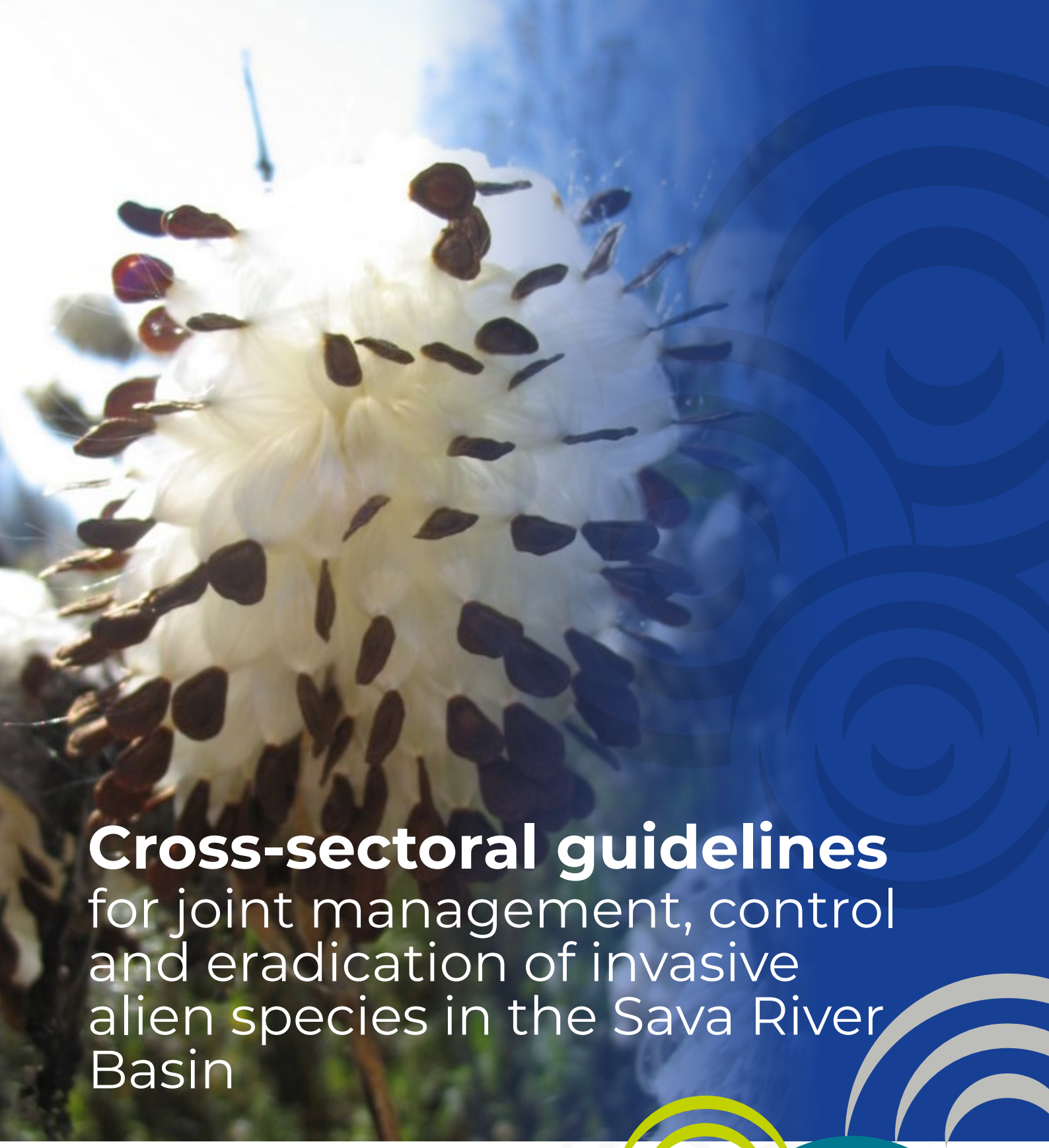

Cross-sectoral guidelines for joint management, control and eradication of invasive alien species in the Sava River Basin

Interreg
EUROPEAN UNION
Danube Transnational Programme
Sava TIES

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Contents

This project is co-funded by the European Union funds (ERDF, IPA)

List of Abbreviations

BMP	best management practices
BFW	Austrian Federal Research Centre for Forests, Natural Hazards and Landscape
IAS	invasive alien species
ILFE	Institute of Lowland Forestry and Environment
JRC EASIN	Joint Research Centre European Alien Species Information Network
PA	Protected area(s)
SRB	Sava River Basin

Remark:

This document is one of the outputs from the Sava TIES project, developed to jointly serve as the Strategical Framework for effective control of invasive plants in the Sava River Basin.

This project is co-funded by the European Union funds (ERDF, IPA)

Introduction

Less than 1% of the intentionally and unintentionally introduced alien species on global scale are considered invasive, which means that they have a negative impact on biodiversity and related ecosystem services, sometimes also affecting human health. When it comes to introduced plants, the percentage is significantly higher and recent studies are reporting about 25% of non-native plants as successful in taking consecutive steps of the invasion process.

Decades of modest presence and acclimatization may go along before they started spreading over lands or waters, competing with native species, affecting animal species which depends on domestic plants, changing landscapes, affecting the ecosystems with long term impacts on species diversity, human health and economies.

An introduced species which is spreading in uncontrolled manner always brings more troubles then benefits. To put it in a nutshell, when an alien species shows the tendency to distribute uncontrolled and massively, management measures shall be considered to protect the native species diversity and the associated ecosystem services.

Some people are benefiting from some of those invaders (like bee-keepers from some blooming plants, people collecting medicinal herbs among invasive species, rural households from 'self-regenerating' IAS woods).

There are thousands of domestic and imported plants which were introduced over centuries ago and do not behave invasive; proving that there must be some among them, which can meet our needs without causing harm to landscapes, human health or the economy.

Some IAS are even already anchored in their new environments and infiltrated into folk' songs and local cultures. Those can hardly be forced out from both culture and lands, but they still should be controlled from dispersing to places where people do not want to grow them, where these species interrupt natural ecosystems, exhaust soil beneath, destruct facilities or cause other damage. Therefore, we recommend to integrate local stakeholder and the public in the decision making process of IAS management.

Prevention of IAS introduction is the best way to avoid long term and often irreversible changes caused by them. When a species (just) starts spreading, there is the possibility to eradicate it by fast response. Therefore, prevention and early detection through awareness-raising campaigns and citizen science networks are the priority because established populations can be expensive to manage and difficult or impossible to eradicate. When this moment has passed, there are further control methods such as containment using strictly controlled conditions, applying different methods of suppression or a planned substitution with non-invasive species.

Scope and target audience

The primary focus of these guidelines is preventing the introduction and spread of invasive plants by addressing gaps and improving cross-sectoral matters in IAS management. Land use practices may have both positive and negative effects on IAS control. An overview of activities in protectted areas in the Sava River Basin, which are affected by invasive species, are presented in the Land Use Study (developed within this project as one of elements in the Strategic Framework for IAS management). The guidelines are emphasising cross-sectoral synergies and addressing the revealed gaps.

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Therefore, this manual does not focus on eradication methods or planning process, which are described in other Sava TIES products: The Review of BMP in IAS management and the Joint Pilot Report with Transferability Plan are other elements of the “puzzle deliverables” making the Strategic Framework this project was aiming to provide.

IAS-smart land management needs to be implemented in land use practices which are related to the spread and control of invasive species.

Implementing these recommendations, land use practitioners and protected area managers can identify and adapt tasks in their accustomed practice which eventually cause the spread of invasive plants.

The key understanding for successful IAS control is that each operation which includes management or transportation of biomass or soil, management of water, forest, wild game, tourism and other outdoor activities can be both in favour of IAS spreading or its control.

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1. The cross-sectoral and transnational character of IAS management

It is already well known that invasive plant species are easily spreading across different landscape types, infesting different land uses and landowning categories, both natural and man-made habitats such as forests, meadows, riverbanks, canals or hedgerows between arable plots. Floodplains and riverine habitats are particularly threatened by plant invasions. Part of the vegetation is very often destroyed by floods, creating available space and light for the newcomers. The deposited sediment provides free space and in most cases is rich in nutrients. Rivers are natural ecological corridors characterised by strip-shaped habitats facilitating the migrations of animals and spread of plants. The seasonal flood is at the best vectors of seeds, while a massive production of floating seeds is one of the key features of successful plant invasion.

The Sava River, with its tributaries, is recognized as a part of the blue heart of Europe and referred to as one of most preserved, transnational European river systems (Schwarz, 2016). The river is crossing EU and non-EU countries, which have different national policies and land management systems.

In a contemporary language IAS is referred to be "a *cross-cutting issue*" because they affect many sectors, both governmental and NGO, rising not only economic but also environmental, social and health issues. The problem of the IAS is differently addressed in the Sava River Basin countries. Some are already implementing international policies (EU strategy on IAS, EU *Regulation* 1143/2014, national action plans), which in the non-EU countries are in the transpositions. The development of a common, IAS-smart approach in land management practice as an answer to emerging plant invasions is essential.

In all of the considered Sava River Basin countries there are few examples where land users have recognized the threat from IAS and have implemented eradication activities, while protected area managers in all countries were more proactive in IAS eradication.

Invasive alien species have become a serious threat to the productivity of forests and plantations, also affecting water supply, flood risk management, crop production, nature-based tourism and many others. These guidelines are focused on the land use practices, as pragmatic approach to develop capacities of land users to eradicate or contain IAS.

Land management practices in agriculture, water management, forestry, tourism and beekeeping are the most common land use types in protected areas and environmentally important sites in the Sava River Basin, related to spreading or controlling of invasive plants along the ecological corridors. These may also have common interest considering one IAS species and totally divergent in another.

Previous project deliverables (reviews, risk assessments, studies, reports, manuals and applications) make a sort of "toolbox" for IAS mapping and eradication. In the *Review of the BMP* the meaning of "invasiveness" was described and distinguished methods for the eradication of key IAS plants were presented. The *Mapping and Monitoring Protocol* gave instructions and examples on methods in mapping IAS species adjusted to the scale of mapping. In the *Risk Assessment Study,* the selected invasive species were systematically assessed for the risk of spreading, while actual and historical land use changes along

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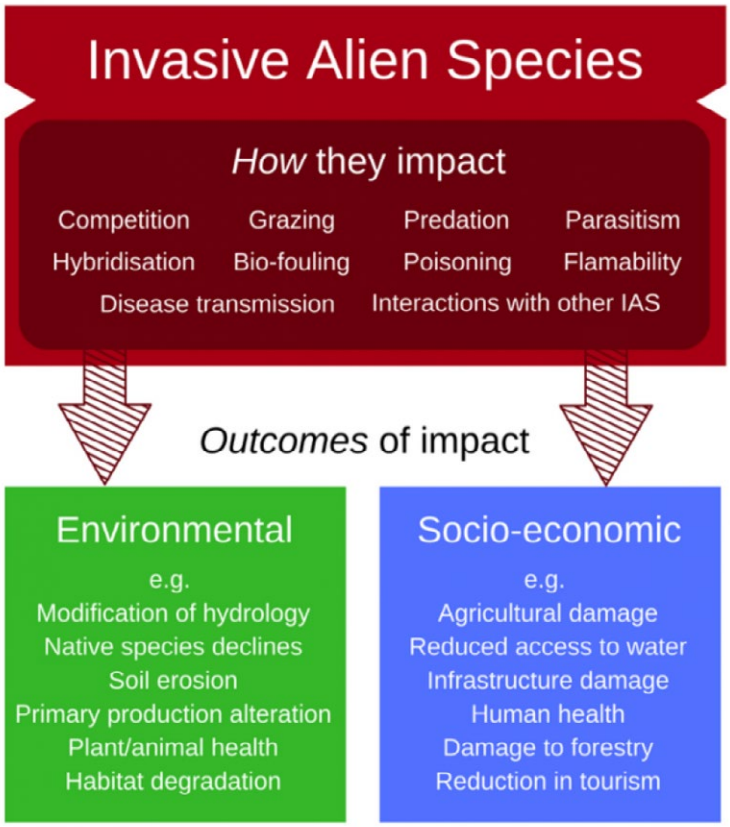

Figure 1: Issues Briefs/Invasive alien species and sustainable development

(Source: https://www.iucn.org/)

ecological corridors in the Sava River Basin have been analysed to reveal the drivers of spreading of IAS in protected areas and ecological networks within the corridors. Planning and eradication activities that have been piloted on 7 protected areas in the Sava Basin for the project targets are presented and explained in the Joint Pilot Report with Transferability Plan. Spatial analysis of cadastral parcels in the context of type of ownership gave a clear example how a very complex tenure structure in protected areas can hinder the implementation of legislation for IAS management.

All of those deliverables including these guidelines have been jointly delivered by the Sava TIES project partners and were tailored for the Sava River Basin, thus making it the *Strategic Framework for IAS Management in the SRB*.

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A transnational cross-cutting challenge

Both the causes and consequences of alien species introductions are **transnational** in character, and calling for a **cross-sectoral** approach. These two are the prerequisites for effective IAS management in case the target area is a transnational river corridor.

