HABIT-CHANGE

adaptive management for protected areas

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Management practices for invasive species in Danube Delta Biosphere Reserve (Romania) and Triglav National Park (Slovenia)

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1. Summary

All four reports for output 3.4.1 have the objective to document, analyse and evaluate the effectiveness and impacts of different management practices in nature conservation. Profound knowledge about the effectiveness of management practices is essential for an effective and efficient management of protected habitat types in protected areas and to assess the - actual and potential - contribution of different practices in obtaining goals and objectives under climate change.

This report at hand contains elaborated reports from two different HABIT-CHANGE investigation areas about the experiences made with the management of invasive species. Mihai Doroftei and Marian Mierlă from the Danube Delta National Institute for Research and Development (DDNI) in Tulcea, Romania and Tina Petras-Sackl, Tanja Menegalijan and Miha Marolt from Triglav National Park in Slovenia present their management experience with invasive species and refer to reviewed national and international literature.

The detailed information about the distribution and spreading of invasive species, the monitoring techniques and measures for removal and control of invasive plant species highlight one specific and increasingly important task of the protected area management under climate change. The spreading of invasive species is one of the most obvious and threatening impacts of climate change and is a major challenge for protected area management. It is expected that an increasing number of protected areas will have to deal with an increasing number and density of invasive plant species that affect the biodiversity within the area negatively. Strategies and concepts have to be developed to respond to this new challenge in nature conservation.

The management practices introduced and tested on invasive species stands in Danube Delta Biosphere Reserve and in Triglav National Park consist of measures that potentially can be implemented in other protected areas that also face the threats by invasive species. Management practices for invasive species must be considered important response options to mitigate the impacts of climate change in protected areas and should be part of a climate-change adapted management.

This report evaluates different management practices for different invaders and gives an overview about generally applicable measures. The measures described in this report may potentially be integrated into climate-change adapted management plans (CAMPs) that will be developed in work package 5 of the HABIT-CHANGE project in six different investigation areas. The information in this report is also one main information source for output 4.6.4, a study with an assessment of potential neophyte invasions of xenophile ruderals and with management options for eradication.

Part A: Danube Delta Biosphere Reserve

1. Introduction

The actual phenomenon of climate changes leads to unification, making that the natural barriers should not have an important role in maintaining biologic biodiversity (Bernd & Rolf, 1995; Anastasiu & Negrean, 2005). Nowadays perception on the invasion process is a distorted one due to the fact that the monitoring/control actions are only focused on the aggressive species which eliminate the native ones or modify the invaded ecosystem (Cogălniceanu, 2007). Despite all the anthropogenic activities carried out in the past, in Danube Delta after 1989, it has been acknowledged that the deltaic territory still preserves an impressive diversity of habitats and species characteristic to wetlands in a relatively restrained space. This natural patrimony determined, in 1990, the declaration of The Danube Delta and of its coast part as Biosphere Reserve by the Romania Government, decision subsequently confirmed by the Romania Parliament, by means of Law no. 82/1993 and completed afterwards by H.G. No. 248/27 May1994. internationally, it was acknowledged its universal value by including this area within the biosphere reserves network (1990), in The MAB Programme launched by UNESCO (The Danube Delta is the only delta in the world a Biosphere Reserve out from the total of 352 reserves in 87 countries). At the same time, since September 1990, D.D.B.R. (Danube Delta Biosphere Reserve) has been acknowledged as a wetland of international importance (RAMSAR), and since December 1990, over half of its surface has been included in The List of the World Natural and Cultural Patrimony (Gâştescu & Ştiucă, 2008). As a confirmation of its value, The Danube Delta's territory was integrated (2005) in Natura 2000 network as an area of comunitary interest and of avifaunistic importance.

The present report aims to accomplish integrated information on different management strategies for the invasive plant species in D.D.B.R., thus offering up-to-date and specific data not only to the authorities that make political decisions, but to the public also. This report will include information on alien species' ecology, information on the characteristics that the alien species possess. In this way, a distinction between non - invasive and invasive alien species will be made.

Preliminary data will be presented, which regards the research history made by a review of the literature in Romania and actual preservation strategies in relation with the invasive plant species as well. Based on our methods and work aids, presented also in this report, we have compiled and identified in the study key areas: the black list of the invasive species and the most affected areas within D.D.B.R. by making up a digital map in which their critical level is gradually presented. The field mapping of the studied species were made by G.P.S. devices and by the analysis of satellite images throughout different years and seasons (1991 – 2009 (except 2003)) in order to identify the possible habitat fragmentations as a result of anthropogenic activities. The elaboration of digital maps was made in Arcview 3.1 format in which the most affected areas will be indicated or the presence of the invasive plant species has strongly modified the habitats. Partial download and analysis of the G.P.S. points taken in the field in order to build up the invasive species' distribution within D.D.B.R. represents 375 points/plant communities lifting.

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According to the Pan – European strategy on control of the invasive species in order to preserve the natural capital we have elaborate recommendations for the management practices with specific cautions, control and/or eradication (if it is the case) that are applicable measures for each area presented as being affected. The management measures will especially regard the alien plant species which have proved invasive subsequent to the results of the working study methods. The report results can be used by the Ministry of Environment and Forest in Romania, Ministry of Agriculture and Rural Development, Danube Delta Biosphere Reserve Administration, other local authorities/stakeholders, scientific community and the public as well.

2. The strategy on alien species in D.D.B.R.

2.1. Abstract on alien plant research in Romania

On Romanian territory, the first information about the existence of plants introduced by man is found in *„Descriptio Moldaviae"* (1715), work carried out by Dimitrie Cantemir (1623-1723) at the request of Berlin Academy. He describes the spontaneous and cultivated vegetation that covered Moldova's fields and hills.

During the VIIIth century, our country was studied by various foreign travelers: the German Kramer (1720-1726), the Venetian Francesco Griselini (1774-1777), Domenico Sestini (1779-1780), the famous professor from Pavia, Spallanzani L. (1786), Felice Caroni (1800), who include in their works data regarding spontaneous and cultivated flora.

The first valuable botany work published in Latin in 1816 is *„ The enumeration of plants in Transilvania"* by the doctor J.G.Baumgarten from Sighisoara, who describes a series of herbal and ligneous alien plants cultivated in Transylvania (Ştefan & Oprea, 2007). Thus, all this time, many botanists brought valuable contributions to the knowledge of spontaneous and alien flora in our country. Many of these works had a floristic character, based on the plants inventory and spreading within various areas in the country: Ferdinand Schur (1799-1878), Florian Porcius (1816-1906) – „*Transilvania Flora*", Fr. Herbich (1859) – „*Flora der Bucovina"* , Victor Janka (1837-1900) – „*Dobrogea Flora*", Rochel A. (1828) „*Plantae Banatus rariores, inconibus et descriptionibus ilustratae*" and Heuffel J. (1958) „*Enumeratio Plantarum in Banatum temensiensi sponte crescentium et frequentus cultarum*".

Towards the end of XIXth century, the works of two great botanists were remarked, Dimitrie Brânză (1846-1895) and Dimitrie Grecescu (1841-1910). The former publishes between 1879-1883 *„The Prodromul of Romanian Flora or the Enumeration Up to Date from Moldova and Valachia"*, with about 2100 plant species among which the species introduced in our country up to that period are mentioned (Păun et al, 1980). After the death of Dimitrie Brânză, the Romanian Academy publishes his work „*Dobrogea Flora"*, in which 1176 alien and spontaneous plant species are enumerated. This book is considered very valuable in determining the species at present. A part of the species described in the work above mentioned are studied in this paper, too. Dimitrie Grecescu publishes *„The Outline of Romanian Flora"* in 1898, in which he includes 3000 species and varieties, data upon the Romanian phytogeography, with a first zoning of vegetation. The alien species *Robinia*

pseudoacacia, introduced in 1878 in forest plantations in Dobrogea, is mentioned in this work. *Elaeagnus angustifolia* and *Amorpha fruticosa* are also presented as species spread within hill areas.

Panţu C. (1866-1934) publishes an important work (1900) in which he refers to alien ligneous species on the Romanian territory, namely *„The Plants Known by the Romanian People"* Ferdinand Albin Pax (1858-1942), German botanist, also treats the spreading of the cultivated ligneous species in his work about the Carpathians' flora (1908).

Later, another great botanist Iuliu Prodan publishes *"The Outline of Dobrogea Flora"* in 1935 – 1939, in which he gives to the public knowledge a series of alien species found within Dobrogea steppe: *Gleditsia triacanthos* is mentioned as being cultivated and used as hedges. *Amorpha fruticosa* is mentioned in Cadrilater, at Bazarcic (Basardchyk, Hadchi Oglu), as being cultivated. *Robinia pseudoacacia* are noted as being a lot cultivated alongside paths, roads, and parks. *Ailanthus altissima* is mentioned as existing in parks and planted on sands. *Acer negundo* is characterized as species cultivated in gardens and parks. *Elaeagnus angustifolia*, also, is presented as cultivated plant. *Lycium barbarum* is described as plant that forms bushes on hill coasts.

During 1947 - 1949, Alexandru Borza publishes "*The Outline of Romania Flora*" in which he also refers to hybrid and alien ligneous species aforementioned

Important reference to alien ligneous plants in Danube Delta can be found in Forest Arrangements of Tulcea Forest Stock. As it has been mentioned since 1954, from the first arrangement, the induction of some acacia forest (*Robinia pseudoacacia*) and the consolidation of channels banks with *Amorpha fruticosa* species were aimed.

The most important of the works appeared in our country is " *Romanian P. R. Flora – Flora Romania S.R."* in 13 volumes (1952 – 1976), elaborated by 25 botanists (after the model of *S.S.R.U. Flora.*) under the coordination of Traian Săvulescu (1889-1963) and E. Nyarady (1881-1966). The work presents about 3450 species grouped in 786 genders which belong to 152 families out of which 129 spontaneous and 23 cultivated. The 23 families have representatives (approx. 1000) both in the ornamental flora originary from different climatic areas and the cultivated one for economic interest.

The work of I. Dumitriu-Tătăranu (1960) is also worthy to be mentioned, who publishes a guide book for the spontaneous and cultivated ligneous flora in our country.

Reference to alien ligneous species are made by Constantin C. Giurescu (1975) as well in his book, "*The History of the Romanian Forest"*, in which it is reminded that, in 1878, plantations of *Robinia pseudoacacia* were to be found on this territory.

"*Flora of the Danube Delta",* published (1976) by Gheorghe Dihoru and Gavril Negrean, is a work in which about 1100 vascular species are enumerated on the basis of rich literature and personal data. In this list, the cultivated plants on the territory of the Danube Delta are also included.

Another work of the same type is the pocket atlas (1978), as the author Ioan C. Voiculescu calls it, about the trees and shrubbery within our forests, parks and gardens. In this book, 35 alien ligneous species are ecologically described and characterized.

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Alexandru Beldie (1977, 1979) and Vasile Ciocârlan (1988, 1994, 2000), in their works about the Romania and Danube Delta's flora mention numerous ornamental alien ligneous species, cultivated for economic purpose or sub spontaneous, as the species *Amorpha fruticosa, Robinia pseudoacacia, Ailanthus altissima, Acer negundo* and *Lycium barbarum* are also identified at present.

In 1996-2004 periods, V. Zanoschi and his collaborators publish the work "*The Spontaneous and Cultivated Ligneous Flora in Romania"*. In the same period, Ion Sârbu and his collaborators (2001) elaborate a guide book for the Eastern flora of the country in which the species introduced by man are presented, too. For the species *Amorpha fruticosa, Robinia pseudoacacia, Fraxinus pennsylvanica, Lycium barbarum, Acer negundo, Elaeagnus angustifolia* and *Ailanthus altissima* are mentioned a series of ecologic characteristics as well as data on their spreading and use.

In the work "*Vegetation of the Biosphere Reserve Danube Delta – with Transboundary Vegetation Map"*, Ion Sârbu şi Nicolae Ştefan (2002) mention that in the Danube Delta are approximately 1400 cormophyte species. The work presents a series of vegetation associations in which the frequency of the alien species *Amorpha fruticosa, Elaeagnus angustifolia, Morus alba* and *Lycium barbarum* is presented.

According to the frame programmes of the European Union for the invasive species control, a number of botanists elaborate, in 2003 – 2008 period, scientific works towards this direction. Among these, the works published by Anastasiu Paulina and Negrean Gavril (2005) are mentioned, "*Alien plants in Romania"* and "*Invasive and potentially invasive alien plants in Romania– Black List*", then, together with Corina Başnou, Culiţă Sârbu and Adrian Oprea, "*A preliminary study on the neophytes of wetlands in Romania*" (2008).

In the last decades, the scientific community, getting more aware of the unification phenomenon, elaborated numerous important works in this domain. The history shortly presented in these pages does not have the aim to describe them all, but to point out man's interest in these plants since the very beginning, as well as his actual preoccupation to preserve and maintain the economic and natural values within he lives.

2.2. Present status on actions that involve Danube Delta area

In the Global Strategy of Plants Conservation, adopted at Haga in 2002, as part of the Convention on Biodiversity (Rio de Janeiro – 1992), it is recommended that until 2004, all the involved countries should elaborate the black list of invasive species and until 2006, they should elaborate control measures on the species indicated in these lists.

Romania integrated within this process by Law no.13/1993 ratification, which includes the Convention's measures regarding wildlife and European natural habitats conservation, and by Law no. 58 since13th July 1994, which includes measures statutory in the Convention on Biologic Diversity. In 2004, a project CNCSIS was also started up, "The identification of the alien invasive species or with invasive potential in Romania and the impact determination on the natural habitats in order to elaborate prevention and control measures ", which had the same objective. One of this

project's results was the black list of the alien plants in Romania, book edited by the Romanian Academy, summing up a number of 435 species (Anastasiu & Negrean, 2005).

In Belgrad Report (2005), section IV.2 – The control of the invasive alien species, there are mentioned certain invasive alien plant species, many of them existing within the Danube Delta, too.

The Convention on Biologic Diversity, - The Third Report, mentions 12 species of alien trees for Romania, among which Acer negundo, Ailanthus altissima, Amorpha fruticosa, Fraxinus pennsylvanica, Lycium barbarum and Robinia pseudoacacia.

At national level, there are another two research projects towards this direction:

The Elaboration of an Alien Species Monitoring and Rapid Detection System, a project carried out within the University in Constanţa;

A Complex study on alien plants within the Danube Delta in order to establish their ecologic impact, to evaluate risks and elaborate the minimum of measures for their management, project carried out within the Bucharest University

Within the Danube Delta National Institute, a research project on the alien species Amorpha fruticosa in the Danube Delta was completed.

In Romania, there is not any national strategy for the monitoring of alien plant species, only sartorial management measures were elaborated but they do not reach the desirable objective. An example in this direction is the forest management at the Forest National Administration level which includes a set of control measures for the invasive alien ligneous species. According to the actual European tendencies, by these measures, it is aimed the replacement of the identified invasive alien species with native ones, specific to the habitat or with other non – invasive alien species, economically valuable. This compromise, at least within the Danube Delta, has proved not to be viable. Within the Euroamerican poplar forest plantations (Populus x canadensis), in the arborescent layer, the invasive species Amorpha fruticosa installs very well within an extremely compact brushwood. This phenomenon generates significant economic loss.

Within the Danube Delta Biosphere Reserve's management plan, for the period 2007 – 2013, at the objective to stop the biodiversity decline it is included the action of inventorying the invasive species and the elaboration of caution measures for their management. At present, at the level of the Danube Delta Biosphere Reserve there is not a black list of the invasive species, or relevant data which to determine the elaboration of prevention and control measures. The problem of the invasive alien species has not been generally made known at national level purposefully.

The proof is that there is not a national centre formed of experts to represent authority in this domain. On one hand, the actions started up by means of research projects within profile institutions show the fact that there are human resources to support the general frame specific to Romania. On the other hand, the decision institutional support cannot provide the centralized success of an action due to lack of political involvement in the state administration.

3. Distribution of vegetation units and study areas

Among the first systematic studies on Danube Delta's vegetation, there were the ones initiated by the Romanian biologist Grigore Antipa who, between 1896 – 1944, published numerous scientific works that include particular aspects concerning reed beds within this territory. Since then, multifold studies and research on delta vegetation have been carried out by Romanian and foreign researchers. Some of the published works are mentioned: „Pajiştile naturale din Delta Dunării" (Vasiu et al, 1963); „Monografia stufului din Delta Dunării" (Rudescu et al., 1965); „Contribuţie la studiul vegetaţiei acvatice şi palustre a Deltei Dunării" (Tarnavschi & Nedelcu, 1970); „Flora of the Danube Delta" (Dihoru & Negrean, 1976); „Contribuţii la cunoaşterea vegetaţiei psamofile din Delta Dunării" (Popescu & Sanda, 1976); „Consideraţii generale asupra principalelor asociaţii acvatice şi palustre din Delta Dunării în condiţii naturale şi amenajate" (Godeanu M., 1976); „Vegetaţia României" (Doniţă et al, 1992); „Flora Deltei Dunării" (Ciocârlan, 1994); „Vegetaţia Deltei Dunării" (Popescu & Sanda, 1997); „Vegetation of the Biosphere Reserve Danube Delta"(Hanganu et al, 1993, 2002).

The types of natural vegetation within Danube Delta territory are represented by marshes (43%), aquatic vegetation (27%), meadow grassland (2%), halophyle and seaside vegetation (7%), meadow and continental forests on sands (6%), as well as shrubbery (1%) (figure 1).

Artificial areas within Danube Delta are represented by agricultural fields, forest plantations, fishery arrangements' vegetation and human settlements as well. Agricultural arrangements have been started before World War Second, within Tătaru Islet (1939). They have been intensified after the 60s, by means of draining and diking of larger and larger areas. In 1990, these areas summed up 53,000 ha distributed into several arrangements (agricultural, forestry and fishery). From this surface, because of inadequate conditions for agriculture, only 39,000 ha are left for exploitation. At present, artificial areas within Danube Delta Biosphere Reserve represent 14% out of the entire area.

It is an already accepted fact that human settlements especially, within Danube Delta, are characterized by an obvious discontinuity, they are real enclaves, the first to appear and modify natural ecosystems in here.

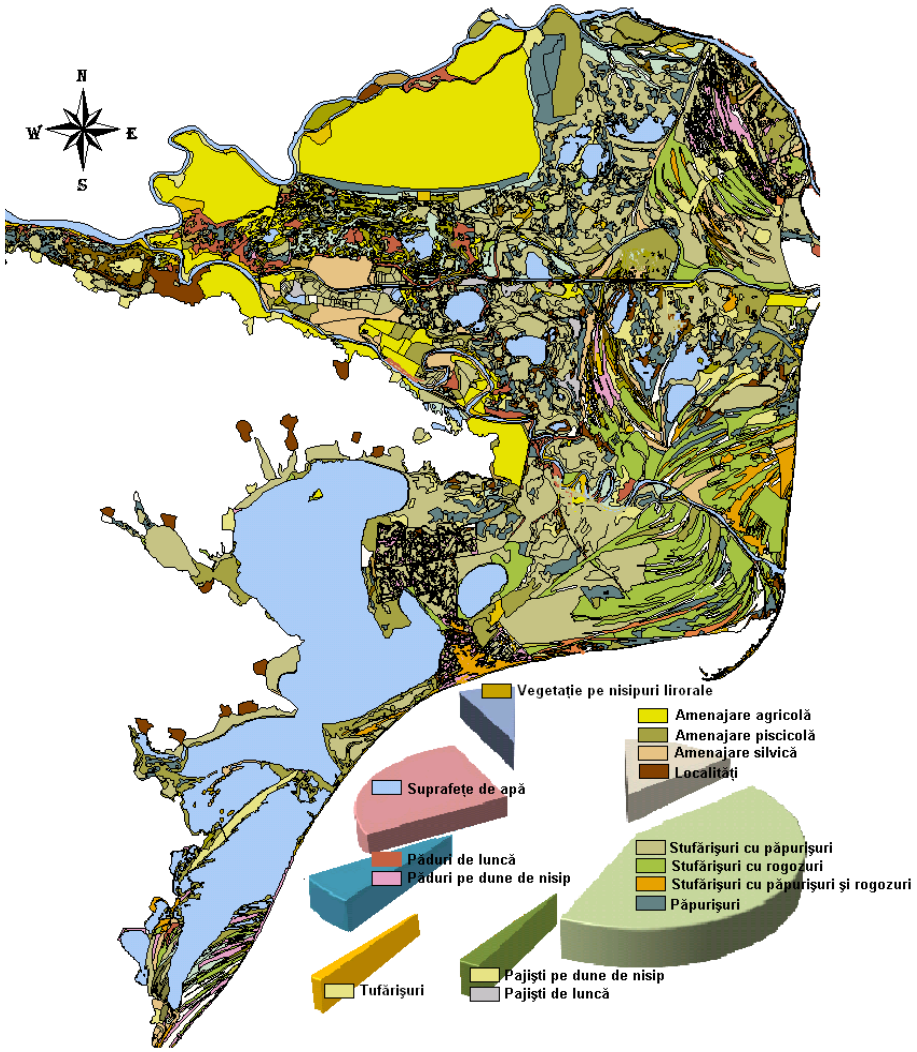

Figure 1: Distribution of vegetation units in Danube Delta (modified) **(after Hanganu et al, 2002**

For field investigations, five different study areas have been selected (figure 2) from the two sectors of Danube Delta.

In fluvial delta, three areas have been selected:

- Depression of Şontea - Fortuna
- Depression of Matiţa – Merhei
- Depression of Dranov.

In fluvial-maritime delta, two areas have been selected:

- Seashore sector Sulina – Sfântu Gheorghe
- Caraorman Sandune.

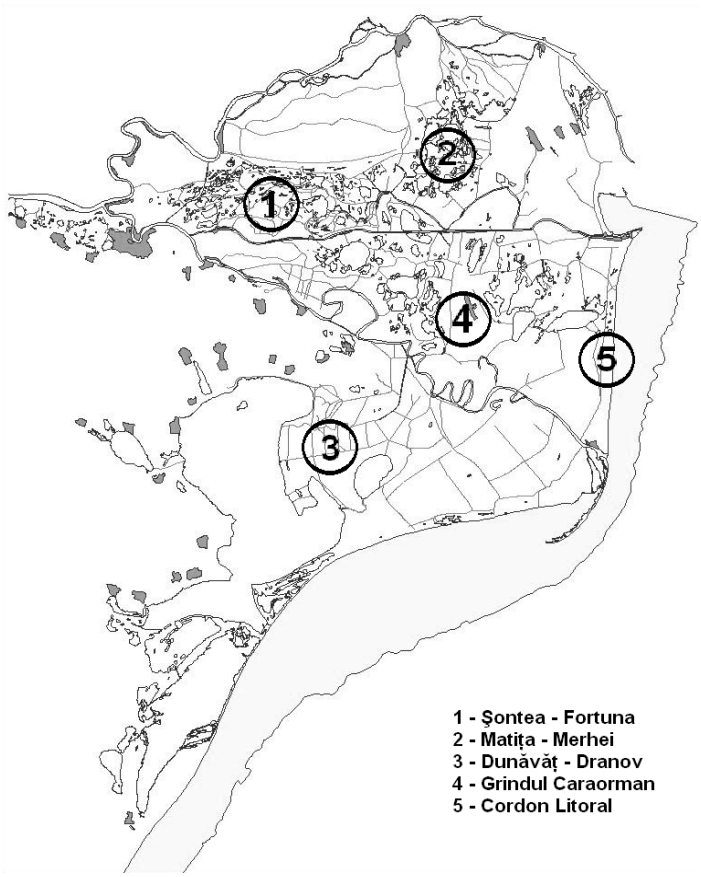

Figure 2: The location of study areas.

1. Şontea – Fortuna Depression. In comparison with the other studied areas, the complex represents diversity in vegetation, soils and higher altitude. The vegetation within the depression is prominently formed of shrubery and meadows, and alongside channels is generally formed of natural forest easily flooded (figure 3). The exception from this description is represented by the areal included in Gârla Păpădia, Dunărea Veche and Braţul Sulina. This one includes, mainly, planted forest vegetation. Draining is slow on the entire complex area, factor that is favourable to alien species development. From altitude perspective, Şontea – Fortuna Depression is included alongside banks:

- Between 0 and 1 m on Olguţa and Războiniţa channels;
- Between 1 and 2 m on Gârla Şontea, Păpădia Nouă, Păpădia Veche, Mitchina, Crânjeală and Mila 35 channels (northern part);
- Between 2 and 3 m on Dunărea Veche, Păpădia and Mila 35 channels (Sulina branch area).

Vegetation units which have been investigated in Şontea – Fortuna Depression are (Sanda et al, 1983; Popescu şi Sanda, 1997; Sanda şi Arcuş, 1999; Hanganu et. al., 2002):

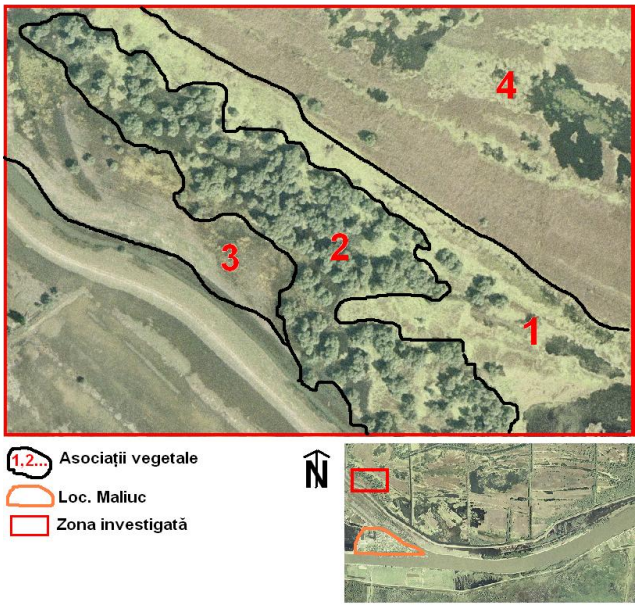

Figure 3: Vegetation profile on Old Danube (Şontea – Fortuna Depression): 1-Cynodonto – Poetum angustifoliae, 2- Salicetum albae, 3- Bassietum sedoidis 4- Scirpo-Phragmitetum

Old Danube

- Natural forests easily flooded: S*alicetum albae* 1924 s.l., *Salicetum cinereae* Zolyomi 1931, *Populetum marylandicae* Mititelu 1970 (ass.cult.)
- Meadows on high dams: *Cynodonto – Poetum angustifoliae* (Rapaics 1926) Soo 1957, *Lolio-Plantaginetum majoris* (Linkola 1921) Beger 1930, *Bassietum sedoidis* (Ubrizsy 1949) Soo 1964, *Hordeetum murini* Libbert 1923 emend.Pass. 1964.

Gârla Şontea

- Mixed reed and club rush vegetation on organic soils: *Typhetum angustifoliae* (All.1922) Pign.1934, *Scirpo-Phragmitetum* W.Koch 1926;
- Reed vegetation on mineral soils: *Scirpo-Phragmitetum* W.Koch 1926;
- Mixed reed and club rush vegetation on mineral soils: *Scirpo-Phragmitetum* W.Koch 1926, *Typhetum angustifoliae* (All.1922)Pign.1934;
- Natural forests easily flooded: S*alicetum albae* 1924 s.l., *Salicetum cinereae* Zolyomi 1931.

Olguţa Channel

- Mixed reed and club rush vegetation on mineral soils: *Scirpo-Phragmitetum* W.Koch 1926, *Typhetum angustifoliae* (All.1922)Pign.1934;
- Mixed reed and club rush vegetation on organic soils: *Typhetum angustifoliae* (All.1922)Pign.1934, *Scirpo-Phragmitetum* W.Koch 1926;

- Natural forests easily flooded: S*alicetum albae* 1924 s.l., *Salicetum cinereae* Zolyomi 1931.

Gârla Păpădia

- Plantations of Salix sp., Populus sp., Fraxinus pennsylvanica, Robinia pseudoacacia;
- Natural forests easily flooded: Salicetum albae 1924 s.l., Salicetum cinereae Zolyomi 1931.
- Reed vegetation on mineral soils: Scirpo-Phragmitetum W.Koch 1926.

Crânjală Channel

- Natural forests easily flooded: S*alicetum albae* 1924 s.l., *Salicetum cinereae* Zolyomi 1931, *Salicetum triandrae* Malciut 1929;
- Mixed reed and club rush vegetation on mineral soils: *Scirpo-Phragmitetum* W.Koch 1926, *Typhetum angustifoliae* (All.1922)Pign.1934.

