INVASIVE TERRESTRIAL PLANT SPECIES IN THE ROMANIAN PROTECTED AREAS. A GEOGRAPHICAL APPROACH

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The current paper is aiming to present some of the most significant scientific results developed in the framework of ***FP7 enviroGRIDS project – Building Capacity for a Black Sea Catchment Observation and Assessment supporting Sustainable Development***, in terms of assessing the occurrence, development and spread the main Invasive Terrestrial Plant Species (ITPS) in the Romanian protected areas. Taking into consideration the intensification of the human-induced influences in various habitats, the authors undertook an in-depth analysis of selected ITPS (*Amorpha fruticosa, Acer Negundo*, *Ailanthus altissima, Fallopia japonica, Impatiens glandulifera*) in relation to the key environmental driving forces in some protected areas considered as case-studies for each biogeographical region in Romania: Maramureş Mountains Natural Park (Alpine region), Mureş Floodplain Natural Park (Pannonic region), Comana Natural Park (Continental region), Măcin Mountains National Park (Steppic region) and Danube Delta Biosphere Reserve (Pontic region). Based on the complex assessment of spatial and statistical data as well as field surveys an ITPS potential distribution model (ITPS-podismod) was also developed. Additionally, some relevant biological indicators (abundance, frequency and ecological significance) in relation to its key environmental driving forces (both natural and human-induced) have been calculated.

1. INTRODUCTION

Under the current global changes, biological invasions ranks among the most critical ecological threats to biodiversity and ecosystem services, especially since the *Convention on Biological Diversity's 2011–2020 Biodiversity Target* has stimulated global initiatives to quantify the extent of biological invasions, their impact on biodiversity and the related policy responses (McGeoch *et al.,* 2010). As a consequence, are often categorized as economic, environmental, or social threats (Charles and Dukes, 2006, Bailey *et al.,* 2007; McGeoch *et al.,* 2010), thus becoming key components of global change (Shea and Chesson, 2002; Arim *et al.*, 2006) through their high adaptive capacity enabling them to penetrate natural geographic barriers or political boundaries (Richardson *et al.,* 2000; Anastasiu and Negrean, 2005; Anastasiu *et al*., 2008; Andreu and Vila, 2010; Dumitraşcu *et al.*, 2010, 2011a).

As a result, ITPS have become successfully established over large areas in Europe causing significant environmental socio-economic damages (Pysek and Hulme, 2005; Lambdon *et al.,* 2008, Dumitraşcu *et al.,* 2012) and, under the increasing trade and travel means the threat they produce is likely to increase (McGeoch *et al.,* 2010). In protected areas, in particular, biological invasions are disturbing drivers for the ecosystem functioning and structure, as well as for species, species communities or habitats (De Poorter *et al.,* 2007).

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In order to exchange information and knowledge on invasive species and assure the bridging the gaps between research, policy and practice, in 1994 the *Invasive Species Specialist Group (ISSG)* was set up as a global network in the framework of *Species Survival Commission (SSC)* of the *World Conservation Union (IUCN).* This structure is assuming an important role in fighting against invasive species by reducing the threats they stress upon to natural ecosystems and the native species they contain (Dumitraşcu *et al.*, 2010).

Prior to the EU-FP6 project *Delivering Alien Invasive Species In Europe (DAISIE)*, the assessment of ITPS at European level mainly consisted in scattered regional studies. Afterwards, a valuable and comprehensive database was created comprising 5,798 alien plant species in Europe, out of which 2,843 are alien to Europe (of extra-European origin) and 2,671 of European origin (Lambdon *et al.*, 2008) (Fig. 1).

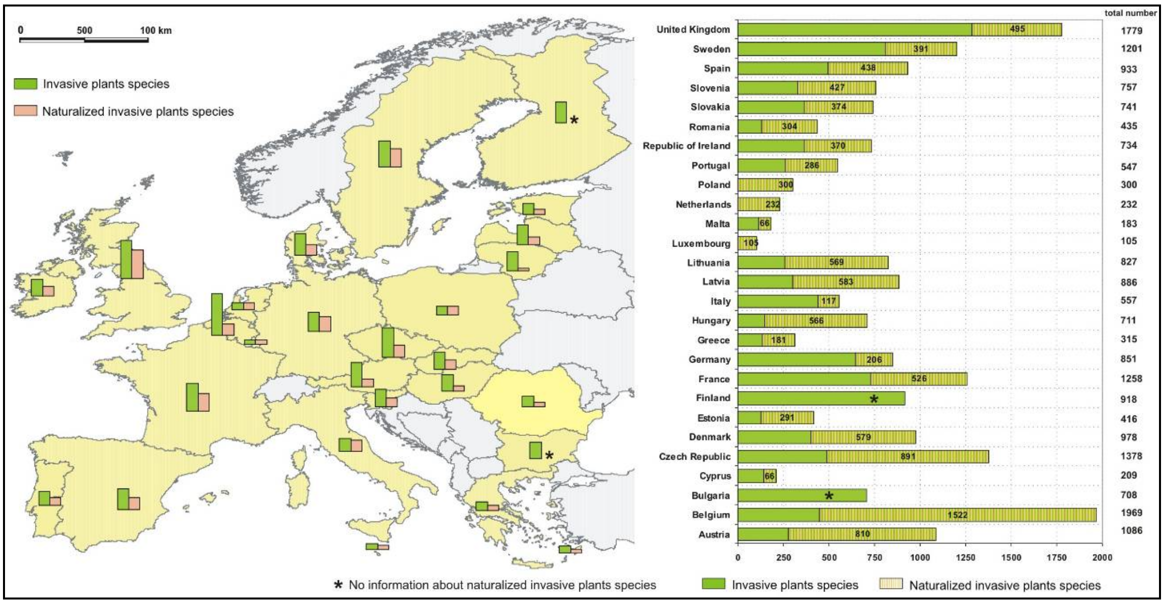


Fig. 1 – Invasive plant species in the EU countries (processed and adapted after FP6 – Delivering Alien Invasive Species Inventories for Europe – DAISIE and Lambdon *et al.,* 2008; Dumitraşcu *et al.*, 2010)

Under the global context of increasing biological invasions, the damage caused by alien species (both animals and plants) in the EU sums up to over 12 billion Euros every year (BirdLife Europe, 2013). As a result, the *New Strategic Plan of the Convention on Biological Diversity – Aichi Biodiversity Targets for 2011–2020* is proposing, among its strategic goals and targets (*Target 9*), to diminish direct pressures on biodiversity through identifying, controlling or eradicating invasive alien species and pathways as well as adopting measures to manage pathways and prevent their introduction and establishment (UN CBD, 2010; GEO BON, 2011).