We must stay alert of risk when introducing species:

The introduced species may not become invasive at the moment of introduction. A period of newcomer species adapting to the new environment may last for decades or even longer, while the species from just surviving and occasionally regenerating, passes through the phase of becoming 'naturalized' (established self-sustaining populations) or even a full-potent invader which is spreading and supressing native species within their natural habitats.

IAS in Sava River Basin:

The Sava River with tributaries runs through countries of different legal systems, practicing different land use and different policies for the same invasive species and associated environmental and economic challenges.

Land use changes on the landscape level significantly tribute to the introduction and spreading of IAS.

IAS species which PA managers jointly listed as the key invasive plants in the Sava River Basin are given in the Annex 1

2 Landscape history and IAS - results of Land cover change survey

2.1. Changes in traditional land use practices during the last 150 years

The land use analyses undertaken in this project (ILFE, 2020) considered that extensive agriculture was the dominant land use type in the river valleys and lowland areas of Sava basin. Domestic animals were bred not only for food, but as a source of energy, too. The terrestrial transport was based on the use of draft horses and oxen. Animal power had been used for ploughing and threshing grains, for milling, logging and land excavation. To secure fodder for draught animals, not only grasslands, but also forests and wetlands were included into complex grazing systems, always adapted for local conditions and maintained during the centuries. In the early period of industrialisation, even the road edges and canal banks were rented by poor rural families and used

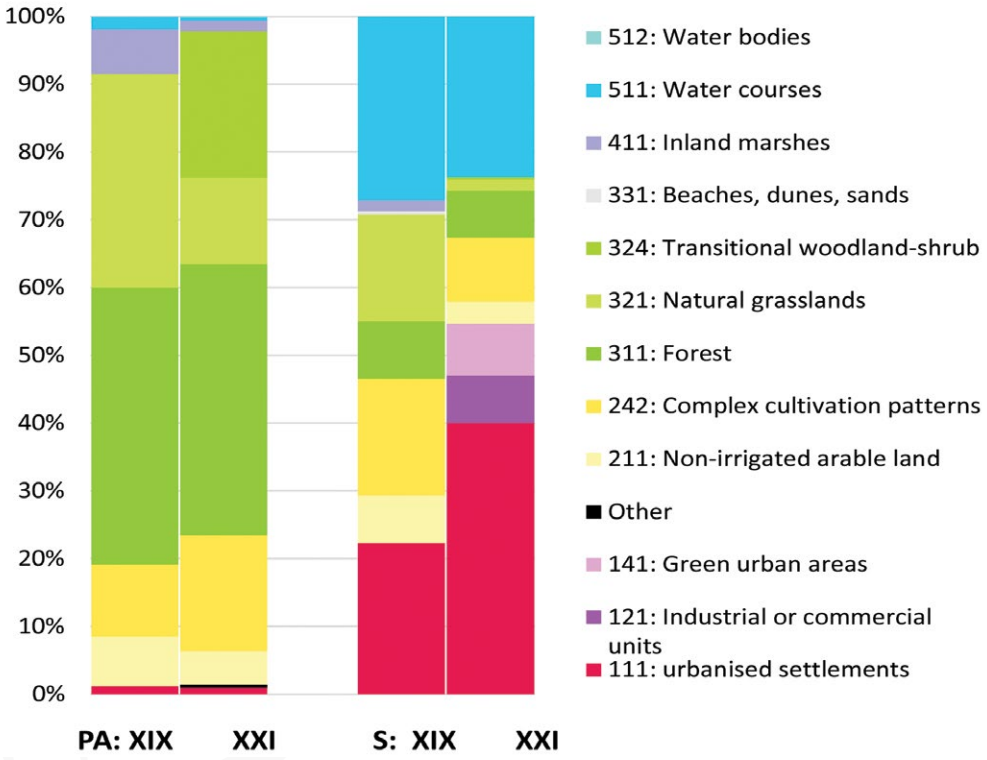

Figure 2: The land use changes from 19 to 21 century on protected areas (PA) and within the sampled floodplain sections (S).

(Source: Land Use Study in SRB, ILFE 2020)

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for haymaking. Afforestation or spontaneous forest regeneration were possible only on the plots protected by grazing animals. Traditional grazing methods have been focused on the preservation of habitat productivity, but unintentionally have also maintained high levels of biodiversity and prevented (or slowed down) plant invasions.

These land use practices were abandoned in the last quarter of the XX century and replaced by modern methods in agriculture and forestry, and by planned maintenance of common green surfaces - always depending on the available budget. Mowing roads and rail edges or clearing shrubs along canals and in poplar plantations have became activities demanding extra resources and reducing the profitability. This crucial change in agricultural practices has resulted in the rapid extension of abandoned land surfaces, enlarged with a rising number of small plots left fallow by owners getting too old to cultivate them. The ongoing modernisation in agriculture and global economic changes cut off the number of farmers willing to continue the traditional breeding of animals on pastures or in forests. Furthermore, forest grazing has been banned in many countries in favour of the intensification of wood production and it is ever declining even in the countries where it is still allowed.

The most important change in lowland forestry is the shift toward the production of fast-growing monocultures, mainly poplars on the floodplains. Poplar plantations have become the most productive and thus economically most important softwoods. In hardwood riparian forests pedunculate oak is not only the most economically valuable, but also edificatory species of most forest communities. In response, the forestry sector has paid special attention to silviculture of pedunculate oak and the species has become dominant in many forest compartments. By the silvicultural measures species that naturally form lower forest layers and shading the forest soil, have been diminished in many forest compartments (maples, hornbeam, pear and apple). It is known that invasive species have the ability to fill those gaps faster than native ones.

Figure 3: Single-layered poplar plantation, understory overgrown in false indigo (*Amorpha fruticosa*)

2.2. New landscape elements facilitating plant invasions

The developing road and rail network and the growing number of commercial areas have created new landscape corridors for the transport of material goods that also become pathways for the spread of the IAS: Alien species usually arrive with transported goods and establish their populations in the green belts along roads and railways. Poorly maintained vegetation of infrastructural networks provide ecological corridors for invasive plants. The well-documented spread of ragweed (*Ambrosia artemisiifolia)* in the region proves the importance of these pathways.

Certain forms of urban and suburban green areas within the Sava floodplain are also characterised by the low level of maintenance. Beside the ill-kept green surfaces of industrial sites, some amenity areas (small suburban parks, gardens of weekend houses, abandoned plots) also enable the establishment and spread of invasive species, often imported and planted as ornamental plants in the gardens.

The land use changes were analysed in protected areas and on the sampled floodplain sections (The Land Use Study in SRB – component "Land use change maps")

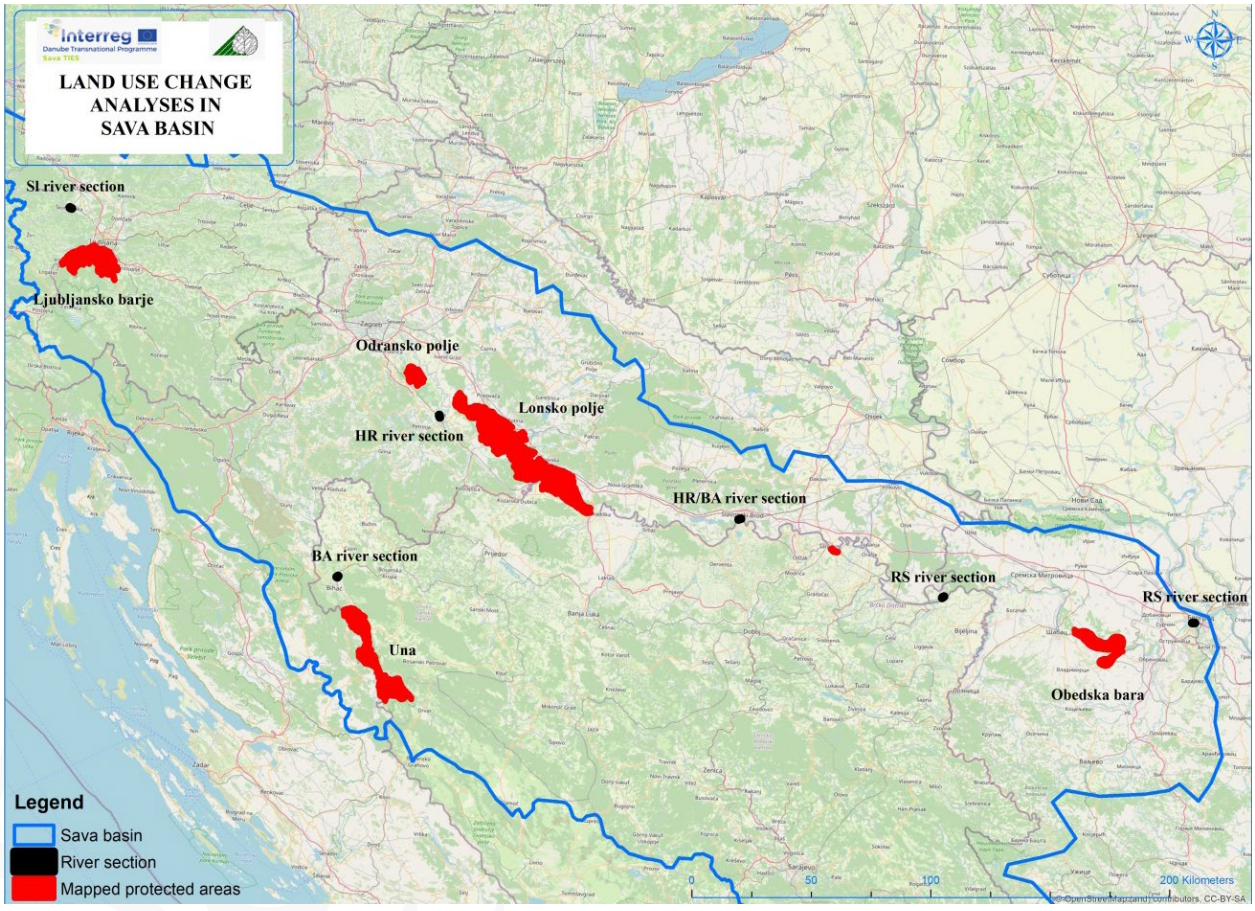

Figure 4: selected areas where land use changes were analysed between 19 and 21 century

3 Gaps in the land use practices

Analysis of actual land use practices in protected areas and different habitats along ecological corridors in Sava River Basin is the key to recognizing pathways by which invasive species are introduced, how they are spreading or effectively managed in everyday land use practices.

For the Sava TIES project such an analysis was developed on questionnaire that involved answers from land users in protected areas in four Sava River Basin countries, and revealed the gaps and potential synergies for effective IAS management. The analyses considered land use management operations which can promote or prevent IAS introduction and/or spreading such as:

- mowing and grazing,
- mulching,
- spraying herbicides,
- afforestation and forest regeneration,
- soil excavation/transportation.

Data on IAS management (whether the stakeholders consider IAS in management planning) were gathered, too. The analyses proved many gaps but also identified possible ways for cooperation.

Based on the answers to the question as to whether the land users check the presence of invasive species on their lands (figure 5) and activities of those who do not (figure 6), it can be concluded that there is a high risk of unintentional spreading of invasive plants.

The risk is not proportional to the percentage of land users who think of invasive species, because IAS need only "one open door" for invasion, not all.

The most common pathways of for the IAS introduction and its spreading are infested soil, hay or other winter fodder for game management, or the mowing the green areas at sites of importance for tourism and transporting biomass to other sites.