2. Matiţa – Merhei Depression. The dominant vegetation within the complex is formed of reed associations (70%) (figure 4). Eracle, Iacob, Gârla Lopatna channels, as well as the linking channel between Old Danube and Bogdaproste Lake, are the access ways that make possible the entrance into the complex through the southern part. From altitude point of view, the depression has the lowest values, comprised between 0 and 1 metres, in the central part, while in the southern and western parts, there are values comprised between 1 and 2 metres. Draining is slow on the entire depression area. This aspect, corroborated with the low heights, favours reed vegetation development. Salinitz is verz low, the same as in the rest of the lake complexes that belong to fluvial delta.

The vegetation units that have been investigated within Matiţa – Merhei Depression are (Sanda et al, 1983; Popescu şi Sanda, 1997; Sanda şi Arcuş, 1999; Hanganu et. al., 2002):

Gârla Lopatna

- Reed and shrubery vegetation on compact reedbed: *Thelyptero – Phragmitetum* Ştefan et al.1995;
- Natural forests easily flooded: S*alicetum albae* 1924 s.l., *Calamagrostio-Salicetum cinereae* Soo et Zolyomi (1934) 1955.

Bogdaproste Channel

- Reed and shrubery vegetation on compact reedbed: *Thelyptero – Phragmitetum* Ştefan et al.1995; *Scirpo-Phragmitetum* W.Koch 1926.

Old Danube

- Natural forests easily flooded: S*alicetum albae* 1924 s.l., *Calamagrostio-Salicetum cinereae* Soo et Zolyomi (1934) 1955, *Salicetum triandrae* Malciut 1929.

Eracle Channel

- Reed and shrubery vegetation on compact reedbed: *Thelyptero – Phragmitetum* Ştefan et al.1995; *Scirpo-Phragmitetum* W.Koch 1926.

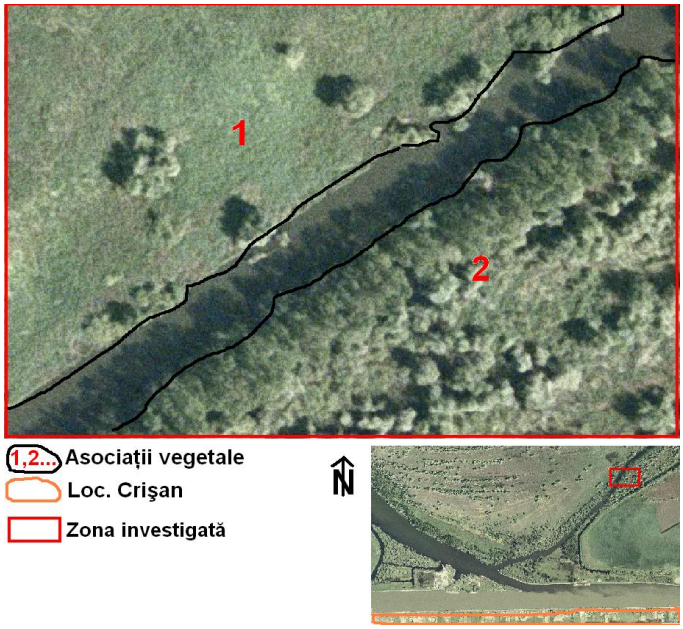

Figure 4: Vegetation profile on Old Danube (Matiţa – Merhei Depression): 1-Scirpo-Phragmitetum, 2- Salicetum albae

3. Dunăvăţ – Dranov Area. Within this area, reed vegetation prevails. Alongside channels, the vegetation is formed of forests easily flooded (figure 5). Draining, although it is changed on almost the entire area, i slow. From altitude perspective, the arrangement is included between 0 and 1 m, rarely 2 m.

The vegetation units zhat have been investigated within Dranov Depression, on the main channels, Mustaca, Dunăvăţ, Dranov and canalul Lipovenilor, are (Popescu şi Sanda, 1997; Hanganu et. al., 2002):

- Reed and shrubery vegetation on compact reedbed: Thelyptero – Phragmitetum Ştefan et al.1995; Typhetum angustifoliae (All.1922) Pign.1943; Scirpo-Phragmitetum W.Koch 1926;
- Meadows on high dams: Hordeetum murini Libbert 1923 emend.Pass. 1964; Cardarietum drabae Timar 1950;
- Natural forests easily flooded: Salicetum albae 1924 s.l., Calamagrostio-Salicetum cinereae Soo et Zolyomi (1934) 1955, Salicetum triandrae Malciut 1929.

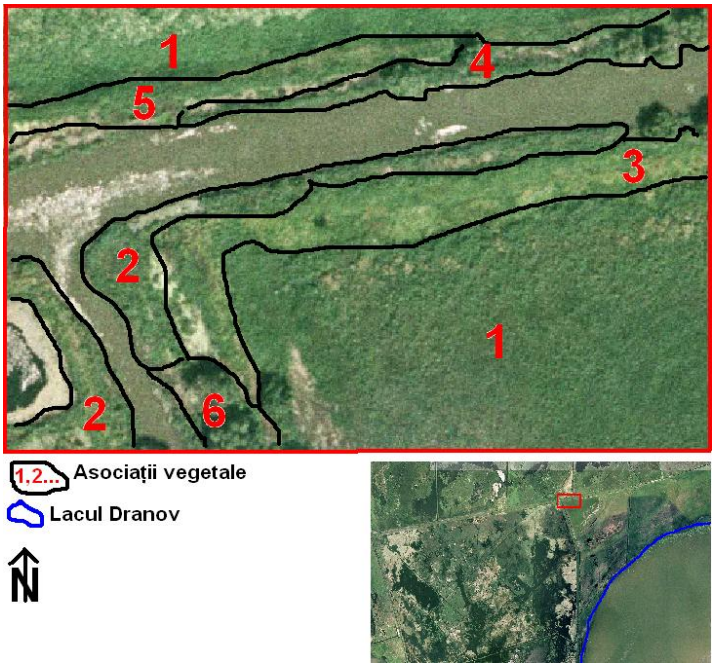

Figure 5: Vegetation profile on Mustaca Channel (Dunăvăţ – Dranov Area): 1-Scirpo phragmitetum, 2-Typhaetum angustifoliae, 3-Hordeetum murini, 4- Salicetum triandrae, 5-Cardarietum drabae, 6- Salicetum albae

4. Caraorman Sand dune. The landscape is structured with dunes of diverse heights and interdunes spaces with various heights compared to the sea level. They also have various width and forms. This type of landscape influences the display of vegetation on Caraorman Sand Dune (Figure 6). Its display is dependent on ecological gradients (humidity, salinity, insolation) as well. Vegetation distribution is made up according to land height, soil granulometry, the depth of the ground water layer, and in some places, it is dependent on dune slope inclination and exposition towards sunrays.

The most important role for the various plant communities is the role of the hydric regime. The ecological conditions reflect themselves very well in ligneous vegetation distribution, within the so called haşmac forests; the floristic composition from the herbaceous layer is represented according to the type of soil, the depth of ground water layer, and in the eastern part of the sand dune it depends on the ground water salinity as well.

The vegetation units that have been investigated on Caraorman Sand dune are (Sanda et al, 1983; Doltu et al, 1983; Hanganu et. al., 2002):

- shrubbery: Calamagrostio epigei-Hippophaetum rhamnoides Popescu, Sanda, Nedelcu 1968;
- vegetation on high dunes: Caricetum divisae Slavnic 1948, Saliceto (rosmarinifoliae) – Holoschoenetum vulgaris Mititelu et al. 1973; Cynodonto – Poetum angustifoliae (Rapaics 1926) Soo 1957;

- meadows on sand dunes: Holoschoeno – Calamagrostetum epigeios Popescu et Sanda 1978; Plantaginetum arenarie (Buia et al.1960) Popescu, Sanda, 1987; Ephedro-Caricetum colchicae (Prodan 1939 n.n.; Morariu 1959) Sanda, Popescu 1973) (figure 17);

- mixed oak and ash tree forests: Fraxino pallisae-angustifoliae –Quercetum roboris Popescu et al 1979 (figure 18).

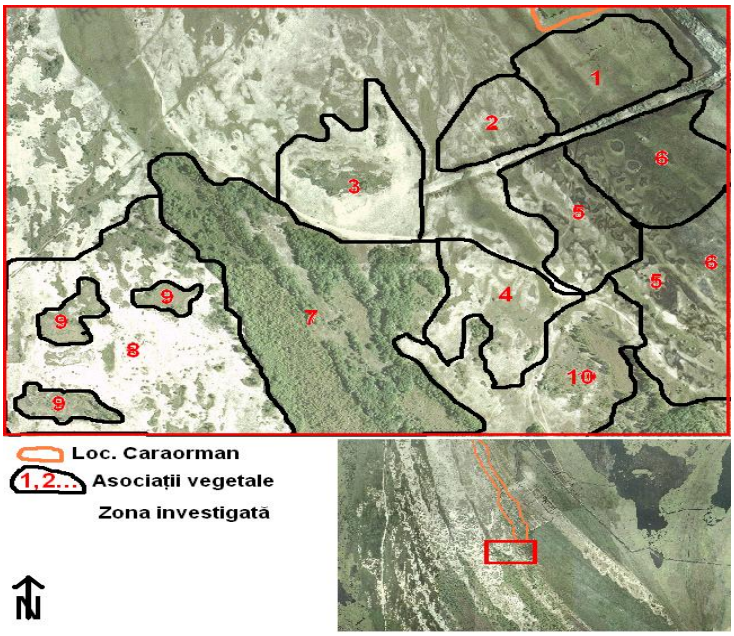

Figure 6: Vegetation profile at south of Caraorman village (Grindul Caraorman): 1 – Plantaginetum arenarie 2- Cynodonto – Poetum angustifoliae 3-4 – Calamagrostio epigei-Hippophaetum rhamnoides, 5- 6 - Scirpo-Phragmitetum, 7- Fraxino palisae-angustifoliae-Quercetum roboris,8- Scabioso argeteae-Caricetum colchicae, 9 – Ephedro-Caricetum colchicae, 10- Saliceto (rosmarinifoliae) – Holoschoenetum vulgaris

A large part of Crişan channel length is within Caraorman sand dune. The vegetation existent alongside the channel alterns both in height and composition. In the northern part of the channel there is a vegetation specific to fluvial delta, while on the rest of the channel, up to Caraorman locality, the vegetation becomes specific to fluvial – maritime delta.

The vegetation units that have been investigated on Crişan channel are (Sanda et al, 1983; Doltu et al, 1983; Popescu and Sanda, 1997; Sanda and Arcuş, 1999; Hanganu et. al., 2002):

natural forests easily flooded: Salicetum albae 1924 s.l.; Calamagrostio-Salicetum cinereae Soo et Zolyomi (1934) 1955;

- shrubbery: Calamagrostio-Tamaricetum ramosissimae Simon et Dihoru (1962) 1963;

- mixed reed and club rush vegetation on mineral soils: Scirpo-Phragmitetum W.Koch 1926, Typhetum angustifoliae (All.1922)Pign.1934;

- meadows on high dams: Cynodonto – Poetum angustifoliae (Rapaics 1926) Soo 1957 (figura 44); Bassietum sedoidis (Ubrizsy 1949) Soo 1964; Hordeetum murini Libbert 1923 emend.Pass. 1964;
- vegetation on high dunes: Secaletum sylvestre, Ephedro – Caricetum colchicae, Artemisietum arenariae Popescu et Sanda 1977.

5. Seashore – Sf. Gheorghe-Sulina sector. Seashore sands may have width from a few dozen metres to a few hundreds metres and it has specific landscape, with the following landstrips parallel with the line that separates land from sea (figure 7):

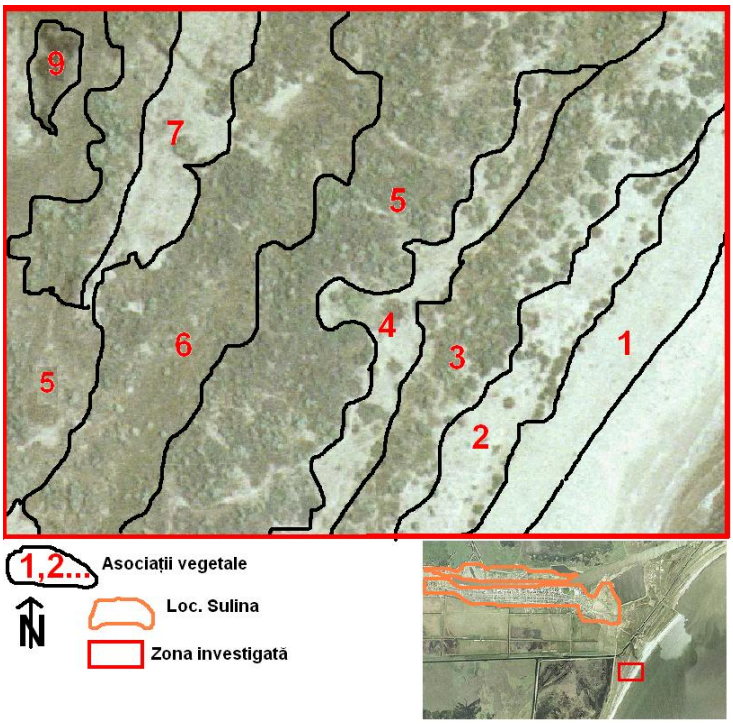

Figure 7: Vegetation profile Sulina area: 1-Atripliceto hastatae – Cakiletum euxinae 2-Elymetum sabulosi 3- Calamagrostio epigei-Hippophaetum rhamnoides, 4- Brometum tectori 5- Calamagrostio-Tamaricetum ramosissimae 6- Junceum maritimi 7- Plantaginetum coronopi 8- Scirpo prhagmitetum

- beach exposed to waves, with not solified sand, permanently wet, without vegetation;
- beach not exposed to waves, with not solified sand, wet at the surface, with pioneer vegetation, poor in species;
- high dunes with weakly fixed and not solified sand, slightly exposed to wind;
- middunes with sand partly fixed, where solification process has begun;
- low dunes with fixed sand and solification process more advanced, in complex with depressions where the sand is salinized, wet, frequently gleized. In this part, vegetation associations with

dominant ligneous species are usually seen, depending on salinization degree and layer's humidity;

- marshes which gradually turn to surfaces with permanent water.
- According to the specific microlandscape, there are biotops with various life conditions under humidity aspect or water stagnation and salinity (figure 8).

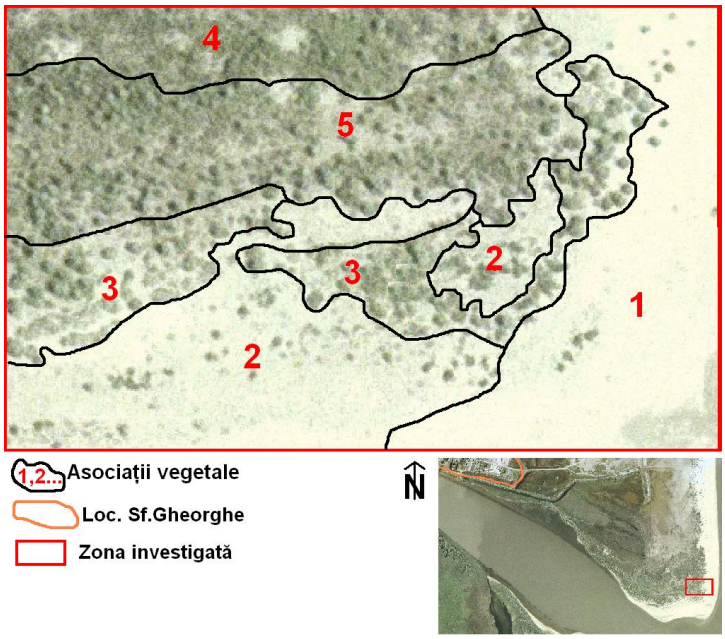

Figure 8: Vegetation profile in Sf.Gheorghe area: 1-Atripliceto hastatae – Cakiletum euxinae, 2-Argusietum sibiricae, 3-Calamagrostio-Tamaricetum ramosissimae, 4- Juncetum acuti-maritimi, 5-Calamagrostio epigei –Hippophaetum rhamnoides

Within the depressions with permanently wet sand, very strongly salinized, one can see the association Salicornietum europeae. On the depressions shores, the association Suaedetum maritimae appears. On the drier sand on flat places within depressions, the association Aeluropetum littoralis is located (Prodan 1939) Şerbănescu 1965.

The vegetation units that have been investigated within this sector are (Doltu et al, 1983; Popescu and Sanda, 1997; Hanganu et al 2002):

- shrubbery: Calamagrostio epigei-Hippophaetum rhamnoides Popescu, Sanda, Nedelcu 1968; Calamagrostio-Tamaricetum ramosissimae Simon et Dihoru (1962)1963;
- seashore vegetation on not fixed sands: Atripliceto hastatae – Cakiletum euxinae Sanda et Popescu 1999; Argusietum (Tournefortietum) sibiricae Popescu et Sanda 1975; Plantaginetum arenariae (Buia et al. 1960) Popescu, Sanda; Juncetum acuti-maritimi Popescu et Sanda 1972; Elymetum sabulosi Morariu 1957 corr.hoc loco.

4. The methods and ecologic indices used

In order to carry out the project, field trips have been made, as follows:

- The vernal period – the monitoring of different development stages of the studied species, visual mapping on itinerary;
- The estival period – sample taking, visual mapping on itinerary, aero photographic mapping on the basis of satellite pictures; the monitoring of the key areas where repeated observation will be done;
- For the autumnal period, the monitoring specific to each species will be carried out, the completion of the phytocenosis species list, observations on alien plant species distribution;

Within the fluvial delta, along channels and within the maritime delta, the littoral cordon area, the observations will be carried out by the squares method within well established routes. These routes will be repeated during each vegetation period. The phytocenosis composition will be determined by the elaboration of lists of species present at the time. For a comparative research, a minimum representative area will be determined within which the most of the species of the phytocenosis can be identified. This minimum area, constantly monitored, is established at 10 m² for the pasture and reed phytocenoses and at100 m² for the forest and brushwood phytocenoses.

The most frequently used materials in field research were the camera Canon EOS 1000D, with different teleobject glasses (24-85 mm Cannon, 150-500 mm Tamron and 14-17 mm F3.5-4,5 DN Tokina), Ph-meter WTW 340 and the G.P.S. Magellan device.

For the study of phytoindividuals, specific procedures for the populational study are selected. They allow the employment of certain qualitative and quantitative phyto – populational indices. The approached qualitative phyto – populational indices are vitality and the phytoindividuals'phenological state.

For the evaluation of vitality, the vitality Braun – Blanquet system (1964) is employed, appreciated in value indices.

The phenological state is evaluated by means of the phenological system differentiated according to the vegetation type, system conceived by Ivan and Spiridon (1983), in which four stages are distinguished: vegetative stage, buttoning stage, inflorescence stage and fruit stage.

The practical method in the field will be enforced by writing down the stage in which the most (60 – 70%) specimens of each identified species are within the phytocenosis structure. The approached quantitive phytopopulational indices are abundance, coverage, frequency and the species age, in the case of the ligneous ones.

The ecologic signification index represents the relation between frequency and abundance, thus showing the species position within the phytocenosis.

The impact index (the competitive ability index) can be quantified on the basis of the following characters:

The reproduction capacity of the invasive species:

- prolificity – a big amount of seeds; short time of life between generations;
- early phenological stages as compared to indigene species;
- early sexual maturity; rapid vegetative regeneration;
- potential of asexuate reproduction; high rate of growing;
- the existence of resistance stages; high rate of seed germination.

Characters related to the invasive species' biology and ecology:

- species that live within masses; species adapted to shade conditions;
- well - developed radicular system; unspecific trophic preferences;
- invasive species within other areas;
- high abundance within the originary habitats;
- ecologic plasticity; high capacity to spread;
- competitive ability in exploiting the ecologic niches;
- resistance to mechanical factors; resistance to flooding periods of over 3 months;
- high capacity to replace indigene species;
- resistance to consumers or predators within the new habitats;
- the capacity to repopulate disturbed habitats;
- the capacity to develop within unspecific habitats.

Characters related to the invaded habitats:

- species deliberately introduced;
- the lack of special adaptation in the case of the indigene species;
- the lack of competitors among the indigene species; the lack of predators within the indigene species;
- the lack of parasites within the new habitats; species of economic interest.

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The method lies in introducing the described characteristics into a grid. To build up the species' profile, each situation of the studied plant will be marked in this grid.

The values obtained following the applying of the index formula are confined between 1 (reduced impact) and 10 or 9 major impact).

The aero photographic mapping method will be enforced by the means of an appropriate detailed exploration of the entire territory or of some representative parts (key areas) within less – accessible areas. The objective of this method is to get first information on vegetation, on the repetition in space of some plant species and their relation with the landscape and the conditions created by it. The exploration of the vegetation unit's existent within the territory adds to the building up of a matrix on probable types of the studied species' distribution and it serves in gathering the descriptions necessary for the actual mapping action. The basic aids for mapping are: G.P.S. device, topographic maps, satellite pictures from different seasons and vegetation maps. The actual work procedure consists of the selection of some transects which, subsequently, will be checked in the field with the help of the G.P.S. device in order to have a picture of the vegetation profile. Thus, to each field G.P.S. point an item of information corresponds – the sample, species presence, Ph, sub layer type. The most favorable periods to carry out the description are those when the specific type of vegetation records the most number of species fully developed. For the main vegetal units within the Danube Delta, these periods are: May – June: steppe and silvosteppe pastures, pastures on sands and June – August: meadow forests and willow forest, salt pastures, marshes and reeds.

In the Danube Delta Biosphere Reserve, was elaborated a list of 187 alien species (65 woody species), which represents 43% from the total of 435 alien plant species of national inventory.

5. The list of invasive plant species in Danube Delta Biosphere Reserve

On basis of reference literature and of Danube Delta National Institute for Research and Development Tulcea, the alien plant species present in Danube Delta have been selected. The present list includes 187 alien species, most of which are originary from Northern America and Asia.

From the list of the alien plants identified in Danube Delta, the species with the highest impact index (competitive ability index) have been extracted on the basis of ecological features. The method involved including the presented characteristics into a table. In order to make out the species profile, each situation of the plants studied in this table will be pointed out. The values obtained by means of impact index formula are confined between 1 (reduced impact) and 10 (major impact). Following this quantification, the data has been interpreted by using the impact index formula below:

$$I_{impact} = \sqrt{(N_{ci} \times 100/N)}$$, where:

I_{impact} - represents the competitive ability index of the invasive species;

N_{ci} – represents the number of characteristics registered by the invasive species;

N – represents the total number of characteristics.

Table 1: The list of invasive plant species in Danube Delta and their selection criteria.

Species characteristics	***Acer negundo**	***Ailanthus altissima**	***Amaranthus albus**	***Amorpha fruticosa**	****Azolla filiculoides**	****Cuscuta campestris**	***Conyza canadensis**	****Elaeagnus angustifolia**	***Elodea nuttallii**	****Fraxinus pennsylvan.**	****Gleditsia triacanthos**	***Iva xanthifolia**	***Lindernia dubia**	***Lycium barbarum**	****Morus alba**	****Paspalum paspalodes**	***Robinia pseudacacia**	****Vallisneria spiralis**	***Xanthium strumarium**	****Xanthium spinosum**	***Xanthium italicum**
Prolification	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x
Short lifespan between generations			x	x	x	x	x		x			x	x			x	x	x	x	x	x
Early phenological stages compared to indigene species	x														x						
Early sexual maturity			x	x	x	x	x	x	x			x	x	x		x		x	x	x	x
Fast vegetative regeneration		x	x	x	x	x	x		x			x	x	x	x	x	x	x	x	x	x
Potential for asexuate reproduction	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
High growing rate	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Presence of resistance stages	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
High seed germination rate			x	x	x	x	x	x	x			x	x			x	x	x	x	x	x
Species that live in agglomerations			x	x	x	x	x	x	x		x	x	x	x		x	x	x	x	x	x

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Species adapted to shade conditions	x									x					x					
Well- developed radicular system	x	x		x				x		x	x			x	x		x			
Unspecified trophy preferences	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
Invasive species in other areas	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
High abundance in the originary habitats		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Ecological flexibility	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
High spreading capability		x	x	x	x	x	x		x			x	x			x	x	x	x	x
Competitive ability in exploiting ecological niches	x	x	x	x	x	x	x	x	x	x		x	x		x	x	x	x	x	x
Resistance to dryness		x						x			x			x			x			
Resistance to flood periods of over 3 months										x										
High capability to replace indigene species			x	x	x	x	x		x			x	x	x		x	x	x	x	x
Resistance to consumers and predators in the new habitats	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x

The capability to repopulate perturbed habitats		x	x	x	x	x	x		x		x	x	x	x	x	x	x	x	x	x
The capability to develop in not specific habitats as well	x	x	x	x	x	x	x	x	x	x		x	x		x	x	x	x	x	x
Species deliberately introduced	x	x		x				x		x	x			x	x		x			
The lack of specific adaptation in the case of indigenous species	x	x		x				x	x	x	x			x	x		x			
The lack of competitors among the indigenous species	x			x				x			x			x		x	x		x	x	x
The lack of particular predators among the indigenous species	x	x		x				x	x	x	x			x	x		x			
The lack of parasites within the new habitats				x					x					x					x	x	x
Species of economic interests										x	x				x		x			

*species mentioned in the black list of Romania as being invasive; **species mentioned in the black list of Romania as being with invasive potential

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Table 1.1: The impact index of invasive species

**Acer negundo*	**Ailanthus altissima*	**Amaranthus albus*	**Amorpha fruticosa*	***Azolla filiculoides*	***Cuscuta campestris*	**Conyza canadensis*	***Elaeagnus angustifolia*	**Elodea nuttallii*	***Fraxinus pennsylvan.*	***Gleditsia triacanthos*	**Iva xanthifolia*	**Lindernia dubia*	**Lycium barbarum*	***Morus alba*	***Paspalum paspalodes*	**Robinia pseudacacia*	***Vallisneria spiralis*	**Xanthium strumarium*	***Xanthium spinosum*	**Xanthium italicum*
7,52	8,16	8,16	9,12	7,74	7,74	8,16	8,16	8,16	7,30	7,74	8,16	8,16	8,56	7,95	8,16	8,94	7,74	8,56	8,56	8,56

6. The spread of the studied invasive plant species in D.D.B.R.

Species mapping within Danube Delta has been fulfilled on basis of vegetation transects effected alongside channels within the lake complexes and Danube branches. Within these transects, two devices have been employed, a G.P.S. Garmin 72 in order to note the presence in the territory of species and vegetation associations and a Ph-metre. Subsequently, the data has been interpreted by means of Arcview 3 soft and presented on a digital map (figure 9). Another source that has contributed to completing the spread of species maps was the general forest arrangement and the maps of the 14 arrangements on the Danube Delta Biosphere Reserve.

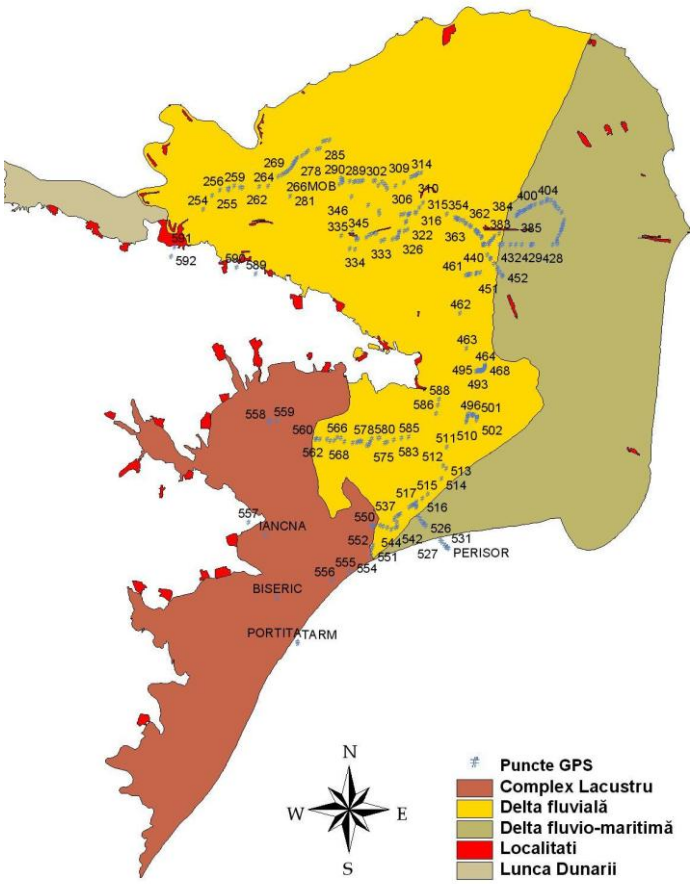

Figure 9: The distribution of G.P.S. points in the field and the high-spotting of the routes made in 2007.

