NON-NATIVE AND NATIVE INVASIVE TERRESTRIAL PLANT SPECIES IN COMANA NATURAL PARK. CASE-STUDIES: *AMORPHA FRUTICOSA* AND *CRATAEGUS MONOGYNA*

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Key-words: invasive terrestrial plant species (ITPS), Comana Natural Park, *Amorpha fruticosa*, *Crataegus monogyna*, environmental driving forces, protected area.

The paper is aiming to assess two of the major invasive terrestrial plant species (ITPS) which are affecting the ecological balance of the Comana Natural Park: *Amorpha fruticosa* (non-native) and *Crataegus monogyna* (native). The authors have undertaken their investigation in relation to the key environmental driving forces responsible for their introduction and spread: *natural driving forces* (relief, lithology and soil, climate, hydrology, vegetation, etc.) and *human-induced driving forces* (agricultural practices, grazing, forest exploitation, transport network). Taking into consideration the ecological importance of this natural protected area, the paper have as main purpose to make a complex assessment of these ITPS in terms of creating a GIS-based inventory of their spreading areas in order draw up the distribution maps and identify the main particular environmental features of their habitats. Taking into consideration the intensification of the human-induced influences in various habitats, their geographical spread as well as their environmental driving forces, our approach aims at predicting the further distribution and extent of *Amorpha* and *Crataegus* in order put forward necessary management strategies for control. Based on this complex assessment, the potential users (foresters, environmentalists, etc.) will be able to predict the expanding of ITPS and identify their impact upon the natural habitat of some rare species, especially when talking about protected area's conservative importance.

1. INTRODUCTION

The invasion of alien species is considered as one of the most critical ecological consequences of the global changes as well as one of the leading threats to biodiversity of the natural habitats. These species can cause significant, irreversible environmental and socio-economic damages through their spreading and multiplication. Therefore, the augmented development of human activities determined an enhanced expanding of invasive species, enable them to get through 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). Therefore, numerous invasive alien species have become successfully established over large areas in Europe, thus having an increasing invasive potential (Pysek and Hulme 2005; Hulme, 2007 cited by Lambdon *et al.*, 2008; Dumitraşcu *et al.*, 2010).

According to the *Biological Diversity Convention* definition, the ***invasive alien species*** are considered *all species and subspecies introduced outside their natural habitat, both past and present, from all taxonomic groups (gametes, seeds, eggs or propagules that might survive and later reproduce)*. In compliance with IUCN, the invasive species might cause *immense, insidious and usually irreversible* ecological consequences, thus highlighting the real dimension of their environmental impact.

In order to exchange knowledge on invasive species and relate scientific research to policy and practice, in 1994 the ***Invasive Species Specialist Group (ISSG)*** has been established. ISSG is a global

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network in the framework of ***Species Survival Commission (SSC)*** of the **World Conservation Union (IUCN)** 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.

In Europe, significant contributions to the assessment of invasive plant species have been made through several disparate studies. Since the development of the EU-FP6 project *Delivering Alien Invasive Species In Europe (DAISIE)*, valuable and comprehensive information on biological invasions in Europe were provided in terms of putting together a complete database (5,798 alien plant species), undertaken scientific and institutional cooperation, etc. (Lambdon *et al.*, 2008).

2. METHODS AND DATA

The paper is willing to point out the occurrence and the development of invasive terrestrial species into Romanian protected areas on the basis of different approaches in terms of cross-references in the biological and geographical scientific literature and scattered field surveys. When considering Comana Natural Park, in particular, supplementary methods and data were added: spatial data (GIS processing of the most relevant cartographical materials: topographical, geological, hidrogeological, soil, vegetation maps, etc.), statistical data (biological and geographical scientific literature) and detailed field surveys (three field champagnes in 2010 and one in 2011). The first field surveys undertaken in 2010 aimed at certifying the prevalence of *Amorpha fruticosa* and *Crataegus monogyna* as the most aggressive invasive plant species in the Comana Natural Park, identifying distinct ecologic stations of the two species, mapping their spreading areas and describing the main ecological features of their habitats in terms of declivity, hydrologic regime, topoclimatic parameters, vegetation structure, etc. Based on this field work, preliminary information on the main environmental local features of the two species was obtained.

