective approach. Prevention can include any measures to prevent the introduction of alien species. This can involve any legal restrictions on the intentional introduction of alien species, or at least these are only authorised after a risk assessment has been made. For species for which there is already clear evidence of their invasiveness, a legal ban can be imposed, prohibiting transporting or importing a limited set of species. Any measures affecting free trade must be scientifically justified with a risk assessment, to fit into the legal framework constituted by the rules on the Single Market and obligations of the World Trade Organisation.

From 2016 onwards, the European Union introduced a ban on several alien species of Union concern, for which the rules of the EU IAS Regulation 1143/2014 apply. The species are determined with the Commission Implementing Regulations, and the list is periodically updated. Until March 2021, 66 species were listed as invasive alien species of EU concern32. Restrictions on movement and introduction also apply to some of the pests of alien origin. Under the phytosanitary rules, which aim at preventing the introduction of plant pests, there are strict quarantine and border controls.

## Box 4. Legal frameworks in the countries of the Sava River basin

Part of the Sava TIES project is dedicated to proposing legal solutions for more effective management of IAS to policymakers.

To be able to develop meaningful recommendations to policymakers, we analysed the current key policies which are relevant for the management of IAS. Under the guidance of an external expert, the partners of the Sava TIES project prepared a comprehensive review of all legislative and strategic documents, which at least in some parts, cover the issues of invasive alien plants[32]. This document was the basis for developing recommendations for improving current legal frameworks on IAS in the countries of the Sava River basin.

The outcome of this policy review is not a surprise. Practitioners in protected areas face many challenges when working on IAS, and many are related to underdeveloped legal systems. This makes it difficult to find practical solutions for the prevention and control of IAS.

Our policy review shows that the introduction of IAS is prohibited in all project countries. Only in exceptional cases, the intentional introduction may be allowed, based on a positive risk assessment. However, mechanisms to prevent unintentional introductions, a primary pathway for IAS, remain poorly developed.

Moreover, there are no mechanisms and rules for early warning and rapid response. The only exception among the four analysed countries is Croatia, which recently adopted a dedicated law on IAS and provided a legal basis for the implementation of EU regulation on IAS 1143/2014 . Croatia is also the only country which, so far, has set up a legal basis for an institutional framework. In Bosnia and Herzegovina, Serbia and Slovenia, there are no dedicated institutional frameworks for IAS. Problems with IAS are if at all, solved on a case-by-case basis.

Management of IAS is challenging due to the variety of species and pathways, as well as the many stakeholders who are or should be involved. In all countries, issues with IAS are primarily dealt with within the environmental sector, and only fragmented rules for the prevention and control of IAS are included in the legislation of other sectors. Efforts should be made to ensure that IAS are addressed by the principles of an ecosystem approach and are tackled by all sectors.

**Figure 12.** Common Ragweed (*Ambrosia artemisiifolia*) is regulated by law in all countries of the Sava River basin. Landowners are required to prevent spread of this invasive plant, which is harmful for human health and causes significant losses in agriculture. Photo: Institute Symbiosis

## 2.3 Early warning and rapid response

The next level of defence against invasive alien species is an early warning and rapid response, aiming to detect incoming alien species in the early invasion stages. As alien species are rare in the early stages, detecting species can be challenging.

Early detection requires active searching for alien species, for example, in areas where they are more likely to show up (e.g. ports, airports) or in areas of nature conservation importance where alien species' presence is even less desirable. Once an alien species is discovered, the level of threat should be assessed. If the species is (potentially) invasive, eradication measures should be initiated as soon as possible. If measures of early warning and rapid response are not successful, alien species may quickly spread beyond control.

Early warning and rapid response require significant institutional capacities. Roles and mandates have to be clearly divided so that the chain of command is clear at the moment of discovery of an alien species. Rapid response protocols can be developed to define the roles clearly.

## 2.4 Eradication and control

Once alien species are present in the environment, attempts can be made to remove them. This requires substantial financial resources, as the eradication actions usually have to continue for several years.

When alien species becomes more spread, it is usually impossible to eradicate. However, control measures can be introduced to mitigate the impact of alien species. If their populations are reduced, it usually also reduced impacts to an acceptable level. Control measures are costly and perpetual and can impose a significant financial burden on countries.

Many eradication and control methods are in use. The choice depends mainly on the biology of the species, characteristics of the site and legal possibilities. It is beyond the scope of this manual to describe these methods in detail. In general, methods are divided into mechanical methods (e.g., digging, mowing, cutting, trapping), chemical (use of pesticides) or biological control (introduction of a specific pest that is affecting the invasive species.