The spread of the species ***Amorpha fruticosa*** in other areas than the studied ones (figure 10): Arrangement Popina (ponds 21 -22), on the belt channel between Letea sand dune and the arrangement; Sfiştofca; Sulina branch, in the areas with ligneous vegetation, usually in the second line; Litcov Channel – in clusters of a few dozen specimens along the channel (more abundant in the area of channels linking lakes Gorgovăţ, Potcoava, Cuibul cu Lebede şi Isac); Perivolovca Channel, the species has a reduced presence (more frequent in the southern part, Sfântu Gheorghe branch area –

Taranova channel); Candura channel (at Scăunele) – Durnoi (Nebunu) landmark; the islet neighbouring Erenciuc channel; Cioban Gârlă channel; Old Danube, both of them loops of the great M, Sfântul Gheorghe branch;

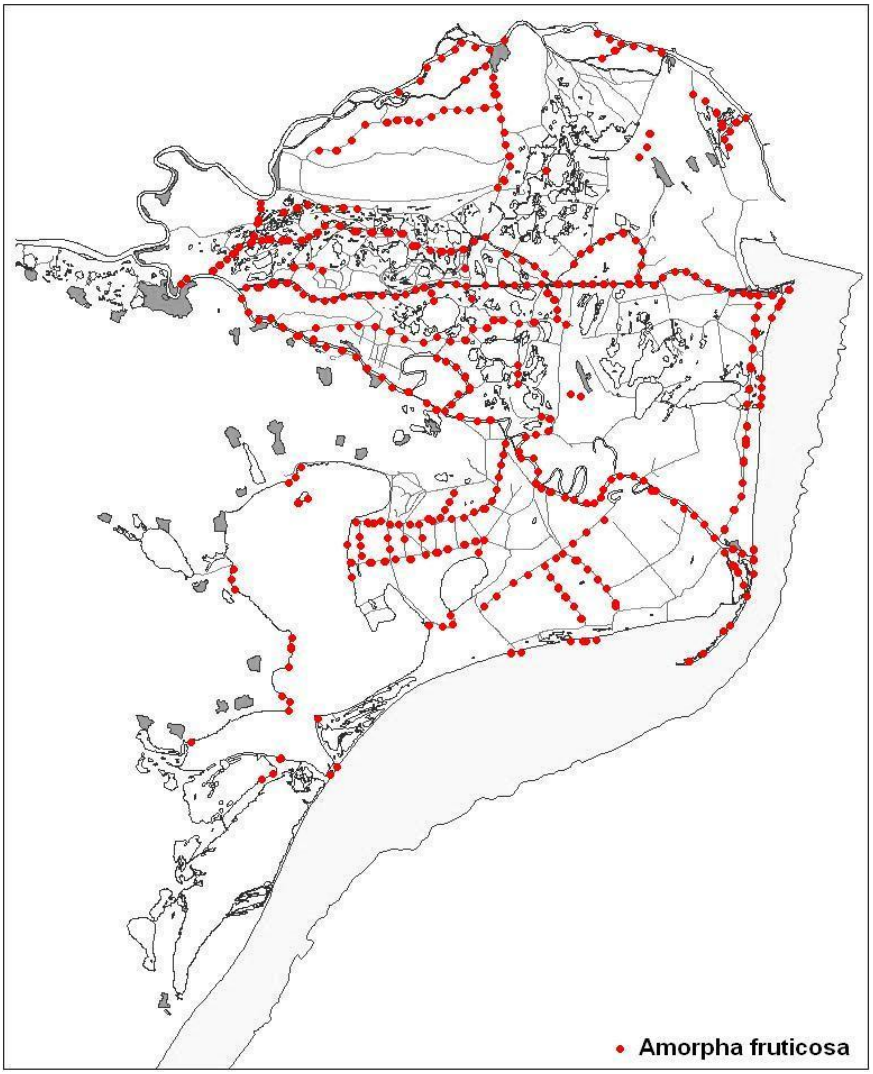

Figure 10: The spread of the species *Amorpha fruticosa* in Danube Delta.

On Chilia Branch, Periteaşca, at the end of the channel; seashore area; Popina Island; Sahalin Island – a few specimens of amorpha of reduced dimensions (max. 50 cm), present in association with sand bindwind; Erenciuc Channel, few specimen son the channel's edge, under willows; Wolves Sandune, channel 5 area – few specimens; Portiţa – in the station, few specimens of high dimensions, plante don the beach; within the strict protected area, scarce specimens of reduced dimensions (max. 50 cm); on the channel linking Sfântu Gheorghe branch and Melea, at the fishery – few specimens of de 2 – 3 metres high; Dranov Mouth – big specimens forming a grove; Iancina area, at Bisericuţa – few specimens of reduced dimensions; Leahova channel (on rock); Dunăvăţ Mouth; Tudor Vladimirescu area – in poplar plantation; Pătlăgeanca; Cernovca branch; Caraorman Sandune, amorpha specimens (1-2 m) are presented in the interdune area within the sandune;

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The spread of the species ***Robinia pseudoacacia*** in other areas than the studied ones (figure 11):

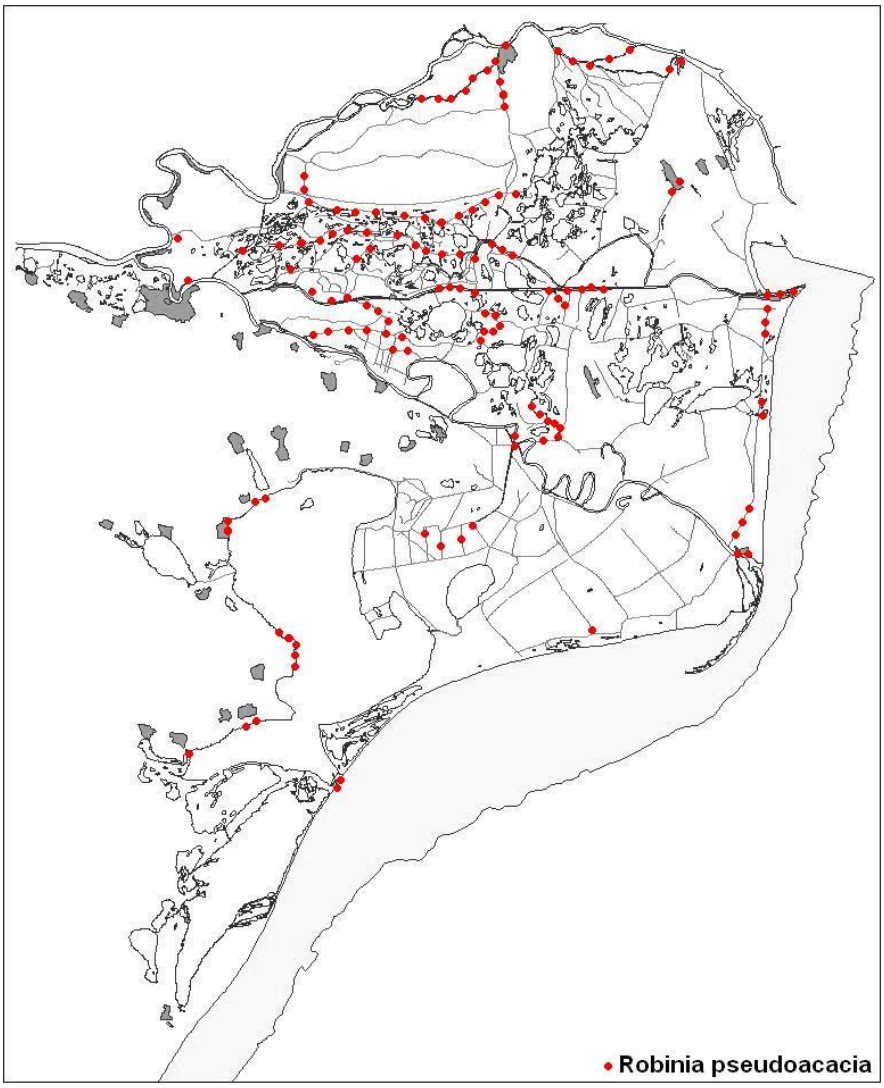

Figure 11: The spread of the species *Robinia pseudoacacia* in Danube Delta.

Popina Arrangement; Litcov Channel – in the second line, specimens of large dimensions; Sfiştofca – a few specimens; Perivolovca Channel – the species has been identified in the southern part, in the area of Sfântu Gheorghe Branch, just a few specimens; Old Danube, both loops of the great M, Sfântul Gheorghe Branch; Popina Island; Sahalin Island; Wolves Sandune; Portiţa – a few specimens, Gârla Ciobanu; Cernovca and Babina branches, a few specimens; on the connection channel between Sfântu Gheorghe Branch and Melea; Ceatal; within Rusca arrangement; Ilganii de sus, Ostrovul Ilgani; Canal Mila 35; Sulina Branch between Tudor Vladimirescu and Partizani, Iancina Cape, Tudor Vladimirescu area; within the area of Sfântu Gheorghe on Sărăturile Sandune, the seashore area, at Roşuleţ Fishery; Ivancea Channel, Gârla Păpădia; on Caraorman Sandune, in the production unit VIII; within Sălcieni area; within the area of agricultural arrangement Pardina, on Tătaru branch, on Pardina and Ceamurlia channels; within the forest arrangements in Uzlina, Carasuhat and Bălteni; on Danube bank, at Băltenii de jos.

The spread of the species ***Gleditsia triacanthos*** in other areas than the studied ones (figure 12):

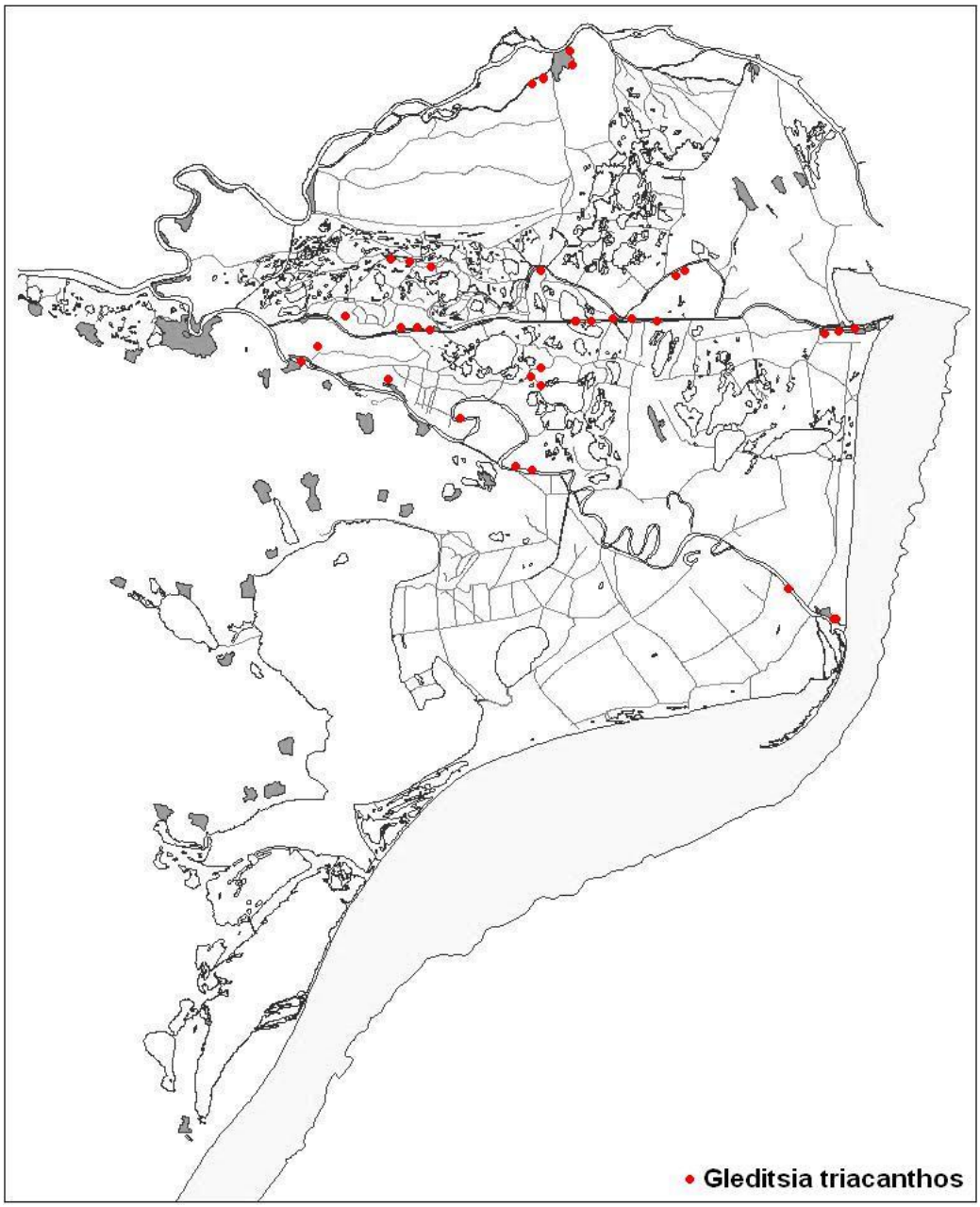

Figure 12. The spread of the species *Gleditsia triacanthos* in Danube Delta

The presence of the species is on Şontea channel – in a few specimens; Gârla and the forest arrangement of Păpădia; Tătaru Branch, in the vicinity of Chilia locality; within the forest arrangements Carasuhat and Rusca; planted on upstream of Sfântu Gheorghe locality; in the entrance area Dunăre – Litcov channel; on the second loop of the great M, in a few specimens.

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The spread of the species ***Elaeagnus angustifolia*** in other areas than the studied ones (figure 13):

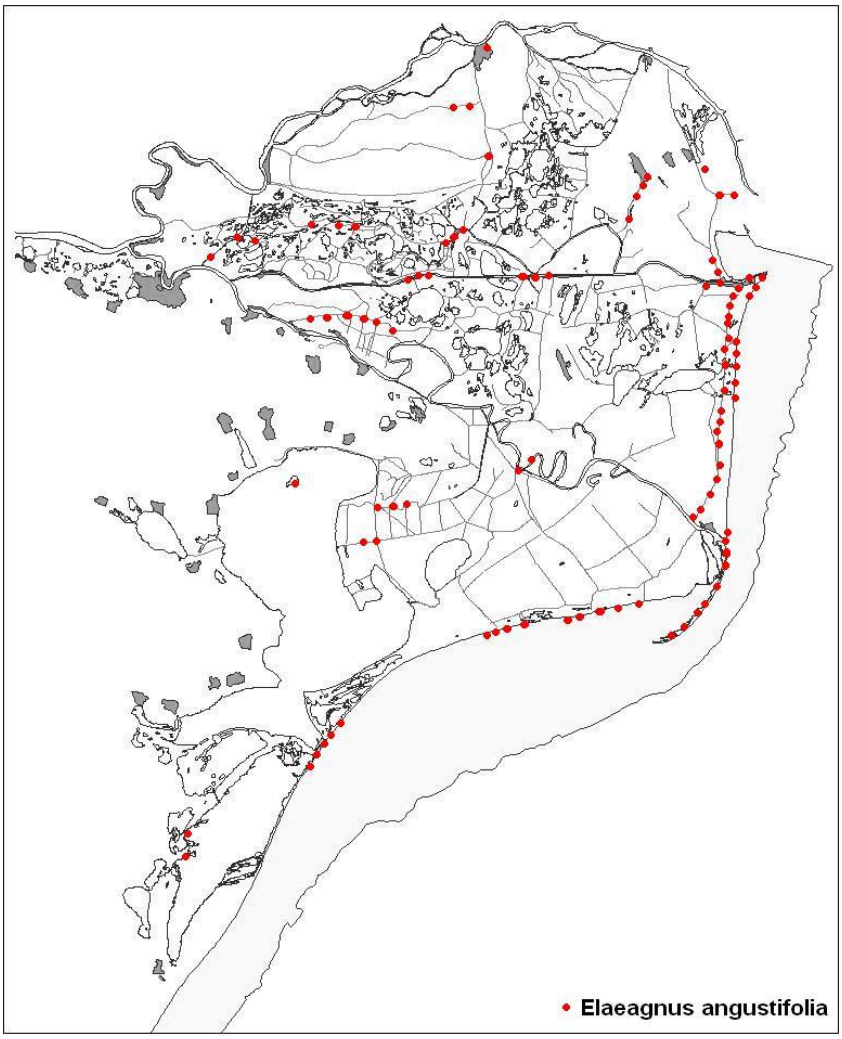

Figure 13: The spread of the species *Elaeagnus angustifolia* in Danube Delta.

On Sulina Branch, in the vicinity of localities; Sfiştofca; Litcov Channel – a few specimens along the channel; in the area of Sălceni, Old Danube, the first loop of the great M, Sfântul Gheorghe Branch, scarcely, in willow parks; the arrangement of Popina, on the belt channel between Letea Sandune and the arrangement; on Chilia Branch, in the vicinity of localities; Periteaşca, at the end of the channel, towards the seashore area; in the area of Sulina, on the beach, it forms a dense vegetation cordon, it was planted in association with Hippophae rhamnoides; Popina island – in a few specimens; Sahalin Island – a few specimens within the most arenicole vegetation associations; on Wolves Sandune, along the road and in the area of channel 5; at Portiţa - in the station, a few specimens on the connection channel between Sfântu Gheorghe Branch and Meleaş on Dranov channel – a few specimens; alongside the western coast of Razim lagoon; at Dunavăţ Mouth; the area of Tudor Vladimirescu – in poplar plantation; Pătlăgeanca; Cernovca branch; in the production unit VIII Caraorman, as planted species and on Caraorman sandune as well, in specimens of 2 -3 m present in the dunes area between the border of the village and forest.

The spread of the species ***Ailanthus altissima*** in other areas than the studied ones (figure 14):

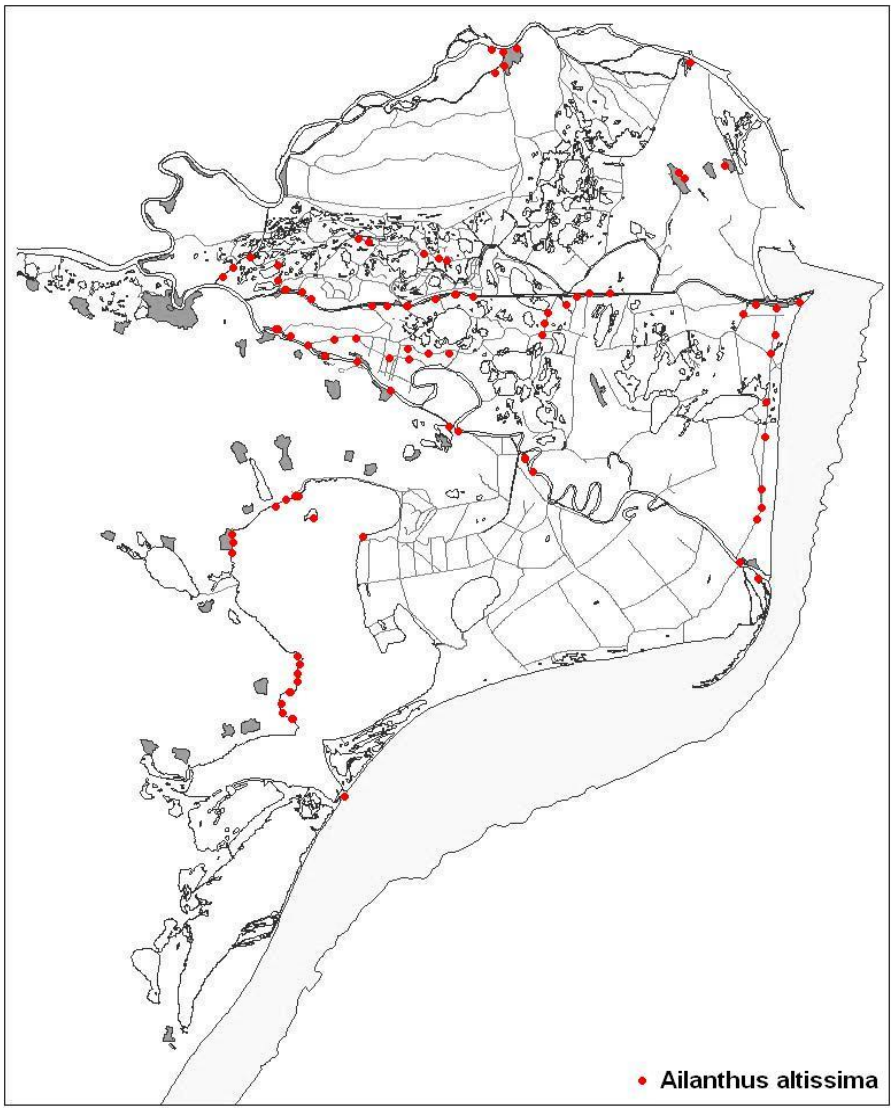

Figure 14: The spread of the species *Ailanthus altissima* in Danube Delta.

In the vicinity of localities and in the localities on Letea Sandune, in a few specimens; on Sulina Branch, in the areas with ligneous vegetation and scarcely in the areas where bank consolidation work has been effected; Litcov Channel – spread within the areas which were used as temporary household in the past and along the channel as well; in the northern part of Crişan channel; on Sfântu Gheorghe, in the area of the dead branches; on Chilia Branch, in the area of Chilia localiy and Tătaru branch, the area of the belt channel of the seashore; Popina island; at Portiţa – in the station, in a few specimens; on the connection channel between Sfântu Gheorghe Branch and Melea; Dranov Mouth – a few specimens; in the area of Iancina Taşburun; the area of Tudor Vladimirescu, along the dam, it is present in clusters; on Mila 35 channel, in the second line of forest vegetation; in the forest arrangements of Carasuhat and Uzlina; within the wetland in the vicinity of Tulcea town, in the place called Old Danube and in the vicinity of Periprava locality.

The spread of the species ***Acer negundo*** in other areas than the studied ones (figure 15):

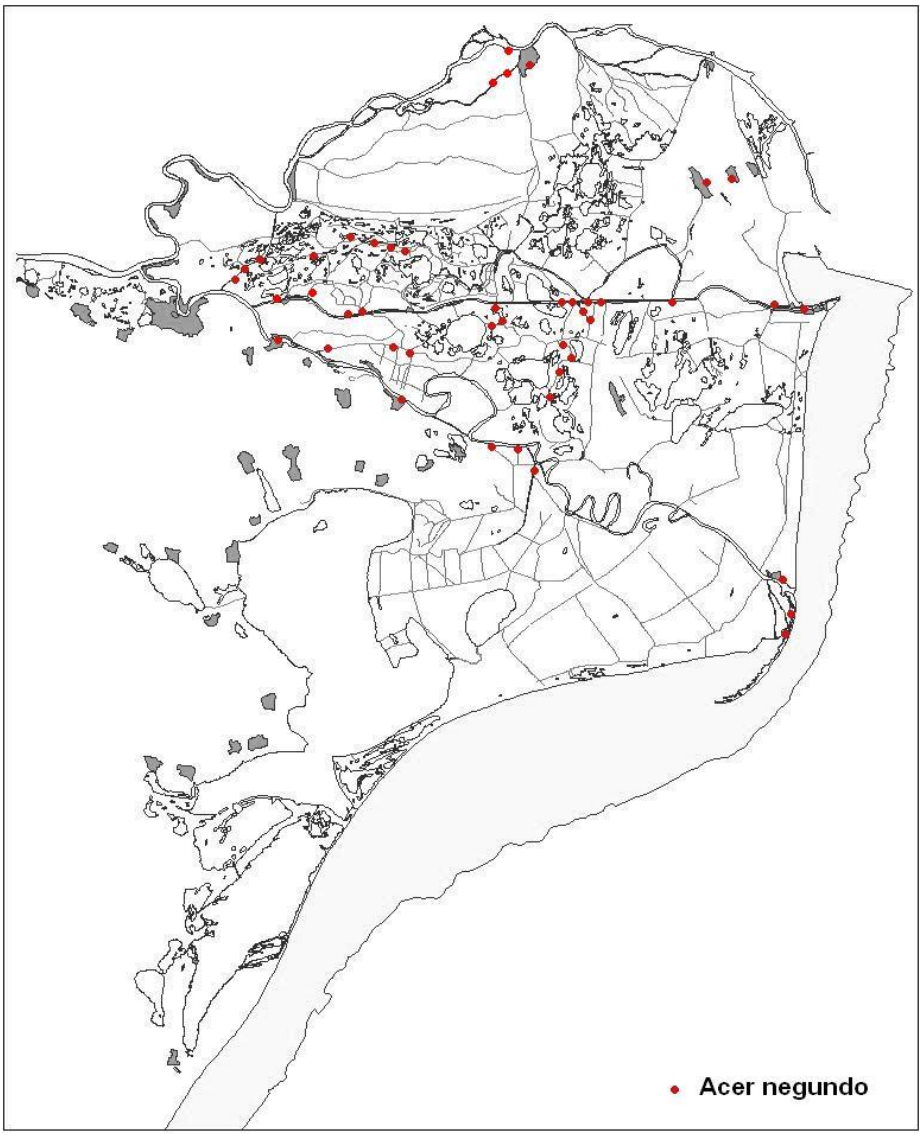

Figure 15: The spread of the species *Acer negundo* in Danube Delta.

In the forest arrangements within Danube Delta; on Sulina Branch, at the border of willow parks; on Litcov channel – in areas where temporary settlements existed; on Candura channel (at Scăunele) – registered in few specimens; on the linking connection channel between Sfântu Gheorghe Branch and Melea, on Dranov channel – registered in the second line of ligneous vegetation; in the area of Tudor Vladimirescu – at the border of the poplar plantation; at the border of Tulcea town, in the wetland area called Old Danube; in the vicinity of Letea and Cardon localities; on Rusca channel, within areas where interventions in the forest stock have been effected, in the forest arrangement of Carasuhat and at Dranov Fishery as well.

The spread of the species ***Morus alba*** in other areas than the studied ones (figure 16):

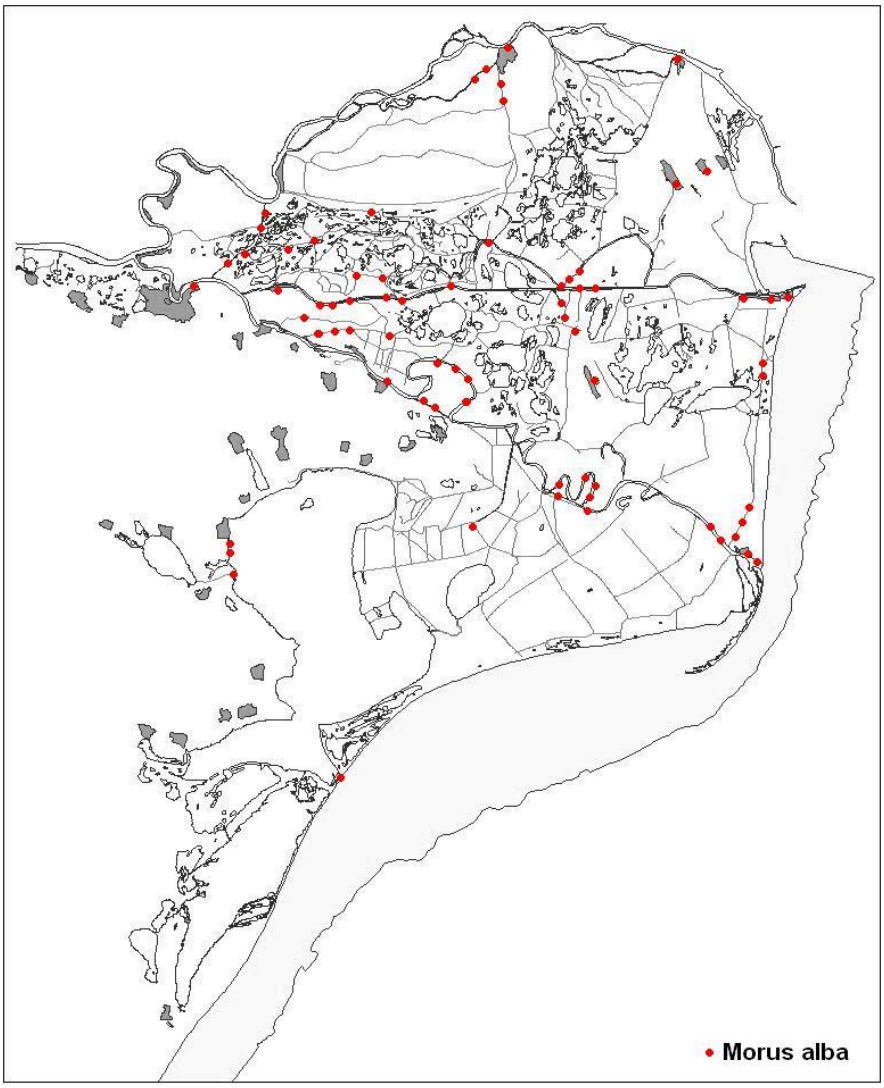

Figure 16: The spread of the species *Morus alba* in Danube Delta.