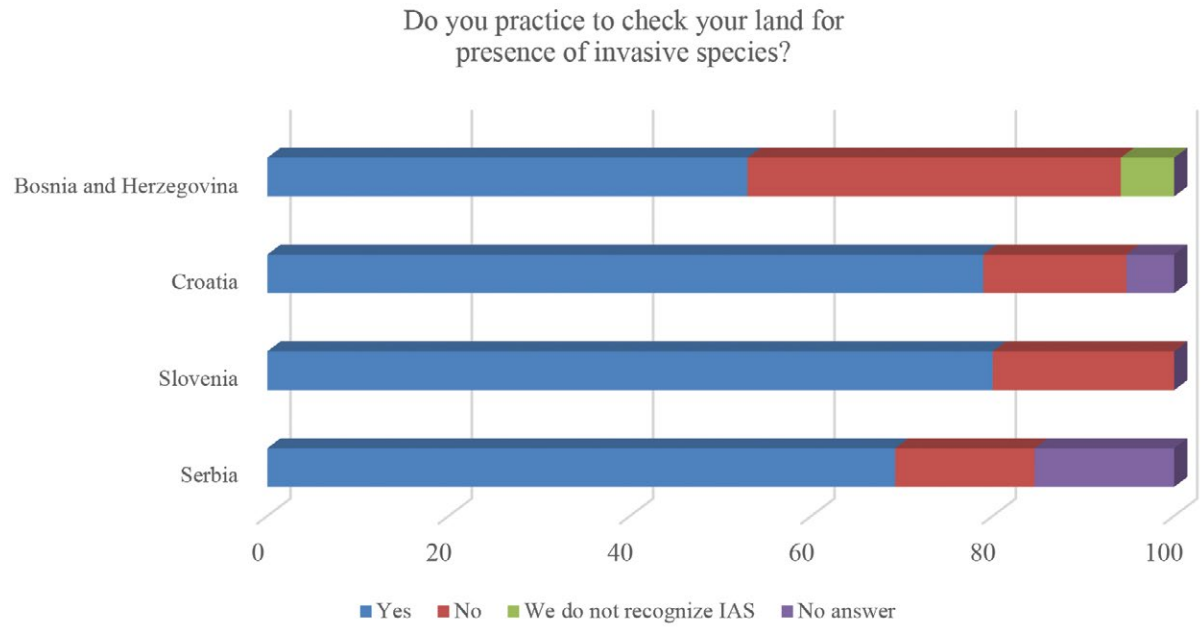

Figure 5: Information about if land managers are checking the IAS presence

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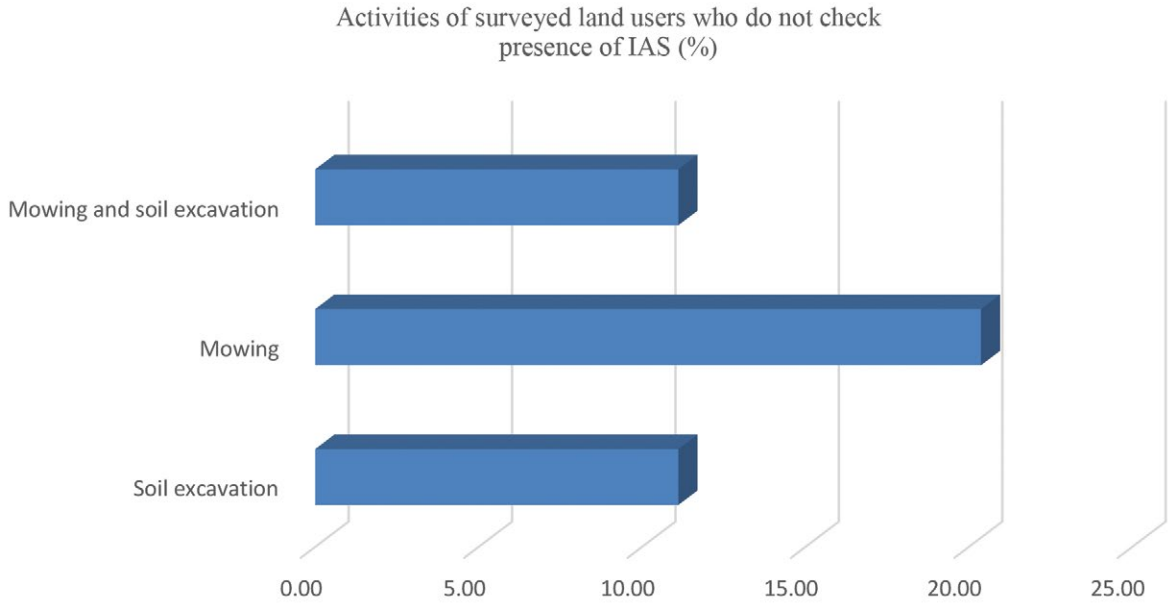

Figure 6: Activities of the land users who do not check for the presence of IAS on their property

According to the previously cited data, the number of users who have and do not have a plan for land management is equal, and among those who have a plan about half are considering possible damage from invasive species.

It is known that invasive species can certainly increase direct and indirect costs in land management. The lack of recognizing damage (figure: 7) indicates the likelihood that existing damage is not acknowledged. In such circumstances the users do not give importance to preventing the spread of invasive species.

The IAS is spread in circumstances when land managers do not check the presence of invasive plants is happening when a user transports soil, fodder, cut biomass, since often many of these materials contain seeds and other viable propagules (Figure 8).

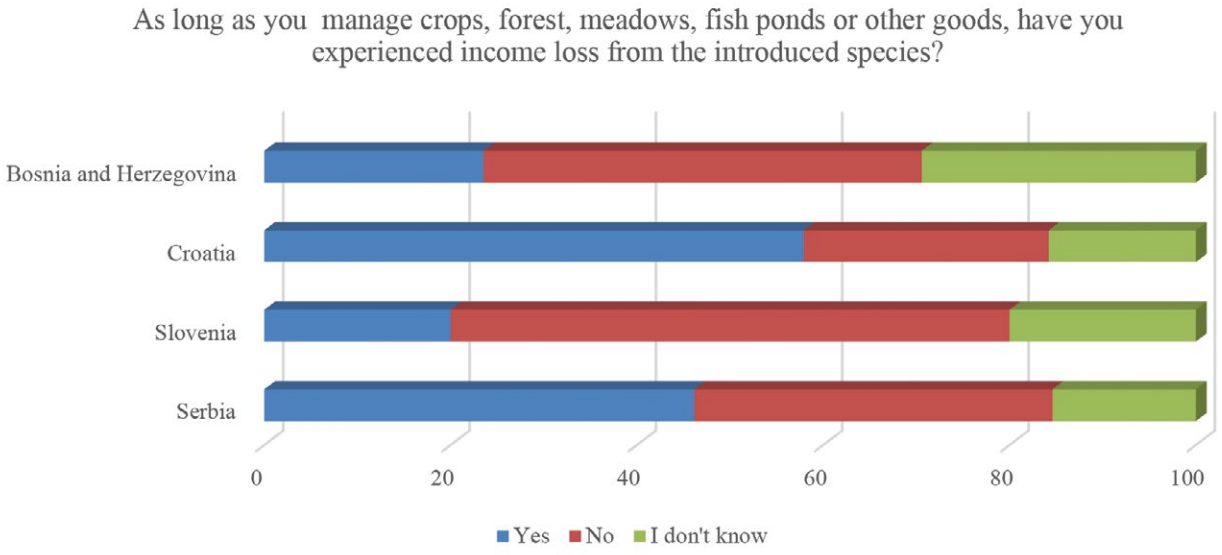

Figure 7: Recognizing income losses from the IAS - although the invasive species are present, people hardly recognize the associated losses.

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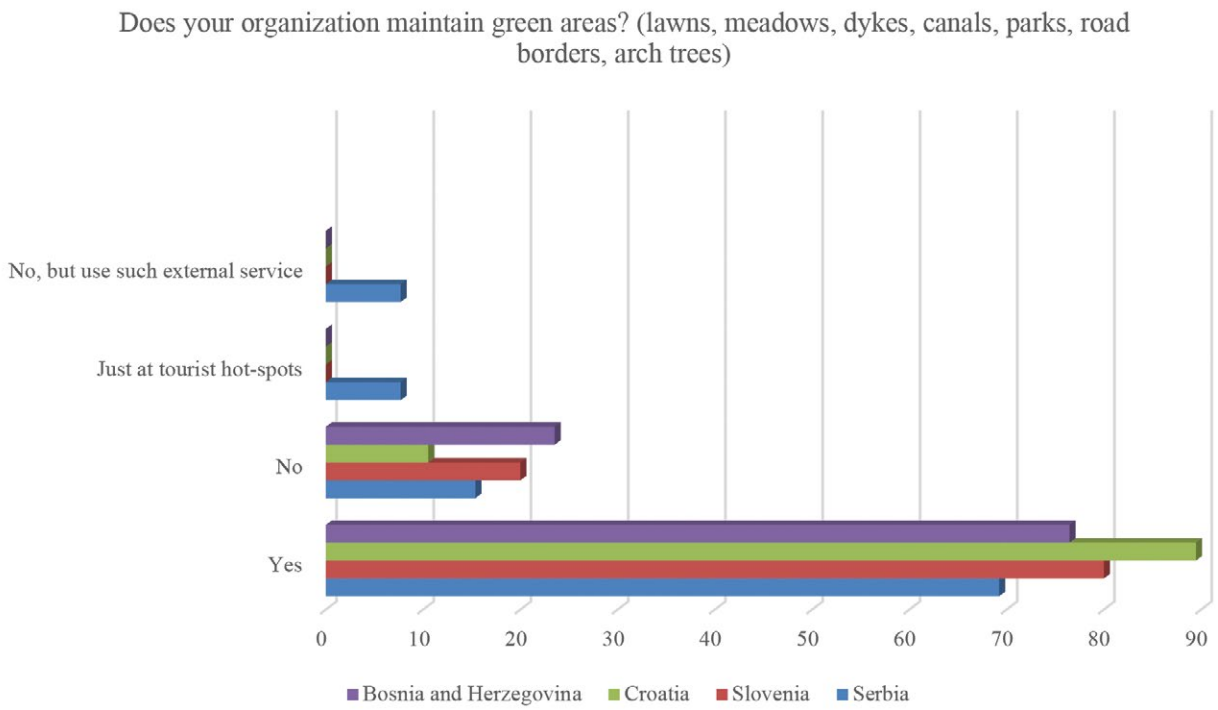

Figure 8: Maintaining green areas – an activity which can result in the different impact on the presence and spread of the IAS

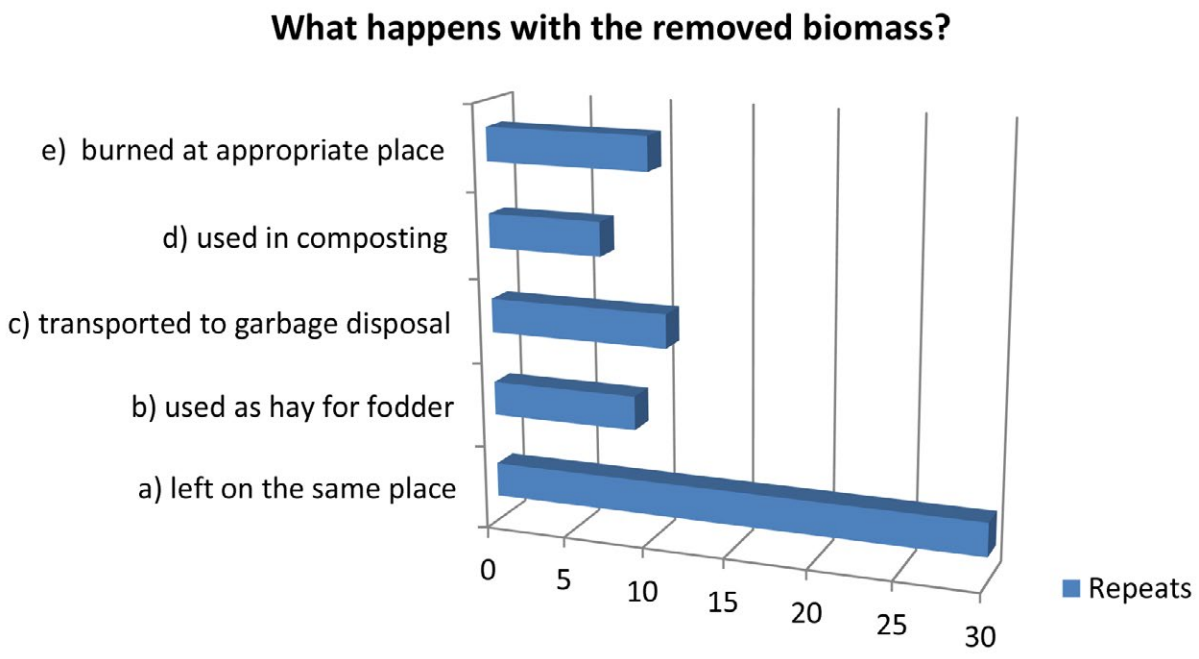

Figure 9: The IAS can be unintentionally dispersed by the removing biomass

The reproductive parts of IAS in biomass are not devitalised, which happens in situations when they are used for hay, composting, or when biomass is left in place or transported to garbage deposits. Burning is not suggested for fire risks and emission of carbon dioxide. Biomass used as composts also increases the risk of spreading IAS seeds and propagules, and it should not be used near natural corridors or sensitive habitats.

Another big gap revealed is that less than half of the surveyed land users have recognized any

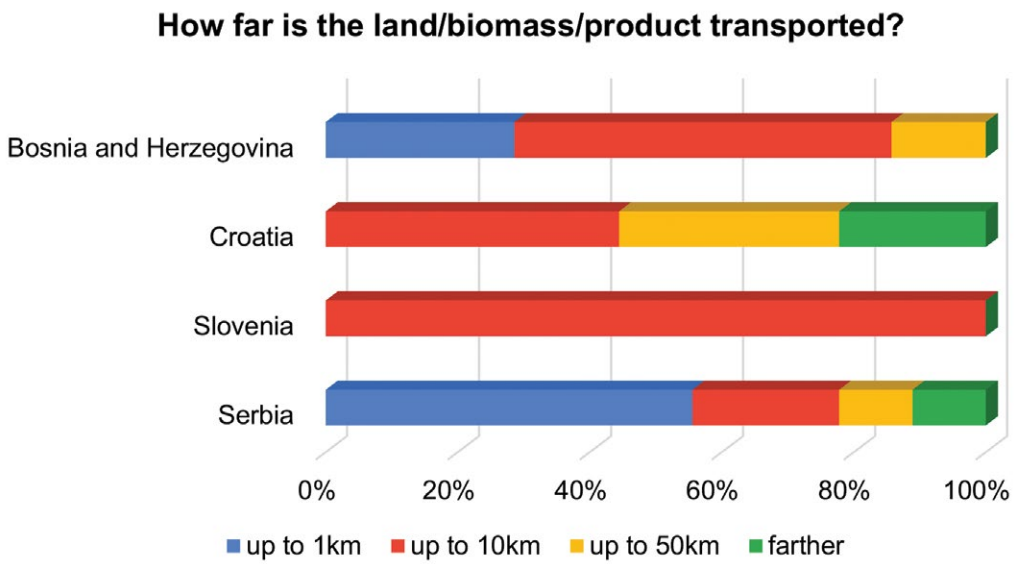

Figure 10: The further biomass is transported, the more important are safety measures

type of the loss of income and only a few of many common invasive species (the highest-ranked IAS species recognized by the negative impact on economies were *Amorpha fruticosa* and *Ambrosia artemisiifolia*).

