Danube Transnational Programme
Sava TIES

Sava TIES
Mapping and monitoring protocol for IAS

Project co-funded by European Union funds (ERDF, IPA)

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

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Mapping and monitoring protocol for IAS

Project	Sava TIES, DTP2-096-2.3
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Interreg Danube Transnational Programme Sava TIES

Foreword

Mapping and monitoring protocol for IAS was made for the needs of the project Preserving Sava River Basin Habitats through Transnational Management of Invasive Alien Species – Sava TIES.

This manual has been designed to help the user to effectively map invasive species in the region of Sava River Basin. Invasive alien species are a major driver of biodiversity loss and lead to changes in the structure and composition of ecosystems leading to significant detrimental impacts to ecosystem services, affecting economies and human wellbeing. Only early detection of locations and spreading pathways can lead to success in dealing with the problem of invasive species.

Parallel with this manual, there will be made online user interface by which data will be entered into the database created by the needs of the project.

The protocol consists of two parts: Basic and Additional information.

The first part should be filled out by everyone and consists of basic data essential for the IAS early detection and functionality of the Sava TIES IAS database. This basic data will be compatible with online Sava TIES IAS user interface and an online form that will be available for data input. The data entries in this way will be stored directly in the Sava TIES IAS database.

The second part requires more complicated data and that part should be completed by the experts. This part will give detailed information on infested habitat types and priority species, which will give complete information about the spreading pathways of invasive species, types of habitat and endangered species.

This manual is intended for managers of protected areas, professional biologist, non-governmental organizations, users or owners of the land, and nature protecting volunteers who are able to recognize the invasive species.

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Invasive species

What Are Invasive Species?

Invasive alien species are one of the main direct drivers of biodiversity loss at the global level. In some ecosystems, such as many island ecosystems, invasive alien species are the leading cause of biodiversity decline. Invasive alien species primarily affect biodiversity by preying on native species or competing with them for resources. In addition to their environmental impacts, invasive alien species can pose a threat to food security, human health and economic development. Increasing travel, trade, and tourism have facilitated the movement of species beyond natural bio-geographical barriers by creating new pathways for their introduction. With increasing globalization, the occurrence of invasive alien species is likely to increase unless additional measures are taken. (https://www.cbd.int)

The Convention on Biological Diversity (CBD) made the Strategic Plan 2011-2020 that include Aichi Biodiversity Targets. The twenty headline Aichi Biodiversity Targets for 2015 to 2020 are organized under the five strategic goals (A, B, C, D, and E). The goals and targets comprise both aspirations for achievement at the global level, and a flexible framework for the establishment of national or regional targets. **Strategic Goal B***: Reduce the direct pressures on biodiversity and promote sustainable use*, **Target 9**, concerns of invasive species and it reads:

> *By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.*

Why Do We Care?

The attempt to control invasive species can be costly in time, effort, and money. Invasive species are directly responsible for the extinction of many native species, causing economic loss and affecting human health. As the number of invasive species increases the amount of damage they cause to our native ecosystems and to the environment increases as well.

Why is it Important to Report an Invasive Species Sighting?

Entering and tracking locations of invasiveness along the Sava River Basin can identify the “leading edge” of invasive species heading our way. Early detection can stop or minimize the spread of an invasive species, allows land managers and agencies to prioritize control needs and strategies while populations are still small.

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Field Manual

Basic information

Name of data collector:			**Institution:**		
Date:					
Locality:					
Protected area:	**Yes/No**	**Name of protected area:**			
Location coordinates:					
Invasive species (scientific name):					
Surface area (m^2):					
Vegetation layer:	**Herbaceous (up to 0.5m)**	**Bush (up to 5m)**	**Tree layer (higher than 5m)**		
Coverage is expressed in percentage:	**1-25%**	**25 – 50%**	**50 – 75%**	**75 – 100%**	

Habitat:

☐ **Natural Forest**	☐ **Beach**
☐ **Forest Plantation**	☐ **Streambank**
☐ **Park**	☐ **Agro. Field**
☐ **Grassland**	☐ **Yard / Garden**
☐ **Wetland**	☐ **Water habitat**
☐ **Dune**	☐ **Road corridor**
☐ **Rocky outcrops**	☐ **Other**_____________________________________
☐ **Mining deposits**	☐

Comments:

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Additional information*:

Habitat types (Habitat Directive):	**Habitat type**		**%**	
Endangered species (Latin):				
Endangering factors and conservation problem:				
The degree of degradation of the habitat:	**Low**	**Moderate**	**High**	
Spreading pathways and vectors (e.g.: river, ditch, road, cattle):				
Risk assessment of spreading	**Low**	**Moderate**	**High**	
Local name of IAS				
Distribution/area covered by invasive species	**Point**	**Patchy**	**Linear**	**Continuous**
Habitat description				

*Explanation how to fill out additional information of the field manual is from the page 35

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How to fill out basic information of the field manual

Where you collected the data?
Locality, the protected status and Latitude and Longitude coordinates (WGS34)

When you collected the data?

Who collected the data?
Name and institution (optional)

Name of data collector:			**Institution:**	
Date:				
Locality:				
Protected area:	**Yes/No**	**Name of protected area:**		
Location coordinates:				
Invasive species (scientific name):				
Surface area (m^2):				
Vegetation layer:	**Herbaceous (up to 0.5m)**	**Bush (up to 5m)**	**Tree layer (higher than 5m)**	
Coverage is expressed in percentage:	**1-25%**	**25 – 50%**	**50 – 75%**	**75 – 100%**

Scientific names of the plants.

Belonging of invasive species to vegetation layer

Approximate surface area in square meters.

Coverage is expressed in percentage and it should define the density of invasive species in the area of concern.

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Maps and mapping

What are maps of distribution?

Maps of species' distributions or habitat suitability are required for many aspects of environmental research, resource management and conservation planning. These include biodiversity assessment, reserve design, habitat management and restoration, species and habitat conservation plans and predicting the effects of environmental change on species and ecosystems. Maps of distribution of invasive species are the basis for applied research and conservation planning as well as for theoretical research investigating patterns of spreading and the processes shaping these patterns.

In order to effectively manage invasive species it is important to first identify the areas occupied by the invasive species and recognize the existing conditions within the area of concern. Knowing range of distribution of invasive species is useful for prioritizing and determining which management practices will be used. In order to identify existing conditions the aid of technology can be extremely useful.

Potential mapping and monitoring methods of invasive alien species

Zsolt Molnár in collaboration with Marianna Biró, Arnold Erdélyi, Judit Hartdégen, Csaba Vadász, Gábor Takács, Dénes Horváth, Ábel Molnár, Gergely Király

Introduction

The following chapter introduces four different methods that can be applied for mapping and monitoring alien invasive species in the Sava TIES project.

Assessing the abundance of invasive species has been considered by now as an undisputedly necessary part of practical nature conservation and many areas of land management. Considering both the monitoring and the treatment of invasive species, a vast knowledge has been gained throughout the world, but we are still very far from achieving an overall solution regarding to this problem.

Selecting (or specifically developing) the most appropriate method is not easy, as is it highly context dependent, depends e.g. on areal extent, staff, money and time availability.

The objective of this chapter is to give an overview of a selection of potential methods that can be used in the different pilot areas of the Sava TIES project along the Sava River to effectively map and monitor invasive alien species in floodplains.

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Table 1. Main features of methods described in this chapter.

	Goal	Extent	Expertise needed	Time and cost
Method 1	Detailed grid mapping to plan eradication	suitable for smaller areas (<100-500 ha)	very good knowledge of the mapped IAS, moderate or good orientation skills and habitat knowledge	time consuming and costly
Method 2	Detailed mapping to prepare for local treatments / contracts	suitable for smaller areas (<1000 ha)	very good knowledge of the mapped IAS as well as the possible treatments, moderate or good orientation skills and habitat knowledge	cost depends on the complexity of the area
Method 3	Large-scale polygon-based mapping focussing on forest layers	suitable for medium and large areas (1000- 10 000 ha)	very good knowledge of the mapped IAS, moderate or good orientation skills and good habitat knowledge	moderately costly and time consuming
Method 4	Large-scale polygon- and point based mapping for general overview	suitable for large areas (>5000 ha)	very good knowledge of the mapped IAS, moderate or good orientation skills and habitat knowledge	the cheapest methods (per area)

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Method 1

A reliable method for assessing the local abundance of invasive tree species

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Introduction

Assessing the abundance of invasive species within a target area usually has a lot of challenges and its accuracy is often limited by the available financial resources. To quantify the abundance of target species, field investigations usually need to be carried out. As the fine-scale spatial distribution of invasive tree species is often extremely aggregated (Figure 1-2), using low sampling intensity can easily result in significant under- or overestimation, either. In this case, for precisely calculating the necessary resources for the planned management interventions, instead of sampling, (nearly) full-cover mapping seems to be the adequate choice, which can provide reliable data.

