Key biological indicators to assess *Amorpha fruticosa* Invasive Terrestrial Plant Species in Romanian protected areas.

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Abstract: - Under the current human-induced impacts, native ecosystems become highly exposed to a wide range of environmental threats such as biological invasions. The paper is aiming to assess the occurrence, development and spread of one of the main Invasive Terrestrial Plant Specie (ITPS) in the Romanian protected areas, *Amorpha fruticosa*, considered one of the most dangerous ITPS in Europe as it causes damages to natural ecosystems. The study is centred on assessing species’ habitat requirements and relevant biological indicators (abundance, frequency, ecological significance and ecological significance) in relation to its key environmental driving forces (both natural and human-induced) in selected case-studies (Danube Delta Biosphere Reserve, Comana Natural Park and Mureș Floodplain Natural Park) relying on scientific cross-references, in-depth field surveys and accurate mapping.

Key-Words: - biological indicators, Invasive Terrestrial Plant Species (ITPS), *Amorpha fruticosa*, protected areas, Danube Delta Biosphere Reserve, Comana Natural Park, Mureș Floodplain Natural Park, Romania

1 Introduction

Invasive Terrestrial Plant Species (ITPS) pose significant treat to biodiversity and ecosystem services particularly since the *Convention on Biological Diversity’s 2010 Biodiversity Target* has stimulated global initiatives to quantify the extent of biological invasions, their impact on biodiversity and the related policy responses [1]. As a consequence, are often categorized as economic, environmental, or social threats [2], [1], thus becoming key components of global change through their high adaptive capacity enabling them to penetrate natural geographic barriers or political boundaries [3], [4], [5].

Consequently, ITPS have become successfully established over large areas in Europe causing significant environmental socio-economic damages [6], [7] and, under the increasing trade and travel means the threat they produce is likely to increase [1]. In protected areas, in particular, biological invasions are disturbing drivers for ecosystem functioning and structure, as well as for species, species communities or habitats [8].

Under the global context of increasing biological invasions, the *New Strategic Plan of the Convention on Biological Diversity - Aichi Biodiversity Targets for 2011-2020* is proposing, among its strategic goals, 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 [9].

Although Romania has ratified the Convention of Biodiversity (Rio de Janeiro, 1992) by means of law 58/1994, until now there were no important steps made, especially in terms of implementation of article 8, with respect to alien invasive species [10]. Therefore, the qualitative and quantitative (using relevant biological indicators) assessment of ITPS species is essential in estimating potential spread and evolution pathways, undertaking proper and sustainable management decisions and mitigating impacts.

2 Methods and data

The current study is trying to assess *Amorpha fruticosa* ITPS in the Romanian protected areas focusing on: Danube Delta Biosphere Reserve, Comana Natural Park and Mureș Floodplain Natural Park (Fig. 1). The authors used scientific cross-referencing, field surveys (using G.P.S device, sample taking, monitoring of the key areas) and GIS mapping in order to able to compute species spreading area.
Fig. 1. Natural major protected areas in Romania

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 analysed case-studies.

**Species’ coverage** was undertaken based on the real and absolute coverage whose values vary depending on the phyto-individual habitus of species. According to Braun-Blanquet the estimation system of coverage includes 5 levels: 1 – weak, under 1/20 of sample surface; 2 – between 1/20 and 1/4 of sample surface; 3 - between 1/4 and 1/2 of sample surface; 4 - between 1/2 and 3/4 of sample surface; 5 - between 3/4 and 4/4 of the test area (Tab. 1).

**Species’ abundance** was carried out based on Braun-Blanquet methodology which considers a visual scale: 1-very rare; 2-rare; 3-less abundant; 4-abundant; 5-very abundant individuals.

**Species’ frequency** was computed based on Raunkiaer (1934) method indicating the number of phytocenosis in which the analysed species was identified [11]: F = n/N x 100, in which: n = number of surveys in which the species is present; N = total number of surveys). According to the frequency value of *Ailanthus altissima*, four categories can be distinguished: F1 – accidental species (1 – 25% of relevées); F2 – accessories species (25.1 – 50% of relevées); F3 – characteristic species (50.1 – 75% of relevées); F4 – frequent characteristic species (75.1 – 100% of relevées).