Some species which are present in the Sava River floodplains (e.g. *F. pennsylvanica, Acer negundo, Solidago sp.*) were identified as low-ranking in the list of damage-causing by land users, which is not in line with their competitiveness to autochthonous species and impact. Partially this can be explained, because some of those are not equally spread in the countries (*Impatiens sp, Reynoutria sp.* are mostly present in the upper and mid-section of the Sava River, while *F. pennsylvanica* is in the lower river section). Some species are harmful but not detrimental to forest development (*Solidago sp.*) and those are not recognized to be "damaging" by the forest managers.

In addition to the above-listed, and taking into consideration all sectors and stakeholders, each of them has some specific land use activities which increase the risk of introduction and spreading of invasive species, but there are also many existing and potential synergies, that will be analysed in further chapters.

3.1. Invasive plants and key land use types in SRB

Forest management in the area

The state-owned forests in the Sava River Basin are managed by public companies, whereas physical persons are responsible for private forests. The first are forming larger management units, the latter are consisting of numerous woodlots. The more owners, the more heterogeneous are management objectives and forest composition.

Small forest parcels under private ownership (usually less than 1 ha) are forming a mosaic with other land use types (meadows, arable lands) and increase forest fragmentation, which is known to enhance plant invasions.

All forests can be grouped into upland forests (outside the rivers floodplains) and lowland forests (along rivers). The forest habitats have been

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converted to other land use types to a large extent, while a majority of forests remained in the active floodplains and other seasonally waterlogged areas.

Generally speaking, management practice in lowland forests usually group forest cover into hardwoods (oak, ash, hornbeam) and softwoods (poplars, willows, alder), while for upland forests "softwood" refers to conifer tree species (spruce, pines, fir). The most common species in upland forests in the Sava River Basin are beech and oaks.

Considering the exposure and susceptibility of forest cover to invasive species, it is essential to stress that forest of heliophilous species (poplars, pedunculate oak) in floodplains are the most susceptible to plant invasions, while forest consisting of sciophilous (shade-tolerant) species like beech or spruce are making strong shade over soil, which is unfavourable for the majority of invasive plants.

Forest habitats along rivers are exposed to higher risk of invasive species due to floods as the seed vector and disturbance causing the semi-open character of the riverine habitat mosaics. On wetlands, forest are mixed with transition vegetation on marshes and rivers, where the forest canopy is naturally lighter and sunlight always reaches some parts of soils. These spots on forest edges are particularly susceptible to IAS if not covered by natural, dense grassland or tall-herb vegetation.

Hardwood forest is the dominant forest category on Sava lowlands (Schwarz, 2016). In the hardwood lowland forests, the pedunculate oak is the most common edificatory species. A basic principles of pedunculate oak cultivation can be pictorially presented in a century old saying: "The root in moisture, the trunk in shade and the crown in light". In rejuvenation phase particularly, oak (saplings) need full exposure to sunlight, which demands removal of complete forest understory and thus make entrance to invasive species. Invasive species use the open space more efficiently and colonize the area. In the sprout development phase, selective cutting of the competitive species can slow down but unfortunately not enough to eradicate the invasive plants from forest stands. Formed young stands of the forest

Figure 11: Frequent thinning combined by salvage cutting makes entrance to IAS

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communities undergo natural differentiation and selection, in which edificatory species of the native forest community, due to altered habitats (river trainings, drainage), often open the path for faster-growing species or wider ecological valence in given circumstances, which is typical to invasive species. The silviculture measures prevent the IAS to enter the higher canopy layer but these are still reproducing in lower layers, while floods, canals and wind spread the seeds.

Forests with multi-layered, dense forest canopies are known to have a good resistance to new coming species. Frequent and light thinning are usual practice in valuable hardwoods, to collect devitalised trees and promote growth of the economically most prominent ones. Whenever machines (harvesters, tractors) comes into a forest, the soil and understory are disturbed along the vehicles paths, while the openings of the upper canopy caused by thinning is beneficial for all seeds and propagules brought on the machinery pneumatics. Together these make favourable conditions for fast-growing invasive species.

Preservation of biological diversity, and implementation of the existing goals in hardwood forest management (high timber quality) determined by the forest management plans, mainly overlap. This coincidence is due to the fact that - the preservation of the habitat type of pedunculate oak forest would mean not only the protection of the rare of oak-specialized protected species, but at the same time would maintain the forest production potential, too.

Lowland softwoods (mainly willows, poplars and alder) are on the second when considering both the coverage and economic importance in forestry. Poplar plantations are the typical and most common intensively managed softwoods. In the planting (rejuvenation) phase by soil preparation (ploughing, mulching), all vegetation is removed, thus creating a biologically „open“ space with no resistance to colonisation of invasive species.

The mechanical weed control, such as mowing or hand pulling, of undesirable species is irregular (once a year in the first half of the rotation period) which enables the establishment and reproduction of fast-growing IAS. Throughout development, the plantations have a simplified structure (one tree layer), enabling light to reach the forest soil and thus favouring the invasive species which are typical in forest (*Fraxinnus pennsylvanica, Acer negundo*) and open lands (*Solidago sp, Conyza canadensis, Bidens tripartitus, Impatiens sp.*, *Amorpha fruticosa*, etc).

Forest roads and canal networks penetrating into inner, non-disturbed areas are new, suitable corridors for invasive plants. Due to sun exposure and pneumatics which are accidentally transport seeds, management (mowing, trimming) of road corridors are particularly important on main (wide) forest roads.

Figure 12: The edge between a natural forest and arable lands is the entrance to IAS and weeds

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Synergies in forest management

In lowland habitats many invasive plants species proved to be aggressive and competitive with key native species which are also economically more important, such as pedunculate oak (*Quercus robur*) and narrow-leaved ash (*Fraxinus angustifolia*). These invaders survive under shade and in forest edges, present in the undergrowth of native lowland forests, waiting for the moment of forest regeneration (spontaneous after natural hazards like storm-brakes or after ended rotation in forestry) to express their full invading potential. Invasive species like green ash (*Fraxinus pennsylvanica*) and box elder (*Acer negundo*) are present mostly at lower sections of Sava River, while knotweeds (*Reynotria* sp.) and Himalayan balsam (*Impatiens glandulifera*) are present mostly upstream. These are just a few of those that are causing damages both to forest biodiversity and which may increase costs in forest management, particularly for the rejuvenation period.

Safeguarding forest regeneration

Alien plant invasions impact natural and artificial regeneration in direct or indirect ways. Aside from browsing, however, different phases of the regeneration process are reportedly also affected by above-ground and below-ground competition between tree seedlings and invasive plant species of the understory herbaceous vegetation cover. The negative effect of IAS on the regeneration of native tree species can be mitigated at an early stage as well as supporting the establishment of an early warning system.

Adaptation in forest management

Recommendations concerning the adaptation of silvicultural measures include preventive actions such as the recommendation to plant native tree species. Furthermore, continuous tree cover and longer rotation periods are recommended where appropriate to promote shadier conditions. Soil preparation of clear-cuttings should also be avoided especially when the area is regularly flooded, because the propagules of invasive alien species can easily be transported by water to the agitated soil, where they can also find sufficient light for germination and growth. Frequent and slight thinning of forest areas should be avoided to reduce the risk of management disturbances that may function as pathways for the introduction of alien plant species into the forest. Forest edges should be preserved because a dense, multilayer canopy can prevent or slow down the entrance of invasive species from their surroundings. Regular mowing of corridors along forest roads is an effective management option for this pathway. Finally, alternative cutting regimes to simple clearcutting, such as the selection or shelter wood systems applied in close-to-nature silviculture, should be preferred.

Restoration of damaged ecosystems

The long-term resilience of riparian forests can be improved by carrying out appropriate restoration measures to assist the recovery of an ecosystem that has been degraded, damaged, or destroyed by invasive alien plants (D'Antonio & Chambers, 2006) or other invasive organisms (for example insects or fungi). The costs of any control measures could be high and disproportionate to the benefits of restoration (EU-Regulation, 2014). However, in some cases traditional land use practices such as forest grazing can be a cost-effective tool for restoration.

Implementing traditional grazing systems for habitat management

Grazing is often recommended as a biological measure for the suppression of invasive plants. Effects of grazing, browsing, pasturing on the IAS depends on the habitat type and grazing animals.

Marshes and bogs are usually free from wooden and most vascular invasive plants. In the case of initial succession (due to changes in hydrological regime), those habitats can be effectively

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managed by cattle (domestic bovines or water buffalo and pigs).

Grazing by cattle on wet meadows can successfully control invasions of wooden species, but it must be considered that overgrazing and opening of bare soils are favorable for spreading of herbaceous invasive species containing toxins or other chemicals protecting them from grazing animals.

Browsing on forest understory may be useful against invasive species within the shrub layer of floodplain plantations and native softwood forests. Cattle regularly browse leaves and young branches of both, domestic and invasive plants.

Traditional pig farming in forests (grazing and pannage) has different impact on forest vegetation. By uprooting, pigs usually cause the higher forest understory to become more "patchy", by opening in the shrub layer. In the cases of heavy grazing and uprooting, pigs can significantly reduce wooden vegetation and tall herbaceous communities, whereas in the riparian forests this could lead to creation of specific types of wetland habitats.

A well-planned and spatial-temporal harmonised pasture with conservation targets and silvicultural treatments is needed for the optimal effect. Based on management experience, forest managers usually allow grazing in poplar cultures after these exceed age of 7 years, while in the hardwood oak forests grazing shouldn't be allowed before age of 30.

Agricultural practice

Considering agriculture, including small-scale gardening and grassland management, it is one of the most prominent area for invasive species control. The land managing periods are more frequent and management usually more intensive comparing to other land use types. At the same time, it opens more paths for IAS introduction and dispersal, but most land management operations can be useful in IAS control.

Figure 13: Traditional pig farming in Bosut Forest. Photo: Abel Molnar

Regular tillage on vast arable plots is a practice which prevents perennial invasive plants from becoming established, but some usually remain at the edges of arable plots. When these invaded spots are near rivers, canals or other suitable landscape corridors, the invasive species easily distributes along.

Small-scale gardening is also an important source of invasive species. Citizens often practice tending of small land-lots in periurban areas, sometimes for growing vegetables, sometimes just for enjoying the landscapes. A usual practice in such cases is planting ornamental species. The practice proved to be one of the biggest source of so-called ornamental invasive species like *Impatiens glandulifera, Solidago serotina or Reynoutria species*. Weekend houses are often near rivers (preferring cosy environment), where IAS easily escape from gardens and spread along the river corridors.

Grassland management (mowing, haymaking and grazing) in general include activities suitable to control the invasive plants, but some inadequate land use practices result in adverse effects. Most of the grasslands in the Sava RiverBasin belong to species-rich secondary habitats evolved from forests or forest-steppe vegetation. The closed structure and high level of organisation of these grassland communities is resistant to plant invasions, but one of the important drivers of the vegetation dynamic is the regular removal of biomass by grazing or mowing.

Lack of grazing or mowing will trigger the succession toward the original forest or forest steppe vegetation. As the growth of bushes and trees on grasslands depend on the available seeds, most of the abandoned pastures and meadows become overgrown by invasive species. Overgrazing or other activities creating open soil surfaces on the grasslands enhance the invasions of herbaceous plants, as goldenrods (*Solidago sp.*) and common milkweed (*Asclepias syryaca*). The established plants could survive long periods of grazing or regular mowing, waiting for the abandonment of meadows or for lower grazing pressure when they are able to develop their populations with astonishing rapidity. The control of IAS on infested pastures requires an additional mowing of the invaded patches.

Beekeeping was also known for spreading honey-producing species. Some of those are also ornamental, some were introduced for preventing erosion, but later found anchorage in honey production, like the common milkweed (*Asclepias syriaca*) and false indigo (*Amorpha fruticosa*). Although representing an economic value in certain aspect, when spread over lands these are causing loss of species-rich meadows, which are far more beneficial to the bees and other pollinators important in agricultural production.

Green infrastructure of agricultural areas

Shelterbelts or windbreaks

Shelterbelts composed of trees and shrubs, beside their benefits, also provide habitats and corridors for invasive plants. Beside their numerous benefits, shelterbelts also provide habitats and corridors for invasive plants. The highly mechanised contemporary cultivation systems don't ensure an efficient maintenance of these vegetation strips. The control of invasive plants almost in all cases needs a manual work, particularly in multi-layer vegetation strips composed from trees and shrubs, when the invasive species grow among the planted species.