The studies undertaken so far stressed upon the relationship between the dynamics of ITPS and the large-scale environmental driving forces (*climatic, geographic and economic*) in some European countries (Lambdon *et al.*, 2008). The present study is aiming to identify at small scale the main environmental drivers responsible for the introduction and spread of the ITPS in Romania: **natural and human-induced** (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, etc.
	vegetation	dominant vegetation types, fragmentation
	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 (adapted and restructured).

Based on the previous approaches, developed mainly as descriptive analyses of each factor involved, the present investigation is aiming to assess the environmental drivers concurrently and integrated into a potential model able to offer both relevant causal rationales and spatial analysis in relation to the species requirements.

3. THE INVASIVE TERRESTRIAL PLANT SPECIES IN THE ROMANIAN PROTECTED AREAS

The complex assessment of invasive alien species was enforced by the ratification of the Convention of Biodiversity (Rio de Janeiro, 1992) by a growing number of states. Although Romania has ratified the Convention of Biodiversity by means of law 58/1994, until now there were no important steps made in this respect, especially in terms of implementation of article 8, with respect to alien invasive species (Dumitraşcu *et al*., 2010).

The first studies on ITPS in Romania date back to the beginning of 18th century. In this respect, important information was displayed in several works having a systematic and floristic character referring to a large number of specimens of *Amaranthus hybridus*, between the villages Moftinul Mare, Terebeşti and Ardud (Satu Mare County), *Amaranthus viridis* in Sasca Montană (Caraş Severin County) and *Echinochloa oryzoides* in Banat. Subsequently, an increased number of invasive species were identified and mentioned in different 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 (Anastasiu and Negrean, 2005).

Currently, the invasive flora of Romania includes over 400 species (13.87% of the Romanian flora) belonging to 82 families, out of which 88.27% are neophytes (which arrived into Europe after 1492) and 11.73% archaeophytes (which arrived into Europe before 1492) (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 altisima, Amopha fruticosa, Fraxinus Americana,* etc. (MODIS, 2007). Among the most spread taxa in Romania, those belonging to Asterececeae, Brassicaceae, Poaceae families range first. Numerous families, such us Orchidaceae, do not have alien representative in our flora, while others (e.g. Amaranthaceae) have almost exclusively alien representatives (Anastasiu and Negrean, 2005).

Recent studies state that riparian areas appear to be more susceptible to invasion than other ecosystems due to periodic hydrological disturbances which destroy or damage riparian vegetation, thus creating openings that provide favorable conditions for the establishment of the invasive propagules. Moreover, rivers act like natural drivers and dispersal agents facilitating the spread of the species (Fenesi *et al.*, 2009). For example, some ornamental plants (*Echinocystis lobata*, *Helianthus tuberosus*, *Solidago canadensis*, *Solidago gigantea* subsp. *serotina* and *Rudbeckia laciniata*) escaped from cultivation and become abundant especially areas from Transylvania, Banat and Crişana where they invaded the local vegetal communities while other invasive species (*Acer negundo*, *Ailanthus altissima*, *Aster lanceolatus*, *Ambrosia artemisiifolia*, *Parthenocissus inserta*) are only scattered (Anastasiu *et al*., 2008).

Within the Romanian natural protected areas, some of the most representative ITPS are: *Ailanthus altissima* (Măcin Mountains National Park, Mureş Floodplain Natural Park, etc.)*, Acer negundo* (Mureş Floodplain Natural Park)*,* and *Amorpha fruticosa* (Mureş Floodplain Natural Park, Small Wetland of Brăila Natural Park, Danube Delta Biosphere Reserve, Comana Natural Park, etc.) (Doroftei, 2009; Dumitraşcu *et al*., 2010).

Currently, protected natural areas in Romania cover 1,798,782 hectares (7.55% of the national territory), that is 958 protected areas, according to the Romanian legislation (*Law no. 5/2000 and the Government Decision 2151/2004*): 13 national parks (316,047.3 h), 14 natural parks (827,799.6 ha) out of which 2 geoparks (206,978.3 ha), 3 biosphere reserves, 54 scientific reserves (100,224 ha), 240 monuments of nature (2,213.3 ha), 626 nature reserves (161,838.3 ha) (Fig. 1). Additionally, after the EU accession (2007), Romania had to reach a 17% protected surface of the national territory (from 7% as it had previously been) by means of other important conservative tools, such as "Natura 2000" European Network (273 Sites of Community Interest – 3,291,854.6 ha and 108 Special Protected Ares – 2,988,713.6 ha) (Bălteanu *et al.*, 2009).