Additionally, in order to identify species’ position within the phytocenosis, the **ecologic signification index** was computed as a relationship between frequency and abundance (Tab. 2).

Thus, based on this in-depth analysis the authors and relate biological indicators with relevant key natural and human-induced driving forces (Tab. 3).

<table>
<thead>
<tr>
<th>Ecological significance index (W) (%)</th>
<th>Class</th>
</tr>
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<tbody>
<tr>
<td>W1 (0,1-1) accidental</td>
<td></td>
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<tr>
<td>W2 (1-5) accessory</td>
<td></td>
</tr>
<tr>
<td>W3 (5-10) associate</td>
<td></td>
</tr>
<tr>
<td>W4 (10-20) complementary</td>
<td></td>
</tr>
<tr>
<td>W5 &gt;20 characteristic</td>
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</tbody>
</table>

Thus, based on this in-depth analysis the authors relate biological indicators with relevant key natural and human-induced driving forces (Tab. 3).
wind, climate change signals
extreme events
flooding, wind and snow falling, heavy rains
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: [12]

3 Invasive Terrestrial Plant Species in the Romanian Protected Areas

The first studies undertaken in Romania on ITPS date back to the beginning of 18th century mainly in works having a systematic and floristic character. Soon after, an increased number of invasive species were recorded and described in other relevant papers or floristic inventories which were synthesized in “Flora României”, vol. 1-13, 1957-1972 and more recently in “Flora Ilustrată a României”, 2000 [4].

Presently, the invasive flora of Romania includes over 400 species (13.87% of the Romanian flora) [4], [13] which is continuously updated through recent studies [13]

In the Romanian protected areas, among the most dangerous ITPS, the following rank first: [14]: *Elaeagnus angustifolia*, *Amorpha fruticosa*, *Ailanthus altissima*, *Acer negundo*, *Robinia pseudoacacia*, *Fallopia japonica* etc.

Recent studies consider *Amorpha fruticosa* as one of the worst invaders, especially in wetland habitats, endangering *Salix* spp. associations (EUNIS code F9.12) [15].

*Amorpha fruticosa* belongs to the south-eastern part of North America flora and was introduced in Romania in the first half of the last century for decorative and practical (protection of degraded land along the Danube River together with *Salix*) purposes. The species proved a high capacity of widening its spreading area, thus being adapted to all types of habitats such as: along river banks (poplar or willow galleries, almond willow-osier scrubs), unvegetated or sparsely vegetated shores, water-fringing reedbeds, riverine and lakeshore scrubs etc. [16], metal-contaminated soils, tailing ponds, fertilized terrains [17], [18], [19] etc.

4 Results and discussions

*Amorpha fruticosa* can be easily adapted to different types of natural and disturbed habitats but its preference for wetlands can be an explanation for its wide spread in the Danube Delta Biosphere Reserve [4], [5], [15], [20]. The detailed investigation undertaken in five pilot areas (Pardina Agricultural Polder, Caraorman sand dunes, Șontea – Fortuna Depression, Matița – Merhei lake complex and Dunăvăț – Dranov fishing pond) for which relevant key biological indicators were computed revealed species preference for the fluvial sand banks along the main Danube branches and fluvial-marine sand banks as well as the flooded areas (Fig. 2).

Fig. 2. The distribution of *Amorpha fruticosa* in the Danube Delta Biosphere Reserve

Thus, highest coverage, frequency and abundance values were registered in the Dunăvăț – Dranov fishing pond and Șontea – Fortuna Depression where wetland habitats prevail (Fig. 3).

In terms of habitat types, *Amorpha* populates in this protected area: 92A0 *Salix alba* and *Populus alba* galleries; 92D0 Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*); 91E0*Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*AlnoPadion*); 91F0 Riparian mixed forests of *Quercus robur*, *Ulmus laevis*, *U. minor*, *Fraxinus excelsior* or *F. angustifolia* along the great rivers (*Ulmenion minoris*).
Besides riparian habitats the species also inhabits dune and steppe-like habitats such as: 2160 Dunes with *Hippophaë rhamnoides*; 92D0 Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*); 62C0* Ponto-Sarmatic steppes as well as 3270 Rivers with muddy banks with *Chenopodium rubri* pp and Bidition vegetation.