Drainage ditches, especially when their maintenance doesn`t include regular mowing, very often become overgrown with invasive species. Most of the ditches and small ameliorative canals in the region are maintained by mechanical dredging carried out every 5-15 years when the whole vegetation cover is removed. During the periods between dredging most of the canals lack any forms of maintenance. The bare surfaces created by dredging offer an optimal habitat for invasive species, converting these important landscape elements into invasion pathways.

This project is co-funded by the European Union funds (ERDF, IPA)

Synergies in agriculture

The above land use examples can be implemented in "IAS smart" way, without much effort. Among others, those are: mowing, trimming hedgerows or seeding perennial cultures which are resistant to weeds and IAS (such as lucerne or hedges of mixed flowering seeds). Simply by repetitive visiting their lands, the owner has good insight into any changes at their own land including the arrival of 'new weeds', as farmers often refer to IAS.

Synergies can be found in spatial optimisation for growing cereal crops and biomass for fodder, maintaining hedgerows and strips of grassland toward rivers and canals, where pollinating insects live, and by tending agricultural plants bringing benefits back to the farmers.

The applying of traditional land use practices in habitat management (grazing, hay-making, reed harvesting, pollarding etc.) could provide job opportunities for local communities, increasing the diversity of economic activities in rural areas in accordance with the aims of rural development.

Water management

In the water sector, types of activities that include the removal of invasive species (mowing, chemical treatment, cutting) and other activities listed in the manual "Review of best practices in IAS management", can be classified as maintenance measures. These measures depend on terrain morphology (different channel morphology in lowland and upland regions), on land use types of surrounding areas and on the available equipment.

For the needs of activities of the canal network maintenance works, project technical documentation is prepared. In this documentation, the reason for undertaking maintenance works are "overgrowing of canal land and canal profile with diverse vegetation (reeds, weeds, shrubs and trees of different diameters)" that negatively affects flow, and the need for "clearing and cutting vegetation " that provides the passage of mechanization that works on siltation.

For the above reasons, the following activities are performed:

- Clearing the terrain of bushes and plants with an excavator and a mulcher;
- Mechanised reed-cutting and mowing of marsh vegetation with a tractor equipped with a specialised mower;
- Removal of aquatic vegetation of the coastal belt and slopes of watercourses with an excavator with a basket for taking out vegetation;
- Cutting trees with a chainsaw with pruning branches and setting aside;
- Manual cutting of sprouts and false-indigo (*Amorpha fruticosa*) bushes;
- Clearing the terrain of weeds and shrubs by bulldozer;
- Control of vegetation by chemicals after removal of plant and aquatic vegetation;
- Other activities in maintaining the water-lands and infrastructure in water management.

These activities are carried out regularly only at dykes and canals of higher importance, while on most others just once in several years. On some remote canals bush and tree species are removed in periods of ten years, when the timber can be used as firewood. IAS capability to recolonize the open soil surfaces of cleaned banks minimizes the effects of IAS removal. The practice is effective only if banks of water bodies are regularly maintained. It must also be considered that the usage of herbicides near the water bodies is not treated in the same way and same restrictions in the EU and the non-EU countries.

These measures are defined by legislation (Law on waters or connected bylaws) as "maintenance of water land necessary for the regular use of water facilities" which are an integral part of the management of publicly owned water land. The maintenance measures are most often carried out by companies to which public water management companies assign part of the entrusted tasks on the basis of tenders and annual contracts. Most of the maintenance activities are planned regardless of the vegetation dynamics. The creation of

Figure 14: Dredging of the ameliorative canal. The grass strips of canal banks are permanently covered by silt, creating an open surface rich in nutritive materials.

bare surfaces (picture 14), neglecting the possibilities to speed up the spontaneous regeneration of grassland strips and the lack of regular mowing all enhance the spread of invasive species.

The legislation also prescribes prohibition measures to preserve and maintain water bodies and water facilities, prevent the deterioration of the water regime, ensure the passage of high waters and implement flood protection, as well as environmental protection. There is an example from Serbian water policy, where prohibited activities are listed (in Box 1) by the Article 133 of the Law on Waters ("Official Gazette of RS", No. 30/2010, 93/2012, 101/2016, 95/2018 and 95/2018 - other law). One can single out those that are in accordance with the methods of removal of invasive species and those that direct or limit certain activities depending on the type of water body.

Box 1: Example from Serbian water policy: List of prohibited activities in water sector that are related to measures in IAS management.

It is forbidden to graze large cattle, pull cut trees, cross and drive a motor vehicle on embankments and other water facilities, except in places where it is allowed and perform other actions that may endanger the stability of these facilities.

It is forbidden to store wood and other solid material on water land in a way that disturbs the conditions for the passage of high waters, washing vehicles and other machines. It is not prohibited to implement measures for the preservation, improvement and presentation of natural values on water land, as well as to take actions to protect people, animals and property.

In the flood area, it is forbidden to plant trees on the embankment for flood protection, in the inundation zone, in the with of at least 10 m between the bottom of the embankment and the watercourse.

It is forbidden to plant trees, plough or dig the ground and perform other actions that disrupt the function or stability of drainage canals and take actions that interfere with the regular maintenance of these canals in belts that are at least 5 m away from the banks of these canals.

It is forbidden to dispose of solid waste and other materials in watercourses, reservoirs, retentions, amelioration and other canals, to introduce polluted waters or other substances and perform actions that may damage the riverbed and banks, affect the change of its route, water levels, quantity and water quality, endanger the stability of protective and other water facilities or make it difficult to maintain the water system.

Considering the above activities, it can be concluded that most of the measures for the maintenance of water bodies by water management, contribute to the measures recommended for the control of growth, reproduction and spread of invasive plant species.

The disadvantage is that invasive species are not recognized as a specific problem in the water management sector. For example, invasive species are only mentioned in the Water Management Strategy on the territory of the Republic of Serbia until 2034 (“Official Gazette of RS”, No. 3/17). However, in this planning document, the term of invasive species is used in the chapter that assesses the current state of water management, a sub-chapter on natural factors and biodiversity, but it is not used in other parts of the document, either when it comes to the prescribed measures or priority activities.

Synergies in water management

River corridors in the Sava Basin are of the highest habitat-connectivity importance. Although not always exactly denoted in national water policies, in both EU and non-EU countries there are possibilities to integrate practices in water management and nature protection.

Flood risk mitigations can be related to IAS management. Contrary to the mountain areas, where the forest cover with dense understory is the best solution to prevent soil erosion , in floodplain lowlands invasive dense thickets of tall invasive plants (wooden and herbaceous) reduce the “permeability” for water waves, slowing down the water discharge and causing a bottle neck on the narrowed inundations. Species like false indigo (*Amorpha fruticosa*), several touch-me-not species (Impatiens sp.), knotweeds (*Reynoutria* sp.) and other IAS making dense thickets are changing the water discharge pattern in floodplains, which could damage the forests of retention

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Figure 15: Domesticated herbivores maintaining Dutch floodplains.

areas by prolongated water logging. The rise in the water level caused by the barriers of invasive plants increases the risk of flood.

Networks of ameliorative canals are of the same importance as natural watercourses, acting as ecological corridors for wildlife and pathways for invasive species. In agricultural landscapes canals and vegetation strips along their banks are important wildlife habitats for some game species as well, and have an important role in erosion mitigation. The proper maintenance of vegetation strips also crucial for their biofilter function, necessary to decrease the diffuse pollution of water from adjacent arable land. Considering all these functions, there is a strong indication to treat these hydrological systems as multifunctional elements of green infrastructure, adapting their maintenance to the needs of several sectors (water management, agriculture, nature protection, and hunting).

Well-planed traditional grazing based on the wetland-site capacity and harmonized with other land use types (forestry, hunting) is an integrative solution for IAS control and reducing bottlenecks in flood control. It has been effectively implemented in the Netherlands for many decades.

The above initiatives are planned and implemented in cooperation with conservation and water management authorities, farmers and other land users. Nature protection funds and subsidies for maintaining priority habitats are managed in a coordinated way with those for levee maintenance and flood protection.

Synergies with other land use activities affected by IAS

Corridors of transportation and electricity distribution infrastructure (transmission lines) contain narrow strips of modified, very often degraded vegetation (e.g. road and railway edges, clear-cut strips under the power lines within a forest). As these strips' vegetation is developing under pressures of pollution and/or inproper maintenance, it is very susceptible to plant invasions. Herbicide application could prevent the invasion of perennial species but create ideal conditions for annual weeds, including ragweed. Mowing the

spontaneous herbaceous vegetation will lead to the development of grassland strips offering additional ecosystem services (habitat for wild species living in suburban or urban areas, ecological corridors for the wildlife etc.).

Nature-based tourism gathers many tourism types based on natural values (ecotourism, adventure tourism, wildlife tourism including bird-watching, photography, camping, hiking, or extracting tourism such as hunting, fishing). By changing the vegetation structure, composition and visual identity of an invaded area, invasive plants can affect any land use or activity related to those features. There is a need for awareness rising to form a partnerships with the sector for tourism on IAS control.

Urban and suburban green areas other than parks belong to habitats most endangered by invasive plants. Green surfaces of public areas (small squares, parking lots, sports facilities etc.) are maintained without adequate plans, preferring cheap, low-budget activities. Many invasive plants are regarded as an ideal species for the urban green areas due to their high vitality, (threatened by lower number of pathogens and insects) or an exceptionally good ability for regeneration which enables them to survive the damages made by construction of underground infrastructure (pipelines, cables). The most widespread of them are tree of heaven (*Alianthus glandulosa*), common hackberry (*Celtic occidentalis*), box elder (*Acer negundo*) and black locust (*Robinia pseudoacacia*). However. as the invasive trees and shrubs are strong competitors, suppressing the other plants in their vicinity, on the extensively maintained green surfaces they form monocultures. Considering the ecosystem services, both the monotonous floristic structure, and the limited possibilities to improve the visual characteristics of these green areas, the IAS are more and more recognized to be unfavourable species. There is a need for lists of alternative species to ensure a suitable replacement of invasive species, replacing them with species adapted to unfavorable ecological conditions of urban areas (air pollution, lower levels of air moisture, higher summer temperatures etc.)

The role of spatial planning

Considering all the above gaps and potential synergies among the land users, the IAS-smart management starts from a planning at a landscape level. Spatial planning is the highest level in dedicating space for green areas, constructing zones, linear infrastructure. Each of those elements is important in invasive species control, while their spatial arrangement could improve the connectivity of ecological corridors.

Spatial plans are important tools ensuring the integration of nature protection policies into development plans and putting them in practice by other sectors. Spatial plans regulate the establishment of urban and rural green areas such as parks and other green surfaces in settlements, recreation areas, shelterbelts etc. Plans referring to spatial entities with protected areas or elements of the ecological network could restrict land use following the measures defined by the act of protection, including the ban on the use of IAS. The efficiency of the spatial plans depend on the strength of the basic regulation(s) on IAS. The planning documents determine the land use for 10-20 (maximum 25) years, including the rules for the establishment of green surfaces other than forests.

The ecological approach in the planning includes the use of scientific background with the aim to implement solutions depending on the invasive species and the managed habitat types of the area. There is a need to harmonise the current development trends of the cultural landscape with the relevant environmental problems.

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Figure 16: Review of key activities in land use practices related to IAS

Activity	Risk of IAS spreading
Crop productions	Introduction and spread of weeds and invasive species specialized to open areas (e.g. *Ambrosia artemisiifolia, Bidens frondosa*)
Tourism	Introduction of new species from distant areas
Forestry processing and rejuvenation, particularly in large areas.	Open, sun-exposed surfaces have small resilience to the invading species. Large regeneration plots are usually close to paved forest roads which are corridors of invasive species.
Protection from wind erosion	The invasive species could grow among the planted trees and shrubs and have to be removed by manual work.
Wintering fodder	Usually the fodder (grains, hay) is bought and brought into the forest/grasslands of the game management area. It can contain and introduce invasive species deeply in natural habitats.
Timber export-import	Introduction of new IAS and IAS spreading.
Species introduction	In forestry, agriculture, beekeeping, gardens, decorative greenery at tourist facilities.
Restoring floodplain (retentions)	Flood as a vector of IAS seeds
Reconnecting oxbows	A similar risk of IAS spreading like in the previous line
Biomass transport or composting after mowing and trimming	Biomass may contain reproductive parts of invasive plants (viable seeds, roots or stems)
Building and maintaining linear infrastructure like railways, roads, gas infrastructure, water supply.	Infested soil and vehicles are source and vectors of IAS. Invasive species are often introduced and spread unintentionally during constructing works. Areas have been infested by soil, sand and other materials from the soil surface. Roads and railways in mountains follow river valleys and infestations are easily spreading downstream. Example: introduction of the knotweeds in Una riverine habitats when the soil used to railway building, was infested and the species exploited Una as a natural corridor.
Machinery (in agriculture, forestry, water management)	The same machinery is working on ruderal, semi-natural and natural habitats, in protected areas and constructing areas. It disperse seeds and propagules between the sites.
Maintenance of the ameliorative canals	The contemporary maintenance plans prefer dredging, although regular mowing is more effective and could be a cheaper solution. Current dredging practices cover the grass strips of canals with the excavated silt, creating open surfaces ideal for plant invasions.
Planning and maintaining the public green areas	There is a need to find replacement for the invasive trees and ornamental plants regularly used during the past decades/ centuries, as suitable for urban environments (tolerable for pollution, urban climate, drought etc.).