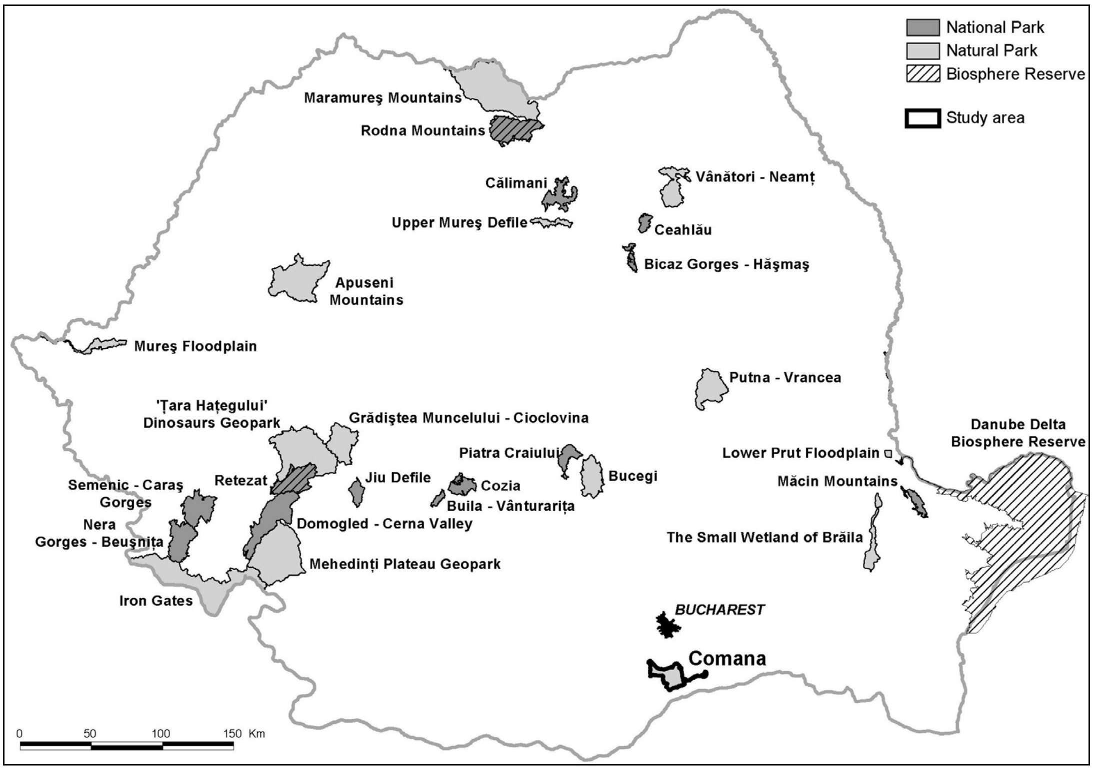

Fig. 1 – Romanian network of major natural protected areas.

As an expression of both geographical diversity and local evolution of human-environment relations over time, the Romanian protected areas mirrors *unique and rich natural landscapes* whose main traits are put into risk by the invasion of alien species with severe consequences on the native habitats.

4. STUDY-AREA – COMANA NATURAL PARK

The study area has granted the protected area status since 1954 through the Decision of Ministers Council by declaring Comana Forest (630.5 ha) natural reserve (Ielenicz *et al.*, 1986). Recently, according to the IUCN Categories and national regulations (*Law 5/2000* and *Law of Habitats no. 462/2001* for the approval of *OUG no. 236/2000 regarding the regime of natural protected areas*), the study-area frames into: *4th category – Natural reserves*: Oloaga-Grădinari Forest, Padina Tătarului Forest; and *5th category – Protected terrestrial ecosystems*: Comana Natural Park (Bălteanu *et al.*, 2009).