On Sulina Branch, in the areas with ligneous vegetation where hygiene work has been effected; on Litcov channel – the species is spread on the channel banks in glades; in the area of Sfântu Gheorghe Branch – upstream of the locality and on the belt channel of the seashore; on Sulina Branch – Old Danube, both loops of the great M; in the vicinity of Letea locality; in the area of channel 5 on Wolves Sandune; on Sahalin island, in a few specimens of reduced dimensions, present together with Elaeagnus angustifolia and Hippophae rhamnoides; in the area of the dead branches on Sfântu Gheorghe, in the forest arrangements; at Portiţa – in the station, species identified in a few planted specimens; on the connection channel between Sfântu Gheorghe and Melea; on Lipovenilor channel; in Enisala area, on the western bank of Razim - Sinoe Complex; in the area of Tudor Vladimirescu, in the vicinity of the settlement and in the area of dam-bank; on Rusca channel, in a few specimens; on Caraorman Sandune, in the vicinity of the locality; on Mila 35 channel, together with Amorpha fruticosa, in the willow parks and Old Danube, the area of Tulcea town.

The spread of ***Lycium barbarum*** in other areas than the studied ones (figure 17):

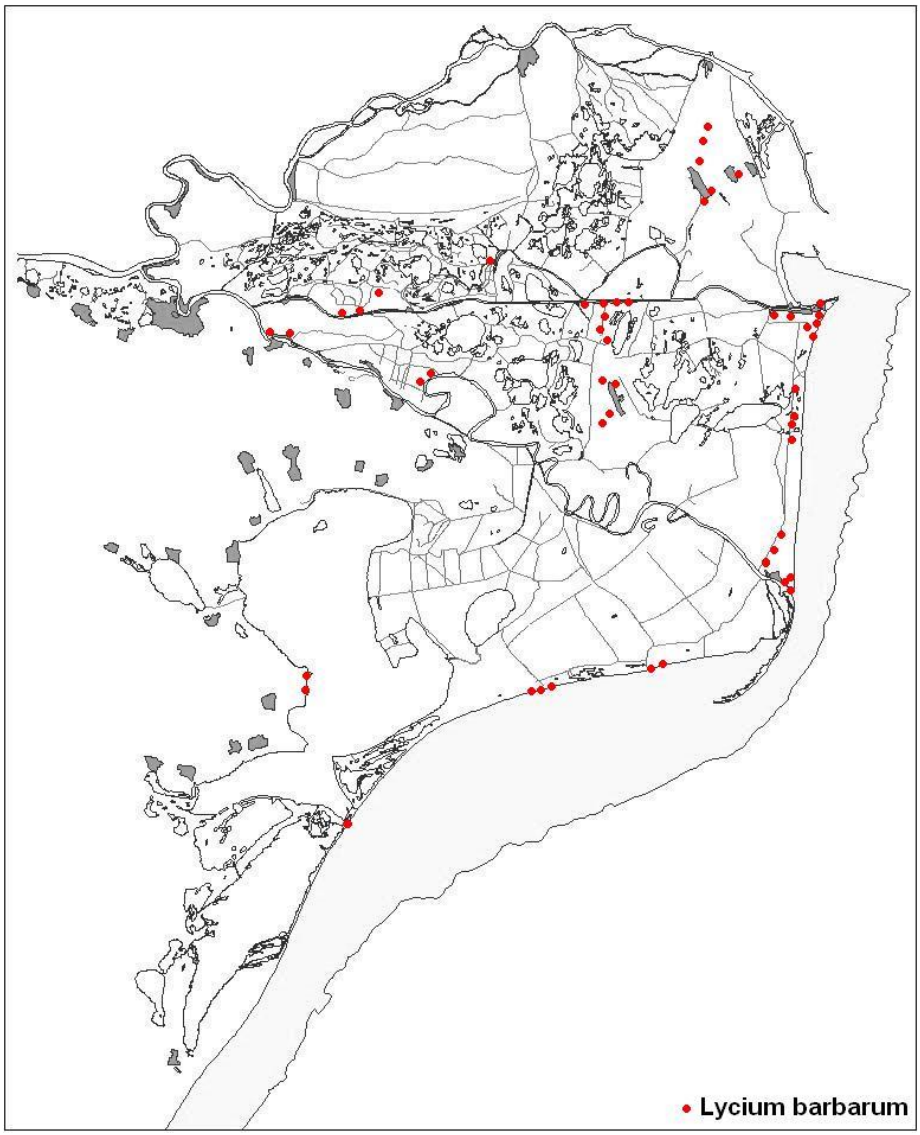

Figure 17: The spread of the species *Lycium barbarum* in Danube Delta.

On the belt channel between Letea sandune and arrangement; Sfiştofca; Perivolovca channel, the species has a low presence; in the northern part of Crişan channel; in the area of seashore, in the vicinity of Sulina and Sfântu Gheorghe localities and in the area of Sonda channel; at Portiţa – in the station, in a few specimens; on the connection channel between Sfântu Gheorghe and Melea.

The spread of the species ***Fraxinus pennsylvanica*** in other areas than the studied ones (figure 18):

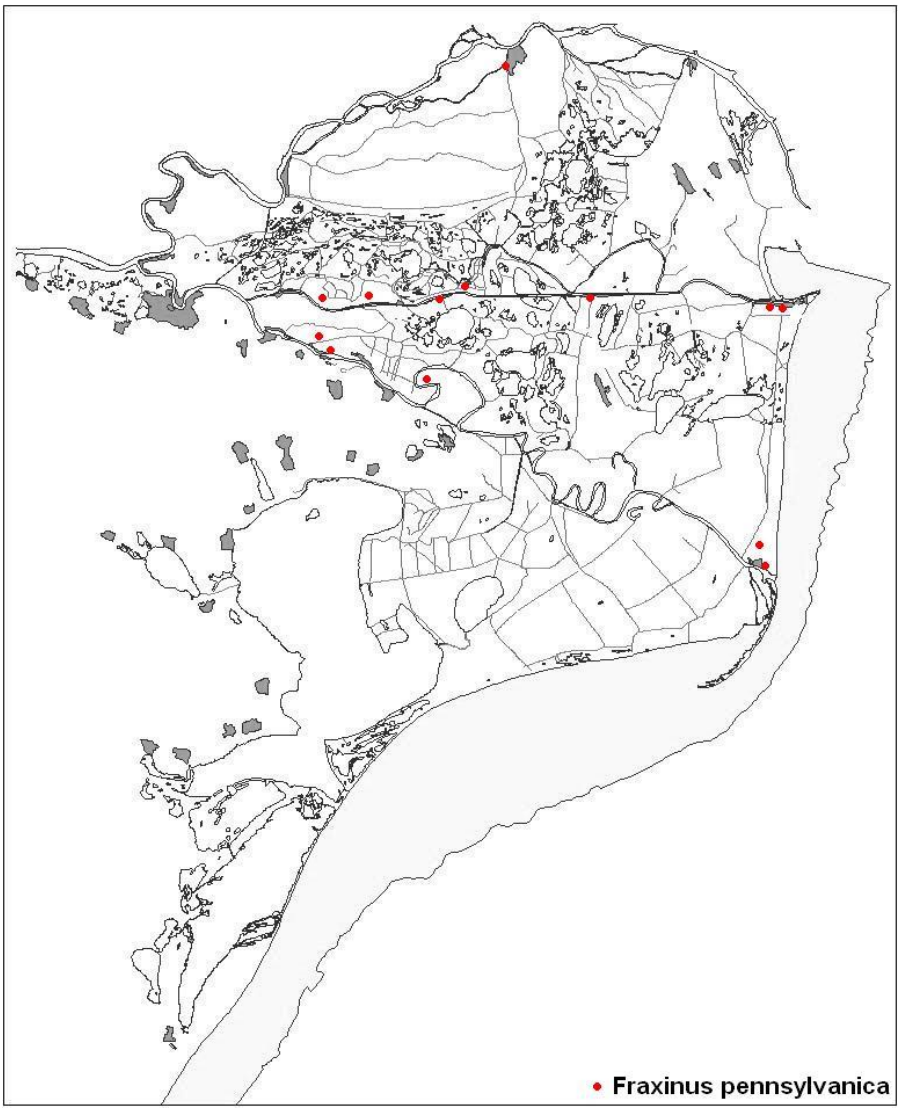

Figure 18: The spread of the species *Fraxinus pennsylvanica* in Danube Delta.

On Sulina Branch, in the areas with ligneous vegetation, usually in the second line; Litcov channel – in clusters of a few dozen specimens along the channel; on Perivolovca Channel, the species has a low presence; the islet in the vicinity of Erenciuc channel; Cioban Gârlă channel; Old Danube, both loops of the great M, Sfântu Gheorghe Branch; Chilia Branch, Periteaşca, at the end of the channel; the seashore area; on the connection channel between Sfântu Gheorghe Branch and Melea, at the fishery – a few specimens; in Tudor Vladimirescu area, at the border of the poplar plantation; at Pătlăgeanca; in the forest arrangements of Carasuhat and Rusca; at Ivancea, on Ivanova Channel; at Băltenii de Jos; on Pardina and Ceamurlia channels within the agricultural enclosure Pardina; on Tătaru branch; on Gârla lui Palade; at Ilganii de Sus and Ceatal area.

The spread of ***Amaranthus albus*** in other areas than the studied ones (figure 19): on the belt channel between Letea sandune and arrangement; Sfiştofca; Sulina branch in the areas with anthropic vegetation surrounding localities, Sulina Crişan, Maliuc, Gorgova Tulcea; Canal Litcov – in the areas where there are temporary households or the ground was deranged; the area of Sfântu Gheorghe branch – near the localities Sf. Gheorghe, at the fishery of Sf. Gheorghe; Mahmudia, Nufărul; Cioban Gârlă channel; Old Danube, the first loop of the great M in the area of Mila 23 locality; on Chilia branch in the area of localities, Dranov Mouth – large specimens forming clusters; the area of Tudor Vladimirescu in agricultural crops, on the sides of the link road with channel 35; at Pătlăgeanca; Caraorman Sandune, in the locality area in the deranged areas.

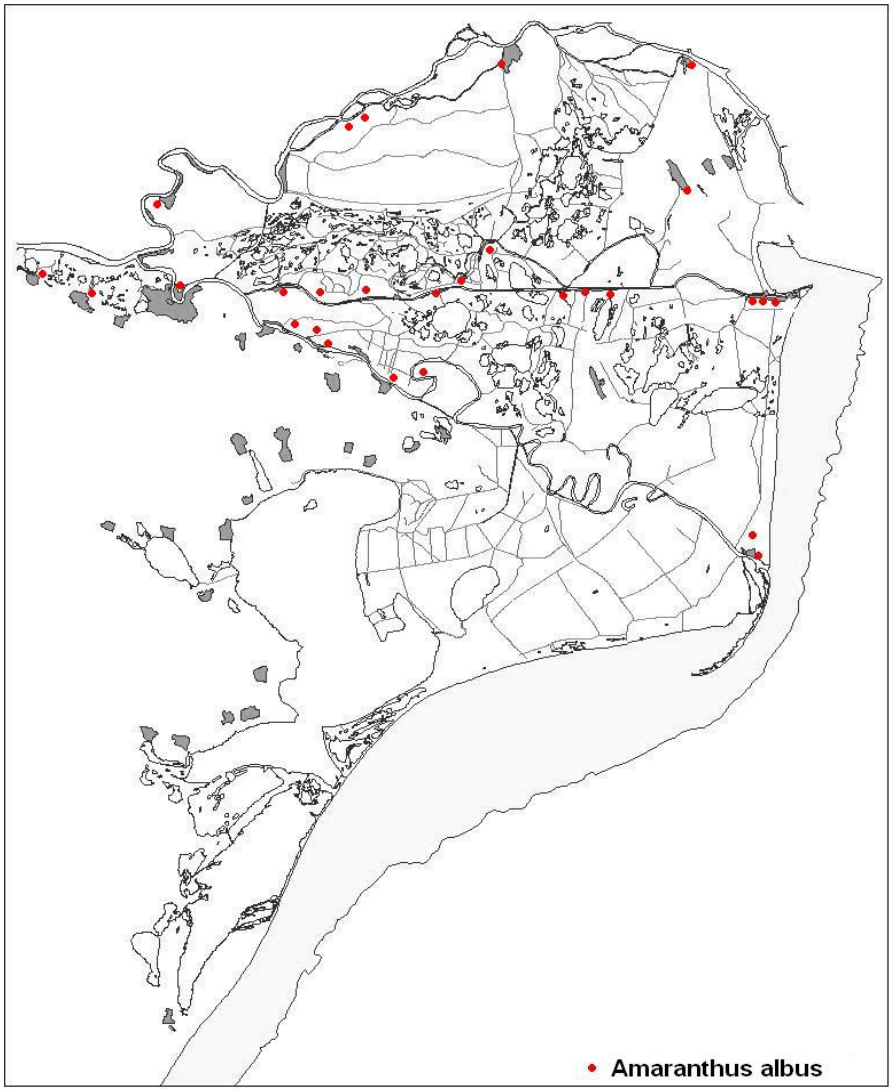

Figure 19: The spread of *Amaranthus albus* species in Danube Delta.

The spread of the species ***Azolla filiculoides*** in other areas than the studied ones (figure 20): generally, this species is spread particularly in the area of fluvial delta in lakes with low depth, weak drift and good transparency. There have been cases when the species was seen on land, too, in the areas recently drained after water reatreat. The species has been identified in Popina Arrangement (ponds 21-22), at Sfiştofca; Sulina branch in the areas with ligneous vegetation where water stayed longer, usually in the first line near the water bank; Litcov channel – in the area of lakes Gorgovăţ, Potcoava, Cuibul cu Lebede, Lunguleţ and Isac; the islet near Erenciuc channel; in the aldertree forest at Erenciuc; Old Danube at Tulcea and Tudor Vladimirescu; in the complex of Dunăvăţ - Dranov on the bank link channels between Dranov, Mustaca and Dunăvăţ channels, on Cocoşu channel.

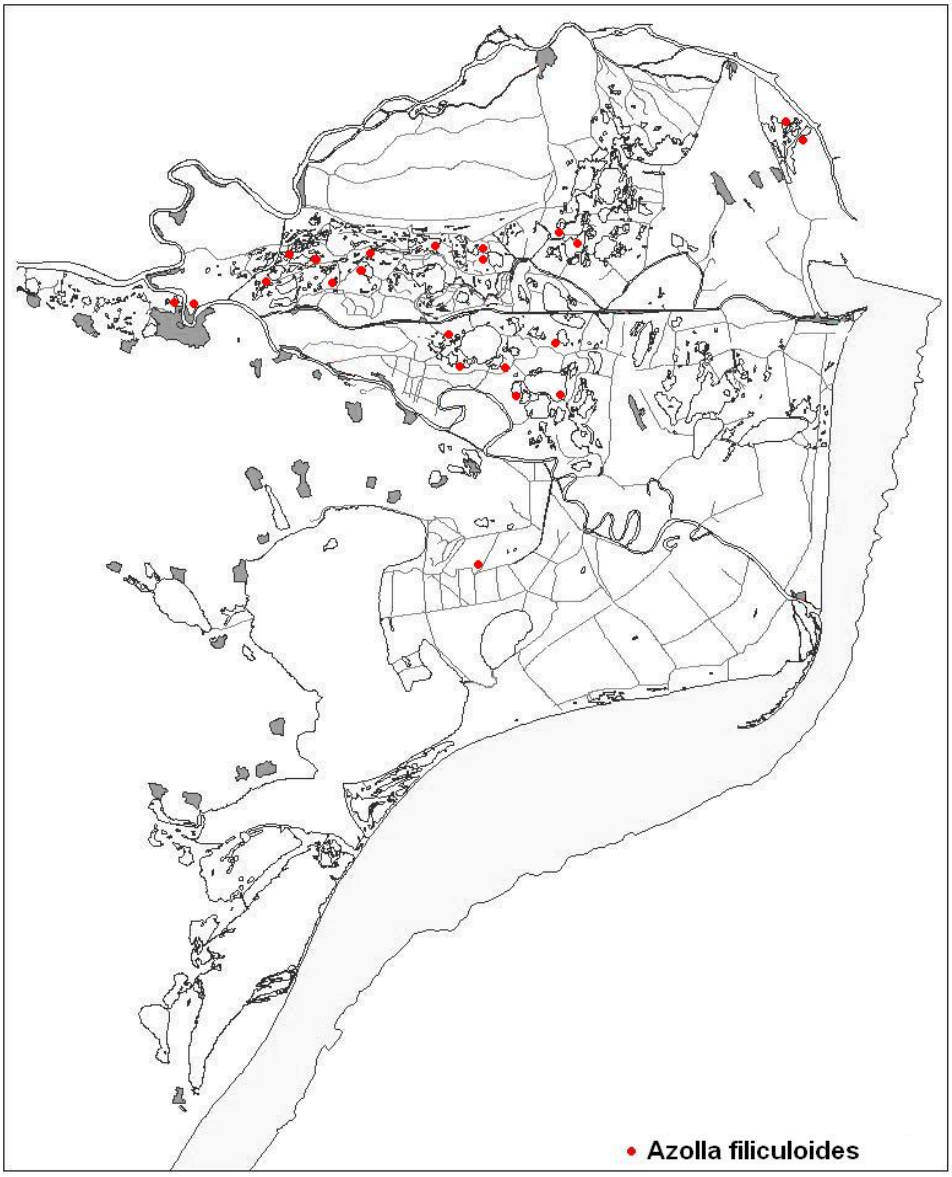

Figure 20: The spread of the species *Azolla filiculoides* in Danube Delta.

The spread of the species ***Cuscuta campestris*** in other areas than the studied ones (figure 21): this species can be observed as a parasite on other vascular plant species such as: E*ryngium maritimum, Scolymus hispanicus, Xanthium italicum, X. strumarium, Medicago minima*, and *Trigonella monspeliaca*. Referrence literature presents this species as being a parasite generally on plant species from Fabaceae family. In Danube Delta the species has been identified in Popina arrangement (ponds 21-22), Sireasa sandune area, Channel 35, in Pardina arrangement in anthropized areas, on Sulina branch in the areas with anthropic vegetation near localities; Litcov channel at entrance; Sfântu Gheorghe branch area in the area of localities; Old Danube, both loops of the great M; at Mila 23, in Tudor Vladimirescu area in the poplar plantation;

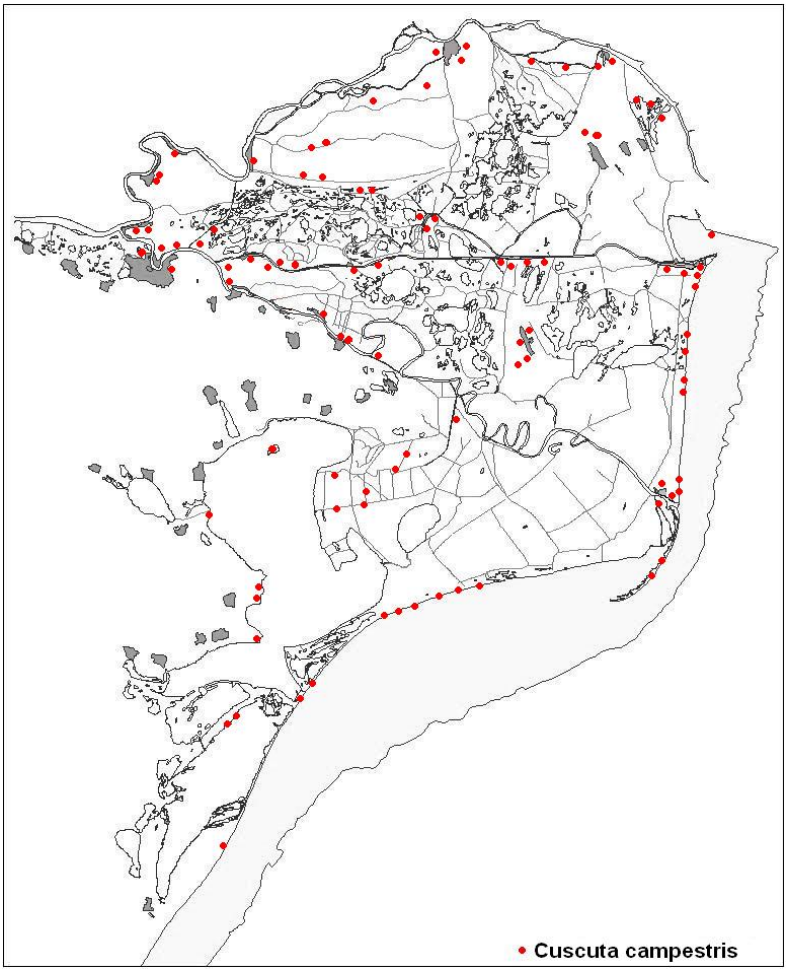

Figure 21: The spread of the species Cuscuta campestris in Danube Delta.

On Chilia Branch, in the area of Pardina, Cetalchioi, Tatanir localities; seashore area at Sulina, Sondei Channel and Sf. Gheorghe; on Musura island and Popina island; also on Sahalin island in association with sand convolvulus; Wolves Sandune, the area of channel 5; at Portiţa – in the station, in the strictly protected area Leahova Periteaşca; in the seashore sector Perişor Periteaşca; on the link channel between Sfântu Gheorghe branch and Melea, at the fishery; Dranov Mouth, Mustaca channnel and Dranov; Iancina, Doloşman, Taşburun and Enisala areas; Pătlăgeanca locality; Cernovca branch; Caraorman Sandune, the specimens are present in the interdune area within the sandune.

The spread of the species ***Conyza canadensis*** in other areas than the studied ones (figure 22): generally, this species is spread in grassland area near Danube Delta localities. The species has been seen on the belt channel between Letea sandune and arrangement; at Sfiştofca; Sulina branch in the areas with grassland vegetation; Litcov channel, more abundant in the area of link chanels Gorgovăţ, Potcoava, Cuibul cu Lebede lakes; the area of Sfântu Gheorghe branch near forest arrangements; the islet near Erenciuc channel; Old Danube at Tulcea and Tudor Vladimirescu; Sfântul Gheorghe locality;

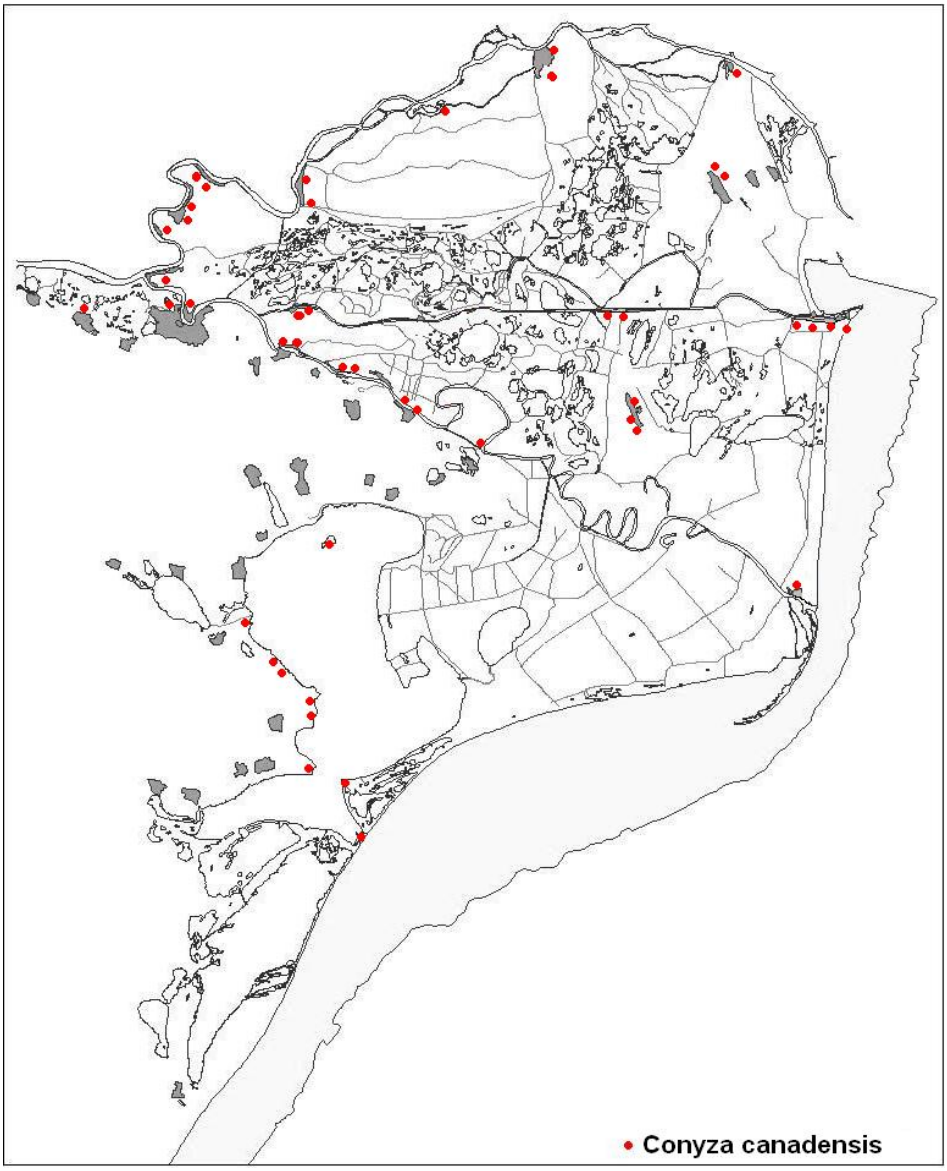

Figure 22: The spread of the species *Conyza canadensis* in Danube Delta.

On Chilia branch in the area of Cetalchioi, Pătlăgeanca, Tatanir, Pardina, Chilia and Periprava localities; the area of seashore at Portiţa; on Popina island; Iancina area, Taşburun, Dolşman and Enisala, also at Bisericuţa; Caraorman Sandune and Letea Sandune in localities area.

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The spread of the species *Elodea nuttallii* in other areas than the studied ones (figure 23): the species is generally spread in eutrophic lakes, stagnant with depths between 0,5 and 1 m, poor in species. The species coverage is generally limited between 40 – 60% of the lake surface. The largest cenoses formed by this plant are on Lopatna Channel, Mila 18 on Sulina branch, Fortuna, Păpădia, Meşter and Nebunu lakes within Şontea Fortuna complex; Rotund, Gorgovăţ, Potcoava, Taranova, Isăcel and Obretinul Mic lakes and Gorgova Uzlina complex.