2. INVASIVE TERRESTRIAL PLANT SPECIES IN THE ROMANIAN PROTECTED AREAS

Under the global environmental changes, the role of protected areas in conserving biodiversity and landscape becomes increasingly important. Under the given circumstances, the growing surface of protected areas, creating corridors link between them and reducing human impact are just some of the needs for ensuring an adequate management (Geacu *et al*., 2012).

Currently, protected natural areas in Romania cover 1,798,782 hectares, that is, 7.55% of the national territory. An increased surface of protected areas was a priority of Romania's over the accession to the European Union, thus having to reach a 17% protected surface of the national territory (from 7% as it had previously been before EU accession, in 2007) by means of other important conservative tools, such as "Natura 2000" European Network (Bălteanu *et al.,* 2009; Dumitraşcu *et al.,* 2010). As a consequence, a series of decisions taken by the Romanian Government during 2004–2010 led to the extension the number of protected areas to 998 (79 scientific reserves – I; 13 national parks – II; 230 natural monuments – III; 661 natural reserves – IV; 15 parks – V) (Fig. 2). Regarding Natura 2000, in 2011 Romania totalised 54,067 km^2 (39,952 km^2 SCI and 35,542 km^2 SPAs) which represent 22.68% of the national territory (Bălteanu *et al.,* 2009; Geacu *et al.,* 2012).

In Romania the first invasive plants species have been reported at the beginning of 18th century and, significant information having a systematic and floristic character (Anastasiu and Negrean, 2005) was regularly displayed ever since. Consequently, an increased number of invasive species were identified and further mentioned in several scientific works or floristic lists which were synthesized in "Flora României" vol. 1–13, (1957–1972) and more recently in "Flora Ilustrată a României" (2000) and "Plante adventive în flora Românei" (2011) (Dumitraşcu *et al.,* 2011b).

At present, over 400 species (13.87% of the Romanian flora) are considered biological invasions (Anastasiu and Negrean, 2005; Sîrbu and Oprea, 2008). According to the third National Report of Biological Diversity Convention (2005), some of the most important invasive alien tree species in Romania are: *Acer negundo, Ailanthus altissima, Amorpha fruticosa, Fraxinus americana* etc. (MODIS, 2007).

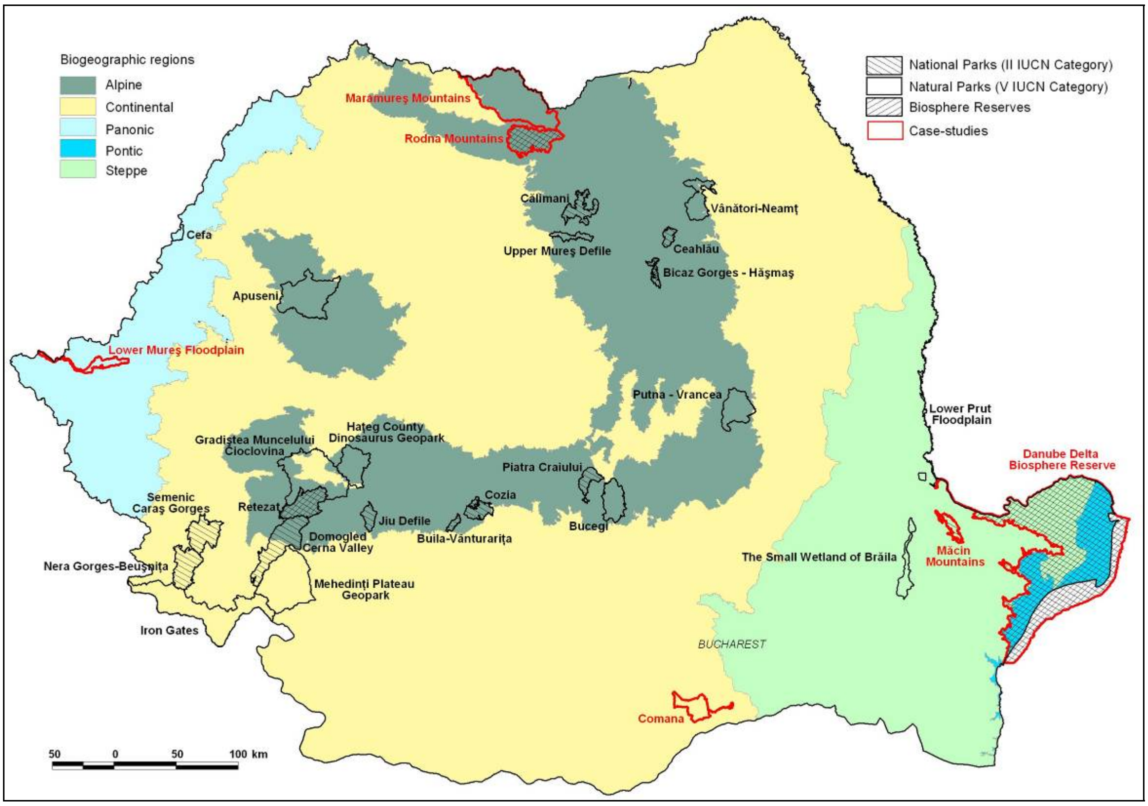


Fig. 2 – Selected case-studies in the Romanian natural protected areas.

Although Romania endorsed the Convention of Biodiversity (Rio de Janeiro, 1992) through law 58/1994, up till now there were no important steps undertaken, especially in terms of implementation of article 8, with respect to alien invasive species (Dumitraşcu *et al.,* 2011a). Thus, the complex assessment of ITPS species, both qualitative and quantitative, is crucial in estimating their potential spread and evolution pathways.

The assessment of the Terrestrial Invasive Plant Species was focused on some significant case-studies, one for each biogeographical region in Romania: Maramureş Mountains Natural Park (Alpine region), Mureş Floodplain Natural Park (Pannonic region), Comana Natural Park (Continental region), Măcin Mountains National Park (Steppic region) and (Danube Delta Biosphere Reserve (Pontic region) (Figs. 2, 3).