As it was necessary to increase its protected surface after the EU accession, Romania had to adopt new legislative measures (*Government Decision no. 2151/2004 regarding the setting up the regime of natural protected area for new areas from Romania*) which lead to the extension of this natural protected areas surface. Therefore, after 2007 the study-area granted the actual status (Comana Natural Park), becoming **5th IUCN category**. Currently, this protected area is almost entirely overlapping the ***Natura 2000 Network*** (one *SPA – Special Protection Areas* and one *SCI – Site of Community Importance*) aiming to protect wildlife and its habitats (Grigorescu, 2010).

Due to its position in the central-eastern part of the Romanian Plain (Fig. 1) at the biogeographic limit between mesophyllous deciduous forests and the sylvo-steppe, the study-area has favoured the development of different floristic and faunistic associations of different geographical origin. The position of Comana Natural Park at the crossing point of some floristic influences and its particular environmental features explains the biodiversity given by the large number of taxa, the great number of endemic species (*Achillea getica, Dianthus trifasciculatus ssp. desertus, Viola jooi, Paeonia peregrina var. romanica*) and species with different geographical origin (*Ruscus aculeatus, Convalaria majalis, Crocus flavus,* etc.). For some of them Romania represents the limit of their specific spreading area. Since the beginning of the XIXth century, the study-area was covered by Vlăsia Secular Forest, whose remnant patches appear as left-over of the one of the best-preserved forests in Europe. Over the last century, this natural ecosystem was massively transformed by human activity and replaced with secondary meadow associations and croplands, strongly affecting the floristic structure and composition.

5. NON-NATIVE AND NATIVE INVASIVE TERRESTRIAL PLANT SPECIES IN COMANA NATURAL PARK

Considering the ecological significance of the study-area, the authors undertook a complex assessment ITPS which are affecting the ecological balance of this protected area. The studies and the field campaigns carried out over the last two years (2010–2011) revealed that two ITPS have the highest impact on Comana Natural Park's ecosystem: ***Amorpha fruticosa*** (non-native) and ***Crataegus monogyna*** (native).

Amorpha fruticosa (the desert false indigo or the indigo bush). The species originates from the south-eastern part of North America and was introduced in Romania in the first half of the last century for decorative purposes and, together with other species, for the protection of degraded land. Soon after, the species penetrated the natural *Populus* and *Salix* forests and also the artificial forests along the Danube River. Starting with 1975 it becomes invasive species and after 1985 it spreads upon broader areas proving a high capacity of widening its habitat (Stănescu *et al.*, 1997; Dumitraşcu *et al.*, 2010). Presently, the plant is adapted to all types of habitats, but it prefers mainly the wetlands from Danube Floodplain and Danube Delta (Anastasiu and Negrean, 2005; Anastasiu *et al.*, 2008, Dihoru, 2004; Doroftei, 2009a, 2009b). It also adapts to reduced soil moisture which characterise the sylvosteppe soils. Recent studies stated that *Amorpha fruticosa* developed normally on metal-contaminated soils (lead, zinc, copper, nickel, molybdenum, arsenic, 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). In terms of climatic requirements, *Amorpha* is adapted to a warmer climate with long vegetation periods, protected from dangerous climatic phenomena characteristic to the cold semester of the year (cold waves, early frosts and hoarfrosts, etc.).

The multiplication and spread are made by means of seeds, rarely by springs or layering which explains its high dissemination capacity. Desert false indigo has a symbiotic relationship with certain soil bacteria which forms nodules on the roots and fix atmospheric nitrogen (Huxley, 1992).

Spreading and ecological conditions in the Comana Natural Park. Due to its preference for light, *Amorpha* is mainly developing on sunny slopes with southern, south-eastern and south-western orientation. The species resides mainly on reddish-brown soils (reddish-brown typical sub-type) with loam clay texture. The mapping undertaken so far have revealed a special preference of the species to this soil type with deep profile (1.2–1.6 m), 30–40% clay substance and nitrogen, potassium and phosphorus enrichment.

Important surfaces covered by *Amorpha* were found on the agricultural land in the Călugăreni village. Its preference for this type of habitat was highlighted by several researches undertaken in USA, China and Korea on phytoremediation which revealed that increased fertilization, mainly of organic nature, had improved the growth of this species (Li, 2006; Seo *et al.*, 2008; Marian *et al.*, 2010; Xiang, 2011).