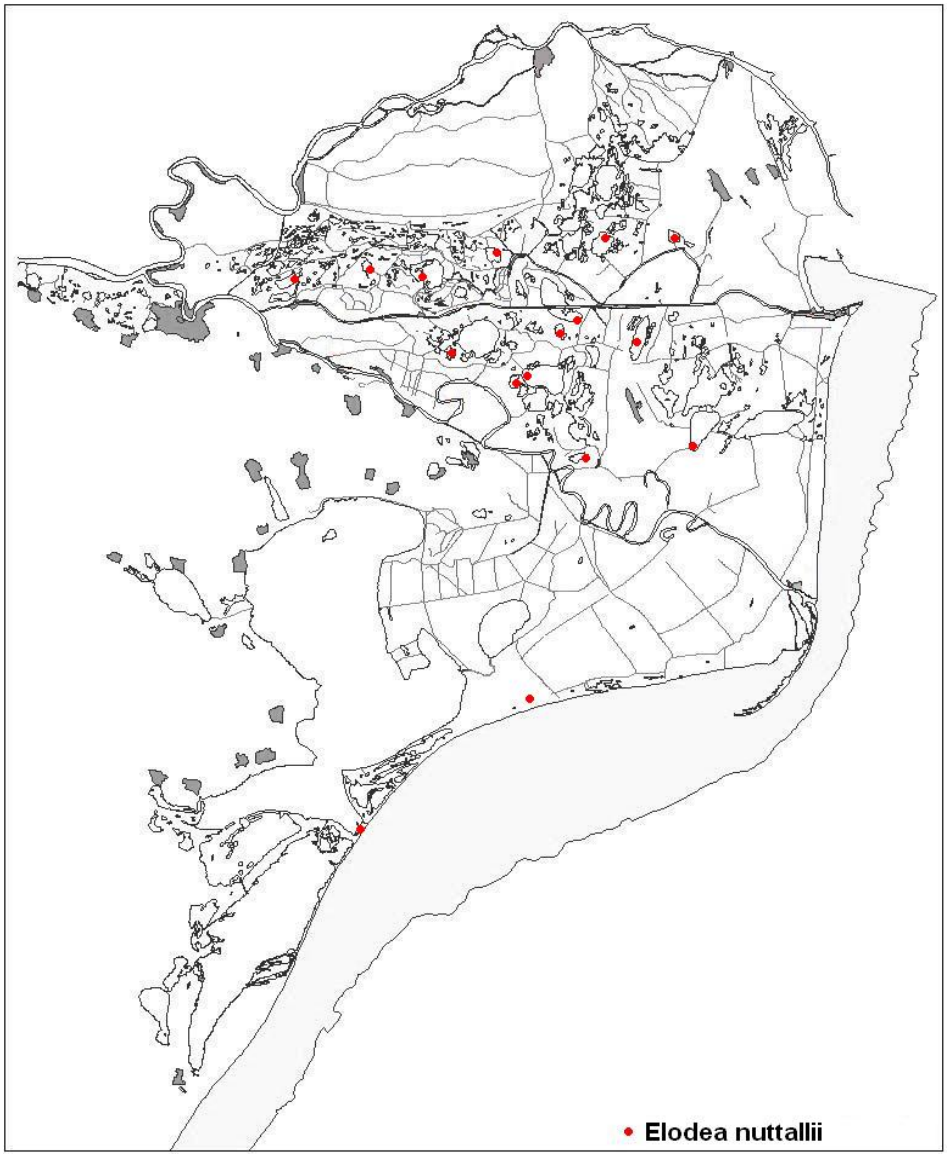

Figure 23: The spread of the species *Elodea nuttallii* in Danube Delta.

The species has also been seen in the waters in Portiţa area, but with reduced coverage; in the marshes in seashore sector, in Perişor area, on Puiu lake within Roşu Puiu complex; Răducu and Bogdaproste lakes within Matiţa Merhei complex.

The spread of the species ***Iva xanthifolia*** in other areas than the studied ones (figure 24): the species is present in anthropized areas, battered, access ways near localities. It is species directly connected to anthropic activity, being considered an opportunistic species. The areas ehere it has been identified with a higher frequence are: agricultural arrangement at Pardina, on abandoned agricultural fields, in deserted buildings' precincts, on protective dams and in the area of sheepfolds. Near Pardina, Tatanir, Chilia and Pătlăgeanca localities on Chilia branch; in the grassland area at Enisala, Enisala, Taşburun and Iancina; in the area of Sf. Gheorghe branch near Nufăru, Ilgani, Mahmudia, Sf. Gheorghe localities and on Sahalin island.

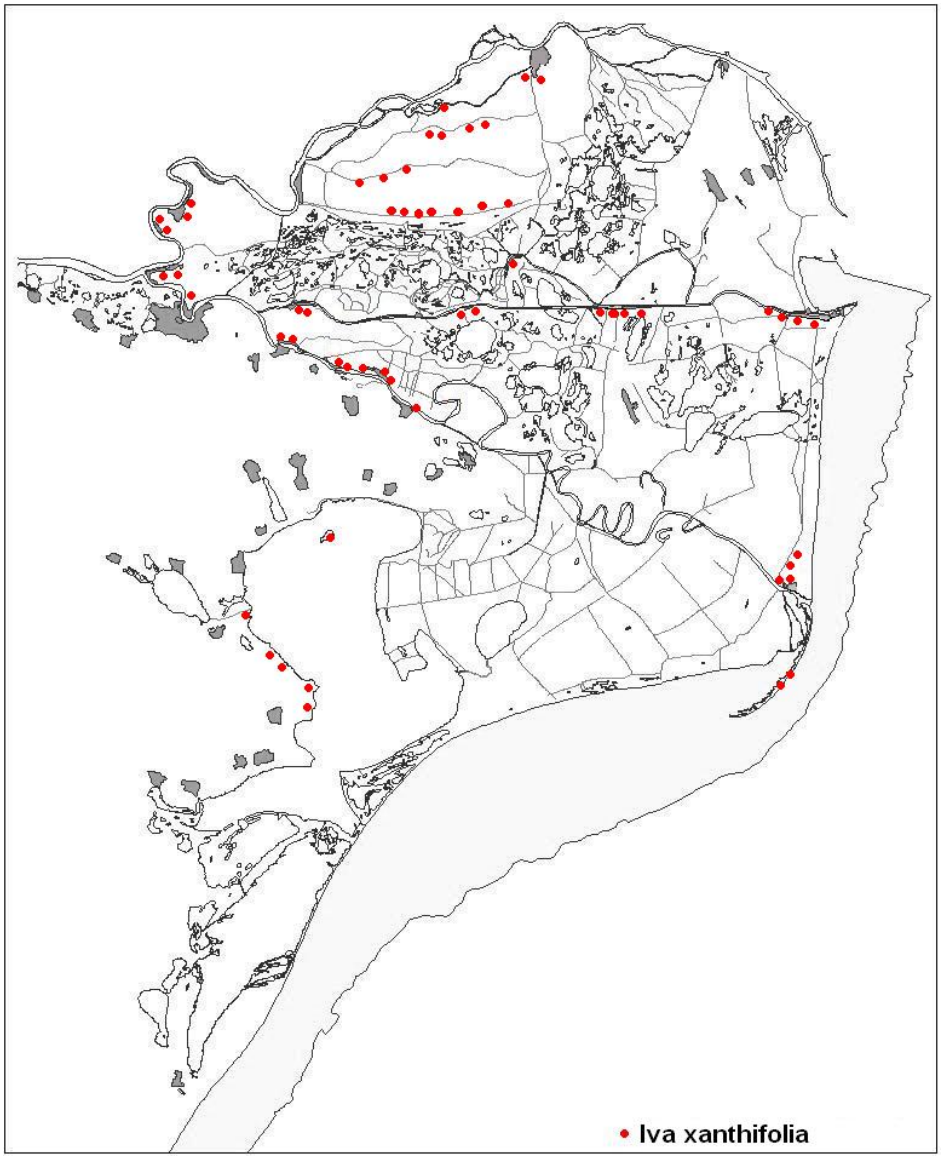

Figure 24: The spread of the species *Iva xanthifolia* in Danube Delta.

The species has also been seen on Popina island, but with low frequency in the area of Tulcea locality on Old Danube and at Tudor Vladimirescu.

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The spread of the species ***Lindernia dubia*** in other areas than the studied ones (figure 25): in Danube Delta, this species generally is identified in fluvial delta in the areas with high humidity. The presence of high humidity in soil is a favourable to this species development. The areas where the species has been seen predominantly are included within Şontea-Fortuna complex: the banks of Şontea, Păpădia, Draghilea, Păpădia Nouă, Sireasa and Mila 35 channels. Within Gorgova Uzlina complex: on the banks of Litcov, Marchelu and Costache channels. Within the same complex, the species has also been identified in the forest arrangements, but with a lower frequence.

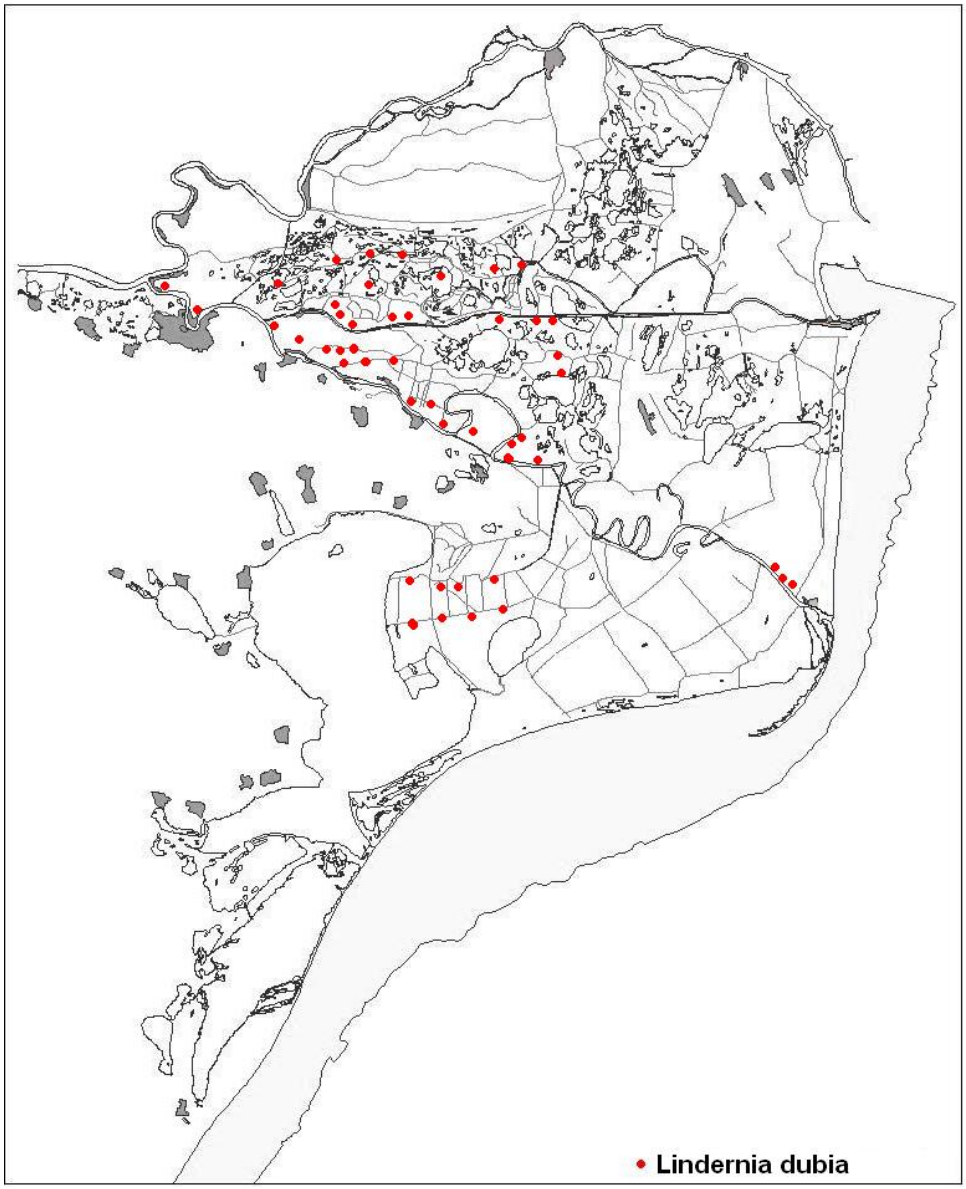

Figure 25: The spread of the species *Lindernia dubia* in Danube Delta.

The species has also been identified on Sf. Gheorghe branch in the willow parks and in the poplar forest arrangements. Within Dunăvăţ-Dranov complex, the species has been identified predominantly on the banks of Mustaca, Cocoşu and Dunăvăţ channels.

The spread of the species ***Paspalum paspalodes*** in other areas than the studied ones (figure 26): the presence of this species has been recorded in Popina arrangement (ponds 21-22), on the belt channel between Letea sandune and arrangement; Sfiştofca area; Sulina branch in areas with higrophyle vegetation; the banks of Litcov channel; Perivolovca channel; the islet near Erenciuc channel; on Sfântul Gheorghe branch in areas with higrophyle vegetation;

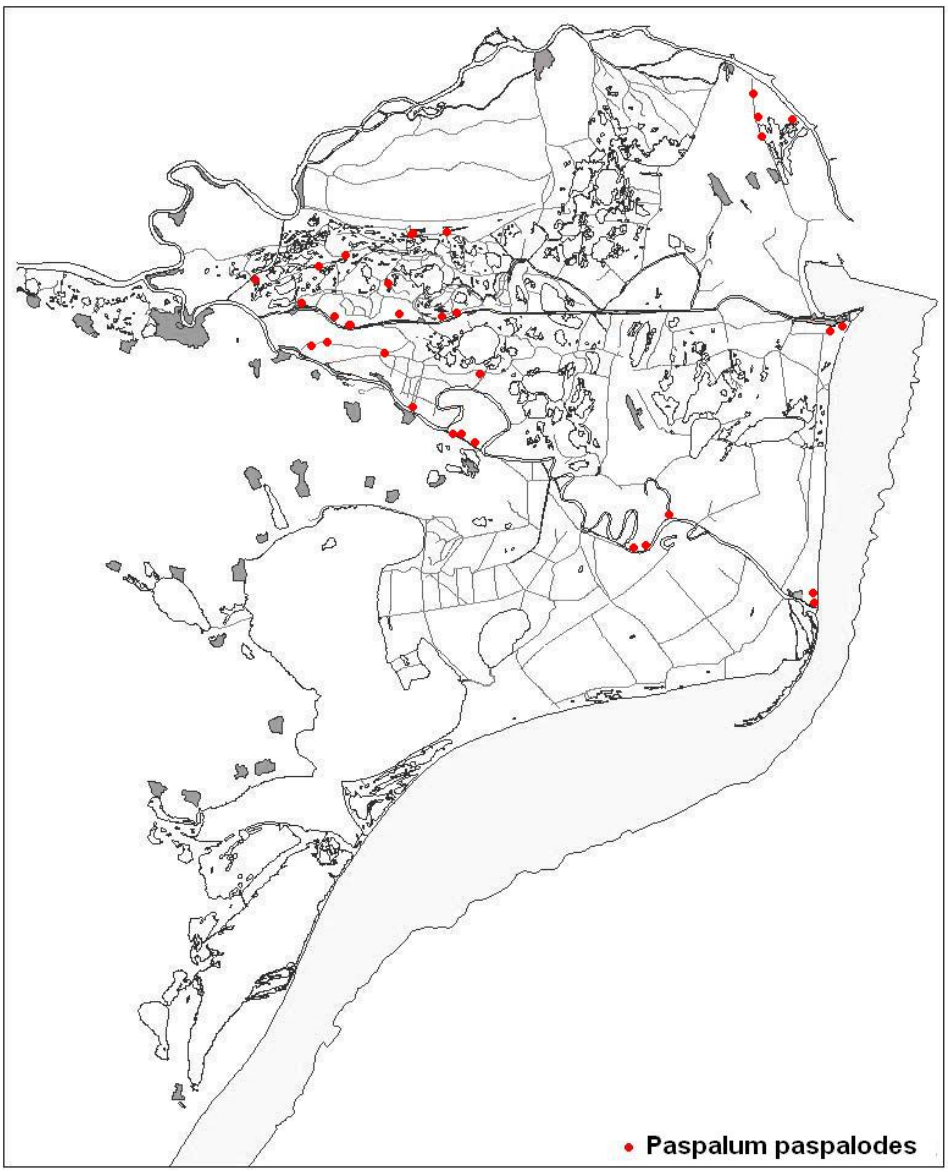

Figure 26: The spread of the species *Paspalum paspalodes* in Danube Delta.

The spread of species is on seashore area, on soils with high humidity and low salinity at Sulina and Sf. Gheorghe. Also within Şontea Fortuna complex, on the banks of Şontea, Păpădia and Draghilea channels.

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The spread of the species ***Vallisneria spiralis*** in other areas than the studied ones (figure 27):

Fortuna, Martin, Nebunu, Tătaru and Lung lakes within Şontea-Fortuna complex; Răducu, Bogdaproste and Matiţa lakes within Matiţa-Merhei complex; Fâstic, Rotund, Gorgovăţ, Obretinul Mic and Isac lakes within Gorgova Uzlina complex; Iacub, Roşu and Erenciuc within Roşu – Puiu complex; also on Dranov lake.

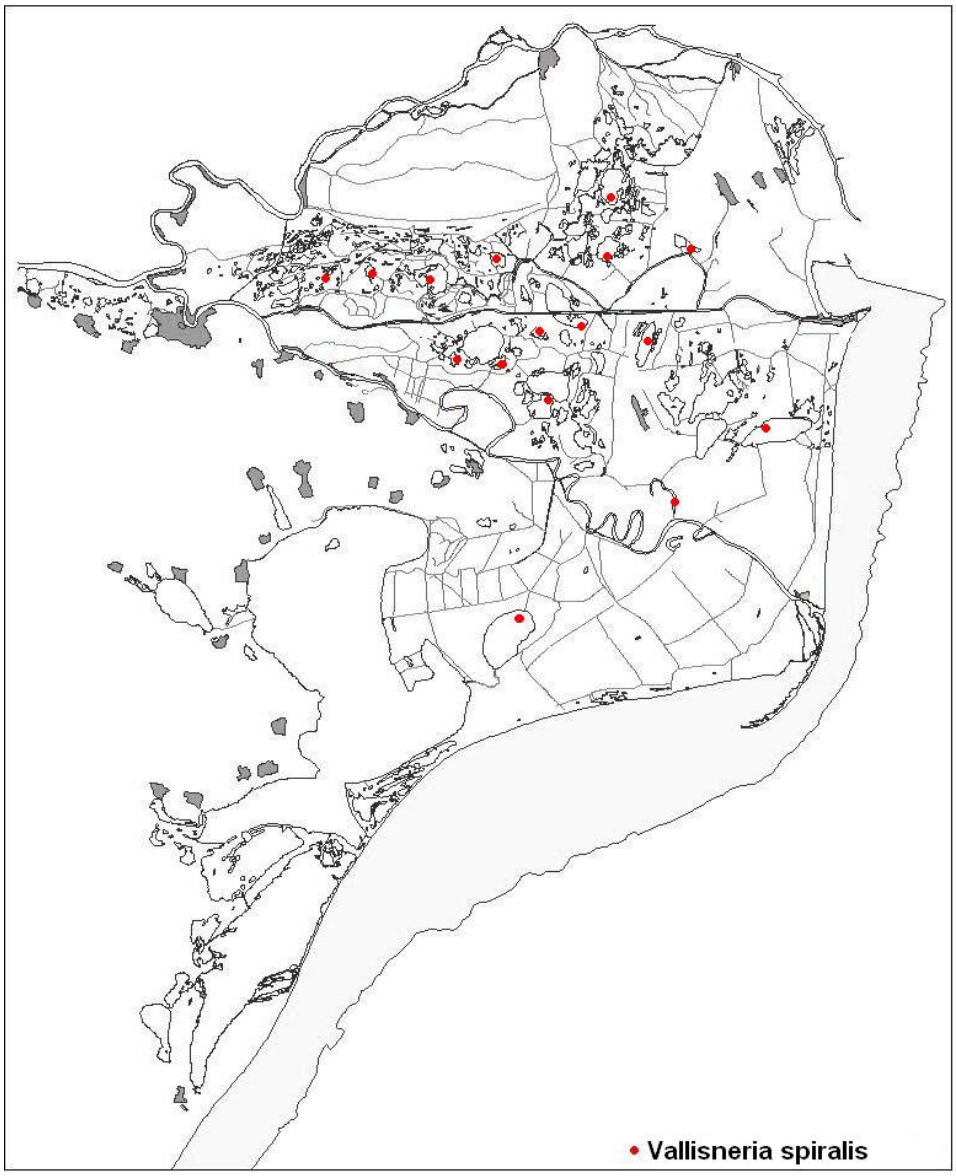

Figure 27: The spread of the species *Vallisneria spiralis* in Danube Delta.

Other areas where this species has been met are the channels with reduced speed of water flow, in areas with clear waters in Ceratophyllum demersum cenoses.

The spread of the species ***Xanthium strumarium*** in other areas than the studied ones (figure 28): this species is rather spread within Danube Delta. Its presence is conditioned by anthropic activities. It is present in Popina arrangement, on the belt channel between Letea sandune and arrangement; Sfiştofca; Sulina branch in areas with ligneous vegetation, Litcov channel – in clusters of a few hundred specimens along the channel; between Mila 26 and Mila 29; Candura channel (at Scăunele) – Durnoi landmark (Nebunu); the islet near Erenciuc channel; Cioban Gârlă channel; Old Danube at Tulcea and Tudor Vladimirescu in the poplar plantation; on entire Sfântul Gheorghe branch in open areas;

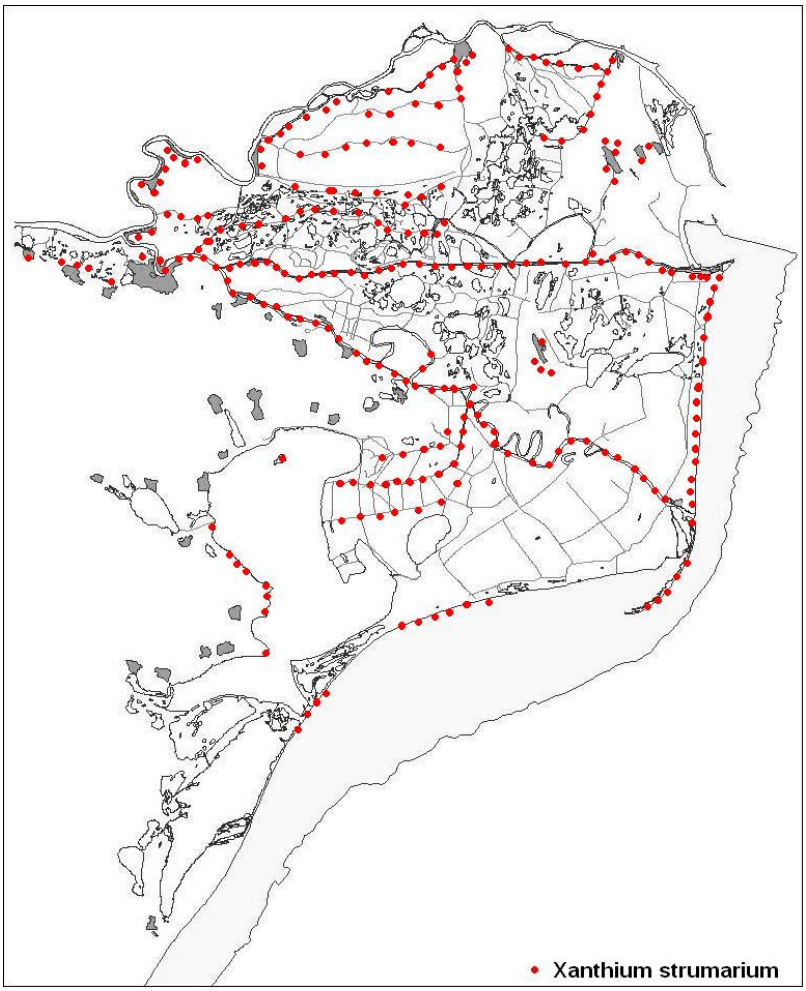

Figure 28: The spread of the species *Xanthium strumarium* in Danube Delta.

On Tătaru channel; between Periteaşca and Portiţa; on entire seashore between Sulina and Sf. Gheorghe, also on Musura, Sahalin and Popina islands, it is present in association with sand convolvulus or as associations with no other species; Erenciuc channel, few specimens on the edge of the channel, under willows; Portiţa – in the station and in the strictly protected area, scarce specimens, on the link channel between Sfântu Gheorghe branch and Meleaua Sahalin; in Dunăvăţ Dranov complex on the banks of main channels, forming stable associations; Iancina, Taşburun, Doloşman area, with lower frequence; at Pătlăgeanca; Cernovca branch; Caraorman and Letea sandunes (near localities and on grasslands); in Somova Parcheş complex.

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The spread of the species ***Xanthium spinosum*** in other areas than the studied ones (figure 29);

It is an opportunistic nitrophyle species which colonizes habitats extremely anthropized. Generally, it is met near and within localities. It is also present in overgrazed or anthropized areas. The species has been identified in the agricultural arrangement of Pardina, in Chilia, Pardina, Cetalchioi and Periprava localities. The presence of the species is along Sulina branch; in the area of former fishery arrangements, at Maliuc, Gorgova, Crişan and Sulina (at the basin, along the link road with the beach); at Old Danube, in the area of Tulcea locality, at Tudor Vladimirescu, along protective dikes and in former sheepfolds.

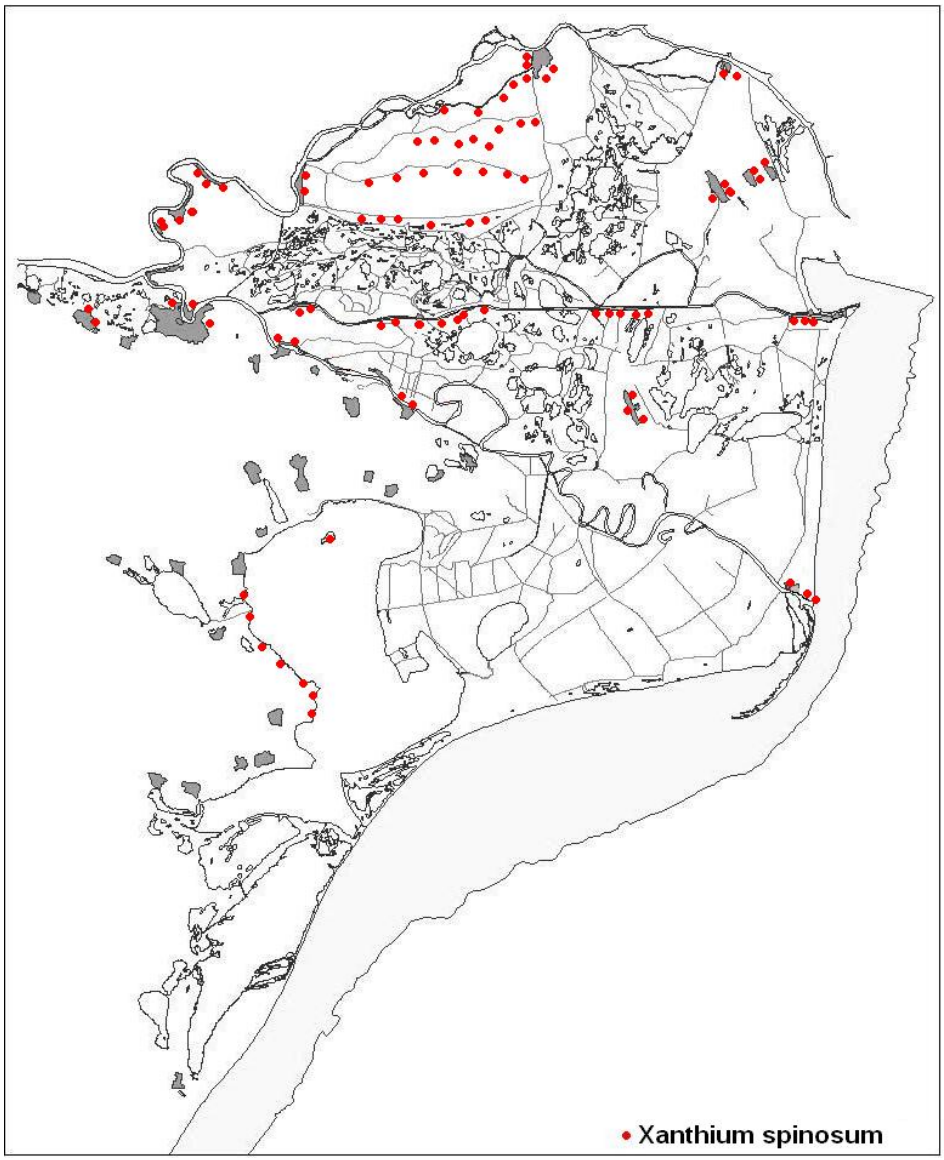

Figure 29: The spread of the species *Xanthium spinosum* in Danube Delta.

Other places where this species is met are Enisala, Taşburun and Iancina Cape in the anthropized areas due to overgrazed. On Letea and Caraorman sandunes, near localities; on Popina island and in the area of Parcheş localities within Somova Parcheş complex.

The spread of the species ***Xanthium italicum*** in other areas than the studied ones (figure 30);

Generally, this species is very spread within Danube Delta, the same as the species mentioned above *Xanthium strumarium*. Its presence is also conditioned by anthropic activities, and by the new active areas of sedimentation that form/raise themselves from the water as new islands. The presence of this species is similar with that of *Xanthium strumarium*. On the other hand, it is opportunistic under the conditions of frequently flooded areas or newly formed areas by means of sedimentation as in the case of channel intersections, new islets, Musura and Sahalin islands, and generally, in areas with high humidity and abundant with higrophyle species.