The best practice introduced in this chapter takes place in the Peszéri-erdő (HUKN20002) forest steppe habitat complex, within the frame of the OAKEYLIFE - LIFE 16/NAT/HU000599 project (http://oakeylife.hu/en).

Methodology

Specifying categories regarding the necessary treatment

According to the treatments to be applied, it is important to categorize the individuals of invasive tree species present in the management area. In our case, 3 different categories are used:

1. „Thick fraction", which refers to the number of individuals with dbh (diameter at breast height) exceeding 5 cm. The accuracy of the estimations is about ± 10% (example in Figure 1). Moreover, for the resource calculations an average dbh is also estimated for each species within each data collection unit. Injection technique can be easily applied as the trunk is wide enough to be bored and herbicide can be squirted safely into the drilled hole. So, in this case the fraction is defined as the set of individuals to be treated using the stem injection technique.
2. „Thin fraction", which refers to the number of those individuals with dbh not exceeding 5 cm that cannot be removed manually with its complete root (example in Figure 2). The accuracy of the estimations is usually worse than in the previous case. Accordingly, an estimated ordinal variable is used to represent the local abundance. Individuals belonging into this category can be managed by partial girdling and painting with herbicide, so the fraction is defined as the set of individuals to be treated using these techniques.
3. „Pull-out fraction", which refers to the total number of individuals of a species, that can be safely pulled out by hand together with its complete root. The accuracy of the estimations is the worst of the three categories, as seedlings also belong to this class. Therefore, the categories are much broader than in the previous fraction.

Defining the boundary between the last two fractions is not always easy as it may vary between different circumstances (e.g. soil conditions) and also between species. E.g. on sandy soils *Prunus serotina* and *Acer negundo* individuals can be pulled out safely up to cc. 0,5 m height with their complete roots, which is hence the fraction margin in their case. The root of *Celtis occidentalis* is more fragile, so the height maximum of the manually removable fraction is lower. Regarding this species, only the 1-(2) year seedlings (usually with 10-20 cm height) belong to the third fraction. The root of *Alianthus altissima* is the most fragile, so the third fraction is not used in the case of this species. In its case, only the fine-scale presence of massive germination is registered.

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Technical background

Field data collection is being carried out with smart rugged tablets. The device has to be able to bear different weather conditions and accidental drops, moreover it needs to be compatible with certain platforms (e.g. GIS) as well. High GPS accuracy is also important. In our case, ArcPad software is used on field books (Windows OS). Data are collected directly in the attribute tables, whilst GPS position is also visible (Figure 4-5).

Data collecting

The surveying units were created previously in GIS. A 25x25m grid was laid down on the project area for splitting the site to equal and joining quadrates. The total area of each quadrate is 625 m^2. During the fieldwork, surveyors have to fill the fields of the attribute table (Figure 5).

According to the Hungarian forestry administration system, forested areas are divided into subcompartments/forest stands, which can be considered usually as forest management units, so it is necessary to adjust the grid to the stand borders as well. This can be easily achieved by simply dividing the grid units according to forest stand borders. If the new edge polygons are too small to examine – primarily due to GPS inaccuracy –, they can be totally omitted or abundance data from the surrounding polygons can be extrapolated to them. There can be also quadrates, quadrate groups or even whole subcompartments, which are practically impenetrable for surveyors or too dense for making accurate estimations, so they also have to be excluded from the examination. These are the two main reasons why the method was referred as „nearly" full mapping in the introduction part.

GPS tracklogs are also recorded for later verifications and future analyses. Displaying the tracklog during the survey is very useful, as this way the surveyor can judge whether the actual unit has been thoroughly examined. As soon as a quadrate is thoroughly examined and all the estimations (regarding the abundance of target species) have been done, data can be written in the actual polygons attribute table (Figure 3). Amongst some conditions, e.g. when the „thick fraction" is present with high stem numbers, it is reasonable to mark the centre point of the quadrate with a visible object and start making estimations by walking around in a circle with 12.67 m radius. This circle covers most part of the quadrate, approx. 5/6 of the 625 m^2 quadrate can this way be examined. Afterwards, checking the corners is going to be necessary for the rest besides the estimations of the other fractions and correcting the estimations on the thick fraction using the point of reference. If the vegetation is very dense, a reliable estimation can be done using another method. Two persons traverse the same quadrate parallelly (at the same time in line with each other). Hence the area is divided into 2 parts and slaloming becomes unnecessary (Figure 3).

Practical information

In our project full mapping covered approx. 16000 quadrates (approx. 1000 hectares), which was a challenging task. According to the vegetation density, on average 50-100 quadrates (3-6 hectares) could be surveyed in one day by one person. Accordingly, about 210 days of fieldwork was calculated as the necessary time demand (for one person). It is important to mention that the vegetation was dense in most parts of the project area, which led to increased time demand. Also, the forest stands could be characterised with expressed spatial variability in terms of local abundance of invasive tree species. Accordingly, making accurate assessments using traditional (sample-based) methods was considered unreliable. However, a similar investigation was completed in a nearby forest of the same extent within only 120 field days (calculated for one person) due to lower vegetation density, which evidently resulted in higher number of surveyed units per day.

Completing the above detailed assessments resulted in accurate and sufficiently detailed datasets, which can contribute to precise conservation (and also land management) planning. Accurate maps could be created, so calculations on resource demands for the treatment of particular forest stands and logistics planning become easier. Also, certain predictions (e.g. regarding the future activation of the seed bank) can also be made, e.g. those parts with numerous seed-producing individuals will surely be characterised by mass germination after and interaction which reduces the canopy closure. Accordingly, after identifying the infection hotspots, clear cut and artificial reforestation practices – including stump removal and complete site preparation – may be used

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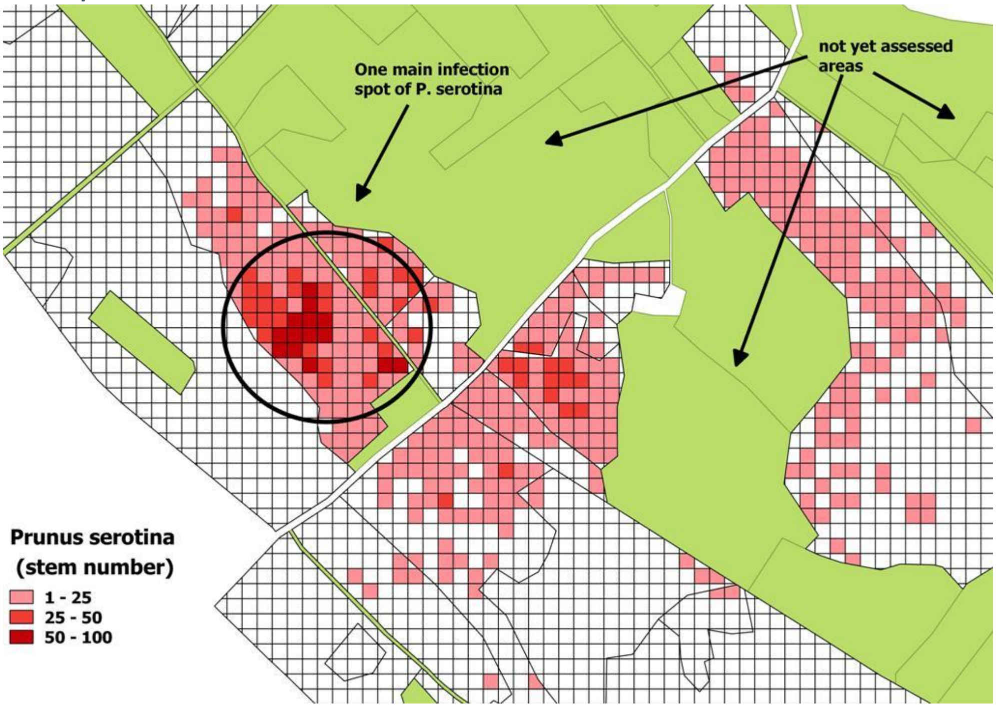
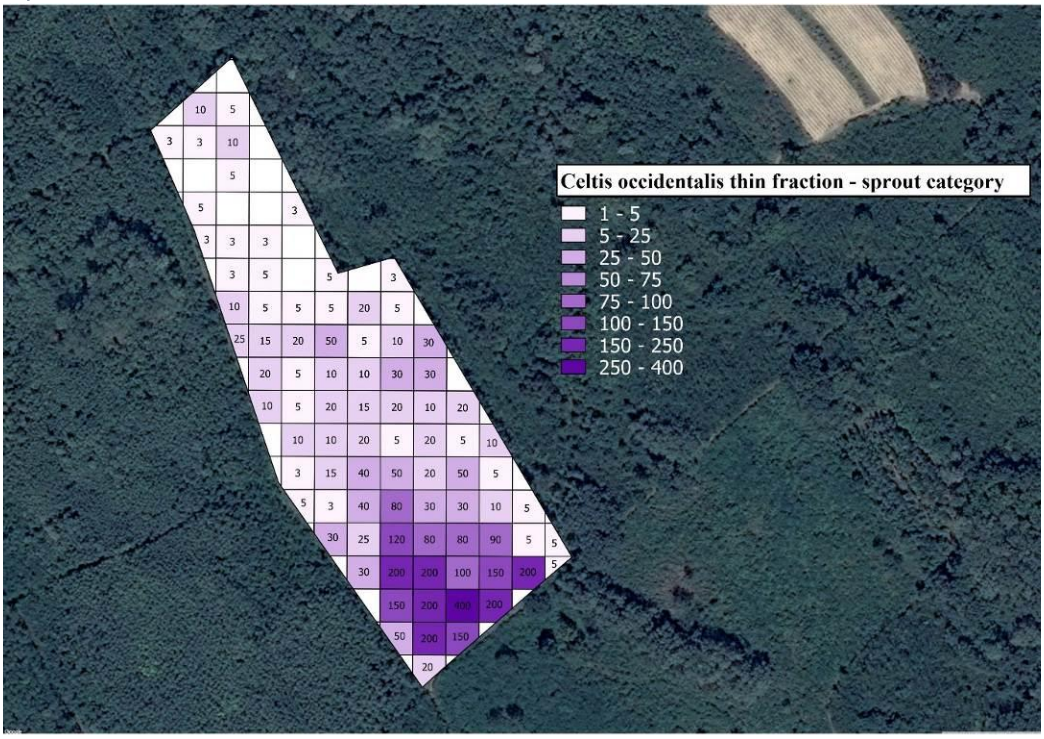
(Figure 6), which reduces the amount of applied chemicals. Complete site preparation eliminates basically the majority of the seed bank. However, for assigning an area for complete site preparation, field investigations focusing on protected species are also necessary to prevent their destruction.