The excellent development of the species on contaminated areas (Li, 2006; Seo *et al.*, 2008; Marian *et al.*, 2010; Xiang, 2011) explains its largest spread on the spoiled soils located along the non-electrificated railroad which connects Comana to Mihai Bravu villages (Fig. 2, B) or on the European road connecting Călugăreni and Uzunu localities. Simultaneously, these areas correspond to introduction and spreading pathways.

The species also prefers the wetlands' surrounding areas, including temporary streams and euthrophised ponds due to soil enrichment in organic matter. E.g. significant exemplars were found in Brănіştari village where it spreads upon the reed habitats (*Phragmites australis*) trying to substitute them (Fig. 2, C). *Amorpha*'s penetration into pasture ecosystems enhances its invasive potential forasmuch recent studies undertaken in western Romania showed that indigo bush has increased its invasive potential on grasslands and shrubs, thus having negative effects on the native vegetation (Sărățeanu, 2010);

Fig. 2 – *Amorpha fruticosa* in the Comana Natural Park.

The invasive character. Its widespread into wetlands, on extreme moist soils or throughout transport network, mainly railroads, areas that could represent introduction and spreading pathways, as well, lead us consider this species as having a fairly high invasive potential into the undisturbed native habitats of this protected area.

***Crataegus monogyna* (Common Hawthorn).** Along with *Amorpha* in the Comana Natural Park, the Common Hawthorn, indigenous invasive plant species was also considered as potential threat to ecosystems' integrity and health. The growth of *Crataegus* in the forest outskirts and glades makes it a natural barrier for the forest natural development and regeneration. Its invasive character was also pointed out by the foresters and rangers of Comana Natural Park' Administration as having negative impacts on the proper development of specific forest ecosystems (Fig. 3).

Fig. 3 – *Crataegus monogyna* in the Comana Natural Park.

Crataegus is a species of hawthorn native to Europe, northwest Africa and western Asia. The Common Hawthorn is a broadly spreading shrub or small tree 5–14 m tall, with a dense crown. The plant is largely spread on neutral to alkaline soil as a hedge plant which colonises sites with very high light intensity, scrubby forests especially oak or mixed, as well as pastures and hays. The Common Hawthorn tolerates frost but also dryness and drought, being extremely resistant to wind (Huxley, 1992; Burrell *et al*., 2006; Ferrazzini *et al*., 2008). The assessment of the seed dispersal ecology reveals the prevalence of zoochoric (mainly bird and mammals) dissemination over many kilometres which increase its spreading and invasive capacity (Bass *et al*., 2006).

It has long been associated with human-related activities, accompanying European emigrants around the world, thus becoming an invasive weed in several areas (Kean, 2009), often as a hedge and garden plant in rural districts but with a high potential to spread to adjacent waste lands, riverbeds, forest remnants and hill country farmlands (Williams and Buxton, 1986; Bass, 1990).

Spreading and ecological conditions in the Comana Natural Park. The species is mainly encountered at the oak forests edges, flanking the road connecting Comana and Vlad Țepeş localities (Comana Forest), and especially alongside the forest roads of Crângul lui Pele and Crucea Dumitraşcului Forests, east of Vlad Țepeş area.

Here, the Common Hawthorn is grouped into quite large and compact strips of several meters or even tens of meters width. Relevant such nuclei are found at the forest border near Comana Lake, alternating with other species such as: willow, ash, indigo bush, etc. At the same time wide strips covered with *Crataegus* were also found along the forest roads and glades of Islaz Forest. The plant is forming the most extended areas over the 75–90 m relief step, on low declivity slopes (0–7°). It prefers typical brown luvic soils and reddish-brown luvic soils with clay loam and loamy textures.

The invasive character. The large expansion of *Crateagus* into woodland outskirts and clearings coupled with natural favourable driving forces enable its rapid spread into the forest's compact areas thus affecting their proper natural development and regeneration. Therefore, based on Park's Administration opinion on *Crataegus* invasive character and the field surveys undertaken between 2010 and 2011, the authors consider this species as having a quite significant invasive character upon native forest ecosystems.