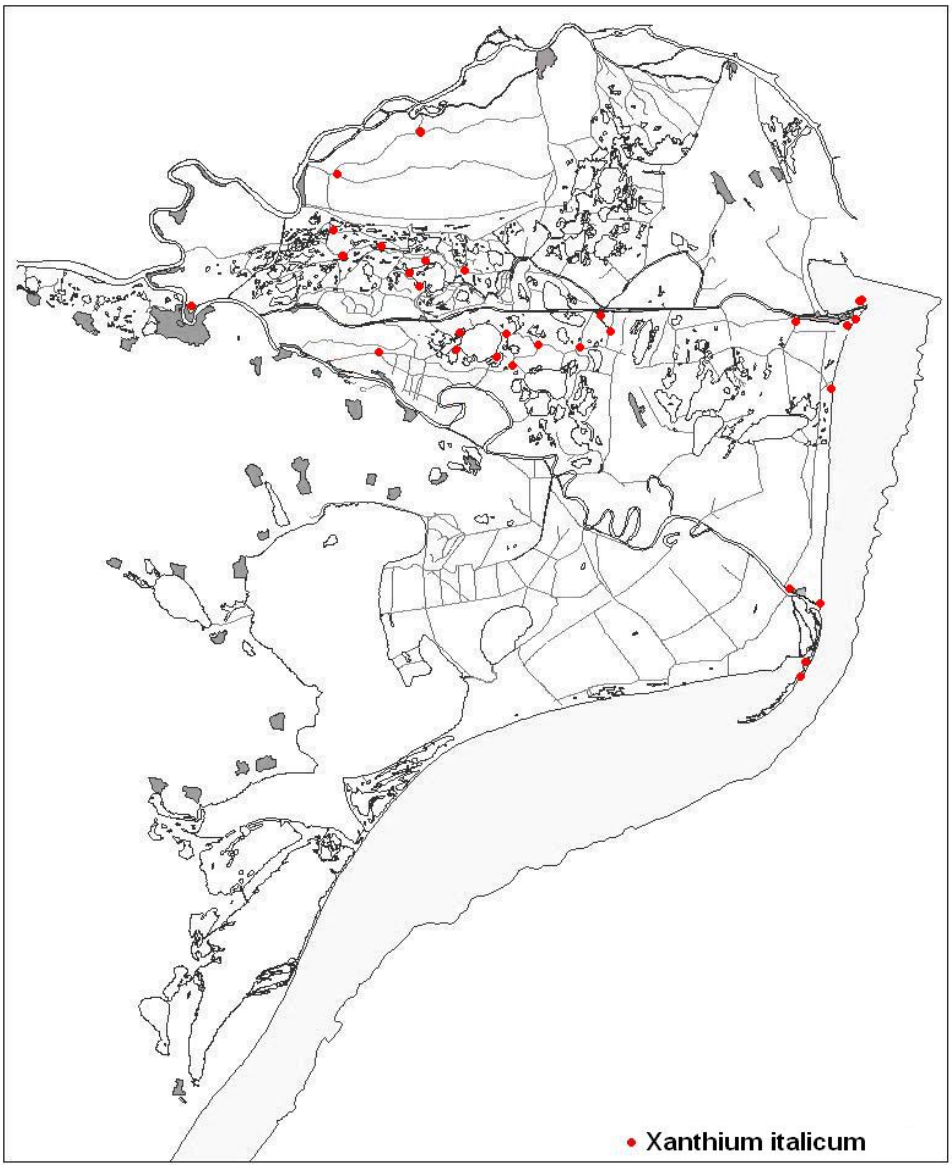

Figure 30: The spread of the species *Xanthium italicum* in Danube Delta.

7. Evaluation and control management of invasive plant species

The aspects related to the evaluation and control management of invasive plant species in this chapter are based on Invasive Species Guide for a good prevention and management practices (Invasive alien species: A toolkit of best prevention and management practices), elaborated under the guiding of Global Invasive Species Programme (G.I.S.P.) in colaboration with International Union for Conservation of Nature (I.U.C.N.).

Early detection of non-indigenous species should be based on a system of regular surveys to find newly established species. However, not all species will become established, and only a small percentage of those that do will become invasive, presenting threats to biodiversity and the economy. Thus, some surveys will need to focus on specific target species known to be invasive under similar conditions or species that have been successfully eradicated before. Methods to detect species differ between taxonomic groups, and their success depends largely on taxonomic difficulties and how conspicuous species are. Sampling techniques are discussed for the major taxonomic groups. In addition, site-specific surveys looking for alien species in general can be carried out. They should be targeted at key sites, e.g. areas of high conservation value, within the range of highly endangered species, and at high-risk entry points such as airports and harbours. The drawback of these general surveys is that only well-trained staff will be able to identify nonindigenous species.

Another factor in early detecting is public education which should focus on groups using or acquainted with the natural environment, such as farmers, tour operators, and the concerned public. This education campaign can be based on media promotion, displays, and personal interactions. A crucial part of early detection is a contingency plan, which determines the action to be taken when an alien species is been found. However, the longer detection takes at this stage, the lower is the opportunity to intervene, less will be control and eradication options and more expensive will be any intervention. For example, eradication will ceise rapidly to be an option the longer alien species is allowed to reproduce and spread. That is the case of the species Amorpha fruticosa in Danube Delta. Another aspect to consider is that not all alien species will become invasive as well, so that the species known to be invasive somewhere else, especially the ones spreading within a region, should represent priorities for early detection.

Field surveys

Some invasive species are easily seen while others are cryptic and require special efforts to locate or identify them, particularly when they are in low numbers.

Three types of surveys can be considered: general surveys, site specific surveys and species specific surveys. Depending upon the purpose, these categories may merge or overlap, e.g. species specific surveys may be carried out in a site specific way.

General surveys

For large or conspicuous animals and plants this is a " transect looking survey". Public reporting of new sightings should be encouraged. The Danube Delta Biosphere Reserve Administration can then identify the species and report back to the member of the public to maintain good public relations. Interest groups, such as botanical societies, are designed to undertake specific searches for new species should be encouraged.

Site specific surveys

These could be characterized as general surveys targeted at key sites, e.g. high value biodiversity areas and areas near high-risk entry points. High value areas may be entire reserves or small and valuable habitats where you will either want try to exclude new arrivals or document environmental impacts of new arrivals to that cannot be controlled.

Plant communities at high-risk

The best method is to use an experienced botanist who knows the botany of the area. This person should be able to readily identify a new arrival. For people with less botanical knowledge the provision of identification aids is essential. These aids in the form of books, field guides and posters need to target known prior invaders, invasive species which are present in neighbouring countries, easily transported species and invaders of similar bio-climatic zones.

Species specific surveys

When habitats divided because of invasive species are identified, it will be appropriate to make regular surveys that are carefully planned using specific methods in potential habitats of possible invaders. The methods are very specific and will need to be designed, adapted or developed for each situation. Frequency and timing of surveys is important. The potential range of newly arrived invaders needs to be considered along with the climate of the region. In equable climates new invaders may be difficult to detect at all times of the year so more frequent or more diligent survey will be needed. Specific survey methods for invasive plant species will depend on how easy to recognize are the target species.

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7.1. Assessment and management

The management of alien invasive alien species involves:

- the initial assessment of the situation,
- the process of identifying the species of highest priority for a management programme,
- detailed information on methods for eradication, containment, control, and mitigation for the various biological groups,
- an introduction to monitoring approaches,
- identification of major principles for projects,
- activities to secure resources,
- the importance of stakeholder commitment and involvement, and
- training in control methods.

The first step of a management programme is to assess the current situation by determining the management goal, the extent and quality of the area being managed, the invasive target species affecting the area, and the native species threatened. The management goal should be the conservation or restoration of intact ecosystems that support the delivery of ecosystem services. Eradication and control options need to be evaluated on the basis of the likelihood of success, cost effectiveness and any potential impacts.

Invasive species need to be arranged in a priority list that takes into consideration the extent of the area infested by the species, its impact, the ecological value of habitats invaded, and the difficulty of control. Species with the highest priority would be those known or suspected to be invasive but still in small numbers, species which can alter ecosystem processes, species that occur in areas of high conservation value, and those that are likely to be controlled successfully.

The four main strategies for dealing with established invasive alien species are eradication, containment, control, and mitigation. When prevention measures have failed, an eradication programme is considered to be the most effective action, because of the opportunity for complete rehabilitation of the habitat. Since eradication programmes are usually very costly and need full commitment until completion, the feasibility of eradication needs to be carefully and realistically assessed beforehand. Eradication has been achieved using mechanical, chemical and biological control, as well as habitat management.

Containment is a specific form of control. The aim is to restrict an invasive species to a limited geographical range. The population can be suppressed using a variety of methods along the border of

the defined area, individuals spreading outside this area are eradicated, and introductions outside the area prevented.

Control of invasive alien species should be planned to reduce the density and abundance of the target to below an agreed threshold, lowering the impact to an acceptable extent. The suppression of a population will reduce its competitiveness and, under optimal conditions, native species will regain ground and replace the invasive species.

Aspects related to alien invasive plant species will be detailed further on.

Eradication

Eradication is the elimination of the entire population of an alien species, including any resting stages, in the managed area. When prevention has failed to stop the introduction of an alien species, an eradication programme is the preferred method of action. Eradication as a rapid response to an early detection of a non-indigenous species is often the key to a successful and cost-effective solution.

Eradication programmes can involve several control methods on their own or a combination of these. There are few situations where a single method is a proven eradicator of an invasive species. The methods vary depending on the invasive species. Successful eradication programmes in the past have been based on:

- mechanical control, e.g. hand-picking and hand-pulling of weeds;
- chemical control;
- habitat management, e.g. grazing and prescribed burning.

Each single situation needs to be evaluated to find the best method in that area under the given circumstances.

Plants can be best eradicated by a combination of mechanical and chemical treatments, e.g. cutting of woody weeds and applying an herbicide to the cut stems.

In the case of the species Robinia pseudoacacia, Amorpha fruticosa şi Morus alba these methods have successfully been employed in different wet areas. It is the only option that totally meets the management purpose because the invasive species is completely eliminated.

A well-designed and realistic eradication approach has to be developed to achieve the required goal. In most cases, well-established populations and large areas of infestation are unsuitable for eradication programmes. Many failed attempts were highly costly and had significant side effects on non-target species.

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The best chances for successful eradication of most unwanted species are during the early phase of invasion, while the target populations are small and/or limited to a small area. The chances for success can be improved by identifying a period when the target species is particularly vulnerable.

Although eradication methods should be as specific as possible, the rather rigorous nature of concentrated efforts for eradication will often inflict incidental casualties to non-target species. In most cases these losses can be seen as inevitable and acceptable costs to achieve the management goal and can be balanced against the long-term economic and biodiversity benefits. When attempting eradication using toxins, it should be ensured that these are as specific as possible and that their persistence in the ecosystem is of short duration.

Eradication (or control) of well-established non-indigenous species, which have become a major element of the ecosystem, will influence the entire ecosystem. Predicting the consequences of the successful elimination of such species will be difficult but it must be done. The relationships (e.g. synergistic effects) of the invasive species to indigenous and non-indigenous species have to be considered. Control of one species in isolation could have drastic direct or indirect effects on the population dynamics of the second species. Successful eradication of a weed can also lead to negative effects in the plant community, if it is replaced by another non-indigenous plant species. Some of these effects on the ecosystem might not be anticipated, thus monitoring of the outcome is crucial for mitigation efforts.

By way of synthesis, basic criteria for a successful eradication programme are summarized as follows:

The programme needs to be scientifically based. Unfortunately, most traits rendering species invasive make eradication efforts more difficult, e.g. high reproduction rate and dispersal ability. That means that invasive species are likely to be difficult to eliminate due to their very nature.

Eradication of all individuals must be achievable. It must be borne in mind that it becomes progressively more difficult and costly to locate and remove the final individuals at the end of the programme, when the population is dwindling away.

Support by the public and all stakeholders must be ensured beforehand.

Sufficient funding must be secured for an intensive programme, allowing for contingencies, to make sure that eradication can be pursued until the last individual is removed.

Small, geographically limited populations of non-indigenous species are easiest to eliminate. Thus, immediate eradication is the preferred option for most species found in early detection surveys. Therefore it is crucial that the early warning programme has funds available for these actions.

Immigration of the alien species must be zero, i.e. the management area must be completely isolated from other infested areas, as is the case for islands, particularly oceanic islands. Potential pathways for the species between infested areas and the management area must be controlled to prevent new invasions.

Effective team management and motivation will be needed. No single person can achieve an eradication success – it has always been achieved by teamwork. A core of field and research

expertise is needed to lead the eradication from the beginning to the end in order to maximize efficiency. This is particularly important to maintain the political and administrative support for the completion of the programme.

A technique to monitor the species at very low densities, at the end of the programme, needs to be designed to ensure detection of the last survivors. Organisms that have less obvious stages, which can survive for long periods, e.g. seed banks of weeds, need monitoring for a prolonged period.

A monitoring phase should be part of the eradication programme to make sure that eradication has been achieved.

Methods to minimize the chances of re-invasion and early detection of the eradicated species should it re-establish need to be in place.

Containment

Containment of non-indigenous invasive species is a special form of control. The aim is to restrict the spread of an alien species and to contain the population in a defined geographical range. The methods used for containment are the same as those described for prevention, eradication and control and are therefore not presented here in detail. Monitoring and public involvement will again be a critical feature.

Containment programmes also need to be designed with clearly defined goals: barriers beyond which the invasive species should not spread, habitats that are not to be colonized and invaded, etc. In order to establish these parameters there needs to be clear understanding of why the containment is being done in the first place, e.g. to protect particular areas or habitats from invasion, to allow time to mobilize other control or eradication measures etc.

An important component of a containment programme is the ability to rapidly detect new infestations of the invasive species both spreading from the margins of its distribution, or in completely new areas, so that control measures can be implemented in as timely a manner as possible.

The invasive species' population is suppressed using a variety of methods along the border of the defined area of containment, individuals and colonies spreading beyond this are eradicated, and introductions into areas outside the defined containment area are prevented. The distinction between containment and eradication is not always clear-cut depending upon the scale of operations considered.

A species most likely to be successfully contained in a defined area is a species spreading slowly over short distances. The nearest suitable habitat for the species should be preferably separated by a natural barrier, or an effective artificial barrier. The most suitable cases for containment are habitat islands without suitable connections that would allow the easy spread of invasive species. The spread of alien freshwater species between different parts of watersheds is a good example where containment may be possible.

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If containment of an invasive species in a well-defined area is successful, habitats and native species are safeguarded against the impacts caused by the harmful alien species outside this area. Containing a species in a defined area will, however, need constant attention and control of the species at the border and prevention measures against spread of the species. Thus, successful containment is difficult to achieve and involves several different costly methods.

The chances for successful containment of invasive species are relatively good for species living in freshwater habitats, e.g. the case of Azolla caroliniana, Valisneria spiralis,și Elodea canadensis. Thanks to human activities, many catchment areas are connected by artificial canals that allow alien species to spread between river systems. However, canals are rather small corridors and therefore easier to control. Some species may be effectively restricted by barriers built in canals, if other pathways, such as over-land boat traffic, can be closed at the same time.

A related but different approach is exclusion, which aims to protect a sensitive area against invasive species by fencing them out. This method also often combines eradication, prevention and fencing techniques. An area of high conservation value is fenced with an animal-proof fence and if the invasive species occurs inside, it will be eradicated. This mainland-islands concept is very effective in supporting crucial populations of endangered species, if eradication of the invasive species within the containment is possible but eradication on a large-scale is not feasible.

Control

The control of non-indigenous invasive species aims for the long-term reduction in density and abundance to below a pre-set acceptable threshold. The harm caused by the species under this threshold is considered acceptable with regard to damage to biodiversity and economy. It is not always clear what this level should be set at in order to achieve the management objective. Research to establish what indigenous biodiversity is at risk and how much of the invasive species' impact can be tolerated may need to be carried out.

Suppression of the invasive population below that threshold can tip the balance in favour of native competing species. The weakened state of the invasive species allows native species to regain ground and even further diminish the abundance of the alien species. In rare cases this might even lead to extinction of the nonindigenous species, but this is clearly not the principle goal of control efforts.

If prevention methods have failed and eradication is not feasible managers will have to live with the introduced species and can only try to mitigate the negative impacts on biodiversity and ecosystems. All control methods, with the exception of classical biological control, which is self-sustaining, need long-term funding and commitment. If the funding ceases, the population and the corresponding negative impacts will normally increase, perhaps leading to irreversible damage.

Since, in the short-term, control seems to be a cheaper option than eradication, it is often the preferred method.

Mechanical, chemical and biological control, habitat management, and a combination of methods are all used successfully in controlling population levels of invasive species. In many cases a cost-effective combination of appropriate measures may be put together in a sustainable way so as to minimize side effects. This is integrated pest management as developed in the agricultural and forestry sectors, based on long and bitter experience of chemical insecticide dependence.

Successful control may be easiest to achieve in areas of lower density of the invasive species. Such control will immediately mitigate the impact of the invasive species, allowing a relatively intact ecosystem to recover from the impacts of the alien species. Successful control in these areas will rapidly show a positive effect on biodiversity, and where it is on the edge of the range of the invasive species, the spread of the alien will be limited.

7.2. Applicable control and eradication measures

In this subchapter, evaluation criteria for habitats and species will be presented according to Order of Ministry of Enviromnent and Forestry 206 in 2007:

The degree of representativeness expresses the extent to how „typical" is a certain species for a habitat.

Reprezentativeness: the degree of representativeness of the invasive species within a habitat. The degree of representativeness expresses the extent to how „typical" is a certain species for a habitat.

A: excellent reprezentativeness,

B: good reprezentativeness,

C: significant reprezentativeness,

D: insignificant presence.

Conservation stage: conservation stage of structures and functions for the natural habitat type, as well as the possibilities to recover/reconstruct.

This criterion includes the following three sub-criteria:

1) Conservation degree of structure

I: excellent structure

II: well-preserved structure

III: medium or partially degraded structure.

2) Conservation degree of functions

I: excellent perspectives

II: good perspectives

III: moderate or not favourable perspectives.

3) Posibilities to rehabilitate the habitat

This criterion is employed in order to evaluate the extent to which rehabilitating a habitat type within a site may be possible:

I: easy rehabilitation

II: possible rehabilitation with medium effort

III: difficult or impossible rehabilitation.

Invasive plant species have a higher frequency, which are widespread in both natural habitats and in those controlled by humans, for example: *Amorpha fruticosa, Robinia pseudoacacia, Acer negundo, Morus alba, Fraxinus pennsylvanica, Ailanthus altissima, Lycium barbarum, Gleditsia triacanthos and Elaeagnus angustifolia, Xanthium strumarium, Xanthium italicum* and *Cuscuta campestris*. According to their origins, the most commonly found are those from North America and Asia.

From the woody invasive plant species, the most widespread in Danube Delta are Amorpha fruticosa, Robinia pseudoacacia in fluvial delta and Elaeagnus angustifolia in maritime-delta.

The literature recommends eradication efficient methods of this species, such as applying chemicals. These actions are not recommended in Danube Delta Biosphere Reserve. The only viable measures are the mechanized by pulling of invasive species and planting of native fast grow species.

Another action that can be efficient at Danube Delta level is the general monitoring that involve prevention of new species introduction; specific monitoring of the key areas by succession of vegetation and species monitoring on the base of existent spread, phenology, development and habitats data and by human interventions (dredging, clearings or burning).

In the present, the share of alien species, according to above mentioned list, is large, from 187 species, only 22 are considered invasive plant species. From which, *Amorpha fruticosa, Robinia pseudoacacia, Ailanthus altissima, Xanthium strumarium, X.italicum, Iva xanthifolia, Elodea nuttallii* and *Amaranthus albus* are considered aggressive invasive species.

The most affected habitats are natural forests easily flooded; meadows on high dams; low dunes with fixed sand and solification process more advanced and seashore vegetation on not fixed sands.

From the management point of view it is recommended to apply eradication measures only in places where other measures do not have effect. The main objective being the monitoring and conservation of strictly protected areas biodiversity. Within these areas only mechanized eradication measures are recommended.

Table 2: Assessment matrix of some management measures according as species representativity in the habitat.

Nr. crt	Habitat type	Reprezentativity of invasive species			Conservation phase of the habitat in which species is present			Management		
		A	B	C	Identified invasive species	Conservation degree of the structure	Possibility of rehabilitation	Eradication	Isolation	Control
	1. Şontea – Fortuna Depression	1	2	3	4	5	6	7	8	9
1	natural forests easily flooded : *Salicetum albae* 1924 s.l., *Salicetum cinereae Zolyomi* 1931, *Populetum marylandicae* Mititelu 1970 (ass.cult.) *Salicetum triandrae* Malciut 1929;	x			*Amorpha fruticosa*	structure medium or partially degraded	difficult or impossible rehabilitation	x		
			x		*Acer negundo*				x	
				x	*Fraxinus pennsylvanica*					x
				x	*Robinia pseudoacacia*					x
			x		*Gleditsia triacanthos*				x	
			x		*Ailanthus altissima*				x	
				x	*Morus alba*					x
			x		*Xanthium italicum*				x	
2	meadows on high dams : Cynodonto – *Poetum angustifoliae* (Rapaics 1926) Soo 1957, *Lolio-Plantaginetum majoris* (Linkola 1921) Beger 1930, *Bassietum sedoidis* (Ubrizsy 1949) Soo 1964, *Hordeetum murini* Libbert 1923 emend.Pass. 1964.			x	*Cuscuta campestris*	structure medium or partially degraded	difficult or impossible rehabilitation			x
				x	*Conyza canadensis*					x
				x	*Iva xanthifolia*					x
			x		*Lindernia dubia*				x	
			x		*Xanthium strumarium*				x	
				x	*Amorpha fruticosa*					x
				x	*Xanthium spinosum*					x

3	mixed reed and club rush vegetation on organic soils : *Typhetum angustifoliae* (All.1922) Pign.1934, Scirpo-Phragmitetum W.Koch 1926;			x	*Amorpha fruticosa*	well preserved structure	-			x
				x	*Paspalum paspalodes*					x
				x	*Cuscuta campestris*					x
4	plantations of *Salix sp., Populus sp., Fraxinus pennsylvanica, Robinia pseudoacacia;*		x		*Robinia pseudoacacia*	well preserved structure	-		x	
			x		*Fraxinus pennsylvanica*				x	
			x		*Amorpha fruticosa*				x	
				x	*Elaeagnus angustifolia*					x
				x	*Lycium barbarum*					x
				x	*Morus alba*					x
5	floating aquatic vegetation: *Myriophyllo verticillati – Nupharetum luteae* W. Koch 1926, *Nymphaeetum albae* Vollmar 1947, *Trapetum natantis* V. Kárpati 1963, P*otametum natantis* Soó 1927. *Spirodelo – Salvinietum natantis* Slavniè 1965, *Lemno – Azolletum carolinianae* Nedelcu 1967.		x		*Azolla filiculoides*	structure medium or partially degraded	possible rehabilitation with medium effort		x	
				x	*Elodea nuttallii*					x
			x		*Vallisneria spiralis*				x	
6	Submerse aquatic vegetation: *Elodeetum canadensis* Eggler 1933, Potamo –Ceratophylletum submersi Pop 1962.			x	*Azolla filiculoides*	structure medium or partially degraded	possible rehabilitation with medium effort			x
		x			*Elodea nuttallii*			x		
			x		*Vallisneria spiralis*				x	

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	2. Depresiunea Matiţa – Merhei	1	2	3	4	5	6	7	8	9
7	reed and shrubery vegetation on compact reedbed : *Thelyptero – Phragmitetum* Ştefan et al.1995; *Scirpo-Phragmitetum* W.Koch 1926.			x	*Amorpha fruticosa*	well preserved structure	-			x
				x	*Azolla filiculoides*					x
				x	*Cuscuta campestris*					x
8	natural forests easily flooded : *Salicetum albae* 1924 s.l., *Calamagrostio-Salicetum cinereae* Soo et Zolyomi (1934) 1955, *Salicetum triandrae* Malciut 1929.		x		*Amorpha fruticosa*	structure medium or partially degraded	difficult or impossible rehabilitation		x	
				x	*Xanthium strumarium*					x
				x	*Robinia pseudoacacia*					x
9	floating aquatic vegetation: *Myriophyllo verticillati – Nupharetum luteae* W. Koch 1926, *Nymphaeetum albae* Vollmar 1947, *Trapetum natantis* V. Kárpati 1963, *Potametum natantis* Soó 1927.			x	*Azolla filiculoides*	well preserved structure	-			x
				x	*Elodea nuttallii*					x
			x		*Vallisneria spiralis*				x	
	3. Zona Dunăvăţ – Dranov	1	2	3	4	5	6	7	8	9
10	reed and shrubery vegetation on compact reedbed : *Thelyptero – Phragmitetum* Ştefan et al.1995; *Typhetum angustifoliae* (All.1922) Pign.1943; *Scirpo-Phragmitetum* W.Koch 1926 ;			x	*Azolla filiculoides*	well preserved structure	-			x

11	meadows on high dams: *Hordeetum murini* Libbert 1923 emend.Pass. 1964; *Cardarietum drabae* Timar 1950;			x	*Cuscuta campestris*	structure medium or partially degraded	possible rehabilitation with medium effort			x
				x	*Lindernia dubia*					x
			x		*Xanthium strumarium*				x	
12	natural forests easily flooded: *Salicetum albae* 1924 s.l., *Calamagrostio-Salicetum cinereae* Soo et Zolyomi (1934) 1955, *Salicetum triandrae* Malciut 1929.	x			*Amorpha fruticosa*	well preserved structure	possible rehabilitation with medium effort	x		
				x	*Elaeagnus angustifolia*					x
				x	*Morus alba*					x
				x	*Robinia pseudoacacia*					x
13	floating aquatic vegetation: *Myriophyllo verticillati – Nupharetum luteae* W. Koch 1926, *Nymphaeetum albae* Vollmar 1947, *Trapetum natantis* V. Kárpati 1963, *Potametum natantis* Soó 1927.		x		*Azolla filiculoides*	structure medium or partially degraded	possible rehabilitation with medium effort		x	
			x		*Elodea nuttallii*				x	
			x		*Vallisneria spiralis*				x	
	4. Grindul Caraorman	1	2	3	*4*	5	6	7	8	9
14	shrubbery: *Calamagrostio epigei-Hippophaetum rhamnoides* Popescu, Sanda, Nedelcu 1968; *Calamagrostio-Tamaricetum ramosissimae* Simon et Dihoru (1962) 1963;		x		*Elaeagnus angustifolia*	well preserved structure	-		x	
				x	*Amorpha fruticosa*					x
				x	*Lycium barbarum*					x
				x	*Morus alba*					x

15	vegetation on high dunes: Caricetum divisae Slavnic 1948, *Saliceto (rosmarinifoliae) – Holoschoenetum vulgaris* Mititelu et al. 1973; Cynodonto – *Poetum angustifoliae (*Rapaics 1926) Soo 1957; *Secaletum sylvestre, Ephedro – Caricetum colchicae, Artemisietum arenariae* Popescu et Sanda 1977.			x	*Cuscuta campestris*	well preserved structure	-			x
				x	*Conyza canadensis*					x
				x	*Iva xanthifolia*					x
			x		*Xanthium strumarium*				x	
16	meadows on sand dunes: Holoschoeno – *Calamagrostetum epigeios* Popescu et Sanda 1978; *Plantaginetum arenarie* (Buia et al.1960) Popescu, Sanda, 1987; *Ephedro-Caricetum colchicae* (Prodan 1939 n.n.; Morariu 1959) Sanda, Popescu 1973);		x		*Cuscuta campestris*	structure medium or partially degraded	possible rehabilitation with medium effort		x	
				x	*Xanthium spinosum*					x
				x	*Elaeagnus angustifolia*					x
				x	*Xanthium strumarium*					x
17	mixed oak and ash tree forests: *Fraxino pallisae-angustifoliae – Quercetum roboris* Popescu et al 1979.			x	*Acer negundo*	structure medium or partially degraded	possible rehabilitation with medium effort			x
				x	*Elaeagnus angustifolia*					
			x		*Robinia pseudoacacia*				x	
			x		*Amorpha fruticosa*				x	
18	natural forests easily flooded: *Salicetum albae* 1924 s.l.; *Calamagrostio-Salicetum cinereae* Soo et Zolyomi (1934) 1955;			x	*Acer negundo*	well preserved structure	-			x
				x	*Ailanthus altissima*					x
				x	*Amorpha fruticosa*					x