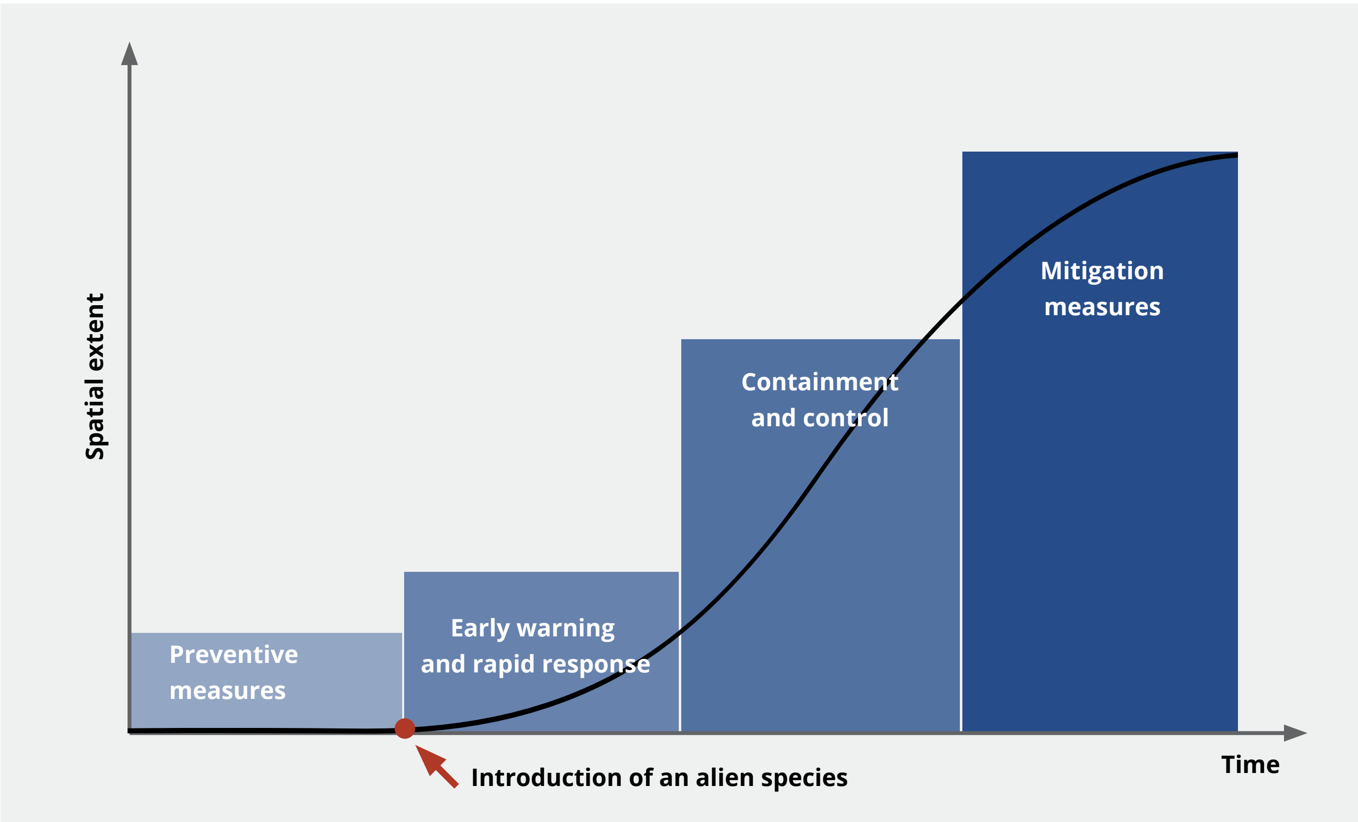


**Figure 12.** After establishment, populations of invasive alien species increase and spatially expand. If we fail to prevent their introduction or are unable to eradicate them in the early phases of spread, we must resort to continuous management measures. As their populations expand, the costs of managing alien species rapidly increase. Adapted after Zidar et al., 2020[33]