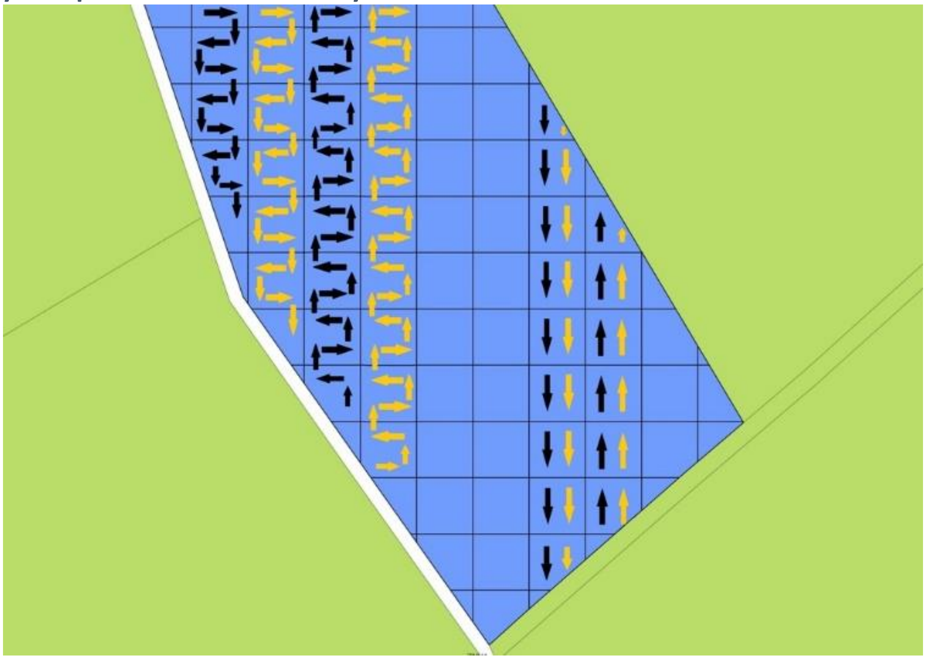
1. Figure – Abundance map of *Prunus serotina* covering particular forest stands (regarding the "thick fraction")



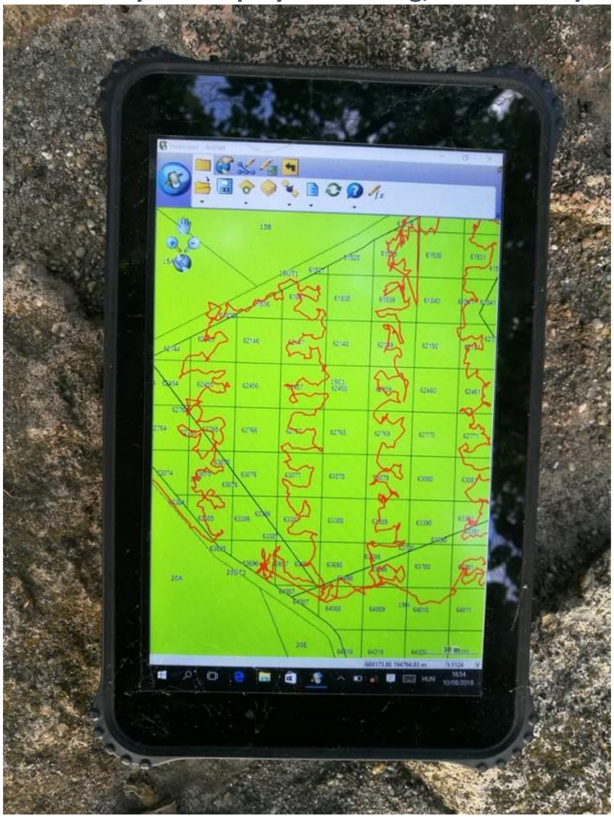
2. Figure – Abundance map of *Celtis occidentalis* in one subcompartment (regarding the "thin fraction")



3. Figure – Theoretical walking patterns of two researchers. Left side: each quadrate is examined by one person, quadrate columns are split between two surveyors. Right side: each quadrate is examined by two persons simultaneously.



4. Figure – Real tracklog displayed in ArcPad. The software is running on a fieldbook. N.B. Those quadrates, which are not covered by the displayed tracklog, were surveyed by another person.



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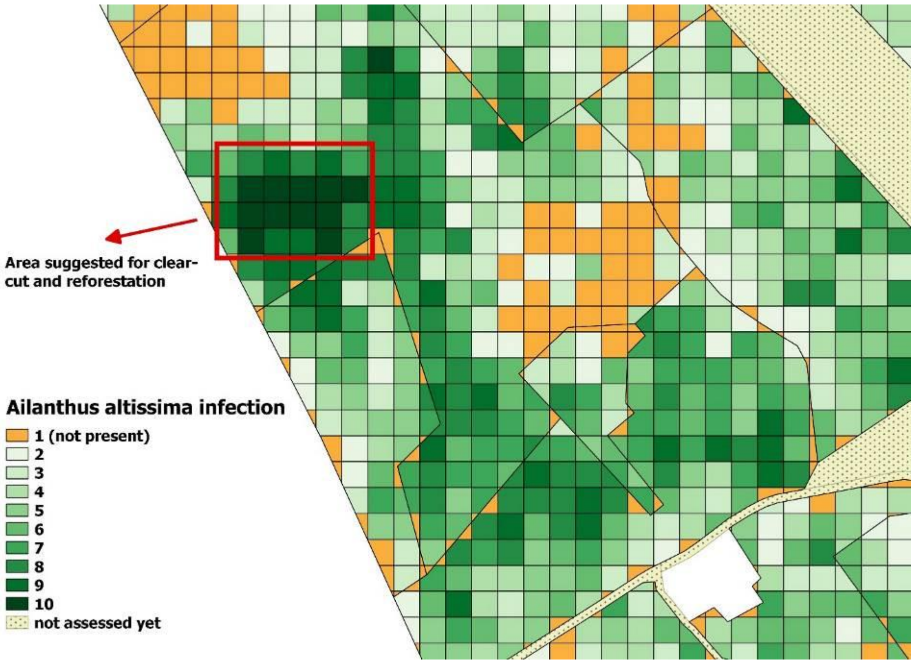
5. Figure – Attribute table of the selected quadrate (blue frame)

6. Figure – *Ailanthus altissima* infection hotspot suggested for clear-cut and artificial reforestation (incl. complete site preparation)



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Method 2

Fine-scale mapping of invasive alien species and planning of their erradication based on an anonymized real example from the Fertő-Hanság National Park

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This example used habitat mapping with special attention to invasive alien and native species. The mapping served as a basis for the planning of erradication. The information below shows the concrete example from the Fertő-Hanság National Park.
We used a polygon-based mapping when invasive species covered larger areas, and a point-based mapping for mapping individuals or small groups of invasive species. We documented: species, percentage cover or number of individuals, habitat type and number of fruit-producing individuals (only in case of *Ailanthus altissima*).