19	mixed reed and club rush vegetation on mineral soils: *Scirpo-Phragmitetum* W.Koch 1926, *Typhetum angustifoliae* (All.1922)Pign.1934;			x	*Azolla filiculoides*	well preserved structure	-			x
20	meadows on high dams: *Cynodonto – Poetum angustifoliae* (Rapaics 1926) Soo 1957; *Bassietum sedoidis* (Ubrizsy 1949) Soo 1964; *Hordeetum murini* Libbert 1923 emend.Pass. 1964;			x	*Iva xanthifolia*	structure medium or partially degraded	possible rehabilitation with medium effort			x
				x	*Cuscuta campestris*					x
				x	*Conyza canadensis*					x
				x	*Xanthium spinosum*					x
21	submerse aquatic vegetation: *Elodeetum canadensis* Eggler 1933, *Potamo –Ceratophylletum submersi* Pop 1962.			x	*Vallisneria spiralis*	well preserved structure	possible rehabilitation with minimum effort			x
			x		*Elodea nuttallii*				x	
	5. Cordon litoral – sectorul Sf. Gheorghe - Sulina	1	2	3	4	5	6	7	8	9
22	beach exposed to waves, with not solified sand, permanently wet, without vegetation ;			x	*Amorpha fruticosa*	well preserved structure	possible rehabilitation with minimum effort			x
			x		*Elaeagnus angustifolia*				x	
23	high dunes with weakly fixed and not solified sand, slightly exposed to wind;	-	-	-	-	well preserved structure	-	-	-	-
24	middunes with sand partly fixed, where solification process has begun;			x	*Amaranthus albus*	well preserved structure	-			x

25	low dunes with fixed sand and solification process more advanced, in complex with depressions where the sand is salinized, wet, frequently gleized. In this part, vegetation associations with dominant ligneous species are usually seen, depending on salinization degree and layer's humidity;			x	*Amorpha fruticosa*	structure medium or partially degraded	possible rehabilitation with medium effort			x
				x	*Amaranthus albus*					x
				x	*Amorpha fruticosa*					x
		x			*Elaeagnus angustifolia*			x		
			x		*Cuscuta campestris*				x	
				x	*Conyza canadensis*					x
				x	*Fraxinus pennsylvanica*					x
26	depressions with permanently wet sand, very strongly salinized, Salicornietum europeae, *Suaedetum maritimae*. *Aeluropetum littoralis* (Prodan 1939) Şerbănescu 1965.	-	-	-	-	well preserved structure	-	-	-	-
27	shrubbery: *Calamagrostio epigei-Hippophaetum rhamnoides* Popescu, Sanda, Nedelcu 1968; *Calamagrostio-Tamaricetum ramosissimae* Simon et Dihoru (1962)1963;			x	*Acer negundo*	well preserved structure	possible rehabilitation with minimum effort			x
				x	*Ailanthus altissima*					x
				x	*Amorpha fruticosa*					x
				x	*Gleditsia triacanthos*					x
				x	*Lycium barbarum*					x

28	seashore vegetation on not fixed sands: *Atripliceto hastatae – Cakiletum euxinae* Sanda et Popescu 1999; *Argusietum (Tournefortietum) sibiricae* Popescu et Sanda 1975; *Plantaginetum arenariae* (Buia et al. 1960) Popescu, Sanda; *Juncetum acuti-maritimi* Popescu et Sanda 1972; *Elymetum sabulosi* Morariu 1957 corr.hoc loco.			x	*Amorpha fruticosa*	structure medium or partially degraded	possible rehabilitation with medium effort			x
				x	*Amaranthus albus*					x
				x	*Lycium barbarum*					x
				x	*Iva xanthifolia*					x
				x	*Paspalum paspalodes*					x
				x	*Robinia pseudoacacia*					x
			x		*Xanthium strumarium*				x	
				x	*Xanthium spinosum*					x
		x			*Xanthium italicum*			x		

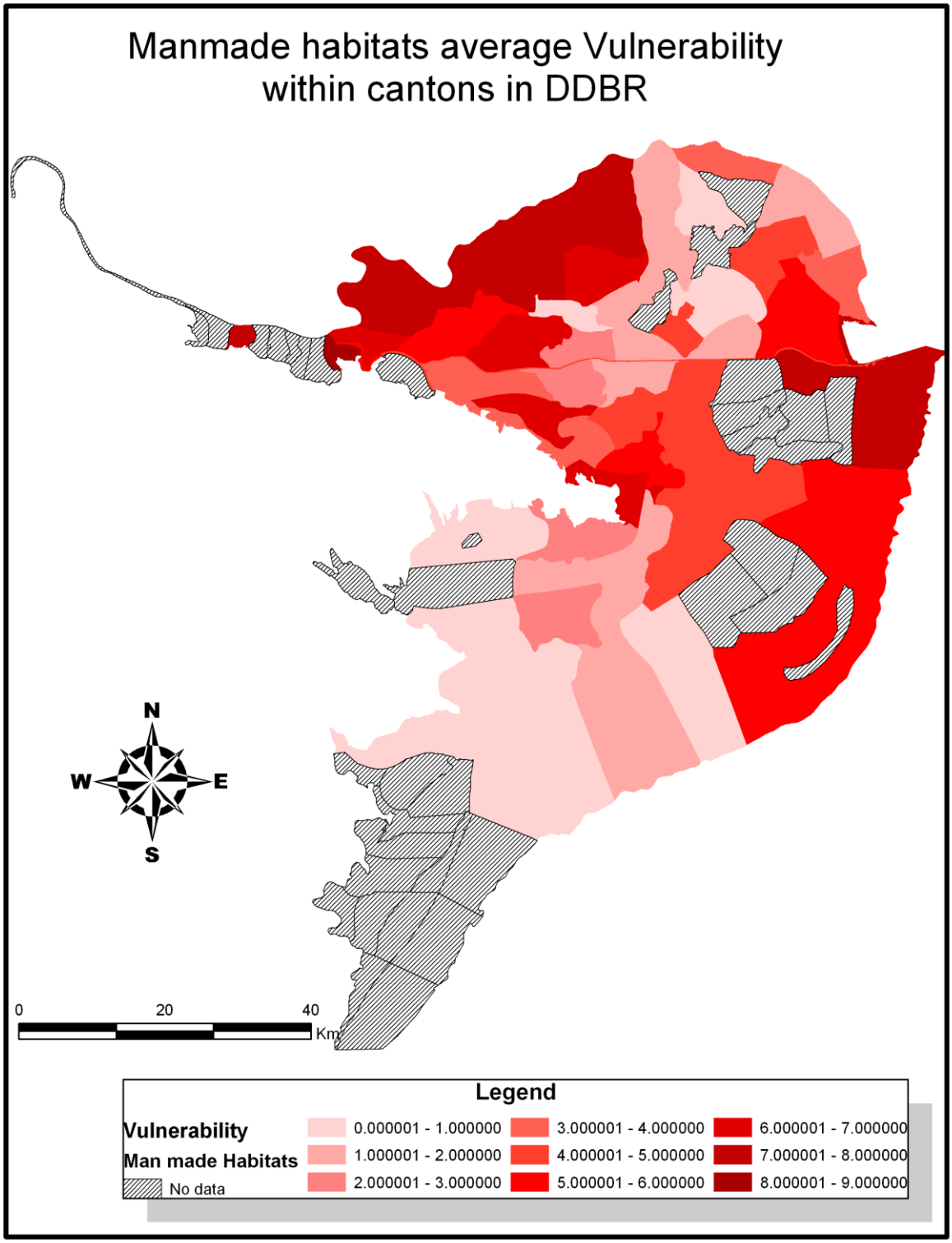

Figure 31: Vulnerability map of man-made habitats within contoons of D.D.B.R.

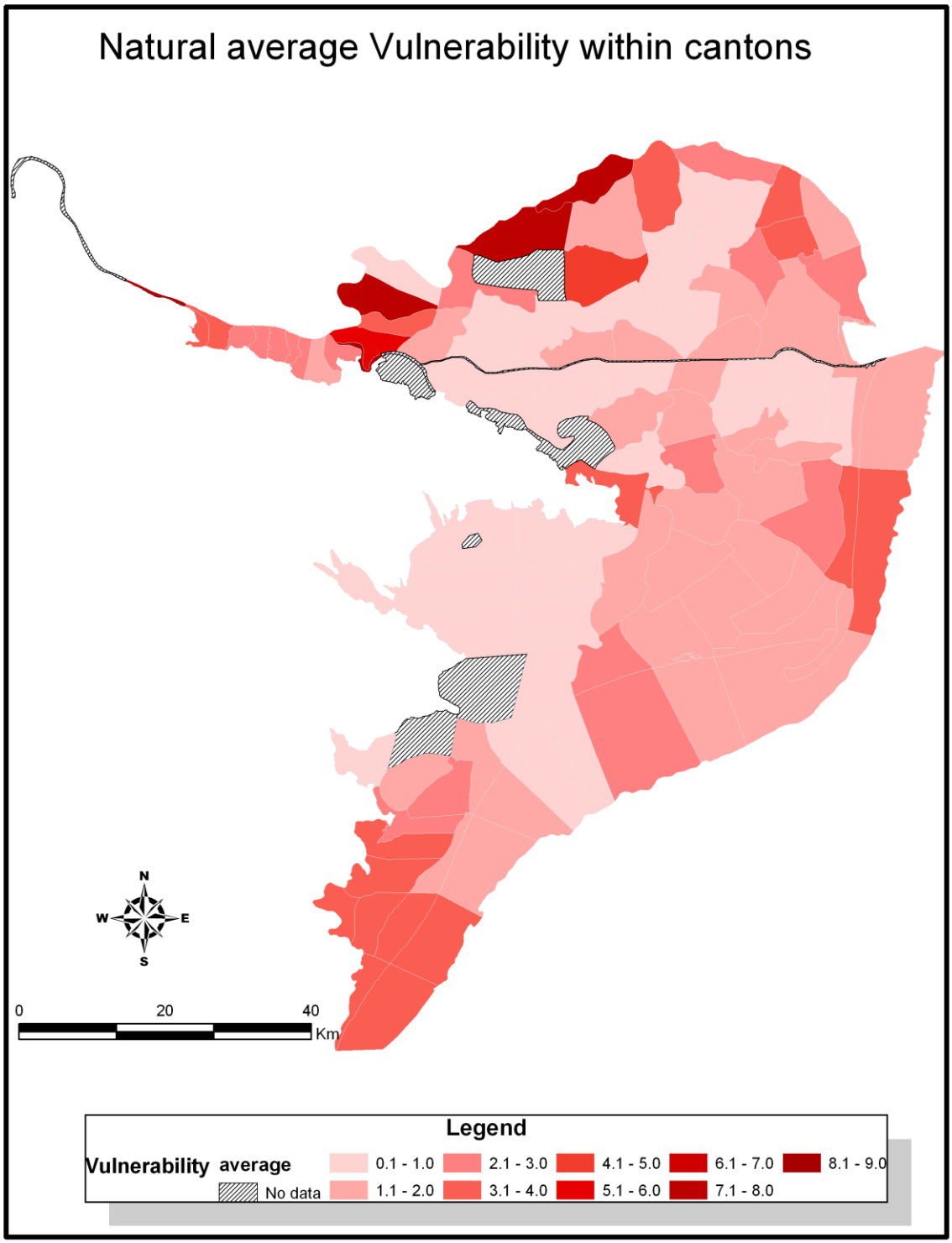

Figure 32: Vulnerability map of natural habitats within contoons of D.D.B.R.

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Part B: Triglav National Park

1. Monitoring of alien species in Triglav National Park and results

Stating the Reports objective; relation to other Outputs, Actions or Work packages; methods applied.

The spread of organisms into new areas is a natural process and a basic feature of biological systems (Klingenstein & Diwani, 2003). Most alien (exotic) species (i.e. species that occur outside their natural ranges, mostly due to human activity) do not become established in introduced places because the new environment is not suitable to their needs. Only a certain percentage of species can establish themselves in new environments. Some of them will establish self-perpetuating populations, i.e. they become naturalized, without causing noticeable destructions to ecosystems. But some alien species can be considered as invasive species – they increase in abundance at the expense of native species. In many cases, invasive alien species suppress or eliminate native species, and cause a loss of biodiversity as well as disturbances of ecosystem structure and functions (Richardson et al., 2000). Successful invasions depend on the characteristics of the invanding species and on the ecological conditions, dynamics, and the history of the site being invaded (Hobbs & Humphries, 1995).

According to new conservation regimes in Triglav National Park (ZTNP-1, 2010), the introduction and breeding of alien species is forbidden. But, until new regulations, alien plant species intentionally or spontaneously have colonised the area. The consequences of these colonisations are apparent; in some cases they are even irreversible.

With the exception of a few cases, the dispersal of alien plant species is limited to the local level. The most common alien species in TNP are: *Fallopia japonica, Erigeron annuus, Solidago canadensis, Solidago gigantea*, and *Impatiens glandulifera*. In some species, e.g. *Fallopia japonica* and *Solidago canadensis*, a constant spread from lower altitudes to higher altitudes is obvious.

From 2010 onwards Triglav National Park is systematically surveyed for alien plant species. Due to the short period of monitoring it is currently difficult to estimate population trends for most species. Anyway, according to past observations, some species, like *Fallopia japonica* (noticed already on Pokljuka)*, Solidago canadensis, Solidago gigantea,* and *Ailanthus altissima* (general distributed in Trenta), are currently more widespread.

Estimations of the pressures caused by specific invasive species have not been done till now, but are planned for the next two years.

Alien plant species are monitored in study areas, where their presence has been noticed before the start of the monitoring program or where a further dispersal of invasive plants is expected, i.e. along roads, rivers and banks of lakes throughout Triglav National Park. The presence and location of all species is recorded with GPS measurements. Additionally, the extension of the stands of all invasive species (in m^2), type of habitat (e.g. meadow, forest edge, road-sides) and, so far as possible, the causes or vectors for the species' dispersal (e.g. deposition of building materials) are noted.

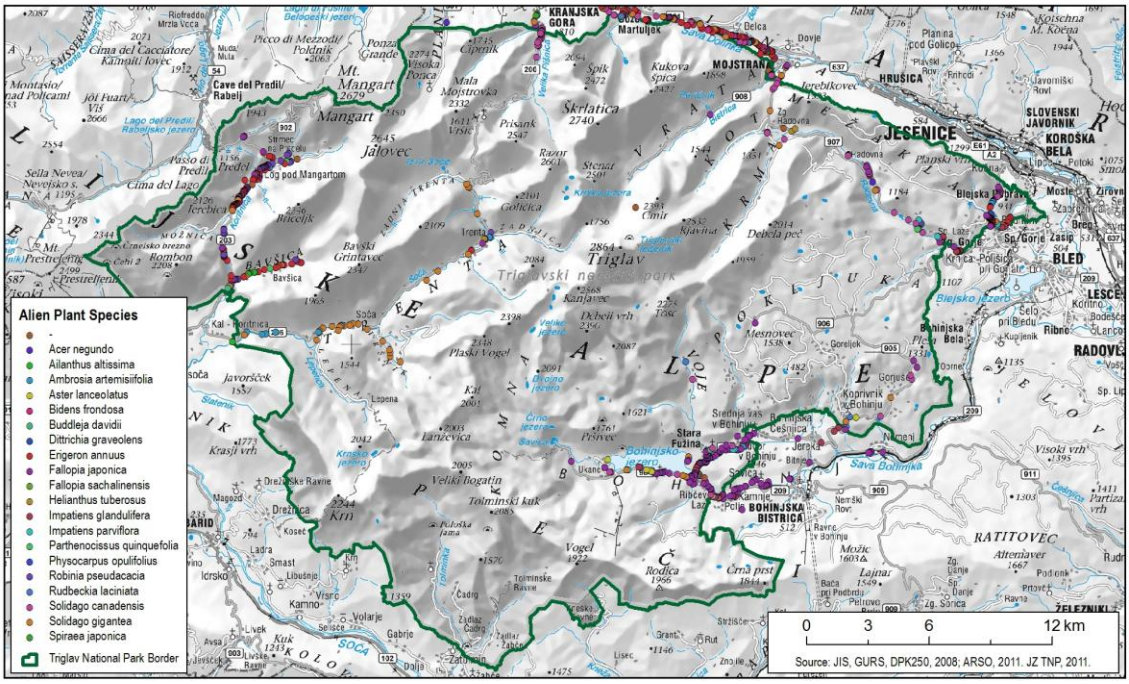

Figure 33: Distribution of alien plant species in Triglav National Park.

Table 3: Alien plant species, their status, distribution and population trends in TNP.

Scientific name	Status	Distribution	Population trend
Fallopia japonica	invasive alien species	frequently only in solitary stands	increasing
Spiraea japonica	no data	only occasionally	no data
Robinia pseudacacia	invasive alien species	frequently only in solitary stands	increasing
Ailanthus altissima	invasive alien species	frequently only in solitary stands	increasing
Acer negundo	naturalized species	only solitary findings	no data
Impatiens glandulifera	naturalized species	only solitary findings	no data
Impatiens parviflora	naturalized species	only solitary findings	no data
Parthenocissus quinquefolia	naturalized species	only solitary findings	no data
Buddleja davidii	no data	only solitary findings	no data
Solidago canadensis	invasive alien species	frequently only in solitary stands	increasing
Solidago gigantea	invasive alien species	frequently only in solitary stands	increasing
Erigeron annuus	naturalized species	only solitary findings	increasing
Bidens frondosa	naturalized species	only solitary findings	decreasing
Helianthus tuberosus	naturalized species	only solitary findings	no data
Rudbeckia laciniata	naturalized species	only solitary findings	no data
Ambrosia artemisiifolia	invasive alien species	frequently only in solitary stands	increasing

In addition the following species were recorded: *Fallopia sachalinensis* (1 site), *Physocarpus opulifolius* (2 sites), *Aster lanceolatus* (5 sites), and *Dittrichia graveolens* (1 site).

1.1. Characteristics of alien plant species in Triglav National Park

Currently, the alien plant flora of Triglav National park consists of 20 species from 9 different families (Fig. 2, 3; Tab. 2). The *Asteraceae* (45%) represent the most common family in the park, while other families are present with only one or two alien species. Invasive plant species which occur in high frequencies in Triglav National Park are: *Fallopia japonica* (25.8%), *Erigeron annuus* (19.7%), *Solidago canadensis* (16.1%), and *Solidago gigantea* (11.2%). All other species were found in frequencies lesser than 10% (*Robinia pseudacacia, Impatiens glandulifera, Impatiens parviflora, Ambrosia artemisiifolia, Parthenocissus quinquefolia, Rudbeckia laciniata, Bidens frondosa*) or lesser than 1% (*Ailanthus altissima, Acer negundo, Aster lanceolatus, Helianthus tuberosus, Spiraea japonica, Physocarpus opulifolius, Dittrichia graveolens, Buddleja davidii, Fallopia sachalinensis*) (Fig. 2). *Robinia pseudacacia, Fallopia japonica* and *Erigeron annuus* which currently cover 1000 m² are the most abundant species in the sampling area. Additionally, larger areas are covered by *Ambrosia artemisiifolia, Solidago canadensis, Solidago gigantea* (300 m² each), *Impatiens glandulifera* (200 m²), *Parthenocissus quinquefolia* (150 m²), *Rudbeckia laciniata, Spiraea japonica, Helianthus tuberosus* and *Fallopia sachalinensis* (100 m² each). In general, *Fallopia japonica* is by far the most frequent species which forms the largest stands in Triglav NP.

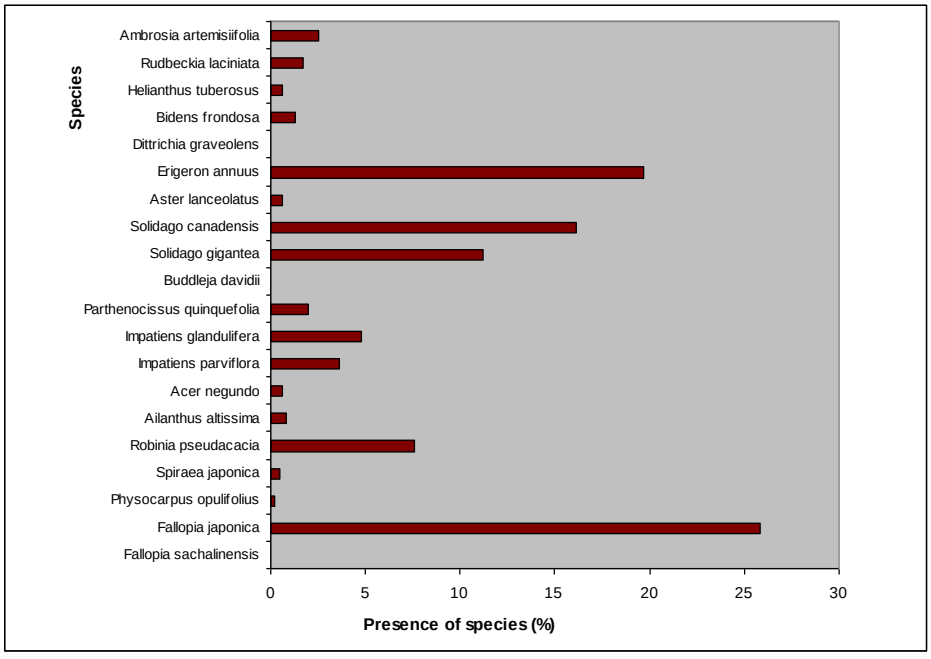

Figure 34: Presence (per cent of all sites) of plant neophytes in Triglav National Park.

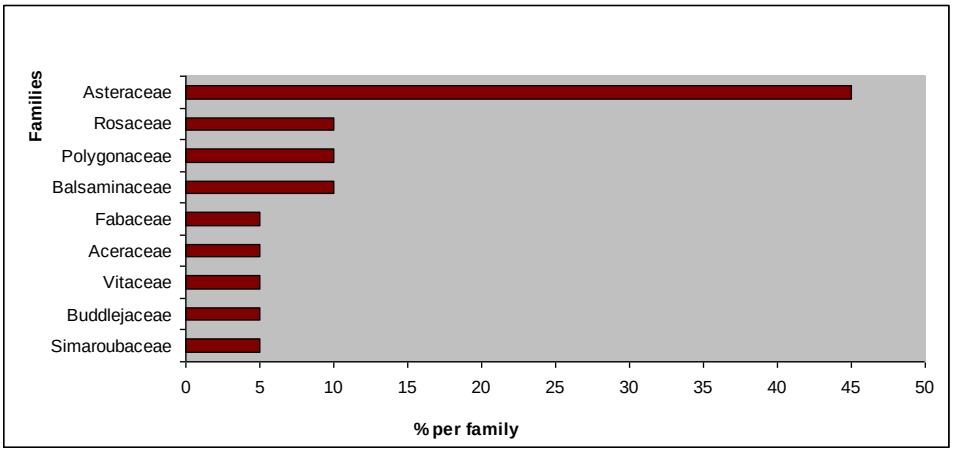

Figure 35: Percentages of families of alien plant species in Triglav National Park.

In contrast to invasive species which alterate ecosystems, with influences on native species populations, on biodiversity, health of people, and local economy, like *Fallopia japonica, Robinia pseudacacia, Ailanthus altissima, Solidago canadensis, Solidago gigantea,* and *Ambrosia artemisiifolia*, most alien species which were found in Triglav National Park are naturalized species (Tab. 1) with currently no obvious detrimental effects to ecosystems.

Because human pressures (infrastructure, buildings, land cultivation) are more concentrated at lower altitudes, opportunities for the introduction and establishing of alien plants in higher elevations are limited. Actually, no alien species is known in the park which is typical only for the mountain climate range. This is in agreement with research findings that most alien plants which invade mountain areas, are mainly climatically broad lowland species rather than mountain specialists (McDougall et al., 2010).

According to the mountainous character of the sampling area, neophytes were found most frequently in the montane altitudinal belt. Only a few species were noticed also in the submontane altitudinal belt: *Solidago gigantea* (402 m), *Ambrosia artemisiifolia* (403 m), *Ailanthus altissima* (422 m) and *Fallopia japonica* (491 m). The highest locations with neophytes are situated near the Pokljuka plateau (near Gorjuše) in the high mountain altitudinal belt: *Fallopia japonica* (1184 m) and *Solidago canadensis* (1078 m).

Following to our results, like most habitats in lower altitudes mountain ecosystems of the Alps are susceptible to invasions by alien plant species. According to literature the spread of invasive species and the extension of their altitudinal range is connected with (1) local adaptations to growth conditions in higher altitudes; (2) frequent disturbances at higher altitudes (avalanches, grazing, trampling, human activities); (3) increasing human use of remote mountain areas and (4) climate warming, in particular warmer winter temperatures (Becker at al. 2005). A better understanding of the distribution, introduction and the establishment of invasive species in higher altitudes will be derived from further monitoring. In addition, for a better understanding of the invasions of alien plants to higher altitudes comparisons of the ecology of those species in their native range are necessary.

1.2. Life strategies of alien plants: life forms, phenology, flowering period, dispersal type and origins

Considering life strategies has important potentials to predict vegetation dynamics in a changing environment due to human pressures or climate change. The alien flora of Triglav NP is dominated by herbs, while woody plants (*Fallopia japonica, F. sachalinensis, Spiraea japonica, Robinia pseudacacia, Acer negundo*, and *Parthenocissus quinquefolia*) which constitute a smaller portion of the flora. Furthermore, the majority concerns phanerophyts (31.6%), followed by hemicryptophyts (26.3%), terophyts (21.1%), geophyts (15.8%) and nanophyts (5.3%) (Fig. 4).

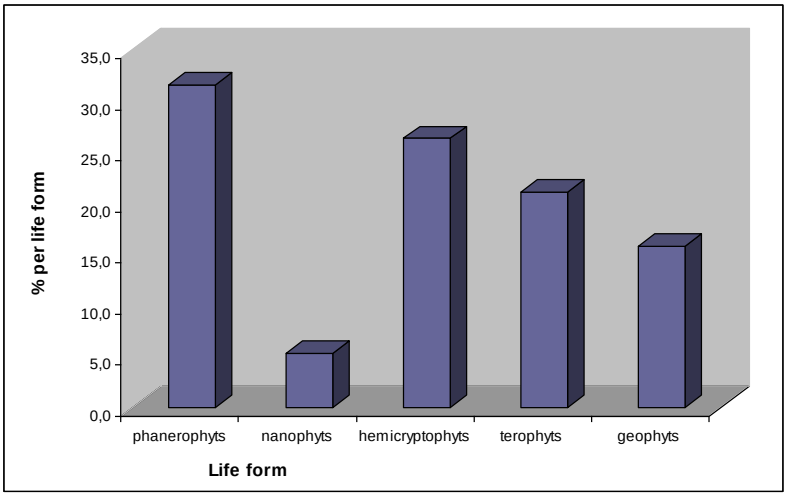

Figure 36: Life forms of alien plants in Triglav National Park.

The species life strategy (Tab. 2) constitutes one of most important components that enable the introduction and establishment of alien plants and their successful competition with native plant species in new environments. Agents for long distance dispersal (by wind, water or animals) enable them to spread over long distances and across extensive areas. Moreover, many species are able to use more than one mechanism for dispersal. Most invasive plant species are perennials or herbs which flower mostly at the end of the flowering period from mid- till late summer. In only a few species which were recorded in Triglav NP, the flowering period is limited to late spring and early summer (*Robinia pseudacacia, Spiraea japonica, Acer negundo*). Some already naturalized species, like *Aster lanceolatus, Bidens frondosa, Erigeron annuus,* and *Impatiens parviflora*, are characterized by the most extended flowering periods, while for many invasive species flowering is restricted to compariteVly short periods of one or two months.

Table 4: Life strategies of alien plant species in Triglav National Park.