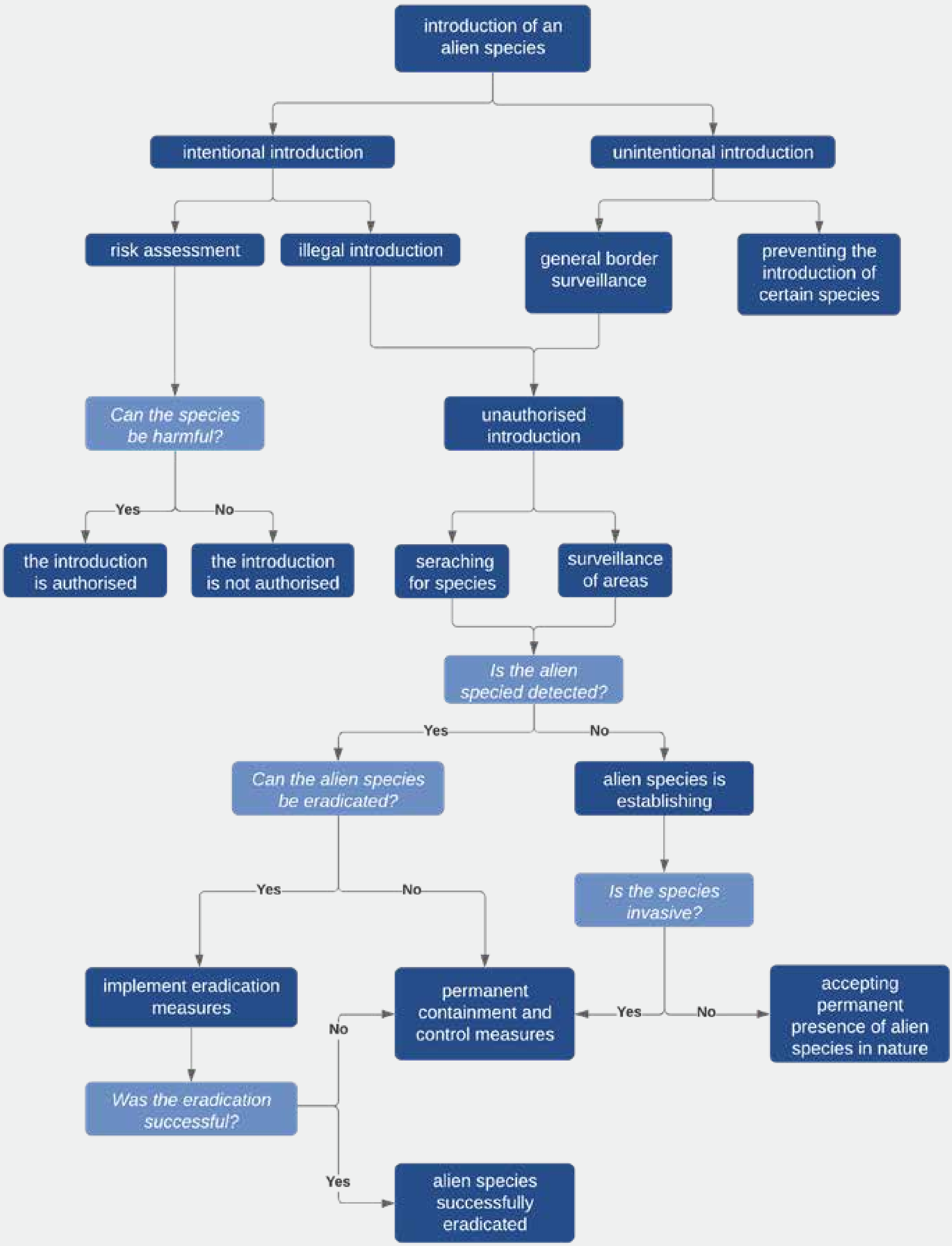


**Figure 13.** A decision flowchart determining the decisions on management measures. Adapted after Wittenberg & Cock, 2001[34].

Prepared by Valeria Hima

## Box 5. Revitalisation of grasslands in Lonjsko polje Nature Park

Lonjsko Polje Nature Park is located in the western part of Croatia, along the middle course of the Sava River. The protected area is a natural floodplain and one part is used as a retention area in the flood control system since 1980. During the nineties of the last century, the area was affected by the Croatian War of Independence, which caused cessation of extensive grazing. The abandonment of land in combination with natural flooding caused the uncontrolled spreading of invasive plants, especially of Indigo bush (*Amorpha fruticosa*). The bush quickly formed dense thickets in former grasslands. Almost half of the large complexes of former communal pastures were completely or partly covered with invasive plants.

Lonjsko Polje Nature Park Public Institution, (LPNPPI) began to manage protected area in 1999 and soon started with eradication of Indigo bush. First actions were implemented by EECONET Action Fund and EuroNATUR donations within the Sava Wetlands–Spoonbill Colony Krapje Đol project. The first 50 ha were revitalised and Slavonian-Syrmian Grey cattle were introduced for grazing. During two LIFE projects – "*Towards Wise Use in Lonjsko Polje Nature Park, Croatia*" and "*Central Posavina–Wading Toward Integrated Basin Management*", implemented from 2001–2008, excellent cooperation with local community was developed. Almost 200 ha of overgrown pastures in Lonjsko and Mokro Polje were revitalised. In the next 10 years, LPNPPI actively cooperated with the EuroNATUR Foundation and "Croatian Waters" PE so that additional 100 ha were restored. Locations for revitalization were selected with local cattle breeders, so that grazing could be ensured.