3. INTEGRATED DATA AND METHODS

The study developed in the framework of ***FP7 enviroGRIDS project – Building Capacity for a Black Sea Catchment Observation and Assessment supporting Sustainable Development***; ***WP5 – Impacts on Selected Societal Benefit;*** *Sub-task 5.6.2: Terrestrial Invasive Plant Species Areas* had in view to assess the occurrence, development and spread of ITPS in relation to their main environmental requirements and, ultimately, their potential distribution in the Romanian protected areas. In view of that, the authors relied on the comprehensive cross-referencing of the geographical and biological scientific literature, the complex assessment of spatial (GIS processing of the most relevant cartographical materials: topographical, geological, hydrogeological, soil, vegetation, aerial photographs, etc.) and statistical data, as well as field surveys.

In important step in assessing ITPS is relating them to the driving forces of change in order to in understand the causal relationships between them, to identify their habitat requirements, spreading territory and, ultimately to develop accurate prediction models (Kucsicsa *et al.,* 2013). For that reason, the scientific literature refers to some large-scale geographical factors able to explain the role of environmental driving forces in the distribution of invasive species in some European countries: ***climatic*** (mean annual precipitation, mean annual temperature, temperature amplitude), ***geographical*** (latitude, longitude and area) and ***economic*** (population density, Gross Domestic Product and roads density) (Lambdon *et al.*, 2008). On a regional scale (for the Romanian protected areas) the authors propose as key environmental drivers responsible for the introduction and spread of the ITPS two main categories ***natural*** and ***human-induced*** rearranged into smaller categories (Dumitraşcu *et al.,* 2010, 2011a, 2012; Kucsicsa *et al.,* 2013) (Table 1).

Table 1

The main environmental driving forces responsible for the introduction and spread of the ITPS in the Romanian protected areas

Major driving forces		**Consequent driving forces**
NATURAL	**soil**	soil type, texture
	relief characteristics	altitude, slopes exposure, declivity, geomorphic features
	vegetation	dominant vegetation types, fragmentation
	water bodies, wetlands	lakes, rivers, ponds, marches
	climate	air/soil temperature, precipitation, air humidity, wind, climate change signals
	extreme events	flooding, wind and snow felling, heavy rains
HUMAN INDUCED	**planting invasive species**	for ornamental/ recreation, forestry purposes
	agricultural practices	crop type, land abandonment, excessive fertilizers
	forest exploitation	deforestation/forest fragmentation, forest infrastructure
	grazing	pastures and land degradation
	urban development	waste deposits, transport network (roads, railways etc.), building sites

Source: Dumitraşcu *et al.*, 2010, 2011a, 2012; Kucsicsa *et al.,* 2013

ITPS mapping and database elaboration relied on different GIS-based procedures (editing, storing and processing) useful for summarizing large datasets for modeling habitat quality and distribution of invasive species (Holcombe *et al.,* 2007; Kucsicsa *et al.,* 2013).

Fig. 3 – *Fallopia japonica* (A, B) and *Impatiens glandulifera* (C) in Maramureş Mountains Natural Park; *Ailanthus altissima* (D) in Măcin Mountains National Park; *Amorpha fruticosa* in Mureş Floodplain Natural Park (E) and Comana Natural Park (F) (Kucsicsa *et al.,* 2013).

For the Romanian protected areas the ITPS was carried out using topographical maps scale 1:25000 and orthophoto images, scale 1:5000. Additionally, in order to achieve more accurate information, GPS measurements were conducted, as well. For each analysed protected area, the authors computed key biological indicators (abundance, coverage, frequency and ecological significance) and collected soil samples with the aim to highlight certain soil characteristic relevant in identifying the ecological requirements of the species at stake: the heavy metal (Zn, Cu, Kd, Mn, Pb, Hg etc.), humus and salts content, pH values etc. The information was stored using polygon (e.g. *Fallopia japonica, Amorpha fruticosa, Ailanthus altissima*) and point spot-like (e.g. *Impatiens glandulifera, Acer negundo*) geospatial data (Kucsicsa *et al.,* 2013).

Based on the primary ITPS assessment (data gathering, mapping, understanding its habitat requirements etc.) a ***GIS-based model (PODISMOD–ITPS)*** was developed. The focal aim of the model is to identify similar ecological requirements of species in different habitat types (other than in the areas where the species was originally found) in order to assess the distribution potential in a certain region (Fig. 4).

Depending on ITPS ecological requirements, ***thematic maps*** displaying the main driving factors which cause species development and spread were elaborated. Besides the general thematic maps taken into consideration for this investigation (soils, climatic parameters, land use etc.), the Digital Elevation Model (DEM – 30 m resolution) was considered, as well. The latter constitutes itself into essential information in ITPS assessment, out of which layers regarding local relief particularities were generated (hypsometry, slope declivity and slope exposure). Therewith, in the case of some ITPS the distance to certain driving factors is critical.