Basic data					
Locality	**The whole parcel?**	**Area (ha)**	**Land use**	**Protection status**	**Natura 2000**
Sopron xxxx/1	**yes**/not	0,5683	arable	protected	HUFH20002
Sopron xxxx/4	**yes**/not	4,7638	meadow	protected	HUFH20002
...					
....					

Owner:	Hungarian State (manager: Fertő-Hanság National Park)

Project data	
KEHOP project:	Name of the project....
Part of the project:	Workpackage name...
Area of reconstruction (ha):	9,75 ha

Present state of the habitat patches
Most of the area was enchroached by bushes, many of these are individuals of invasive species, part of the area is an irregularly managed wet meadow *Examples of subarea descriptions:* ***1. subarea:*** Closed (>90% cover) *Prunus spinosa, Crataegus monogyna, Cornus sanguinea* thicket, near the channel 5-15 m tall *Fraxinus pennsylvanica* trees (diameter 10-20 cm), with some Elaeagnus trees (diameter 20-50 cm). ***3. subarea:*** Moderately closed (<70%), short (1-1,5 m) bushes on degraded wet meadow. There is a regularly cut area under an electric wire. ***4. subarea:*** Degraded wet grassland, cut irregularly. There is rubbish on the area (~ 2 m^3). ***7. subarea:*** Regularly used path, like a road, covered with grassland. ***8. subarea:*** Regularly mown grassland with 5-6 Elaeagnus trees. ***9. subarea:*** Grassland with native trees and shrubs, no treatment is needed. ***12. subarea:*** Degraded mown meadow, no need of treatment in the project.

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15. subarea: Carex stands and wet meadows with enchroached Phragmites, not mown, water-logged.		
Habitat types (Á-NÉR):	**Habitat type**	**%**
	B1a – Reed beds	7,7
	OB – Degraded wet meadows	33
	RA – Native trees in lines	1
	P2a – Wet shrub	43,5
	P2c – Non-native shrub	5,6
	S6 – Non-native trees, spontaneous	8,5
	U11 – Roads	0,7
	and their transitional stands	
Distribution of invasive alien species (see also the map)	**Description**	**Intensity**
Elaeagnus angustifola	Dominant in subarea 13, scattered in other parcels	10%
Fraxinus pennsylvanica	Dominant in subarea 16	10%
Solidago gigantea	Scattered, mostly on areas uprooted by wild boar	2%
Protected species	Breeding birds (e.g. *Erithacus rubecula, Luscinia megarhynchos, Locustella fluviatilis, Lanius collurio*).	
Conservation problem	Enchroachment of grasslands by invasive and native shrub and tree species	

Objectives related to invasive alien species		
Conservation objectives	**Objective**	**ha**
	Restoration of grassland on areas invaded by Phragmites	0,96
	Restoration of grassland on areas invaded by invasive srubs and trees	1,75
	Restoration of grassland on areas invaded by native shrubs and trees	5,69
	Restoration of vegetation on channel sides invaded by non-native trees and shrubs	0,29
	Protection and management of spontaneous woody vegetation (improving habitat quality)	0,13
	Management of grasslands by removing scattered non-native trees	0,84
	Management of grasslands by removing scattered native and non-native trees	0,18
	Management of grasslands (improving habitat quality)	2,57
Habitats to be treated (Á-NÉR):	D34 – Wet meadows E1 – Arrhenatherion meadows B5 – Non-tussocky sedge beds	
Nature 2000 habitat type	6440	

Activities in subareas
Examples of subarea activities: ***1. subarea*** (0,57 ha): Cutting of trees and shrubs, wood material to be removed between August and September 2018. Shredding in 2019, and mulching in autumn 2019 and 2020. ***3. subarea*** (0,88 ha): Cutting of trees and shrubs, wood material to be removed between August and September 2018. Shredding in 2019, and mulching in autumn 2019 and 2020. If mowable by 2020, to be mown with subarea 4.

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4. subarea (0,5 ha): Cutting of shrubs and mulching in summer 2018.
7. subarea (0,08 ha): No treatment needed. If possible the road to be abandoned and be turned into a managed grassland.
8. subarea (0,55 ha): Shrubs to be cut in autumn 2018. Stumps must be cut at soil surface, to allow mowing next year. Management of the area will be done from another project source together with subarea 12.
9. subarea (0,13 ha): Valuable group of trees, no treatment is needed.
12. subarea (2,53 ha): It is a mown grasslands, no treatment is needed in the project.
15. subarea (0,96 ha): Mulching once in 2018.

Type of activity	***Area in total (ha)***
Removal of shrubs and trees by cutting (easy), removal of woody material	0,981
Removal of shrubs and trees by cutting (moderately difficult), removal of woody material	5,43
Removal of shrubs and trees by cutting (difficult), removal of woody material	0,69
Cutting of trees, cleaning of the area	1,06
Cutting/shredding of sprouts	6,3
Shredding	25,98

Place of piling the wood material	In the treatment area on the place of a shrubbery
Risks, expected problems	Subarea 15 is sometimes waterlogged. The whole area can be treated only in a not-too-wet year.
Permitions needed	Cutting of shrubs – nature copnservation authority Cutting of trees in managed forests - forestry authority

Post-project management needs	
Management:	Grass to be cut once (or twice) a year, and the hay to be collected.
Source:	Agricultural, Natura 2000 subsidies

Need for monitoring	
Isophya costata (a grasshopper)	–
Bats	–
Breeding birds	yes
Microtus oeconomus (a rodent)	–
Botany	habitat mapping, invasive species mapping
	
Elaeagnus angustifolia in subarea 10	Regularly cut area under an electric wire in subarea 3 (uncut areas are invaded by shrubs on both sides)

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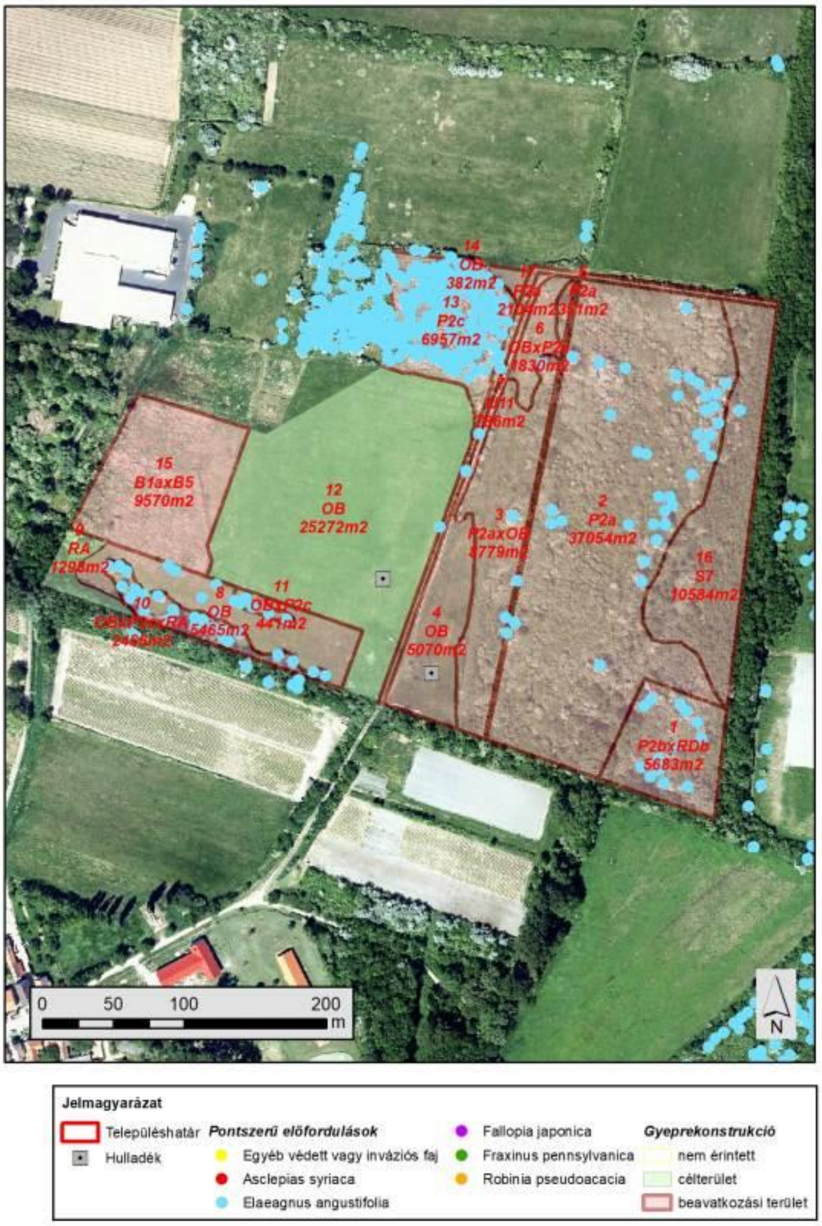