6. RESULTS AND DISCUSSIONS

The assessment of *Amorpha fruticosa* and *Crateagus monogyna* in Comana Natural Park reveals a certain heterogeneity of their distribution areas in relation with their main key environmental driving forces (Fig. 4). Therefore, after carrying out the complex analysis of the two ITPS, a quite perfect relationship could be distinguished between the main features of their natural habitats and their spreading areas.

In the case of *Amorpha fruticosa* one could recognize a perfect causal relation with some of the environmental factors which are favouring their spreading potential: the vicinity of wetlands, the presence of luvisols with loam-clay texture, and the spoiled soils located along the railroad which connects Comana and Mihai Bravu, the development of shrubs and grasslands, etc.

When discussing *Crateagus monogyna*, the species' spreading potential is favoured by the presence of forest open areas (outskirts, roads, glades, etc), especially in the Crângul lui Pele and Crucea Dumitraşcului Forests, east of Vlad Ţepeş area, preferring typical brown luvic soils and reddish-brown luvic soils with clay loam and loamy textures.

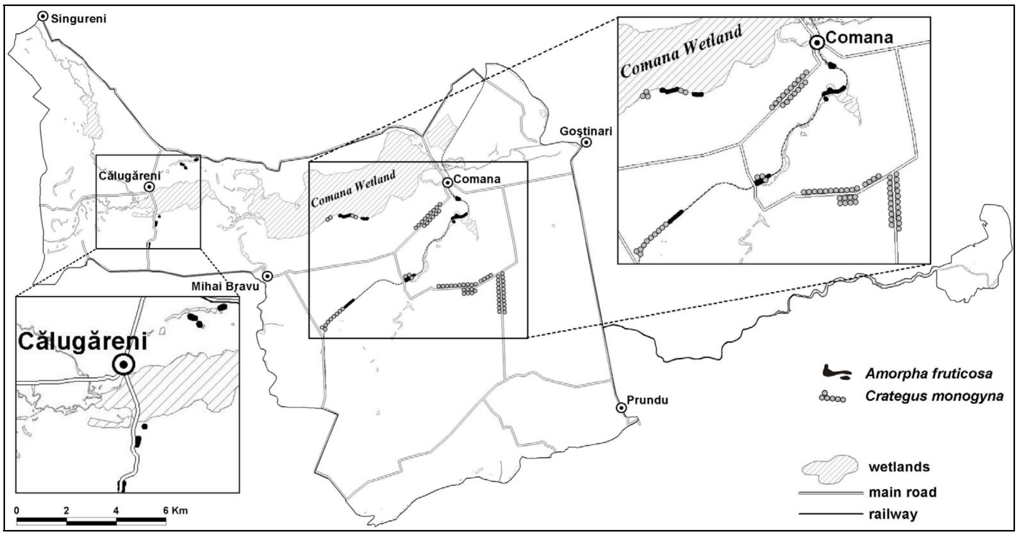

Fig. 4 – Distribution of *Amorpha fruticosa* and *Crategus monogyna* in the Comana Natural Park (field surveys undertaken between 2010 and 2011).

7. CONCLUSIONS

When analyzing the spatial distribution of *Amorpha fruticosa* and *Crategus monogyna* in relation to their key environmental drivers by means of GIS-based methods the authors were able to identify and define important causal and spatial relationships able to predict future species dynamics. Therefore, the main driving factors responsible for their spread could determine significant differences in terms of invasiveness in relation to the human management and the ecological interactions between the plants and the invaded environment (Bass *et al*., 2006).

Taking into consideration the intensification of the human-induced impacts in various habitats which influence the geographical spread of the two species, this approach aims at providing valuable information for future diagnosis of the species' spreading potential. Concurrently it provides a prognosis of the species further distribution and extent depending on the particularities of its dissemination drivers: autochoria (layering), anemochoria (winds), zoochoria (animals), hydrocoria (rivers) and anthropochoria (plantations, transport means, etc.). All of these would have a great contribution in terms of identifying and implementing necessary management strategies for control. Although there are not the first recorded species in the Romanian protected areas, because of their fairly high invasive potential and, thus their impact on native species and biodiversity, we consider that a complex assessment of their potential areas of establishment and spread must be further performed.

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