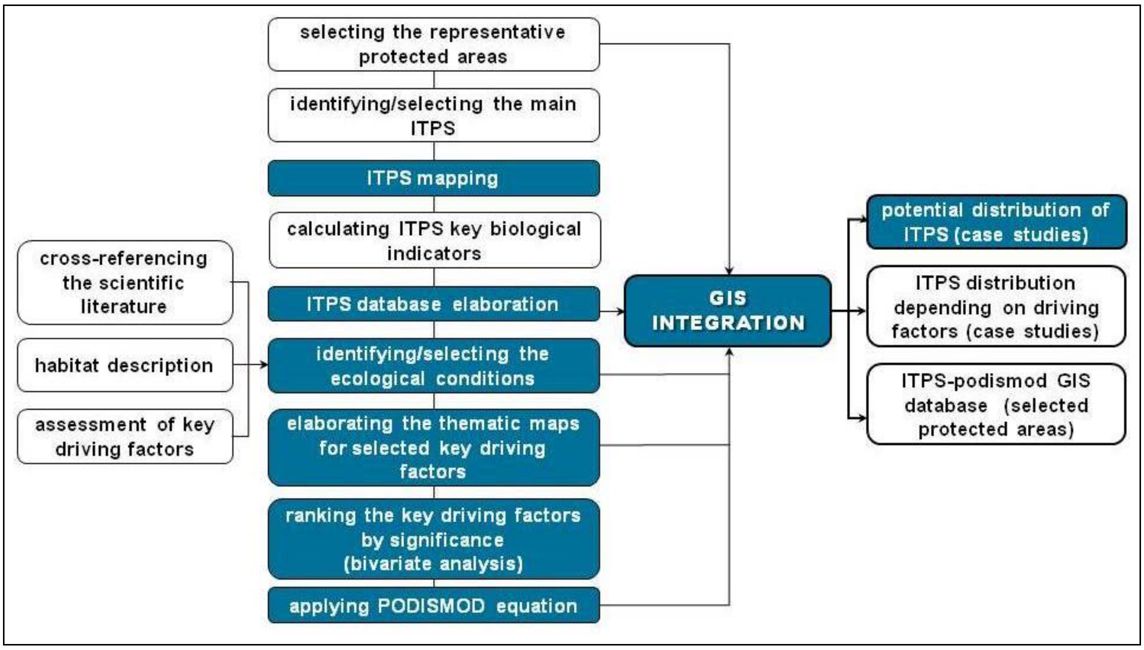


Fig. 4 – ITPS podismod scheme.

Additionally, the authors applied relevant ***biological indicators*** in order to complete the ITPS complex assessment in some protected areas. The surface areas chosen for the comparative research regarding the phenology data were of 10 m² for pastures and reed-covered areas and of 100 m² for the forest and brushwood communities. The quantitative biological indices taken into consideration for the current approach (coverage, abundance, frequency and ecological significance) were computed in several test-areas in the analyzed case-studies (Dumitraşcu *et al.,* 2013a, 2013b). Based on this in-depth analysis the authors were able to relate biological indicators with relevant key natural and human-induced driving forces.

4. RESULTS AND DISCUSSIONS

Over the last century natural ecosystems were massively transformed by human activity trough different practices such as: deforestation, overgrazing etc. and replaced with secondary meadow and scrub associations, strongly affecting the floristic structure and composition. Following the in-depth analysis of the most significant ITPS in some selected Romanian protected areas, the authors were able to obtain useful and accurate information regarding species' spreading area, habitat requirements as well as predicting potential distribution depending on selected dependent and independent driving forces. Therefore, the complex investigations undertaken over the last four years (2010–2013) revealed that the ITPS with the highest impact on local habitats are in the Romanian protected areas are: ***Amorpha fruticosa*** (the desert false indigo or the indigo bush), ***Ailanthus altissima*** (Chinese sumac or the tree of heaven), ***Fallopia japonica*** (Japanese knotweed), ***Acer negundo*** (Box-elder or Ash-leaved Maple) and ***Impatiens glandulifera*** (Himalayan balsam).

Amorpha fruticosa is an ITPS originating from the south-eastern part of North America. It was introduced in Romania in the first half of the last century for decorative purposes. Subsequently it penetrated the natural *Populus* and *Salix* forests along the Danube River (Fig. 5).

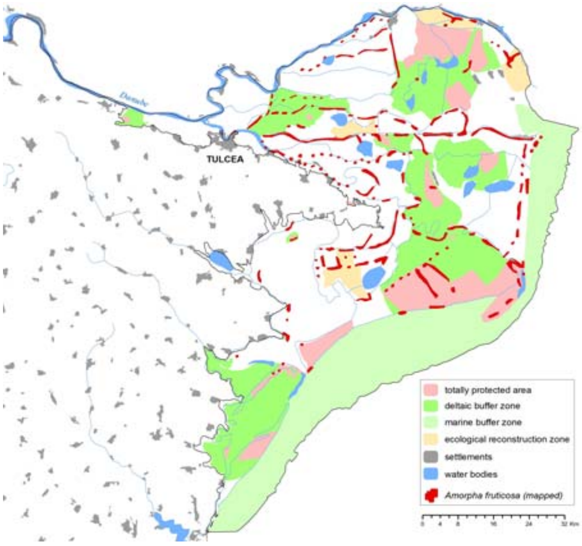


Fig. 5 – Danube Delta Biosphere Reserve. The distribution of *Amorpha fruticosa* (Dumitraşcu *et al.,* 2013 processed after Doroftei, 2009a; 2009b) and species' specific habitat along Danube's branches.

After 1985 it has spread upon broader areas proving a high capacity of widening its habitat (Stănescu *et al.,* 1997; Dumitraşcu *et al.,* 2011a, 2011b). Currently, the plant is adapted to all types of environment, but it prefers especially the wetlands from Danube Flodplain and Danube Delta (Anastasiu and Negrean, 2005; Anastasiu *et al.,* 2008, Dihoru, 2004; Doroftei, 2009a, 2009b) or Mureş Floodplain Natural Park (Dumitraşcu *et al.,* 2013). It can also be adapted to reduced soil moisture which characterise the sylvosteppe soils (e.g. Comana Natural Park).

Although *A. fruticosa* mainly prefers riparian ecosystems, due to the particularities of the habitats they develop one can identify slight differences in terms of the several quantitative and qualitative parameters. For instance, the calculation of some biological indicators in tree wetland areas (Danube Delta Biosphere Reserve, Comana Natural Park and Mureş Floodplain Natural Park) has revealed different abundance, frequency, coverage index values (Table 2).

Table 2

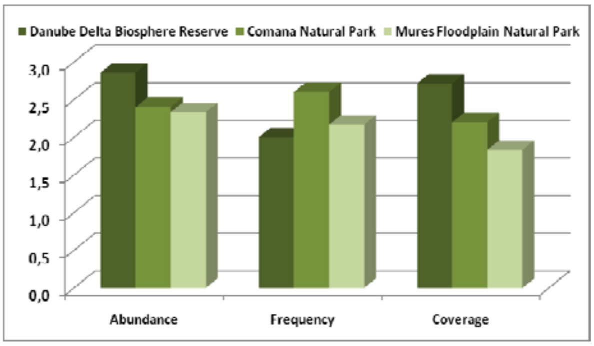
Abundance – coverage scale according to Braun – Blanquet system (Cristea *et al.,* 2004) and the ecological significance index values

Class	**Coverage interval (%)**	**Class value (%)**	**Ecological significance index (%)**	
5	75–100	87.5	>2	characteristic
4	50–75	62.5	10–20	complementary
3	25–50	37.5	5–10	associate
2	10–25	17.5	1–5	accessory
1	1–10	5.5	0,1–1	accidental

Thus, Danube Delta Biosphere Reserve shows higher abundance and coverage rates while the frequency seems lower as compared to the other two study-areas. On the other hand, Comana Natural Park displays higher frequency rates while Mureş Floodplain Natural Park the species records rather even abundance and frequency values and lower coverage as compared to the other protected areas at stake (Dumitraşcu *et al.,* 2013a, 2013b).