In the **Comana Natural Park** *Amorpha fruticosa* prove to have a higher dominance in the surroundings of wetlands (margins of Comana Lake), river channels and alongside the transport network, especially on the spoiled soils located next to the non-electrificated railroad as well in the outskirts of forests (Fig. 4).

In accordance with the identified preferred habitats, the authors selected seven pilot areas for a detailed analysis: **Crucea de Piatra Village**, the northern side of Călugăreni village, southern part of Comana Village (along the rail road), Budeni Lake (south side shore), north of Vlad Țepeș Village, Fântânele Forest along Neajlov River and south of Mihai Bravu Village (Fig. 5).

The monitoring of the areas and the results of the computed biological indicators revealed higher values for abundance and coverage in the Crucea de Piatra Village and Budeni Lake and frequency in Călugăreni Forest and Budeni Lake, thus showing species’ preference for riparian and edge habitats such as: 92A0 *Salix alba* and *Populus alba* galleries; 92D0 Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*); 91E0* Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno Padion, Alnion incanae, Salicion albae*).

In the **Mureș Floodplain Natural Park**, *Amorpha fruticosa* have a preference for forest roads and forest glades (especially north to Mureș river), as well as pastures and edges of arable lands (Fig. 6). This endorsed the authors to select as main key areas for analysis the following: **Zădăreni Village** along the banks of the Mureș River; **Popinilor Forest**; **Rața-Vaida Forest** (Pecica Village); **Bezdin Forest** (Sânpetru German village); riparian habitats, meadows and modified vegetation in Şeitin Village and Igriş Village.

The computed indices for the selected key areas show a higher development of the analysed species in Zădăreni Village and Popinilor and Rața-Vaida Forests, mainly preferring riparian habitats (Tab. 7): 92A0 *Salix alba* and *Populus alba* galleries; 92D0 Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*);
91E0*Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*AlnoPadion, Alnion incanae, Salicion albae*); 91F0 Riparian mixed forests of *Quercus robur, Ulmus laevis, U. minor, Fraxinus excelsior* or *F. angustifolia* along the great rivers (*Ulmenion minoris*); 3270 Rivers with muddy banks with *Chenopodium rubri* pp and *Bidention* vegetation.

The investigation of ITPS *Amorpha fruticosa* in the selected case-studies has slight differences in terms of the analysed biological indicators. Thus, Danube Delta Biosphere Reserve shows higher abundance and coverage values 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 in the case of Mures Floodplain Natural Park the values for the three indicators show rather even value (Fig. 8).

Consequently, the ecological significance considered as the relationship between frequency and abundance, shows values from between 2 and 12 for the analysed key areas in the Danube Delta Biosphere Reserve and Comana Natural Park and rates which does not exceed 9 units in the Mureș Floodplain Natural Park.

The average values points Danube Delta Biosphere Reserve fist in terms of ecological significance of *Amorpha fruticosa* followed by Comana Natural Park and Lunca Muresului. In all studied areas, the species is considered (W3) associate species (Tab. 2, Fig. 9).

### 5 Conclusion

The landscapes of protected areas were transformed, over the last years, by human activities through tourism, deforestation, overgrazing, overexploitation of natural resources etc. All of these have led to the replacement of natural forest and pasture ecosystems with secondary meadow and scrub associations, thus affecting the floristic structure and composition. Considering the strong relationship between biological invaders and their key driving forces of change, assessing species dynamics, impact and spreading potential becomes an important task in identifying natural habitats’ pressures and threats. The identification of both natural and human-induced disturbances and relating them to in-depth biological (through detailed observations, computing biological indicators etc.) and geographical assessment (GIS-based investigations, integrated spatial analysis etc.) could support sustainable management strategies to prevent the invasion of species in natural protected areas.

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