Overview map (blue dots indicate Elaeagnus individuals)

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Method 3

Medium-scale mapping with rich attribute data on alien invasive species (Tisza river)

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MTA Centre for Ecological Research, Vácrátót, Hungary

A medium-scale field survey method of invasive alien species in riverine habitats is described in this chapter. With this method we can map habitat types (including their naturalness) and invasive species in the different strata (layers) of the vegetation patches. We use an example from the Tisza floodplain (Horváth et al. 2005) to show advantages and limitations of the method.
The time needed for the mapping (at ca. 1: 10 000-25 000 scale) of the 2600 hectars with this method was approx. 10 days by implementing the two different aims at the same time (habitat mapping and survey of invasive species). Depending on the patch size and complexity of the area not more than **2-300 hectares can be mapped in a day by one person**. Recommended optimal patch size is 2-3 hectares (to have a reliable, spatially correct description of the patch at this scale).

Data collection
Important tools of the field surveys are the A4 size color preprints of satellites or ortophotos (scale approx. 1: 3000-1: 5000) and the data sheets fixed on a clipboard. Delineation of the 2-3 hectares sized homogenous patches could be the first task during the mapping. This is usually followed by thorough survey of the patches. Filling the data sheet is the next step together with the estimation of the different percentage cover values of the vegetation.
Homogenous patches of big Amorpha stands (10-20 hectares) could be divided into 2-3 hectares large patches. If this is not evident on the basis of the satellite images, divisions can be done after the field survey of the given patch. Collecting and synthetizing local data in the large patch can also be done (using point data localized by GPS).

Advantages of the method
Information could be designed into a spatial database in a GIS system (QGIS or ArcGIS softwares). Records collected and filled into an attribute table can be visualised on different maps. Other attributes can also be joined to the records in the GIS system for example past land cover or land use data, soil and elevation. Cover of invasive species in the shrub layer or in canopy layers can be well estimated with this method. Displaying these values on maps focus areas for the interventions can be delineated effectively.

Disadvantages of the method
Estimation inaccuracies of invasive cover percentages is generally increasing with patch size, as the transparency of the vegetation is usually low. Therefore the seemingly homogenous patches need to be surveyed thoroughly or divided into smaller patches.

Attributes (a potential list to be adapted to local needs)
List of native species in the first (upper) canopy layer *
Cover of native species in the first canopy layer ** (%)
List of alien species in the first canopy layer *
Cover of alien species in the first canopy layer ** (%)
Trunk diameter (DBH) of alien species in the first canopy layer (cm)

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List of native species in the second (lower) canopy layer *
Cover of native species in the second canopy layer ** (%)
List of alien species in the second canopy layer *
Cover of alien species in the second canopy layer ** (%)
Trunk diameter (DBH) of alien species in the second canopy layer (cm)
Native regrowth (frequent/ rare/ missing) (see also Fig. 3)
List of species in the native regrowth * (see also Fig. 3)
Density of shrub layer (permeability: good/ medium/ bad)
Cover of shrub layer (%)
List of native species in the shrub layer*
Cover of native species in the shrub layer ** (%)
List of alien species in the shrub layer *
Cover of alien species in the shrub layer ** (%)
Age of the alien shrubs (young/medium/old) (see also Fig. 4)
Hight of alien shrubs (meter)
Land use in treless pachtes (see also Fig.4.)
List of protected or rare plant species
Habitat type of the patch (see also Fig. 5)
Naturalness (habitat quality) of the habitat patch
Native old trees (frequent/ rare/missing)
Lianes (frequent/ rare/missing)

*** We suggest to use abbreviations for species lists**
For species names of trees and shrubs abbreviations of latin names could be used e.g.:
sa: *Salix alba*
sf: *Salix fragilis*
st: *Salix triandra*
ma: *Morus alba*
um: *Ulmus minor*
ul: *Ulmus laevis*
qr: *Quercus robur*
pa: *Populus alba*
an: *Acer negundo*
ac: *Acer campestre*
af: *Amorpha fruticosa*

****: Cover of species**
Percentage of cover of species in the patch
(Fig. 1)

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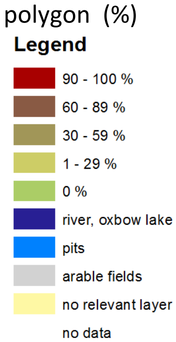
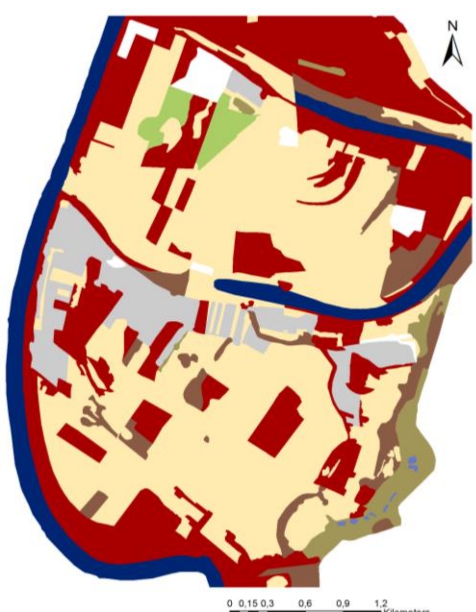
a) Cover of invasive species in the shrub layer (source: Horváth et al. 2005)

Fig. 1. Cover of invasive species in the shrub and canopy layers (maps are parts of ecological survey maps of 'Mártély-Körtvélyes öblözet', Tisza river floodplain) (source: Horváth et al. 2005). Red patches have very high cover values of invasive species (90-100%). The highest rate of invasive cover of the shrub layer is clearly visible (mostly Amorpha fruticosa). Invasive cover in the second (lower) canopy layer was also high in some parts of the area (mostly Acer negundo and Fraxinus penssylvanica). Invasive cover in the first (upper) canopy layer also reached high levels (90-100%) in some parts.

Maps shows the proportion of invasive species in the different layers of the riverine habitats in each polygon (%)





b) Cover of invasive species in the second (lower) canopy layer (source: Horváth et al. 2005)

c) Cover of invasive species in the first (upper) canopy layer (source: Horváth et al. 2005)