The ecological significance, seen as the relationship between frequency and abundance, shows values ranging between 2 and 12 for certain key areas which were taken into consideration in the

Danube Delta Biosphere Reserve and Comana Natural Park and rates which does not exceed 9 units in the Mureş Floodplain Natural Park. The average values points Danube Delta Biosphere Reserve first in terms of ecological significance followed by Comana Natural Park and Mureş Floodplain Natural Park. In all studied areas, the species is considered associate species (Table 2, Fig. 6).



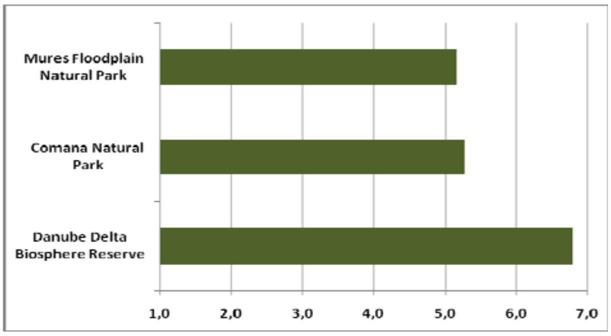


Fig. 6 – Average class values of the key biological indicators for *Amorpha fruticosa* in the Danube Delta Biosphere Reserve, Comana Natural Park and Mureş Floodplain Natural Park.

Additional studies state that *A. fruticosa* develops very well on metal-contaminated soils (lead, zinc, copper, nickel, etc.), on tailing ponds as incipient species together with other fast-growing non-native and native species or on fertilized terrains (Li, 2006; Seo *et al.,* 2008; Marian *et al.,* 2010; Xiang, 2011). This explains species' largest spread along railways and major roads, especially non-electrified routes in Comana Natural Park (Dumitraşcu *et al.,* 2011). The multiplication and spread are made by means of seeds, rarely by sprouts or layering which explains its high dissemination capacity.

The complex assessment of *Amorpha* (habitat requirements, the relationship with each environmental driving factor, the outcomes of the key biological indicators etc.) has allowed the authors to predict its potential distribution by means of the ITPS-podismod. The model reveals index values which highlight a certain dependency of the potential distribution areas to species main preferred habitats. Thus, over 6% of Park's area displays high and very high potential distribution, mainly favoured by the vicinity of wetlands and by the spoiled soils located along the railroad which connects Comana and Mihai Bravu.

Medium values cover roughly 17% of Park's area, largely favoured by the soil type and texture as well as by the characteristic habitats (shrubs and grasslands). In the rest of the study-area, the low representation of its favourable habitat conditions and the prevalence of Cernisols with sandy and sand-loamy texture under forests and open agricultural areas as restrictive factors, determines low and very low potential (67%) (Fig. 7). Furthermore, in order to validate the model, the authors related the potential distribution areas with species' mapped territory, thus identifying a very good match between *Amorpha* highest frequencies and the very high and high potential (82%), as well as medium potential (18%) regions.

Ailanthus altissima (Chinese sumac or the three of heaven) is an invasive toxic pioneer species (Burch and Zedaker, 2003) ranking among the most destructive in Europe as it penetrates native flora and irreversibly changes its structure. It is a deciduous three native to China introduced into Europe in the late 18th century as an ornamental species. In Romania *Ailanthus* was introduced both for ornamental purposes and for the protection of degraded areas or sliding slopes. Species' spreading capacity is given by its fast propagation (up to 350,000 seeds/year) and rapid growth (up to 3 cm/day). Its well known toxicity (through pollen, bark and leaves) restrain the establishment of other plant species in its vicinity (Feret, 1985; Lawrence *et al.,* 1991) and the root system roves to be aggressive enough to cause damage to different underground works. *Ailanthus* can tolerate different kind of environments from abandoned fields to railroad embankments, roadsides, waste grounds, and other disturbed sites (Landenberger *et al.,* 2006), as well as a wide range of pH conditions (Feret, 1985). The species is also drought resistant which made its broad expansion possible (Trifilo *et al.,* 2004.).

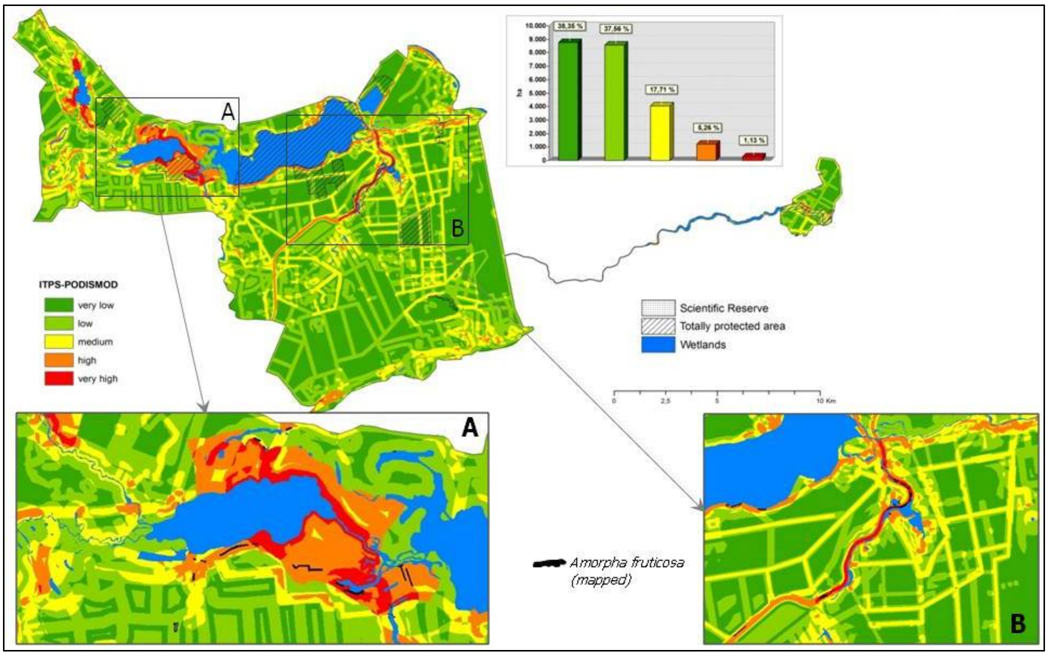


Fig. 7 – Potential distribution of *Amorpha fruticosa* in the Comana Natural Park (ITPS-podismod).