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4. IAS control

Natural habitats of floodplains are considered to be exceptionally vulnerable to invasions of alien plants. The disturbances by regular flooding enhance the establishment of alien species in many ways. Rivers are natural ecological corridors characterised by strip-shaped habitats facilitating the migrations of animals and the spread of plants.

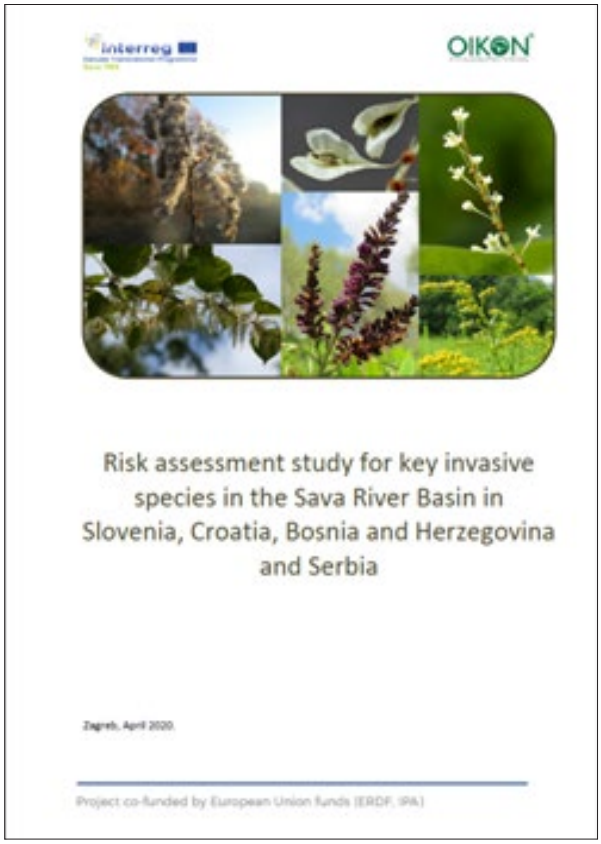
Uncontrolled IAS spreading along the ecological corridors of the Sava River with its tributaries is happening mostly due to the lack of experience in IAS management, cross-sectoral cooperation and transnational approach. It is not only a matter of implementing the right methods in right place at right time, but its applicability very much depends on adjusting the IAS eradication plan with national legislation (procedures and restrictions), which are quite different along the transnational river connecting EU and non-EU countries.

4.1 Risk assessment-a key tool in successful IAS control

A solution for some big challenges in land management, such as controlling erosion, remediation of soil pollution, was found in the introduction of exotic, resistant, self-sustaining plants. At least it looked like a perfect, cost-effective solution, when these species have been introduced. The above features are typical for invasive species and many of those have become the worst invaders, causing much more damage compared to the expected benefits.

Conducting a risk assessment study of invasiveness for species before introduction, or as preparedness for likely invasions from neighbouring countries is the best way to estimate the risk, identify pathways, protect threatened habitats and rationalize efforts in IAS control.

The risk assessment of invasiveness of an alien species is a comprehensive scientific and professional analysis that identifies, analyses and evaluates possible adverse impacts and consequences of the impact of a particular alien species on biodiversity, ecosystem services and human health, taking into account the possible adverse impacts on the economy.



OIKON Institute for Applied Ecology from Zagreb

Figure 17: Risk assessment from the Sava TIES

Sometimes alien plants, such as non-native trees or herbs in meadow seed mixtures, are intentionally used in forestry or ecosystem restoration. In these cases of intentional use of non-native species, we recommend conducting a site-specific risk assessment (Foxcroft, Rouget, & Richardson, 2007). The minimum standards for the risk assessment include the following: (1) basic species description; (2) likelihood of naturalisation or invasion; (3) distribution, spread and impacts; (4) assessment of introduction pathways; (5) assessment of impacts on biodiversity and ecosystems; (6) assessment of impact on ecosystem services; (7) assessment of socio-economic impacts; (8) consideration of species status (threatened or protected) or habitat under threat; (9) assessment of future climate change effects; (10) completion possible even when there is a lack of information; (11) documents information sources; (12) provides a summary in a consistent and interpretable form; (13) includes uncertainty; (14) includes quality assurance (H. E. Roy et al., 2018). However we recommend contacting a national specialist to provide you with more detailed information on the risk assessment in your area and for alien species of your interest.

Examples of the systematically implemented risk assessment for the selected invasive species in the Sava River Basin have been provided by Lonjsko Polje Nature Park.

The study was conducted for six predominantly present invasive alien species in the Sava River Basin. These were False-indigo bush (*Amorpha fruticosa*), three knotweed species - Japanese knotweed, Giant knotweed, Bohemian knotweed (*Reynoutria japonica, R. sachaliensis, Reynoutria × bohemica)* and two goldenrod species - Canadian goldenrod and Giant goldenrod (*Solidago canadensis* and *S. gigantea*).

The English Non-native Risk Assessment (NNRA) methodology (Baker et al. 2008, Mumford et al. 2010) was selected for performing the risk assessment in consultation with the Ministry of Economy and Sustainable Development of the Republic of Croatia. This methodology is a precise tool for assessing the entry, establishment of the population, spread and impact of alien species and the necessary measures were determined in accordance with the results of the assessment of the possible impacts of the species,.

The analysis results showed that a high risk of invasiveness was assessed for as many as 5 species - False-indigo bush (*Asclepias syriaca*),, Japanese knotweed (*Reynoutria japonica)*, Bohemian knotweed (*Reynoutria × bohemica)*, Canadian goldenrod (*Solidago canadensis)* and Giant goldenrod (*Solidago. gigantea)*. The species have been assessed as the species of high invasiveness in the Sava River Basin and the estimations show a high probability of introduction, high impact on biodiversity and spread of these species. For only one invasive species, the Giant knotweed (*Solidago. gigantea)*, a moderate risk of invasiveness have been assessed because the probability of entry have been moderate, the risk of spreading is slow and the impact on biodiversity is moderate.

Depending on the results of the risk assessment invasiveness, species can be added to specific lists, the most common of which are the Black and White lists. A Blacklist is a list of invasive alien species that cause concern in a country, region or the European Union. The White list is a list of alien species that do not pose an environmental risk. Data from the Risk Assessment Study of invasiveness will be available to the project partners for the future formation of national or regional Black List.

This project is co-funded by the European Union funds (ERDF, IPA)

4.2. Prevention (controlling pathways, IAS-susceptible habitats)

The land use changes analysed in the protected areas and on the sampled floodplain sections (Land Use Study – component „Land use change maps“) shows the changes in landscape structure and land use practices that enhance the plant invasions. Some elements of contemporary cultural landscapes, such as the transportation and energy infrastructure and the heavily modified hydrological network, serve as pathways for plant invasions. Alien species spread with the transported goods and establish their populations in the green belts along roads, railways, power-lines and ameliorative canals as well as on the poorly maintained green surfaces of public sites (sports facilities, schools, small squares etc.) within the urbanised areas. The proper maintenance of these pathways should be imposed by the legislation (similarly to the existing regulations on ragweed control) and supported by appropriate information prepared for the stakeholders.

The management of the temporarily abandoned plots, both in urbanised areas (e.g. plots on the sale) and in rural landscapes (parcels left fallow by old owners) can be ensured only by strict regulations supported by regular control. The first step is to define the responsibility for IAS control and integrate it into the legislative of the relevant sectors (agriculture, construction, forestry etc.)

There is also a need to take into consideration the striking contrasts between the land use by traditional practices (hay-making, grazing) and the current management methods in agriculture, forestry and water management. The traditional land use, based on the need for fodder has enabled a considerable vegetation control in almost all rural habitat types, slowing down the spread of invasive plants during the first half of the industrial period. Therefore, the still existing knowledge on gradually disappearing traditional land use practices could be used in IAS control.

The nature protection sector could take the leading role in this process, whereas the former land

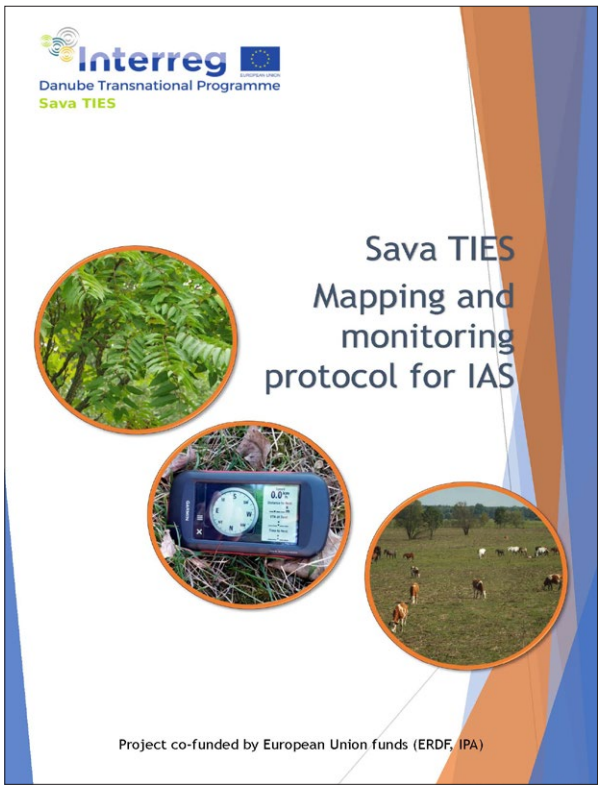


Figure 18: Mapping and monitoring protocol

use practices in forestry and agriculture had key roles in the preserving biodiversity during the last centuries and some of them are still applied to habitat management in the protected areas. For example, traditional grazing is a cost-effective biological method, mainly used in grassland management, but it is also essential for the preservation of certain wetland and forest habitats. The effects of grazing are based on complex biological interactions, because the large herbivores are key species of ecosytems, regulating the vegetation structure and providing resources for many other species. It could control the vegetation not only in natural and seminatural habitats, but in certain antropogenic formations (forest monocultures, canal banks), too. As most of these practices are time-consuming and require a high proportion of manual work, there is a need to work out the necessary adaptions in accordance with the conservation goals and economic restraints.

4.3. Mapping IAS

IAS mapping is the first prerequisite for effective IAS control. Knowing infested areas also helps controll the key IAS pathways (roads, supply lines, ditches, rivers, etc.).

For mapping IAS on the Sava Basin scale the *Mapping and Monitoring Protocol* is giving clear examples and instructions. It consists of two sections, developed by experts from the Centre for Ecological Research (Vacratot) in cooperation with Institute for Nature Conservation of Vojvodina Province (Novi Sad).

The first section of the protocol with exampled field manual is simplified and useful in planning IAS eradication. This is almost identical with the "laic level" in the mobile application for IAS mapping (presented below), developed in cooperation with Joint Research Centre European Alien Species Information Network (JRC EASIN), presented in the lines downward.

The second part is more detailed and developed for PA management experts, giving additional data for consideration where priority actions in IAS management should be taken.

Methods in mapping should be adjusted to the scale (few hundred hectares or a hundred thousand hectares), the habitat types and target invasive species. For this purpose, the protocol provides examples of several affirmed methods in IAS mapping, adjusted to the scale of mapping, available time and capacities. Altogether these make a basis for long-term mapping and monitoring of IAS in the Sava River Basin.

The SavaParks Network is a network gathering a heterogeneous group of organisations from EU and non-EU countries, which are governing and managing protected areas and ecological networks in the Sava Basin. A joint transnational database, in which all stakeholders could record locations of invasive species is a platform that makes possible a joint transnational monitoring of IAS and IAS management planning. The first step of its implementation is achieved. The final result is strengthening the SavaParks Network

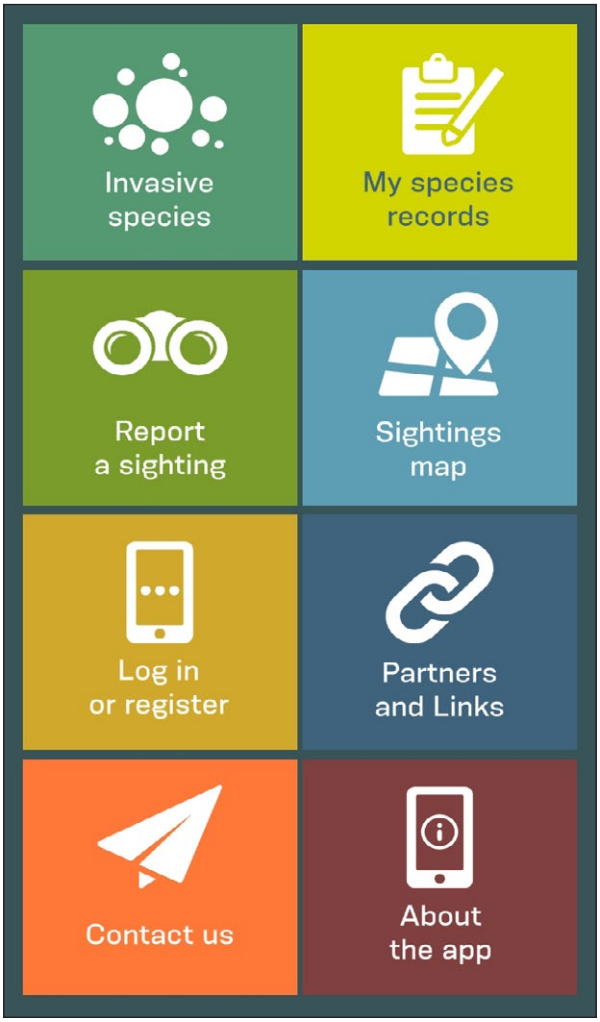


Figure 19: Mobile app adjusted for mapping IAS in the Sava River Basin

and developing capacities for joint, transnational IAS management.