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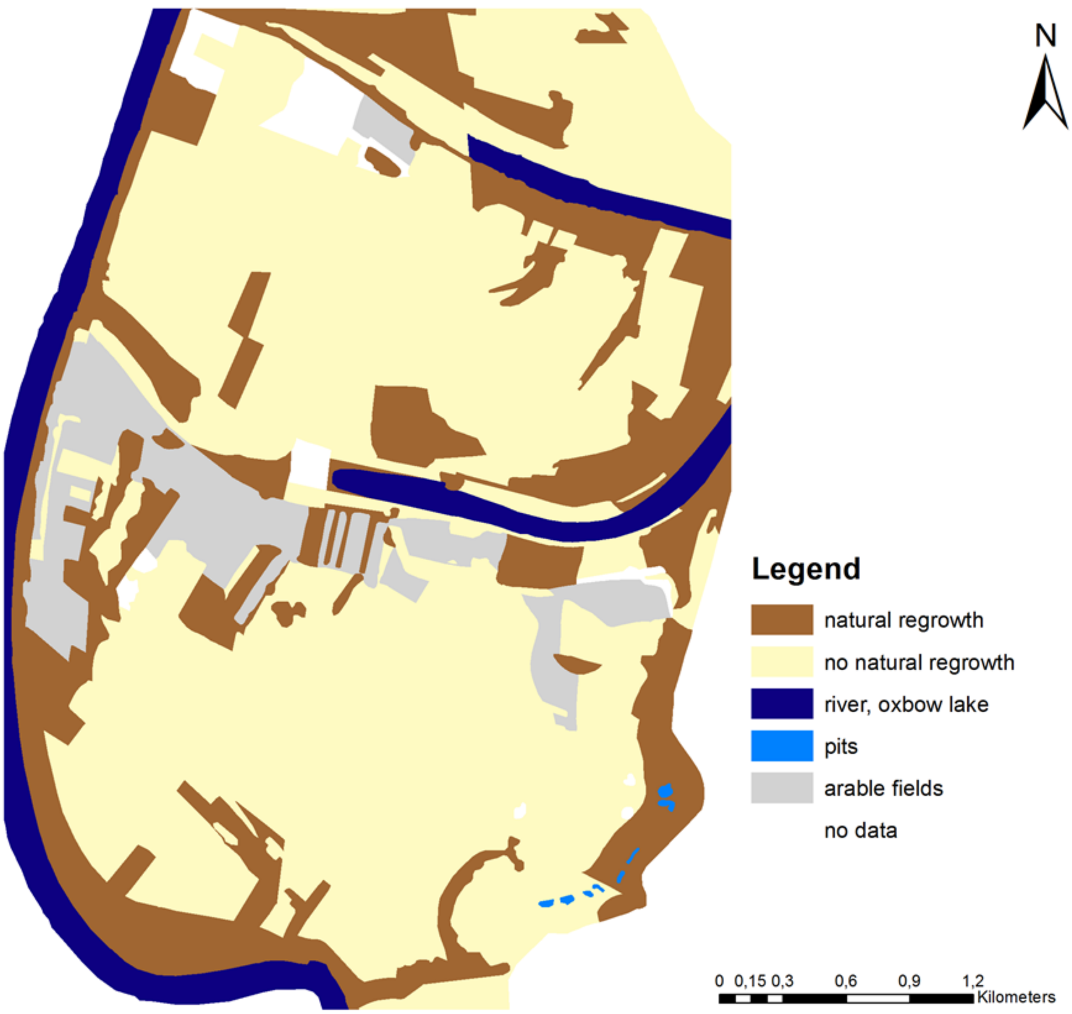

Fig.2. Regrowth of native species in the same area (Mártély-Körtvélyes öblözet, Tisza river floodplain) (source: Horváth et al. 2005).

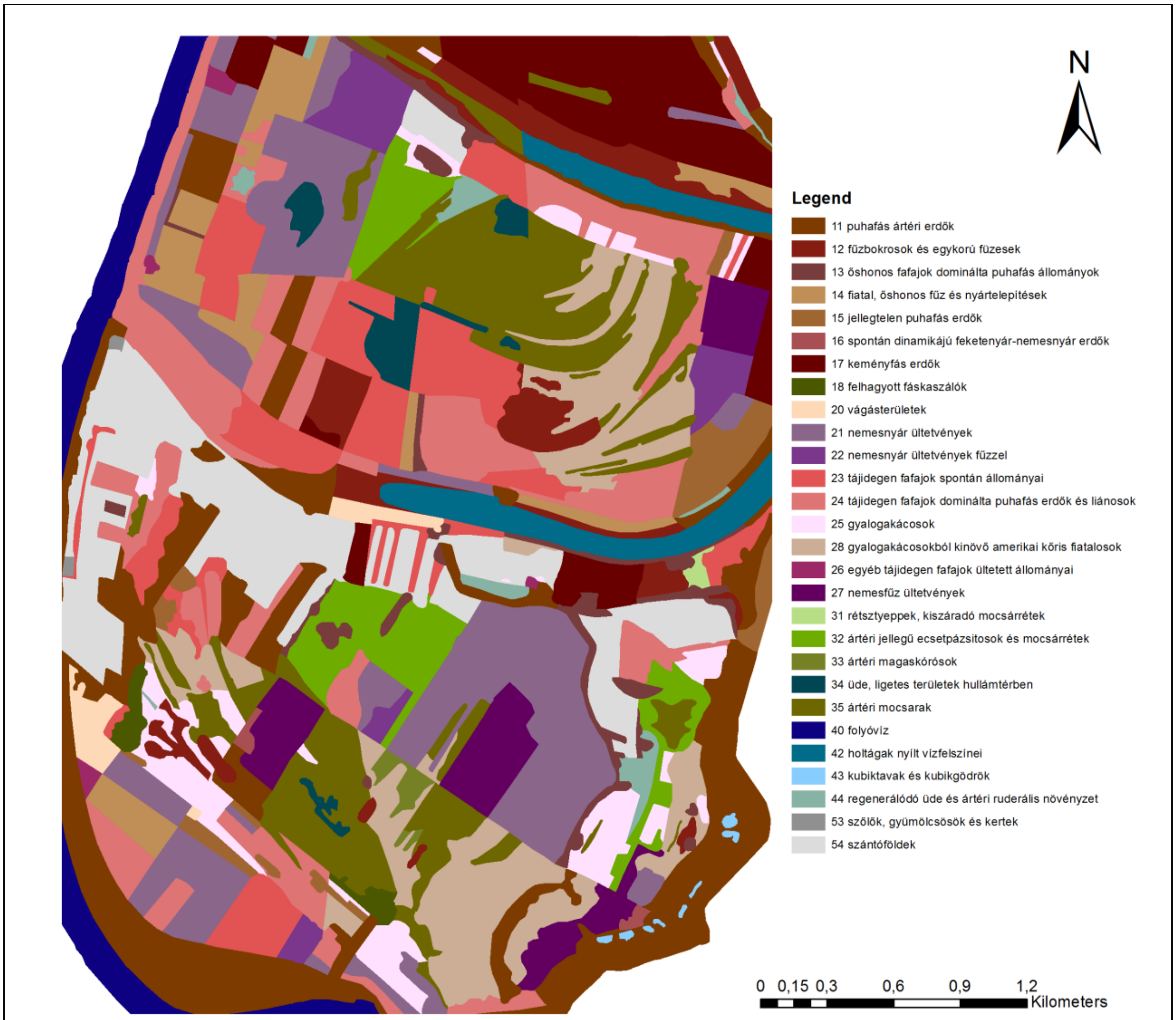

Fig. 3. Part of the habitat map of Mártély-Körtvélyes öblözet (Tisza river floodplain) (source: Horváth et al. 2005). The colour of the habitat groups was designed to help reading the content of the map. Habitat categories were established based on Fekete et al. (1997).

Importance of information on past land use for invasive species management

Success of regeneration after erradication of invasive species can highly depend on former land use. Amorpha generally spreads onto abandoned grasslands (former pastures or hay meadows) or on abandoned arable fields (Fig. 6). After erradication of *Amorpha* regeneration is usually much slower on old fields and the newly forming secondary graslands would be species poor and uncharacteristic. Regeneration can be more successful on former pastures and hay meadows, where fragments of the former vegetation can survive or propagules are still available in the soil seed bank. Therefore knowledge of past land use can be useful to improve the success of foodplain management for biodiversity conservation. Information can be added to the database usually during the GIS work based on historical maps and historical arial photos.

<table>
<tr><td colspan="2">Fig.6. Areas enchroached by Amorpha fruticosa during the 1990s on the arial photos from the 1960s and today (sources: www.fentrol.hu, Google Earth - DigitalGlobe)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Former pasture in a riverine area (on the right) and arable fields (on the left) (sources: www.fentrol.hu 1964)</td><td>The same area covered with dense Amorpha stands in 2009 (source: Google Earth, 2009 DigitalGlobe)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Former wood-pasture in a riverine area (sources: www.fentrol.hu 1960). In case of enchroached wood-pastures it is important to protect the survived old trees during the eradication work. To locate these old trees a point database could be the best solution.</td><td>The area in 2003. Enchroached wood-pasture (on the left), managed wood-pasture with the saved old trees (on the right) (source: Google Earth, 2003 DigitalGlobe)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>In the background: the enchroached wood-pasture with dense Amorpha understorey on the area above in 2010. (Photo: Ábel Molnár)</td><td>A nearby area with erradicated Amorpha and grazing grey cattle (as a management tool) (Photo: Ábel Molnár)</td></tr>
</table>

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Method 4

Medium-scale mapping of habitats with a polygon-level documentation of invasive species (the floodplain of the Hármas-Körös river) and point mapping in the Fertő-Hanság National Park

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In many cases habitat maps are prepared for conservation management. Most such maps are prepared **at the scale of 1: 25 000** (or 1: 10 000). In Hungary we use the habitat classification system called ÁNÉR (Bölöni et al. 2011), and the habitat mapping protocol developed during the 1990s and 2000s (Takács and Molnár 2009) for scientific and practical purposes. The National Biodiversity Monitoring Program also uses this protocol in his habitat mapping projects. The mapping protocol is available also in English: https://www.novenyzetiterkep.hu/node/374
According to this protocol, a detailed description of the flora, vegetation and conservation value of each mapped polygon must be given in the mapping report. For each polygon the characteristic and protected species and the dominant invasive and weed species should be listed. In a newer (not yet published) version of the protocol, also the percent cover of each invasive species has to be estimated in the field for each mapped polygon.