In the Măcin Mountains National Park, the tree of heaven mainly affects the grasslands, forest skirts, river banks, mining and disturbed sites etc. by competing and displacing the native vegetation (Sîrbu and Oprea, 2011). The field surveys carried out so far allowed the authors to identify and map over 120 ha covered by *A. altissima* mainly located in the Pricopan Ridge (north-western part of the Park area), an area entirely included into the *totally protected area* category, thus indicating a higher impact on native valuable ecosystems (Fig. 8).

In the study-area *A. altissima* tolerates different environmental conditions ranging from brightness (shinny and semi-shinny slopes) to open areas (scrub and/or herbaceous vegetation associations) but also prefers some specific soil types (litosoils and kastanozeoms) and textures (loamy and clay loam) with a high mineral content, thus proving species' preference for spoiled and degraded terrains. Moreover, field researches revealed that *Ailanthus* is very well developed on the upper half of the slopes with declivities of over 5^0 (over 95 %) at altitudes of 50 m – 200 m (over 90 %).

Unfortunately, the control of this species is rather difficult because the mechanical eradication methods are not always efficient, therefore they must be completed with other mechanical and even chemical techniques (Meloche and Murphy, 2006).

Fallopia japonica (Japanese knotweed), also known as *Polygonum cuspidatum* or *Reynoutria japonica* is a clonal, herbaceous, fast-growing perennial plant (Aguilera *et al.,* 2010), inhabiting riparian ecosystems and causing serious damages to native flora (NB II, 2005; Barney, 2006). The specie is broadly regarded as one of the most invasive plant species in Europe, also listed by the World Conservation Union and FP6-DAISIE project as one of the top one hundred invasive species of global concern (Lowe *et al.,* 2000 cited by Kabat *et al.,* 2006; DAISIE, 2005–2008; Lambdon *et al.,* 2008). *F. japonica* is native to eastern Asia (Pysek, 2006) whence, since the end of the 19th century, gradually invaded increasingly wider areas in Europe, North America and Australia (Tiébré *et al.,* 2007, 2008;

Aguilera *et al.,* 2010; Moravcová *et al.,* 2011; Sîrbu, 2011), thus becoming one of the most prevalent and destructive alien species. The species is a strongly growing, herbaceous adventive plant which can grow up to 3 m in height (Kabat *et al.,* 2006). In Romania, *F. japonica* was mentioned as sub-spontaneous specie for more than seventy years (Paucă, 1940; Ţopa, 1947 cited by Oprea and Sîrbu, 2011), currently being spread in more than 90 settlements from all over the country (Sîrbu, 2011).

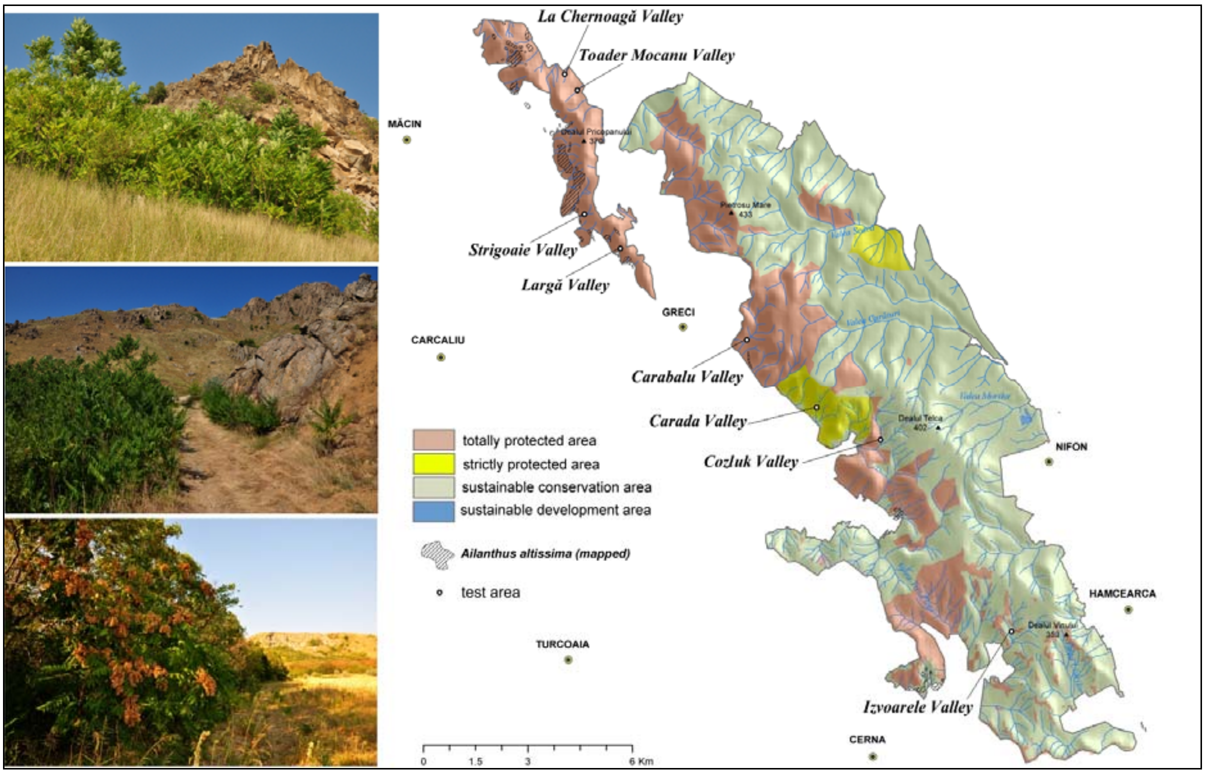


Fig. 8 – *Ailanthus altissima* in the Măcin Mountains National Park.