JRC EASIN as data custodians of the EU invasive species database, in cooperation with the Sava TIES consortium, has provided a mobile application for IAS mapping in the Sava River Basin. The mobile app enabled the mapping of the 32 invasive plants considered to be the most threatening to natural habitats in the Sava Basin. For this purpose, the existing app "Invasive Alien Species in Europe" has been extended by additional 26 invasive plants. There is also an option to register "other species". This is the "laic level" of the protocol, however there is an option to mark precise habitat type, or just note "forest", "meadow" and other categories.

This project is co-funded by the European Union funds (ERDF, IPA)

The application is available on Google Play for both PA managers and people who spend some time in nature, a practice known as "citizen science". All IAS records are gathered on the Sava Basin scale.

The structure of the planned fully developed database mirrors the Field Manual from the Mapping and Monitoring Protocol and is technically defined in *IAS Database_Technical_Specification*. It anticipates installation of additional, "expert" profile. The mapping in the expert profile is targeting additional attributes useful in prioritizing species and sites for treatment. These attributes also help PA managers to recognize potential conflicts with land users and assess resources which are needed in IAS management. For instance: the same invasive species can be recorded in ruderal habitats and natural habitats of high conservation importance. If the invasive species is recorded in the tree layer, on the land managed by the forestry sector, there is a high probability that eradication will not be allowed without special permissions, and only the species substitution with a native tree species might be allowed. Different equipment is needed if the species is still in the herbaceous/bush layer or has reached tree canopy.

Croatia and Slovenia have developed their own IAS databases as the implementation of EU regulation on invasive species management. The IAS records collected in the national IAS databases merged with the EASIN database. The SavaParks members and other PA managers from the non-EU countries do not have their databases.

> The integration with JRC EASIN brings some advantages and one of them is that all IAS records from the Sava Basin will be stored in one place: EASIN database of invasive species. The map of invasive species presence within the Sava Basin will be visible on the SavaParks website. The above approach was foreseen as a pragmatic solution, tailored for the conservation practice in the transnational ecological corridor.

4.4. Stakeholder analyses

Recognizing stakeholders

Every natural person, organization or company present in the observed area and performs some activity is an interested party. Those stakeholders can own the land, have land tenure, concession on some specific resource on the land or just generating income from landscape amenity such as nature-based tourism.

In the protected areas of the Sava River Basin the key stakeholders are usually: PA managers, forest users (public companies, forest owners), water managers (public companies), fishing managers, local governments, citizens' associations (hunting, fishing, ecology ...), eco-tour operators and individuals (owners of private forests, agricultural land, cattle breeders, beekeepers, fishermen, facility owners).

From the above mentioned, it can be concluded that a large number of stakeholders appear in the observed area, which entails a large number of activities, some of which affect the expansion of IAS. One of the examples is earthworks, where excavated soil is transferred from one location to another.

Analysing conflicts, synergies and drivers

As it was described in the above chapter, the management of invasive species brings both synergies and conflicts. Before deciding on the scale of selected IAS species eradication and selecting appropriate method in eradication, it is essential to reveal the key drivers in the introcduction and spread of the target invasive species. How different stakeholders are affected by it, how they are linked considering the IAS, where are synergies and conflicts among them. Each stakeholder has their own view and attitude towards invasive species, which in some cases are very different. For instance, bee keepers can be eager to tending black locust for high-valued honey, local community might be culturally linked to the same species (even spoken in country songs), forest manager consider it useful at eroded and low-quality soils, while protected area manager is committed to put the invasive species at least into containment if the eradication is not achievable. Activities and interests of stakeholders could be viewed in parallel with the survival or destruction of indigenous vegetation species in the Sava River Basin.

Sometimes interests in an invasive species are completely diverging (one stakeholder benefit from IAS while another suffer losses), but sometimes it is just a matter of spatial arrangement. Marking all identified stakeholders on the map (where their biggest interest is and where keeping specific IAS is not so important) might be a useful tool in conflict management and risk mitigation. Beekeepers relay on accessibility to the bee pasture. Knowing that the economic distance from the beehives to the bee pasture is up to few kilometres is useful in planning. Remote and hardly accessible locations are not so conflicting when it comes to eradication of IAS species which is valuable for bee keepers (*Robinia pseudoacacia, Amorpha fruticosa, Impatiens glandulifera, Solidago sp.*).

Forest users (often protected area managers) have increased costs in forest management due to certain invasive plants (*Acer negundo, Amorpha fruticosa, Reynoutria sp.).* At the same time some do not pose a problem to them, and even grow those species in some habitats (*Fraxinus pennsylvanica, Fraxinus Americana, Robinia pseudoacacia*).

Many of the stakeholders, particularly from the local community, are not integrated in the land management planning, but do have their interest in either keeping or eradicating invasive species (e.g. small land holders and local civic organisations), which at some point can stop or harden planning and implementing IAS eradication.

4.5. Prioritizing species and sites for actions

Neophytes have infested many sites along the Sava Basin ecological corridors, and more than one invasive species have already been registered in each of the protected areas in Sava River Basin.

The map of habitats (EUNIS; HD, national classification) is particularly useful for identifying priorities for IAS eradication, namely those areas where the presence of protected species and priority habitats is confirmed.

Recognizing the biophysical and social background of invasive species is important for successful implementation. If a land user`s livelihood is linked to some invasive species (for honey production), the eradication will cause conflicts. In such cases potential autochthon species for IAS substitution should be considered specially if the habitat is heavily changed and there is no natural capacity for revitalisation (by natural seeding from preserved habitats in surroundings).

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Asking questions is useful in the planning phase:

- Which are the most valuable habitats and species (red-listed, protected)?
- Which invasive species have/can invade these habitats?
- Which IAS are in the initial phase of spreading?
- Which are the pathways of the IAS?
- Is there a possible conflict with stakeholders considering the IAS?
- Is the threatened habitat sensitive to some of the control methods (e.g. herbicides shouldn't be sprayed in the vicinity of water)?
- Is there a conflict among conservation targets (e.g. removing IAS in the breeding season of protected animals)?
- Is the IAS economically valuable?
- What is the phase of IAS development (just introduced or wide spread).

Demands in Ecosystem services, affected by the IAS, can be a good argument to find synergies with other stakeholders.

The right moment for planning IAS control in PA is the development of long-term and annual PA management plans, while other sectors have to include this issue into the plans of natural resource management (forest, water, agricultural lands).

4.6. IAS Management options

Facing the problems caused by the established populations of invasive plants calls for the eradication or control measures. Eradication is possible when the invasion pathway is controllable. It is possible to stop further planting of invasive species in the gardens, but it is almost impossible to prevent the transport of seeds by water, nor the transport of `flying` fruits of ashes, maples or milkweed by winds in the areas containing mature populations of these species. In the cases when there is no feasible way to prevent the dissemination, permanent activities are required for reducing the number of young IAS before they reach maturity and begin to reproduce.

Considering the applied methods, there is little or no difference between the plant eradication or control. Three broad categories cover most invasive plant control: mechanical, chemical, and biological. Some of the combinations of mechanical-chemical, and mechanical- biological methods are also widely used.

Planning the IAS control should consider both natural and social background, as explained in the stakeholder analyses. Different methods of control for target IAS are given in *The Review of Best Management Practices*. The most effective way of control should be chosen depending on the invasive species and the area in which they are present. In forest habitats the eradication should not be based just on forest management plans (species compositions), because theye are mostly focused on the composition of tree layer (the economically important). The shrub layer is often reported just by its density, while the presence of invasive species in the herbaceous layer in the forest is both hard to discover from forest management plans and usually not recognized as important in forest development.

Examples in IAS control:

- Eradication (initial phase, like patches of *Reynoutria sp.*)
- Substitution (*Acer negundo, Fraxinus pennsylvanica* with native oak&ash species, or non-invasive cultures with natural buffer along the river courses)
- Containment (*Robinia pseudoacia* in large plots of arable land, isolated from ecological corridors by dense buffers of natural vegetation).

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More about methods and examples in IAS eradication implemented in the Sava TIES project can be found in the *Joint Pilot Report with Transferability Plan*.

4.7. Examples of integrated solutions in IAS management

Traditional forest-farming as an effective tool in IAS management, conserving a group of protected animal species and related with timber increment of key forest species.

A forest productivity research of tree diameter increment was carried out for the purpose of this project, looking for synergies between nature protection and timber production. . Two sites along the Sava River were selected with three samples in poplar plantation and six samples in hardwood forest,of matured age.. The samples represent the forest productivity in the forest and plantation, with scarce or no bush vegetation due to long-term grazing (cattle, pigs, and sheep) and the forest/plantation of the comparable type, age and covered by invasive wooden species in shrub and lower tree layer (without impact from the traditional farming).

A sampling of tree cores was done on dominant trees in comparative forest stands, in similar environmental conditions and development phases. The dendrochronology analysis indicates a positive correlation between traditional pig breeding and pasturing with conservation targets (lesser presence of invasive species) and the increased growth of the principal trees for main tree species in forestry: pedunculate oak and Euro-American poplars.

Both forestry and nature conservation have common benefits from suppressing invasive species, which on the sampled areas was implemented in

Figure 20: Sampling tree cores for increment analyses

a cost-effective way by well-planned, traditional cattle and pig grazing. In doing so, local people from villages settled near forests also benefited from meat production, which in the traditional forest-farming system saves more than 50% cost in fodder, water, electricity and labour (Kiš et al, 2018).

> In the same hardwood forest, forest understory managed by traditional pig herding correlated with the conservation of bats (Chiroptera species).

Forests are the most critical habitats to support the diversity of bat species. The consequences of forest utilization are the loss of the most important habitat resources for bats. Therefore, new knowledge about innovative forest management, which has an impact on bat conservation, is of great importance. The relevance of traditional farming to invasive species control is known and also preliminary explained in the forests belonging to the Sava Basin (Ibid.). We were interested in finding response of bat species to forest livestock grazing and its implications not only for IAS management but, at the same time for bat conservation.

Four sites, cleaned from invasive bushes by traditional pig grazing, were monitored in the area,and four comparative sites (same habitat types not affected by pig grazing), overgrown in invasive understorey were set as control sites. The applied automatic bat detectors sampled bat passes simultaneously in both grazing and control sites. Furthermore, we captured bats with special bat nets to determine them to species level.,.

The comparison of bat passes at the grazing site 1, and associated control site 11 is shown in the graph (Graph 1). This graph includes bat passes of all found bat species, and it represents an overall bat activity at the surveyed sites for each day. Similar results were obtained in the other three pairs of sites. During the netting, fifteen bats were caught: five *Myotis myotis* (Figure 1), four *Pipistrellus pygmaeus* (Figure 7), two *Myotis mystacinus* (Figure 2) and one specimen from each of the *Plecotus auritus* (Figure 3), *Eptesicus serotinus* (Figure 4), *Myotis daubentonii* (Figure 5), *Nyctalus noctula* (Figure 6) species. In the dense understory forests, we were able to catch only one individual of the *Plecotus auritus* species.

The above examples demonstrate how the nature protection objectives (IAS control) can create synergies with the local community (traditional farmers) and forestry as one of the key land use practices along the transnational ecological corridors in the Sava Basin.

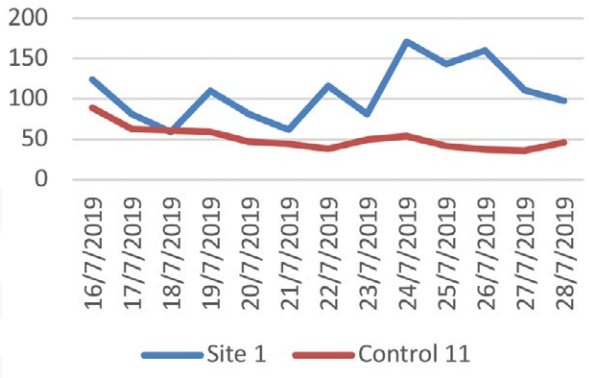

Figure 21: Comparison of bat passes, the blue is grazed

Figure 22: Myotis myotis on 16.07.2019. from the forest nearthe Sava floodplain, Serbia.

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5. Economic and policy incentives to IAS eradication

Support in IAS eradication may be found in subsidies from agri-environmental schemes, the European Agricultural Fund for Rural Development (EAFRD), and LIFE programs for EU countries. There are also national funds for subsidizing PA management (green funds), international donors, crowdfunding or financial mechanism like green bonds for commitment to the conservation targets.