Based on these data **maps can be prepared that show the distribution and abundance of the key invasive species** in the mapped area at a scale of 1: 25 000 (but only with polygon resolution). Field data can be managed by ArcGIS (ESRI) or Q-GIS programs. This method is applicable to plan large projects of invasive species eradication but is not detailed enough to plan the cost and time needed for specific treatments. This method can be applied to large areas, i.e. to thousands of hectares. Usually **in one day 200-400 hectares can be mapped** by one person (using aerial photographs, maps and data sheets).

Map of *Solidago* spp. in the Fertő-Hanság National Park was prepared as a polygon map. Solidago forms large patches so a polygon map is a good estimation of its distribution (Király, 2017). In the case of the very localized distribution of *Fallopia*, a point survey and point database was used during habitat mapping (Király, 2017).

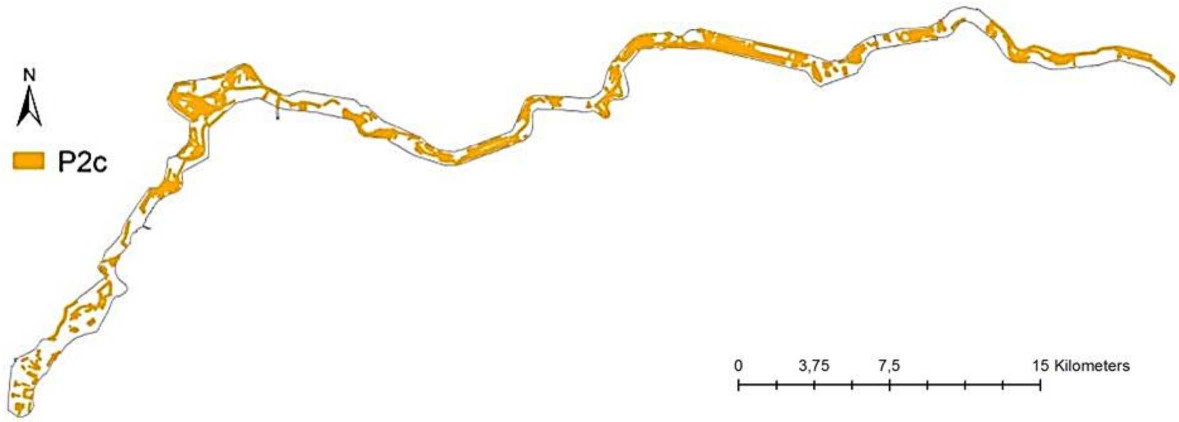

Figure 1. Map of the habitat category P2c (Shrubberies of invasive alien species, in this case mostly Amorpha) along the 80 kilometer long section (ca. 5000 hectares) of the Hármas-Körös river in South-Eastern Hungary, Körös-Maros National Park (Molnár and Biró 2015). White patches on the map do not indicate areas free of invasive species, either. They can be for example plantations or native forests with invasive species in the understorey. Regularly mown grasslands and some deeper marshes are free from dense Amorpha patches.

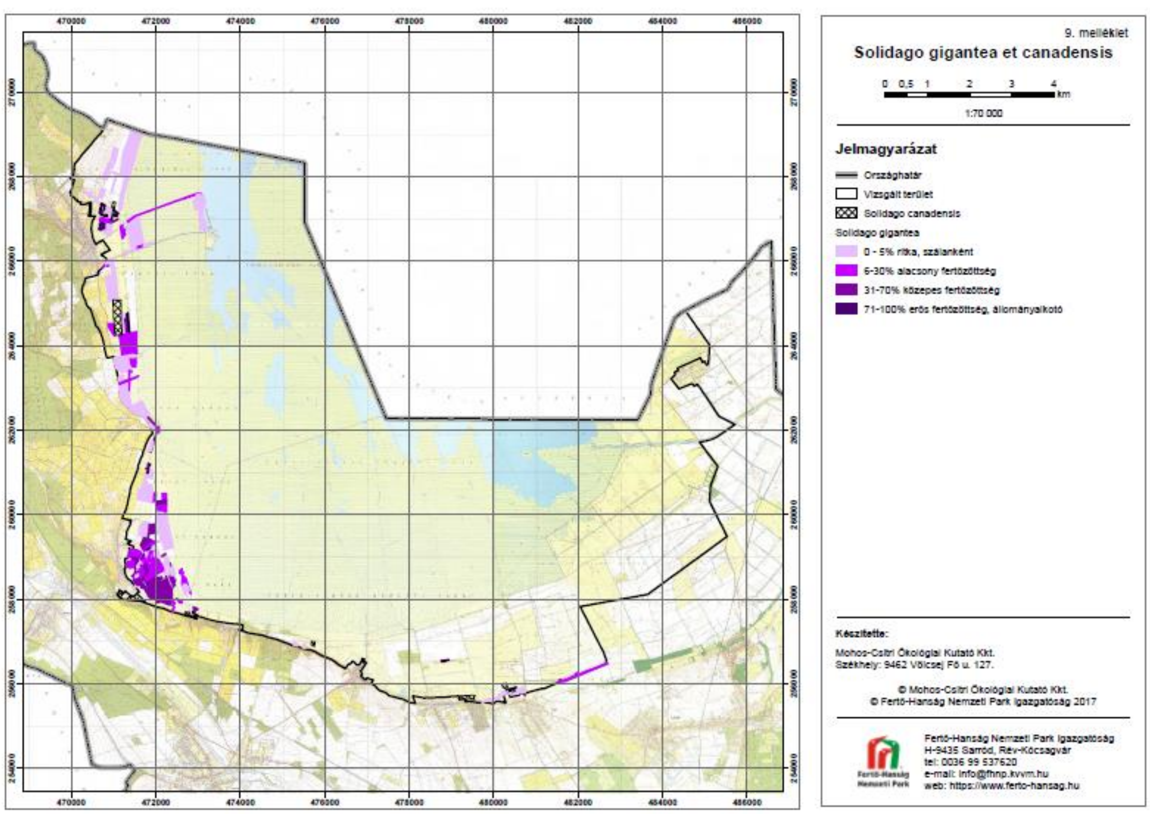

Figure 2. Map of *Solidago* spp. in the Fertő-Hanság National Park based on a habitat mapping database. *Solidago* forms large patches so a polygon map is a good estimation of its distribution (Király, 2017).

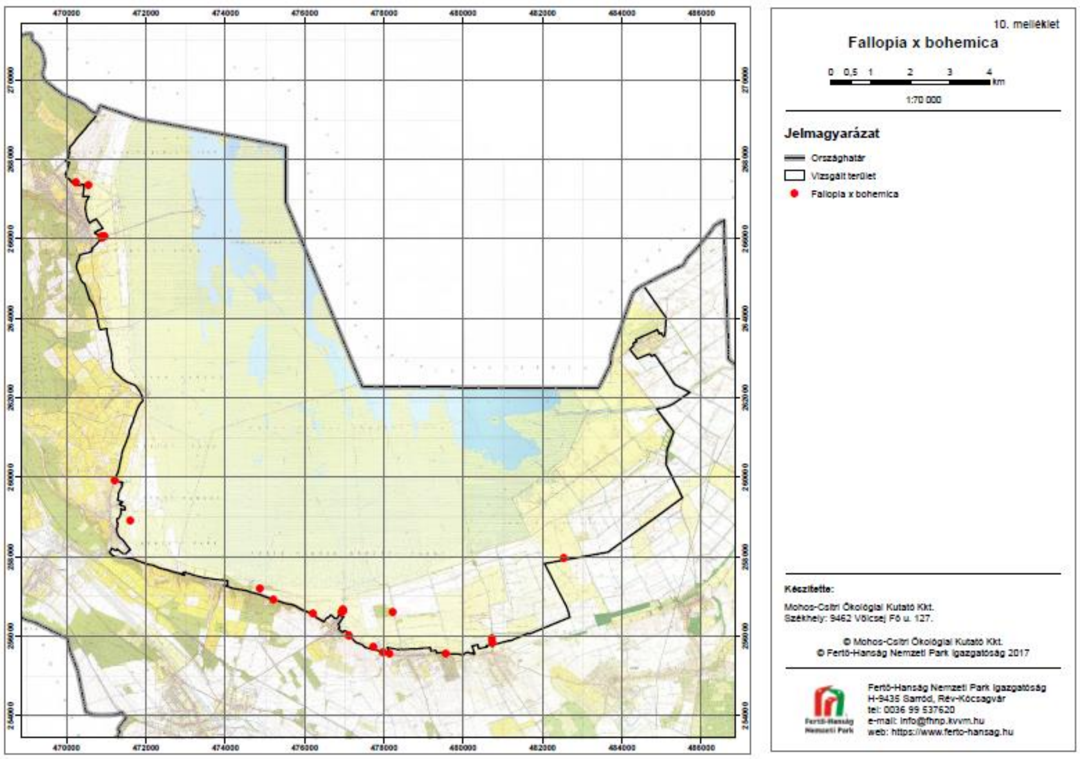

Figure 3. Distribution map of *Fallopia bohemica* in the Fertő-Hanság National Park based on a habitat mapping database. In the case of the very localized distribution of *Fallopia*, a point survey and point database was used during habitat mapping (Király and Takács xx).