The Japanese knotweed can usually tolerate a wide variety of environmental conditions ranging from high shade, high temperatures (even drought) to high salinity. It frequently occurs in riparian habitats (e.g. along river banks) whence it spreads rapidly, turning into dense monoculture structures. When coupled with its capacity of generating huge amounts of rhizomes, the species seriously affects river protected structures, penetrates and displaces foundations, walls, and drainage works (Beerling, 1991), thus triggering significant damages to the riverbanks and, ultimately enabling floods. It also tolerates disturbed habitats, such as railroad tracks and roadsides (Forman and Kesseli, 2003; NB II, 2005).

Among the analysed protected areas, the widest spread of this species was encountered in the Maramureş Mountains Natural Park. Here, large areas were identified in the western (Vişeu River floodplain) and central parts (Ruscova River floodplain and upstream Repedea village on the Frumuşeaua and the Vaser Rivers). *F. japonica* was also found close to the southern limit of the park area in Borşa town on Rodna Piedmont along the Pietroasa flow. The entire mapped surface sums up to approx. 88 ha and indicates areas most invaded by this invasive species mainly on the river banks. Dense areas with Japanese knotweed we also found along the modernized roads, the railway connecting towns of Valea Vişeului and Vişeu de Jos and the flood protection dams along the Vişeu River (Fig. 9 and Fig. 11). In terms of spatial distribution, the species mainly prefers lower altitudes (under 500 m), open spaces (free of coexisting species), tending to invade grasslands, croplands and even courtyards (e.g. in the Vişeu River floodplain), thus seriously affecting native vegetation (Dumitraşcu *et al.,* 2012).

The current assessment on *F. japonica* in the Maramureş Mountains Natural Park in relation to the species' habitat requirements and key environmental features is essential in establishing the relationship between species diversity and invasive success on one hand and the physical extrinsic factors (environmental features) on the other (Shea and Chesson, 2002) in order to provide valuable future predictions through GIS-based modelling techniques. Thus, applying ITPS-podismod the authors were able to identify areas most prone to species future development and spread. Over 32% of the analysed territory for the model displays high and very high potential distribution, while over 33% displays moderate rates which indicates that floodplain areas are the most exposed to *F. japonica's* spreading potential in the Maramureş Mountains Natural Park, widely overlapping the areas in which the species was mapped during the field campaigns (Fig. 9).

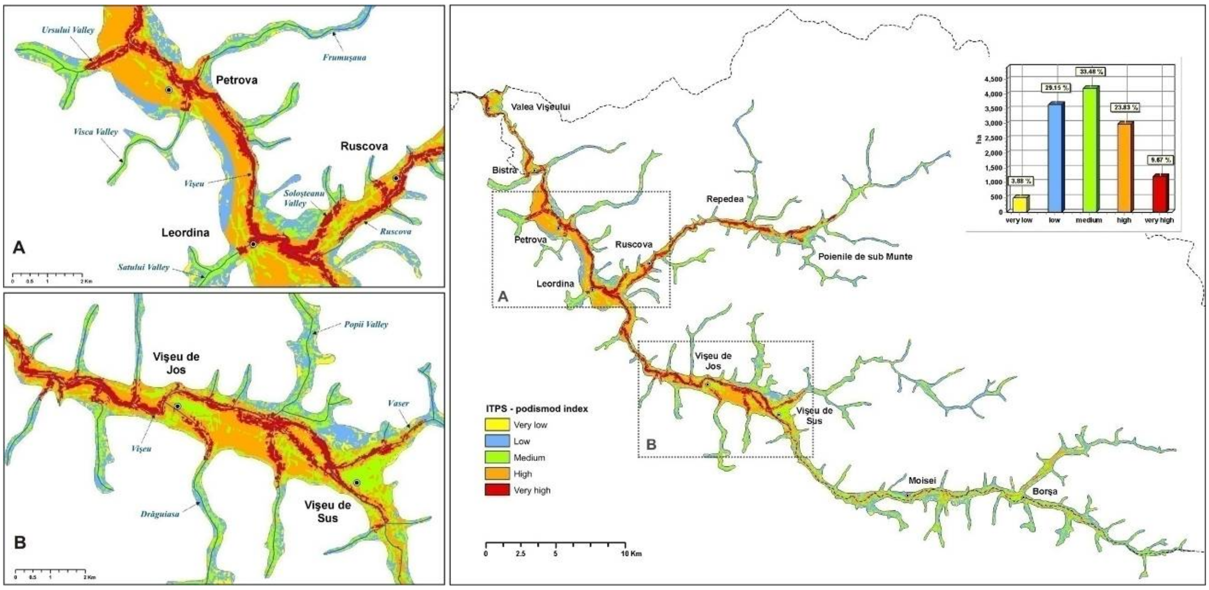


Fig. 9 – Potential distribution of *Fallopia japonica* in the Maramureş Mountains Natural Park (ITPS-podismod).

Acer negundo (Box-elder or Ash-leaved Maple) is a tree native to eastern North America whence it was firstly introduced to England in 1688 (Favretti and DeWolf, 1971), the Netherlands (1690) and Germany (1699), and subsequently to other European countries (Medrzycki, 2007). In Romania, the specie was introduced in forest plantations, anti-erosion forest belts, as well as in parks, gardens or alongside streets as ornamental tree.

Given its high and constant fruit production, which can be easily wind borne, its sprouting ability, and the tolerance to different habitat types, the Box-elder easily spreads from its cultivation sites, thus invading the neighbouring open lands, especially ruderal spaces, road sides, railway embankments, vineyards, wetlands in the plain or hilly areas etc. As a result, there is no longer recommended to perform new plantations with this species (Dumitriu-Tătăranu, 1960; Oprea and Sîrbu, 2011).

In the Mureş Floodplain Natural Park the specie is rather weakly developed, being mapped in two main areas along Mureş River Floodplain: one in the south of Pecica locality, in the Raţa Vaida Forest and the other south of Şeitin locality, on alluvial protosoils with mixed texture at 90–100 m altitude (Fig. 10).

Fig. 10 – The distribution of ITPS *Amorpha fruticosa, Acer negundo* and *Fallopia japonica* in the Mureş Floodplain Natural Park.

Impatiens glandulifera (Himalayan balsam) is a species native to the western Himalayas where it grows from 1800 to 4000 m altitude from where was introduced to Europe in the first half of the 19th century as an ornamental plant, shortly after being reported as escaped from culture (Helmisaari, 2010). Currently, the species is considered invasive in the most part of Europe. *I. glandulifera* becomes accustomed to different habitats, but it thrives best on moist and nutrient rich habitats, especially along rivers banks. It can be also frequently found in human influenced habitats such as grasslands, shrubs, dikes, channels, roadsides etc. (Kurtto 1996).