Local communities substantially contributed to the success of this revitalisation. In the last five years they have, through their own funds, additionally restored another 300 ha. All these efforts also increased interest in protection and maintenance of traditional grazing. The number of cattle and horses in the area increased for 20 %. LPNPPI together with the Ministry of Agriculture found a solution for including large state-owned parcels into the subsidy system.

However, the revitalization process is not finished. LPNPPI mapped grasslands in 2019, in the framework of the Sava TIES project. 1,200 ha are still densely covered by Indigo bush, and another 4,000 ha have various alien species present and need to be revitalized in the future.

**Figure 14.** Areas, covered wit dense thicket of Indigo bush (*Amorpha fruticosa*), were first mulched and then grazing was reintroduced. Photo: Lonjsko Polje Nature Park Public Institution

Prepared by Alen Kiš

## Box 6. Common milkweed on levees along large lowland rivers

Common milkweed (*Asclepias syriaca*) is native to North America. As an ornamental and nectar-rich plant, it was favoured by beekeepers and was intentionally planted near settlements. It can spread vegetatively or by plumed seeds, which are adapted for wind dispersal.

The species prefer well-drained soils. Besides invading dry grasslands and forest-steppe habitats, Common milkweed also found favourable conditions on sun-exposed slopes of large levees along lowland rivers such as Danube, Sava and Tisa. The levees are well-drained, while the dyke structure extending over hundreds of kilometres is a perfect corridor for the spread of this invasive plant.
The levee along the Sava River is almost a century old. Traditionally it was maintained with a combination of mowing and grazing with sheep. This management practice enabled the survival of many native species (e. g. grasses, Autumn crocus (*Colchicum autumnale*)), which prefer open habitats and have almost disappeared when pastures were converted to either arable lands or forests. For some native species, the anthropogenic habitat on levees was their last refugium.

However, traditional management has changed. Nowadays, the flock grazing is limited to sites closer to villages, while water-management companies mow the levees, usually two to three times per during the growing season.

Repeated mowing is preventing Common milkweed from forming seeds and spread to distant areas. The plants, however, survive because of the irregular mowing regime, which is dependent on the water level at dykes. Experience shows that Common milkweed can be effectively controlled to prevent spread by at least three cuttings in the season, where the first one should take place just before it starts flowering. In other words, the timely implemented levee-mowing by water management companies is the best management practice for the control of milkweed on the levees. The dense grassland vegetation on the levee is best maintained when sheep flocks are seasonally grazing on it.

**Figure 15.** Common milkweed along Danube main levee, near Novi Sad (Serbia). Irregular mowing is favourable for dispersal of the invasive species. Photo: Alen Kiš

Prepared by Alen Kiš

## Box 7. Substitution of green ash on pedunculate oak habitats

Green ash (*Fraxinus pennsylvanica*) was intentionally introduced to Europe in 1783. It was planted in city parks, windbreaks and also in forest plantations. In the past 25 years, Green ash has successfully acclimatized and became one of the most rapidly spreading alien woody plants in Central Europe.

Green ash was also planted in some forests in the middle and lower course of the Sava River. Due to circumstances, Green ash did not reach the expected height or the timber quality, compared to the native Pedunculate oak (*Quercus robur*) or Narrow-leaved ash (*Fraxinus angustifolia*). The interest for its growing decreased, but the species started to spread spontaneously over the floodplain, especially in the recently regenerated forests. Green ash is also spreading in the southern part of the Bosut Forest, an ecologically important site in Serbia. There were few Green ash monocultures in the central parts of the old floodplain, protected by dyke. The alien trees could not express their invasive potential as they were surrounded by the old natural oak-ash-hornbeam forests with multi-layered canopy. Mature natural forests with dense canopy are known for their resilience to invasions. In such conditions, invasive species can survive on forest edges and are for decades slowly spreading into the forest undergrowth. However, when the forest reaches the rejuvenation period, the stands become more open and more light is available. In such a phase, Green ash can proliferate and expresses its full invasion potential.

The Bosut Forest and other seven strictly protected forest sites in Serbia are managed by the Public Forestry Enterprise "Vojvodinašume". During the development of the new forestry management plan for the new 10-year period, it was decided to terminate the growing of the invasive Green ash. Nature protection authorities and the forest managers found common ground for the gradual conversion of forests to the natural Pedunculate oak community. These are also ecologically and economically the most prominent tree species. After adapting management practice, Green ash is slowly losing the invasion potential in central parts of the enclosed forest complex. It is still present on the forest edges, where it is much easier to control.

**Figure 16.** The forest extraction roads are exposed to sunlight and function as corridor for invasive species and weeds, which would otherwise not be able to grow in the mature, dense-canopy forest. Photo: Alen Kiš

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