For the project needs and aimed policy impact, a cross-sectoral policy analyses in relation to IAS management in the four Sava River Basin countries was carried out. The results have revealed that in most of the Sava River Basin countries the legal basis for invasive plant eradication and control is unsatisfactory. The policy development is hampered by lack of knowledge and prevailing interests of short-term investments, seeking profit without considering the long-term consequences for the environment. There is a need to adapt the existing regulation on Environmental impact assessment procedures incorporating the obligate assessment of invasion possibilities and defining the necessary mitigation measures.

If a private land owner is growing a specific invasive plant which is detrimental to biodiversity (e.g. *Reynoutria* sp. or *Impatiens* sp. for late honey pasture, *Fraxinus pennsylvanica* for firewood), providing alternative species source of benefit to the stakeholder affected by the eradication is essential. Adequate autochthonous, or at least long time present non-invasive species for IAS substitution should be selected.

If the infested land is public, some of the above sources are not accessible (EAFRD). However, the national commitments in IAS eradication should be carefully analysed and whether there is a binding responsibility for the land managers (species or habitats of national interest threatened by IAS), then measures for the IAS eradication, substitution or containment should be integrated into the land management plans.

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6. Recommendation for IAS-smart land use practices

Sava TIES concluded on the following guidelines for preventing the introduction and spreading of invasive plants in protected areas and the ecological corridors:

6.1. General guidelines for the all land users

Planning

- New species should not be introduced without a Risk Assessment;
- Survey and map IAS presence on lands which you use or manage, particularly in protected areas and near ecological corridors such as rivers and canals;
- Monitor IAS presence on locations where soil, fodder or construction material was brought to;
- Control soil excavation and transportation for IAS propagules. Sites where soil was introduced should be checked a few times for IAS in the next two seasons, particularly if soil came from distant areas or areas known by the presence of some IAS.
- Consider potential side-effects of IAS eradication on non-target organisms (birds, amphibians, bees, etc,);
- Designate waste disposal areas for invasive plant materials away from rivers, roads and other potential vectors and corridors (cattle path). Periodically check the surroundings of the disposal place for IAS occurrence;
- Reduce usage of herbicides. After initial accomplishment in weed control, the open space has no resistance to IAS which are fast colonizing species.
- Implement land management practices which are increasing the density of natural vegetation (e.g. by mowing grasslands), supporting natural richness of plant species, preserving forests canopy and natural understory, make barriers to IAS.

Field works

- Equipment and machines in soil excavation and biomass removal should be cleaned when changing worksites;
- Dedicate a location for cleaning machinery, in appropriate distance to potential corridors and vectors;
- Clean clouts, shoes and vehicles when visiting or monitoring especially important biodiversity hot-spots;
- When composting at home/garden, the biomass should be mowed before the seed

ripens, while for those IAS reproducing by roots, stems and other propagules make sure that the biomass is just wet and covered by dark material which intensifies fermentation and rendering the propagules;

- Mow, cut or mulch areas infested with invasive plants before flowering and never when seed is ripe. Mowing or mulching before flowering exhausts the underground parts of IAS. In such cases the biomass can be left on the place to decompose, away from flood and watercourses;

- Dispose biomass which contains invaded species away from rivers, canals, public roads, recreation paths and other pathways, particularly avoiding preserved natural habitats. Prefer degraded sites which can be periodical controlled from the unwilling IAS propagation;

- The biomass can be used in biogas factories;

- Compost with the IAS plants might have remained vital IAS propagules and should be carefully managed, not used near rivers, springs and other pathways;

- Transportation of the biomass with IAS propagules must be in a closed and covered container which prevents unwilling seeding along the transportation road;

- Where allowed, apply complete burning of the biomass at the place of removal, after it dries out, in the season of lower fire risk and following fire prevention rules;

- Be aware of plants which contain toxic matters (e.g. *Heracleum sp., Phytolacca*), both for your safety and the safety of people, particularly children. Use protective gloves, consider the place of disposal for preventing human health issues;

- Allow animals to graze or cross fields of invasive plants only before they set seeds. If this is impossible, contain animals 4-14 days in a weed-free holding area before moving them into areas free of invasive plants;

- Update your knowledge on IAS and their impacts on the environment, health and economy. Consult PA managers, extension service and colleagues from other sites and organisations who are managing or working in similar areas (lowland/upland);

Data collecting

- When you survey the land or just walking across fields, forest or along IAS pathways (road, riversides) use an android/apple mobile devices to record IAS presence by the online application available from Google Play Store. Application “Invasive Alien Species in Europe” was upgraded for mapping IAS in the Sava River Basin. It is fast and easy;

- If you are not familiar with digital tools, when spotting a new plant which is rapidly spreading over your lands, inform the nearest PA manager and/or extension service.

In addition to the above, general recommendations, different stakeholder groups should also implement specific activities related to the introduction or control of IAS.

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6.2. Guidelines for PA managers

- Map the presence of invasive species on lands in your charge, particularly along ecological corridors and other IAS pathways;
- Map and control the IAs pathways (roads, railways, supply lines, water courses, etc.)
- Prioritise the sites in IAS control by giving the highest priority to:
  - Recently introduced species which are confirmed invaders in similar habitats;
  - Species threatening priority habitats and/or protected species,
  - Infestations along the river corridors and other pathways
- Consider the trade-offs between conservation targets;
- Think of potential conflicts with business activities from IAS removal (e.g. with bee keepers), try to find compromise effective in IAS control;
- If an IAS species cannot be eradicated and is not spreading by wind or flood (like black locust), try on-site containment by establishing a dense, multilayer buffer of native trees and bushes around the infested plot.
- Look for synergies with land users on common benefits (e.g. substitution of IAS by higher valuable native species, like red ash with pedunculate oak), also with local community and traditional land use practitioners (e.g. farmers);
- Inform land users, local community and other people who visit PA, work in the PA or along ecological corridors about negative impacts of IAS, your efforts and actions in IAS control;
- Organize “IAS informing day” at local schools, agricultural fairs and other related public events;
- Forward your IAS records to the national system for IAS control or use the mobile application “Invasive Alien Species in Europe” to map your findings.

6.3. Guidelines for the managers of natural resources and spatial planning

Water management sector

- Provide education on invasive species adapted to all levels, from the Ministry and the water authorities to contractors and companies engaged in the performance of works, in water management;
- Ensure the introduction of a mandatory measure in the planning documentation in the field of water management demanding the removal of invasive species, and harmonising the methods and periods of maintenance s with the recommended activities for the removal of invasive species;
- Introduce a regulation on the use of the mechanisation with the aim of preventing the spread of IAS (cleaning, transport, obligatory checking etc.);
- Introduce subsidies for more frequent maintenance of canal networks, especially by mowing and/or grazing by sheep;

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- Establish cooperation with the sectors of agriculture, game management and nature protection to reveal the common interests and to incorporate the systems of ameliorative canals into the networks of multifunctional green infrastructure, increasing the number of stakeholders and promoting the more cost-effective maintenance methods.

Forest management

- Preserve forest edges from clear-cuts;
- Keep dense, multilayer buffers of autochthons trees and bushes toward agricultural lands, settlements, waste disposal areas and water bodies;
- Promote richness of autochthons wooden species and multilayer forest;
- Substitute the existing stands of invasive species by the native ones in protected areas and at least non-invasive ones in other forests, where feasible;
- Look for co-financing from other sources for the conservation achievements when those would exceed your regular forest management;
- Look for synergies with other co-managers on the land (flood protection, hunting, extensive farming);
- Avoid soil disturbance (ploughing);
- Promote long rotations in forest preserves;
- Check the possibilities for the re-invention of forest grazing.

Agriculture and gardening in peri-urban areas

- Do not introduce foreign plants before finding information about their invasiveness ;
- Ask for the information on the local native habitat types and the autochthonous species suitable for gardens and amenity areas;
- Check if some species from your garden are registered as invasive and substitute them with non-invasive ones;
- Plant a dense buffer of native and non-invasive bushes around your garden. It will provide you privacy, protect your garden from invasive species in your surroundings.

Spatial planning and constructing works

- The planning of linear infrastructure recognized as a potential IAS pathway should take into consideration the prevention of invasions, including the potential costs of long-term IAS control on the protected areas or forests.
- Define localities for buffers and space for the equipment necessary for the management of green surfaces (such as the edges of roads and highways) in spatial and construction plans.
- During the construction works on roads, railways, bridges, etc., soils and constructing materials must be checked for propagules (better not to use the surface layer of soils to prevent the seed introduction)

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Risk management in IAS eradication

- Carefully assess potential trade-offs among the conservation and economy targets (maybe some economic activity get income from the target IAS, e.g. bee keeping, timber production);
- In the planning phase alternative species, alternative sources of income or compensation measures for the stakeholder who are affected by IAS eradication must be considered;
- Maintain good public relations, promote benefits from your activities in IAS control.

Internal Code of Practice for IAS control

National black lists of invasive species neither decreed in Bosnia and Herzegovina nor in the Republic of Serbia. When it comes to practice, a large number of land users in protected areas do not check the presence of invasive species on their lands, do not consider the risk of unintentional transmission by soil or removed biomass, are not familiar with invasive species mitigation measures and are not interested in learning about their negative impact (Land use study, ILFE 2020). Without knowledge and obligate mechanisms for monitoring and eradication of invasive species the risk of their further spreading and damages is real.

Affected sectors and stakeholders can develop their own "Codes of Conduct" for a target species that cause economic loss (invasive trees, fish, mussel) or health issues (ragweed, giant hogweed). In such way they could control the species and its pathways before the national legislation provides an adequate response and IAS coordinating body is established.

There are examples of well-arranged practices such as internal rulings on forest pasture in current forest management practice, internal water-management rulings on lending grasslands on levees for mowing and pasture, and internal rulings for visitors and land users in protected areas.

Until the IAS rulings are decreed as "lex specialis" and supportive measures implemented on the national scale income and biodiversity could be significantly affected by IAS. The issues could be avoided or mitigated by internal (organisation) decisions and adaptation in land management.

For instance, wooden invasive species should be registered in forest inventory and management planning,, even if present only in the shrub layer at the time of the survey, or were not significant by their contribution to timber volume (*Ailanthus altissima*, *Acer negundo, Gledichia triachantos* etc.). IAS plants are highly competitive species with the saplings of autochthonous species, and they take soil moisture and nutrients from senior autochthonous trees.

6.4. Policy development and fund raising

How to get financial and political support from key stakeholders and decision-makers:

- Assess and promote positive impacts of your activities/plans in IAS management on the economies and stakeholders. (e.g. forest management, flood risk, nature-based tourism, crop production, human health);
- Evaluate financial effects and other positive impacts of IAS eradication on the site (forestry, farming, nature-based tourism, human health etc.) and on surroundings where the IAS could invade;
- Apply ecosystems services assessment as an integrated approach in assessing the impact

of IAS on natural values, economy and human health;

- Include local community in the activity and emphasise positive impacts of the eradication;
- Assess how the IAS eradication contributes to national commitments in nature protection (e.g. improving the conservation status of protected species and priority habitats) and to other sectors
- Consider negative impacts of IAS plants on protected species including animals, by changing the vegetation composition, structure and density.
- Search for available funds related to nature protection targets where IAS management could be integrated (projects in LIFE program, Interreg, EU Water Framework Directive, EU Flood Directive, national and EU agro-environmental programs, donations, green bonds etc.)

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Web links:

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https://ec.europa.eu/jrc/en/news/new-application-tracking-invasive-alien-species-your-smartphone

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https://www.cabi.org/?q=invasive&order=relevance-asc

https://oakprotection.eu/sites/default/files/tudastar/rosalia_handbooks_3_en.pdf

Annex: List of key IAS in protected areas of Sava River Basin

1. Acer negundo L.
2. Ailanthus altissima (Mill.) Swingle
3. Ambrosia artemisiifolia L.
4. Amorpha fruticosa L.
5. *Asclepias syriaca L.*
6. *Bidens frondosa L.*
7. *Buddleja davidii*
8. *Conyza canadensis (L.) Cronquist*
9. *Echinocystis lobata (Michx.) Torr. & A. Gray*
10. *Fraxinus americana L. (američki bijeli jasen)*
11. *Fraxinus pennsylvanica Marshall*
12. *Gleditsia triacanthos L.*
13. *Heracleum mantegazzianum Sommier & Levier*
14. *Impatiens glandulifera Royle*
15. *Impatiens parviflora*
16. *Lysichiton americanus*
17. *Oenothera biennis L .*
18. *Paulownia tomentosa*
19. *Panicum barbipulvinatum Nash ex Rydb.*
20. *Physocarpus opulifolius* (L.)
21. *Phytolacca americana*
22. *Pueraria montana var. lobata* (Willd.) Maes. & S. Almeida
23. *Reynoutria × bohemica Chrtek & Chrtková (Fallopia × bohemica (Chrtek & Chrtková) J. P. Bailey)*
24. *Reynoutria japonica Houtt. (Fallopia japonica (Houtt.) Ronse Decr.)*
25. Reynoutria sachalinensis (F. S. Petrop.) Nakai in T. Mori
26. Robinia pseudoacacia L.
27. Solidago canadensis L.
28. Solidago gigantea Aiton
29. Spiraea japonicaL.
30. Symphyotrichum novi-belgii agg. (Aster novi-belgii agg.)
31. Vitis riparia Michx.
32. Xanthium strumarium agg.

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