The species invades the herbaceous perennial vegetation of river banks, floodplain forests and wet meadows tolerating a variety of soil types. Apart from the other ITPS investigates in the current study, in Europe *I. glandulifera* is frost intolerant (Helmisaari, 2010), which means it prefers environments characterised by positive temperature values all year round.

I. glandulifera has been introduced in Romania as an ornamental plant, subsequently escaping gardens. The species was identified for the first time as subspontaneous in Transilvania (1882) (Balogh, 2008), whence it was expanded, however not yet reported in Banat, Oltenia and Dobrogea (Oprea and Sîrbu, 2011).

This ITPS is largely spread in the Maramureş Mountains Natural Park, especially along the floodplains of Vişeu River and its tributaries Ruscova and Ţâsla. The species grows along river banks, often on waste covered terrains (resulting from constructions or wood processing), and sometimes associated with *Falopia japonica*.

The species was mapped at altitudes of nearly 400 m (Vişeu River floodplain, near Leordina locality) to 860 m (Borşa Turistic Complex on Vişeuţ River), especially on cvasi-horizontal terrains with southern and south-western sun exposure, on alluvial soils and alluvial protosoils with mixed texture. Thus, the main areas the Himalayan balsam was largely found are: Poienile de sub Munte (Cvasniţa River valley); Ruscova River floodplain (Ruscova locality), Vişeu River floodplain (close to Vişeu de Jos, Moisei and Borşa localities), Ţâsla River floodplain (near Băile Borşa locality).

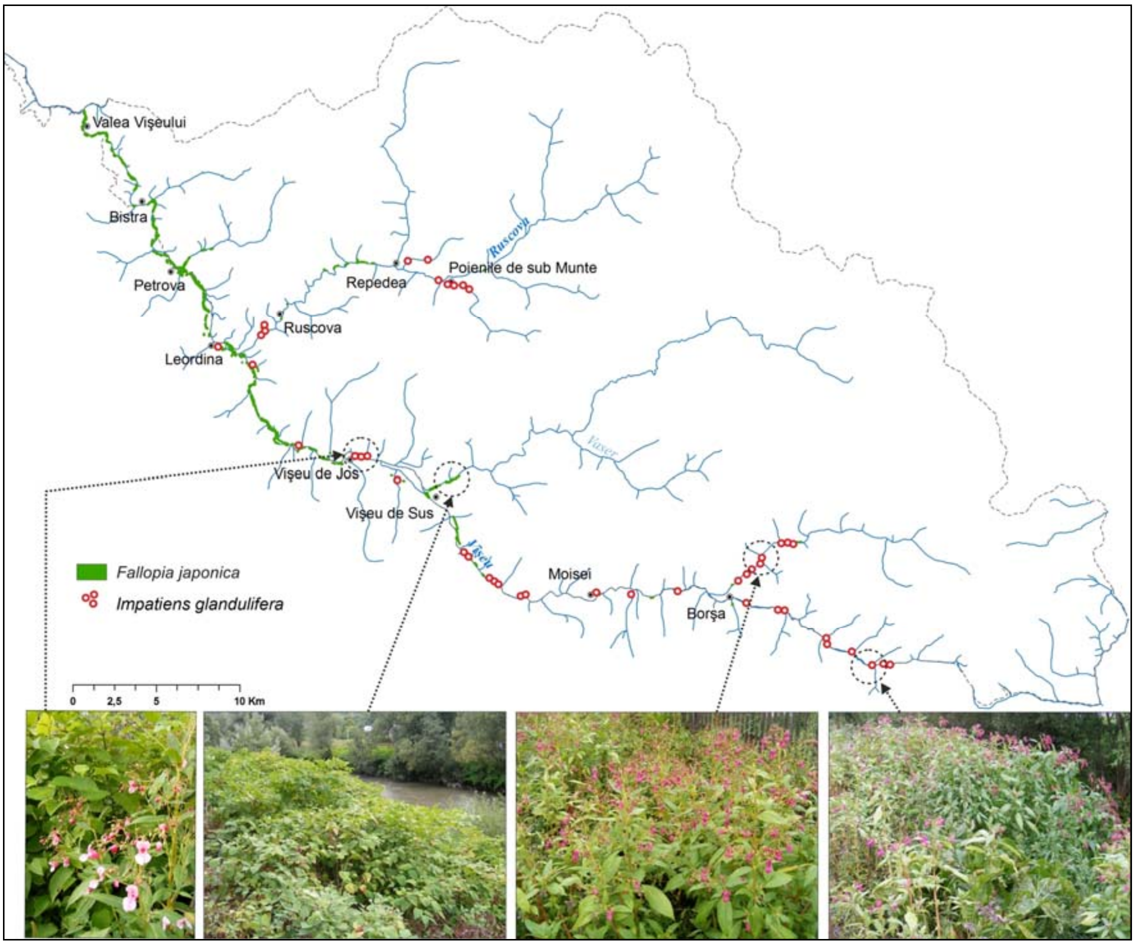


Fig. 11 – The distribution of ITPS *Amorpha fruticosa* and *Impatiens glandulifera* in the Maramureş Mountains Natural Park.

5. CONCLUSIONS

The assessment of ITPS in the Romanian protected areas is an important research direction especially since biological invasions have become increasingly dynamic in native ecosystems. Given the intensification of the human-induced influences in various habitats, the complex assessment of the occurrence, spread and potential distribution of the main ITPS becomes essential task in developing early warning services.

Moreover, a comprehensive geographical assessment of ITPS distribution and spread in relation to their main natural and human-induced driving factors through GIS-based investigations and integrated spatial analysis is particularly useful in identifying the potential distribution of the invasive species. Furthermore, this could support sustainable measures to eradicate or prevent the introduction of invasive species and control their already existing habitats as the most cost-effective means to avoid or reduce the risk of long-term ecological, economic and social costs of their invasion.

Consequently, promoting integrated research assessment, monitoring key pathways, developing early detection and early warning systems and outreach activities that addresses the issues of spreading invasive species into native habitats requires strong cooperation between researchers, foresters, stakeholders, environmental agencies, local authorities worldwide.

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