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Integration of the mapped data into the online database

The reason for the mapped data to be integrated in an online database is primarily to be accessible for early detection and cost-effective management of invasive plant species in transnational context. Considering the fact that transnational rivers such as Sava are favoring dispersal of the most of invasive plants, timely actions can be only planned and implemented if managers of protected areas and policy makers have their decisions made on precise invasive species distribution. The database will enable exchange of the georeferenced records of the invasive plants in a systematic and problem-solving way.

It will also enable further research and analyses, in a comprehensive, comparable and reusable way. The process of integration of the mapped data (mainly consisting of spatial polygons) and the online database (which is going to be a point-based geospatial database) is fairly simple.

First of all, the geographic locations are going to be given specific site-based codes after which all the mapped polygons will be given indexed values. The polygons have the stored field data that is in table form, with columns and rows. The main part of this table is data concerning invasive species, however every polygon attribute table will have two columns that will have the values of X and Y of the centroid point of that individual polygon.

A centroid point or coordinate marks an imaginary center of mass of a structure; a point at a crossing of two diagonals which are connecting the corners of a rectangle constructed from the most north, most south, most east and most west points of a polygon. The values of the coordinates can be calculated and used in any GIS software, and is represented as a double integer, usable in any projection, either geographic or projected.

Then these coordinates will be the basis for constructing the points which will go into the online database, and the coded and indexed values of the adjacent polygons will be joined as two tables, thus „pulling“ the polygon-data of invasive species into the point-data tables.

Each point will have the values of the data from the polygons as the polygons will be the primary “source” of construction of the points. The data concerning the invasive species is then copied from the tables of the polygons into the tables of the points - integration of the data from the map into the online database is then complete.

Habitat

Determination of the habitat

A **habitat** is the natural home or environment of a plant, animal, or other organism. It provides the organisms that live there with food, water, shelter and space to survive. Every living organism has a habitat. Habitats vary greatly from organism to organism, because all living things have different needs for survival. Some species have flexible habitat needs, while other species require very specific habitats in order to survive.

Habitat destruction is a process in which the natural habitat is rendered functionally unable to support the species present. As more humans move into natural habitats and invasive plant species are introduced, the habitats of native species are decreasing greatly.

Determination of the habitat by the Habitats Directive

The Habitats Directive (more formally known as Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) is a European Union directive adopted in 1992 as an EU response to the Berne Convention. It is one of European nature's policies that establishes one organized network—Natura 2000, which intends to protect nature and wildlife. The Habitats Directive requires national governments to specify areas that are expected to be ensuring the conservation of flora and fauna species.

The Habitats Directive assures the conservation of endangered native animal and plant divisions. It aims to protect 220 habitats and approximately 1,000 species listed in the directive's Annexes. These are species and habitats which are considered to be of European interest, following criteria given in the directive. It directs Member States of the EU to take measures to maintain the "favorable conservation status" of protected habitats and species.

This section should include all of the recorded habitat types and percentages of the appearing at the locality.

Habitat types (Habitat Directive):	**Habitat type**	**%**
		10
		20
		30
		40

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Habitat description

A general habitat description provides greater clarity on the conditions in the field. Accordingly, this means to specify the type of habitat and tree layer where invasive species occurs. Also, everything that is considered important for the site can be marked here (e.g. domination of other plant species, proximity to bird nests, etc.)

Local name of IAS				
Distribution/area covered by invasive species	**Point**	**Patchy**	**Linear**	**Continuous**
Habitat description				

Endangered species

An endangered species is an animal or plant that's considered at risk of extinction. A species can be listed as endangered at the state, federal, and international level. Preservation of habitats from invasive species is very important because it saves native plants and other wildlife from going extinct. Once gone, they're gone forever, and there's no going back. Losing even a single species can have disastrous impacts on the rest of the ecosystem, because the effects will be felt throughout the food chain. From providing cures to deadly diseases to maintaining natural ecosystems and improving overall quality of life, the benefits of preserving threatened and endangered species are invaluable.

It is very important to all endangered species be recorded at the infested habitat, because of the fast reaction and effective management. This would focus nature protection efforts on the most important areas and improve conservation status of the key species. Only timely and spatially appropriate actions can prevent the destruction of habitats by invasive species and the disappearance of endangered species.

Factors that can endanger natural habitats are numerous, such as: intensive agriculture, waste, tourism, infrastructure, intensive traffic, etc.

Endangered species:			
Endangering factors and conservation problem:			
The degree of degradation of the habitat:	**Low**	**Moderate**	**High**

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Invasiveness and spreading pathways for the invasive species

Distribution & Invasiveness status

Every species evolves in its home territory to have one to several ways to expand its range. They may be wind-blown; rain splashed, carried by animals, or moved in soil or water. Almost all short-distance spread is through these natural dispersal mechanisms. In their home territory, short distance spread is rarely a problem because the resident plants and animals have evolved to coexist more or less peaceably. On the flip side, long distance spread is almost always human assisted. Because long distance spread takes the species a long way from home, the resident plants and animals are not often prepared to cope with their new neighbor. Natural enemies are missing and host species often lack the natural defenses necessary to survive an attack by the introduced species. Once introduced, invasive alien species are free to expand their range using their short distance dispersal mechanisms with a competitive advantage over native plant and animals due to the lack of natural enemies.

For **Distribution/area covered** it should be defined shape of spreading and shape of grow of invasive alien species:

- **Point** distribution means that invasive species grow in random unrelated points.
- **Patchy** distribution – the invasive species grows in separate groups and does not occupy the entire space.
- **Linear** distribution – the invasive species grow in linear forms (along ditches, roads etc.)
- **Continuous** – the invasive species occupies a large space in continuum.

Local name of IAS				
Distribution/area covered by invasive species	**Point**	**Patchy**	**Linear**	**Continuous**
Habitat description				

Spreading pathways

How colonization and establishment of the invasive alien species occur is a complicated issue as these processes highly vary among groups. Finding a global theory is difficult since a successful invasion requires a species to pass through different stages, including transport, introduction, and establishment phases (Williamson, 1996). Invasive species can adversely affect local biodiversity due to alterations of recipient ecosystems, impacts on native species, such as competition, predation or hybridization, or as carriers of disease (Pejchar and Mooney, 2009).

There are two types of spreading pathways of invasive species, natural and those created by humans:

1) Natural pathways include wind, water and dispersal by wild animals.
2) Man-made pathways are routes by which the majority of invasive species are introduced. Invasive species are primarily spread by human activities, often unintentionally. People, and the goods we use, travel around the world very quickly, and they often carry uninvited species with them. Ships can carry aquatic organisms in their ballast water, while smaller boats may carry them on their propellers. Insects can get into wood, shipping palettes, and crates that are shipped around the world. Some ornamental plants can escape into the wild and become invasive. And some invasive species are intentionally or accidentally released pets.

Riparian areas are vulnerable and easily degraded. Damage can be caused by uncontrolled stock access, clearing for agriculture or urban development. Because of that, riparian zone is the area suitable for growth and spread of invasive plant species. On local level the seeds or plant fragments of invasive species are spreading usually:

- By river watercourse
- Over animal fur or as birds food
- Agricultural equipment and machinery
- Transhumance
- On boat trailers, propellers, or in bait wells
- As ornamental plants escaped from local gardens
- By road or by railway

Spreading pathways and vectors (e.g.: river, ditch, road, cattle):			
Risk assessment of spreading	**Low**	**Moderate**	**High**

Project co-funded by European Union funds (ERDF, IPA)

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