Scientific name	Family	Phenology (months)	Flowering period	Dispersal type				Origin
Fallopia japonica	*Polygonaceae*	7-9	perennials	by wind	by water	with soil	vegetative, sexual	E Asiatic
Fallopia sachalinensis	*Polygonaceae*	7-9	perennials	by wind	by water	with soil		E Asiatic
Physocarpus opulifolius	*Rosaceae*	6-7	perennials	by birds				N American
Spiraea japonica	*Rosaceae*	5-6	perennials	by water	by wind	vegetative		Asiatic
Robinia pseudacacia	*Fabaceae*	5-6	perennials	vegetative	insectivores			N American
Ailanthus altissima	*Simaroubaceae*	6-7	perennials	by wind	vegetative			E Asiatic
Acer negundo	*Aceraceae*	3-4	perennials	by wind	by water	vegetative		N American
Impatiens glandulifera	*Balsaminaceae*	7-8	annualls	by wind	by water	with soil	no vegetative	Asiatic
Impatiens parviflora	*Balsaminaceae*	6-9	annualls	epizoochorous	by water	by birds	no vegetative	C Asiatic
Parthenocissus quinquefolia	*Vitaceae*	7-8	perennials	by birds				N American
Buddleja davidii	*Buddlejaceae*	7-9	perennials	by wind	by water			E Asiatic
Solidago canadensis	*Asteraceae*	8-10	perennials	by wind	with soil	insectivore	vegetative	N American
Solidago gigantea	*Asteraceae*	8-10	perennials	by wind	with soil	by water	vegetative	N American
Aster lanceolatus	*Asteraceae*	8-11	perennials	by wind				N American

This project is implemented through the CENTRAL EUROPE Programme co-financed by the ERDF

Scientific name	Family	Phenology (months)	Flowering period	Dispersal type				Origin
Erigeron annuus	*Asteraceae*	6-10	perennials or biennials to annualls	by wind				N American
Dittrichia graveolens	*Asteraceae*	autumn (around September)	annualls	by wind	by water			Mediterranean
Bidens frondosa	*Asteraceae*	7-10	annualls	by animals				N American
Helianthus tuberosus	*Asteraceae*	9-10	perennials	vegetative				N American
Rudbeckia laciniata	*Asteraceae*	7-9	perennials	by wind	by water	vegetative		N American
Ambrosia artemisiifolia	*Asteraceae*	8-10	annualls	by wind				N American

1.3. Habitats and site conditions

The distribution of alien plant species in Triglav NP according to habitat types is shown in Fig. 5. Many well established species were found in a number of different habitats, while species which until now were noted only in a few sample areas are restricted to specific or a small number of different habitat types (Fig. 5). Artificial structures in nutrient-rich ruderal sites host the highest number of alien plant species. For most neophytes road-sides and the road network appears to function as significant habitat corridors for dispersal (Fig. 6). Additionally, significant source habitats for alien plants were noted along water-courses (15.6%), which may enable some species to disperse seeds by water (*Acer negundo, Rudbeckia laciniata*). Waterside habitats are particularly important sites for *Fallopia japonica, Impatiens parviflora, Impatiens glandulifera*, and *Solidago canadensis*. Other important sites are anthropogenic meadows (10%), forest edges (10%), parking spaces (8.9%), and depots (6.7%), while tracks, paths, abandoned fields and gardens harbour lower numbers of neophytes.

For evaluating the ecological conditions at the sample sites of invasive plant species we applied indirect phyto-indication methods, i.e. Ellenberg indicator values (Tab. 3). For describing site conditions according to climate and soil characteristics, Ellenberg indices for light (L), temperature (T), nitrogen content (N), humidity (H), pH-value (R), and the continentality of the climate (C) were analysed. In particular, mean and mode values were used to evaluate climatic and soil conditions which are prefered by alien plants in Triglav NP. Most neophytes are sub-oceanic species which prefer sites with a higher amount of soil moisture. According to light, *Impatiens parviflora* is the only species with a preference for shady conditions. We have found only three half-shady species (*Robinia pseudacacia, Acer negundo, Impatiens glandulifera*), while half-heliophyte and heliophyte species prevail. Most species are thermophylous and prefer moderate warm to warm conditions. According to the regular presence of neophytes on soils with high nitrogen contents, invasive plants are good indicators for fertile soils. Most species were found on weakly acidophilous to weakly basic soils.

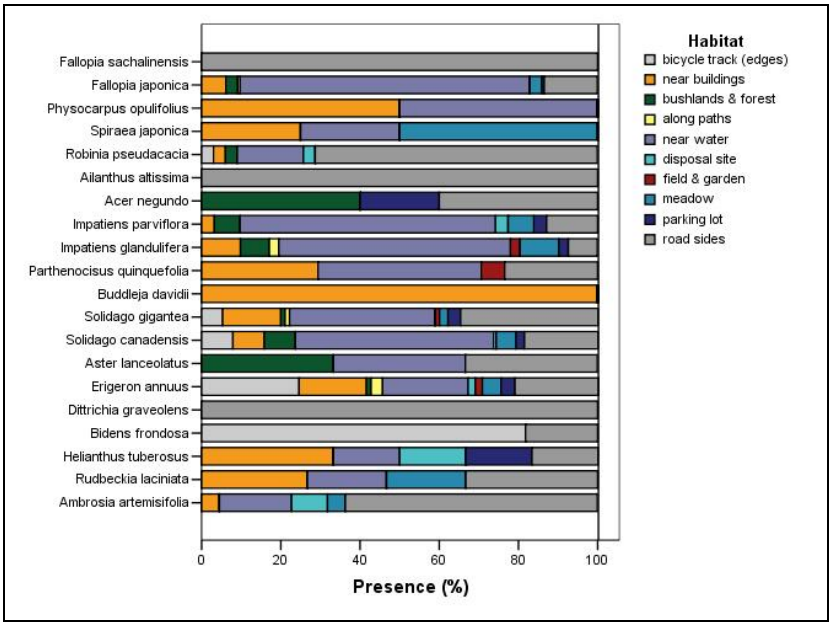

Figure 37: Distribution of alien plant species according to habitat types in Triglav National Park.

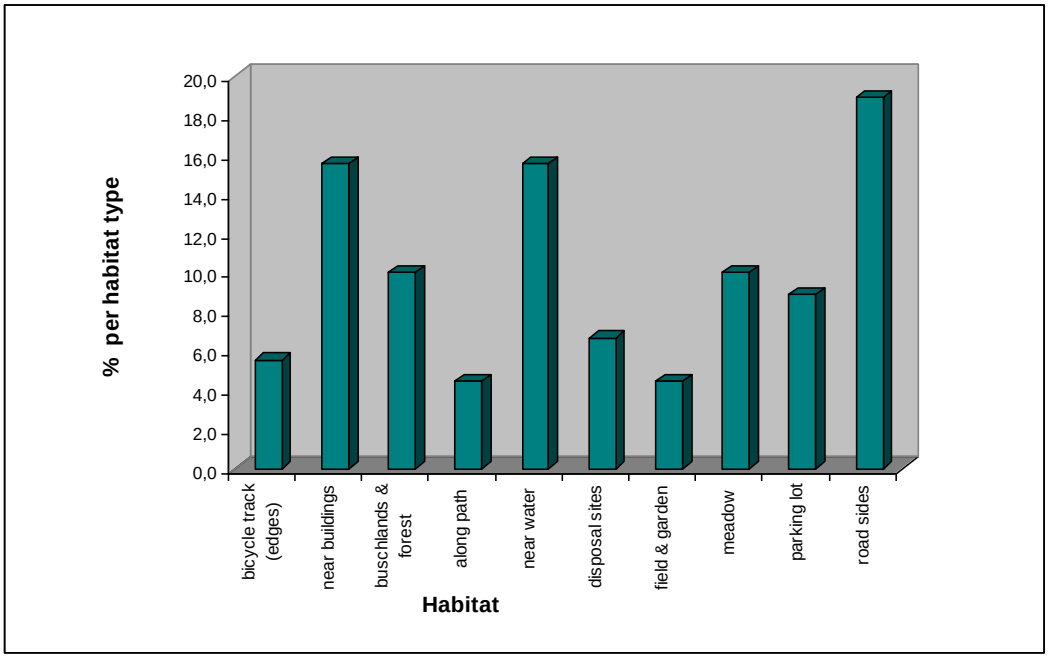

Figure 38: Presence of neophytes (percentage) in different habitat types in Triglav National Park.

Table 5: Ellenberg indicator values for alien plant species in Triglav National Park (Ellenberg et al., 2001). (L – light, T – temperature, M – soil moisture, N – fertility, R – acidity/pH, C – continentality; the meaning of the values are explained in the Appendix)

Scientific name	L	T	M	N	R	C
Robinia pseudacacia	5	6	4	8	x	4
Ailanthus altissima	8	8	5	8	7	2
Acer negundo	5	6	6	7	7	6
Impatiens glandulifera	5	7	8	7	7	2
Impatiens parviflora	4	6	5	6	x	5
Buddleja davidii	7	8	4	4	7	4
Solidago canadensis	8	6	x	6	x	5
Solidago gigantea	8	6	6	7	x	5
Aster lanceolatus	7	7	6	8	x	6
Erigeron annuus	7	6	6	8	x	x
Bidens frondosa	7	6	8	8	7	x
Helianthus tuberosus	8	7	6	8	7	?
Rudbeckia laciniata	7	6	8	7	7	5
Ambrosia artemisiifolia	9	7	4	6	8	?
Mode value	7	6	6	8	7	5
Mean value	7	7	6	7	7	4

1.4. Origins and reasons for the dispersal of alien plant species

In recent years the effects of the invasion of alien species have grown rapidly. The globalization of world economies through transportation and tourisms, the construction of a dense network of roads, railways and shipping lines and ecosystem degradations have opened many opportunities for the invasion of new species. In addition, habitat fragmentation and human pressures produce new favourable conditions for the dispersal and the establishment of alien plant species in mountain regions. Some authors argue that global warming and climate change will accelerate the spread, increase the abundances of invasive species as well as enhance the vulnerability of ecosystems to invasions (Becker et al., 2005; Küffer, 2011; Walter et al., 2009).

The most important reasons for the invasion and spread of alien plant species in Triglav NP are the following:

- transportation of building materials (*Fallopia japonica*),
- escapes from gardens (*Solidago canadensis, S. gigantea*),
- spontaneous invasion from adjacent areas (*Ailanthus altissima*).

The majority of alien plants in Triglav National Park originates from North America (12 species), while a smaller number originates from Asia and the Mediterranean Basin (Tab. 2).

2. Indicators

In many situations species indicator values, defined by Ellenberg, reflect habitat quality rather well. We therefore used Ellenberg values to analyse trends and environmental variables which underlying vegetation change (Diekman, 2003). All alien plant species, recorded in Triglav NP, are good indicators for nutrient-rich habitats and for poor acid to basic soils (Tab. 3). The following table shows the alien plant species of Triglav NP with their indicator characteristics according to Ellenberg values.

Table 6: Indicator values according to Ellenberg values (Ellenberg et al., 2001).

Scientific name	INDICATORS
Robinia pseudacacia	half-shadowy plant, indicator for drought/freshness
Ailanthus altissima	light plant
Acer negundo	half-shadowy plant
Impatiens glandulifera	half-shadowy plant, indicator for humidity
Impatiens parviflora	shadowy plant
Buddleja davidii	indicator for poor/moderate nitrogen content, indicator for drought/freshness
Solidago canadensis	light plant
Solidago gigantea	light plant
Bidens frondosa	indicator for humidity
Helianthus tuberosus	light plant
Rudbeckia laciniata	indicator for humidity
Ambrosia artemisiifolia	light plant, indicator for drought/freshness

Furthermore, the environmental indications of all plant species are listed according to published scientific materials.

In general, the invasiveness of woody species with dry fruits and mean seed mass <2.0 mg (*Populus sp., Salix sp., Betula sp., Alnus sp., Eucalyptus sp., Melaleuca quinquenervia, Tamarix sp.*) appears to be often limited to wet habitats and exposed mineral soils (Rejmánek & Richardson, 2005).

Based on research, made in Austria, the distribution of ***Ambrosia artemisiifolia*** is strongly linked with temperature. The mean temperature of the hottest month (July) appears to be of particular importance, while the mean annual temperature is regarded to be less significant (Essl et al., 2009). Consequently, climate change, i.e. rising air temperatures, promotes the growth conditions for *Ambrosia artemisiifolia*. During the latst 30 years the increase of air temperatures has prolonged the growing season, e.g. in Germany for 8-10 days, allowing some species of ragweed to grow further north and at higher altitudes (http://xwww.agrsci.dk/ambrosia/outputs/ambrosia_eng.pdf).

Robinia pseudacacia prefers high concentrations of CO2 in the air. Studies on the effects of evelated contents of atmospheric CO2 and arbuscular mycorrhizal fungi on the biomass production and N2 fixation of *Robinia pseudacacia* provide strong evidence that arbuscular mycorrhizal fungi play an

important role in the extent to which plant nutrition by symbiotic N2-fixing tree species is affected by enriched atmospheric CO2 (Olesniewicz & Thomas, 1999).

Based on research on indicator plant species for habitat quality and the invasibility in peri-urban forests, ***Antriscus sylvestris, Galeopsis tetrahit,*** and ***Senecio ovatus*** were identified as good indicators for sites which are potentially targeted by non-native species (Godefroid & Koedam, 2003).

3. Measures for the removal and control of alien plant species

So far, in Triglav NP the following actions were taken to produce public awareness for the effects of invasive species. In particular, the park's rangers were informed about the problem of alien species. An "Action Plan for Alien Species" including measures for the management, control and removal of invasive species, will be compiled during the next 3-year period within the Management Plan of Triglav National Park.

In general, prohibiting the cultivation non-native species in the park, removal of alien ornamental plantings, physical removal of alien plants from currently known sites and a continuous monitoring are the most important actions to prevent the further expansion of alien plant species in Triglav National Park.

Last year removal measures were taken for three alien species in Triglav National Park:

In August last year **extraction measures of *Ambrosia artemisiifolia*** were made in Trenta valley. After a year the results of the removal of the species are not very stimulative. The species is still present at the site, but we speculate that the new plants are deriving from older seeds which are able to germinate till more then 30 years of remaining in the soil (Baskin & Baskin, 1980). Therefore, repeated extractions of the species for the following 5-6 years are planned.

The **mowing of *Fallopia japonica*** on the eastern shore of Bohinj Lake (Fužinarski zaliv) was unsuccessful. Only the continuous removing of early succession stages was efficient to remove the species.

Last year an attempt to **remove *Bidens fondosa*** with herbicides was made along the road in Trenta valley. This method was successful to eliminate the species.

A monitoring program on the development of the vegetation on recently cleaned sites is planned for the next years. The monitoring will be important for recognising the regrowth and spread of alien species in time. To prevent the regrowth of alien species it is recommended to plant removal sites with native plants from adjacent sites.

When the gardening of alien invasive plants is recognise as a serious problem, the removal of the plants and the exchange with similar native or other no-problematic exotic species could be a solution. This particularly concerns the *Solidago* species (*Solidago canadensis, S. gigantea*).

For the substitution of invasive species with non-invasive species, the following should be taken into consideration:

- life strategy, plant aspect and ecological demands of the species (habitus, size, leaves, flowers, fruits, phenology etc.),
- ecological conditions of the site,
- the distance of the site to garden centres and parks, i.e. the probability of further invasions (Jež, 2009).

Following to these considerations *Solidago canadensis* and *S. gigantea* should be exchanged with:

- plants with similar life strategies, colour and flowering time: *Solidago virgaurea;*
- plants which flower in autumn and with similar colours: *Chrysanthemum* (garden species of Chrisantemes), *Ajania pacifica, Kirengeshoma palmata, Ligularia przewalskii* (Jež, 2009).

3.1. Prevention actions

The planting of alien species for ornamental, apicultural and similar purposes should be prevented and established neophytes should be replaced with alternative species. The planting of riversites and other degraded areas should be done with autochthonous plant species. The disturbance of soils should be minimized to prevent regeneration from the seed bank. The eutrophication of water bodies and their banks should be reduced. Surveys and monitoring programms of the dispersal alien plants and their effects on native species and native plant communities should be performed as well as public education on the effects of invasive species on native plant species and ecosystems (Bačič, 2008a,b,c; Frajman, 2008a,b,c; Jogan, 2008; Strgulc Krajšek, 2008a,b,c;

http://www.goert.ca/documents/InvFS_buddlleja.pdf).

Further suggested measures for the removal and control of alien species according to literature are the following:

3.1.1. Fallopia japonica, F. sachalinensis

Parts of *Fallopia japonica* which are left in contact with the soil, may survive and regrow; they could regenerate from rhizome fragments of less than 1 gram. Repeated cuttings of the woody weed may eventually drain the resources stored in the root system and kill the plant (Wittenberg & Cock, 2001). Digging is only effective in small initial populations or in environmentally sensitive areas where the application of herbicides is not desirable. Large colonies of the species are extremely difficult to dig out due to the high density of rhizomes. Digging of large colonies for controlling the species is not recommended as it is very labour intensive and it's unlikely that all rhizomes can be removed. Juvenile plants can be hand pulled if they are not well established and soil conditions allow complete rhizome removal. For disrupting plant growth by cutting or mowing the stalks have to be done at

least three times per season. By the procedure rhizome growth will be reduced by slowly depleting stored food reserves and the removing of photosynthetic tissue. Plant stands that are at least five years old have to be mowed for several seasons before a population reduction will be visible (http://cropwatch.unl.edu/web/cropwatch/archive?articleID=4528938). The continuous removing of young sprouts (shoots) will be necessary over a period of years, wherein waste material should be burned or dried out. Inappropriately deposited material has the potential to take roots again. Physical removing is successful only in small populations and during initial phases of invasion. Chemical removal with herbicides is more successful, but should be closely controlled. Additionally, the use of herbicides is very problematic, in particular close to open waters and along water-courses. Appling herbicides (glyphosate or triclopyr) to ca. 5 cm tall mown stems or injecting herbicides into stems is more effective. This procedure is recommended because it minimizes potential harms for the environment. The process should be sometimes repeated. In most cases management efforts are more successful when a combination of different treatment methods are used. For example, a combination of early cutting and later herbicide application allows more options and flexibility. Digging or pulling before spraying may also increase the efficiency of herbicides (Frajman, 2008a; http://cropwatch.unl.edu/web/cropwatch/archive?articleID=4528938).

3.1.2.Ambrosia artemisiifolia

http://xwww.agrsci.dk/ambrosia/outputs/ambrosia_eng.pdf:

Uprooting: All plants at the site should be uprooted systematically, preferably before flowering to avoid the spread of pollen. Uprooting of plants before seed ripening is efficient for small to medium sized populations. Non-blooming and non-fruiting plants should be dried effectively and composted. To prevent re-growth uprooted plants should be stored without contact to the soil. Alternatively, uprooted plants could be put into plastic bags with soil around the roots and rendered to waste collection or incineration. Uprooting of Ambrosia which grows in habitats with undisturbed soil, should be done slowly and carefully to minimize soil disturbance. Trampled and disturbed areas are excellent seedbeds for many weed species.

Hoeing: Hoeing at the 2-leaf stage is efficient for controlling Ambrosia in sunflower and maize crops. Hoeing can also be performed manually on small plots used for growing vegetables and produces good results under dry conditions without rain.

Mowing/cutting: Mowing is used to prevent seed production and for exhausting plants in large populations of Ambrosia in areas where chemical control is forbidden or not possible for other reasons. Cutting should be as close to the ground as possible, but without disturbances to the soil's surface to minimize re-growth. In areas with dense populations of Ambrosia cutting height should be 2–6 cm. Where Ambrosia is growing in vegetation with a dense cover of grasses a mowing height of 10 cm will prevent erosion and re-growth. Timing of cutting is crucial as it influences the plant’s possibility for re-growth and flowering. Successive cuttingss will potentially prevent flowering and fructification, but following cutting the plant is able to develope horizontal flowers carrying side sprouts which grow along the soil surface. These branches are difficult, if not impossible to cut during following cuttings. Mowing while seeds are mature should not be made, because it increases the risk

of seed dispersal. For greater efficiency mowing should be combined with other control measures. Mowing before the blossom in combination with herbicide treatment of re-sprouted plants guarantees a highly efficient control. Mechanical mowing techniques, for example a flail mower, are useful for large infested areas on plane ground. When the population is small or situated in a location unsuitable for mechanical mowing, e.g. on steep slopes, manually cutting with a scythe or a trimmer is recommended. Mowing should be replaced by uprooting where possible. Deep ploughing that buries the ragweed seeds 10 cm deep prevents the germination of seeds, while 2 cm seed burial does not.

Mechanical treatments

In our trials we have observed that Ambrosia is able to re-grow after the first cut. A second cut can hardly reach the horizontal side sprouts growing along soil surface, which are able to produce fertile seeds although at reduced numbers.

Chemical control: Herbicides are recommended for large infested areas and in non-organic crops. Common ragweed has developed resistance to different groups of herbicides. In North America common ragweed was found to be resistant to 10 times the normal rate of glyphosate.

Herbicide treatments

All herbicide treatments used in the trial series (glyphosate, mesotrione, clopyralid, MCPP and florasulam) reduced the biomass of Ambrosia. When controlling Ambrosia with herbicides, the timing of the treatment has an influence on biomass reduction. The best effects were obtained when the plants were treated in the 4-leaf stage. ED50 was calculated for all herbicides. Glyphosate was the only herbicide where the effect was independent of the growth stage. Three growth stages from the 4-leafs stage to inflorescence were investigated. Also other herbicides produced good results for reducing Ambrosia biomass, but doses had to be increased when treatment was done during later stages to obtain the same efficiency level. Sequential treatments – application of herbicides in two passes, the so-called split application – showed synergistic effects. Most split applications were more effective than one application (florasulam, MCPP and mesotrione). Dose requirements were highly dependent on growth stage at application. Low doses should only be applied at early growth stages. Potential negative effects of low doses at the first application was not fully investigated. In this one-year experiment low doses at the first treatment did not reduce the effect of the second treatment. In practical agriculture sequential treatments are common in row crops such as sugar beet and maize. If conditions were perfect for the first treatment, a second treatment could possibly be adjusted according to the efficiency level of the first treatment. On the other hand, if weather conditions were not perfect at the first treatment, a good knowledge about sequential treatments allows farmers to achieve high efficiency with the second treatment. Sequential treatments increase machine and labour costs.

Mulching: Mulching can be used to limit seed germination on small areas, e.g. on construction sites. The ground and/or seedlings is covered with mulch (hay, grass clippings, wood chips, etc.) or other types of ground cover. Mulch cover can prevent seed grains to germinate and prevent the growth of germinated seeds (seedlings).

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Plastic cover: Cover of (black) plastic can be used instead of mulch at construction sites to reduce the light which reaches the soil surface and for raising soil temperature to levels that will kill small plants and prevent seeds to germinate.

Biological control: At present, no effective biological control agent is available for *A. artemisiifolia* in Europe. Biological control has been attempted in Russia, Ukraine and former Yugoslavia, and several insect agents were introduced between 1969 and 1990, but so far the most promising agent, *Zygogramma suturalis* (Coleoptera, Chrysomelidae*)* failed to result in successful control. Further work is needed in this area.

Animal grazing: Animal grazing is not considered to be a feasible control method although common ragweed has a rather high content of crude protein and a high digestibility during spring when the plant eaten in large amounts may be poisonous to the animals. Dairy products from cows feeding on common ragweed have been reported to have an objectionable odor and taste. High grazing pressures which will be necessary for controlling Ambrosia plants, stimulates seedling emergence due to an increased light influx.

3.1.3.Solidago canadensis, S. gigantean

According to the wide distribution of the species in the park, possibilities for its total removal are weak. The spread of small and local populations could be prevented by cutting and the removal of the plants before flowering. Thus, the best practice for managing the species will be by preventing the introduction of new seeds into the soil seed bank and the germination of new plants. In particular, regular and timely mowing may eventually exhaust the nutrient supply in the roots and result in the plants fail. Various sources indicate that mowing twice a year, in May and August, over a number of years reduces the density of the species' stands drastically. In its natural environment in North America where the species is also found in weed fields, *Solidago canadensis* is successfully suppressed by plowing (Strgulc Krajšek, 2008b,c).

3.1.4.Ailanthus altissima

Repeated sawdust (harvesting) or felling of the trees (in early summer) until the plant is exhausted. Younger plants can be removed manually from moisture soils, in which lesser roots remain. The most successful method may be the application of herbicides: putting the spray on leaves and on the green parts of trees, putting herbicides on young trees in late winter or early spring, and by putting herbicides on stumps, and ringing with putting the spray. In Slovenian forests the use of chemical methods is forbidden (Arnšek, 2009; Bačič, 2008a).

3.1.5.Acer negundo

In some parts of Slovenia the species is already widespread, thus, it will be difficult to eradicate it completely, but the prevention of a further spreading appears to be reasonable. Eradication will be possible in sites where the species is present only with few specimens. Young plants can best be

removed by excavation. Higher plants should be cut above the ground parts. Larger trees can be removed by sawing (harvesting). To increase the efficiency of excavations, the stumps should be primed with herbicide containing glyphosate. Cleaned surfaces should be monitored, because underground parts may regrow shoots. When necessary the process should be repeated (Strgulc Kranjec, 2008).

3.1.6. Impatiens glandulifera

Removing plants or mowing before flowering and frooting. Due to the presence of seeds in the soil it will be necessary to repeat the process for two or several years in a row. Such removal can be successful where the species occurrs in isolated stands. Plants should be also removed by regular sheep or cattle grazing. It is further desirable that sites where the species was removed, are planted with native plant species from the environment. Otherwise these surfaces can be easier invaded by other non-native species that will be difficult to remove (e.g. *Fallopia japonica*) (Frajman, 2008b).

3.1.7. Impatiens parviflora

http://www.eppo.org/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/draftds/05-11832%20DS%20Impatiens%20parviflora.doc:

Cutting and pulling of the plants in the flowering phase before seed-set may be an effective control measure (Coombe, 1956). Slugs and *Impatientinum asiaticum* are thought to have the greatest antagonistic effect on *Impatiens parviflora*. Several phytopathogenic fungi are found on *I. parviflora* in central Europe, among them two species of Sphaeropsidales (*Ascochyta impatientis*, *Phyllosticta impatientis*), two Uredinales (*Puccinia argentata*, *P. komarovii*) and a Erysiphales species (*Shaerotheca balsaminae*). All these species are also found on *I. nole-tangere*???, with only *P. komarovii* specific to *I. parviflora* (Schmitz, 1998b). The latter species has spread from the native range of *I. parviflora* to Europe, first recorded in Ukraine in 1921, in Germany in 1935, Switzerland in 1938, Slovakia in 1942 and since then has extended its range further westwards. Even though it is mostly of little apparent impact, it has repeatedly been observed to kill whole populations of *I. parviflora* (Eliás, 1995; Bacigálová *et al.*, 1998).

3.1.8. Buddleja davidii

http://www.invasive.org/weedcd/pdfs/wow/butterfly_bush.pdf;
http://www.evergreen.ca/docs/res/invasives/Invasive-Plant-Profile-Butterfly-Bush.pdf;
http://www.goert.ca/documents/InvFS_buddlleja.pdf:

Butterfly bush plants do not reproduce vegetatively by underground parts, so they are fairly easy to remove. Plants tend to form the greatest infestation densities in the first 10 years. Seeds may lie dormant in the soil for many years, although no precise age for the seed bank has been reported.

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Mechanical control: The best time to remove the plants is when they are just coming into flower but have not yet produced seeds. Small plants can be easily hand-pulled when the soil is moist. Larger bushes can be removed effectively by cutting the plant at the base and either digging up the stump or covering it with a thick plastic bag or mulch to prevent regeneration from the roots. Remove new shoots until the rootstock dies, and do not leave stems on the ground, or they may root regrow???. Extremely large plants may be winched for removal, but care should be taken to limit soil disturbance. Manual or hand pulling can be effective if care is taken to extract all stumps and roots, to minimize soil disturbance, and to prevent seed spread. Normally the following techniques are used: (1) Pull or dig up plants and remove as much of the root as possible in small infestations. Remove all mature plants to prevent new seed production. (2) Mature shrubs can also be cut down. Mowing does not work on young, green plants. Cut near the ground where the stem is more yellow than green, this is best done while the plant is flowering. Cutting when the seeds are set can lead to unintentional seed dispersal. (3) If full removal of the plant is not practical, cut off flower heads in June-July, before the seeds set.

Chemical control: As herbicides usually triclopyr or glyphosate are used. After the plant is cut to ground level, applying a glyphosate herbicide on the stump prevents the plant from regenerating. Areas should be reseeded with desirable native plants. Herbicides should be used only with extreme caution and expert advice.

Biological control: Goats eat the plant. They are damaging the plant by stripping leaves and flowers and by breaking plants over. Areas which can be fenced can be treated with goats if a 3-4 year treatment program is acceptable. A leaf-feeding weevile (*Cleopus japonicus*), and a stem-boring beetle (*Mecysolobus erro*), are considered for releasing in New Zealand, but no biological agents are currently available in Canada,

(more information: www.hortnet.co.nz/publications/nzpps/proceedings/99/99_113.pdf).

3.1.9. Erigeron annuus

Pulling of plants; repeated mowing for several years until the plant is exhausted (Bačič, 2008b).

3.1.10. Spiraea japonica

Low mowing for at least once a year prior to flowering over a row of years will largely deplete the population but usually does not destroy it. It is suitable to monitor small populations on more easily accessible terrain. Large populations can be successfully suppressed by various herbicides, but the use of chemicals is, of course, related to the environment from which we want to remove the species (Jogan, 2008).

3.1.11. *Dittrichia graveolens*

http://www.dpi.qld.gov.au/documents/Biosecurity_EnvironmentalPests/IPA-Dittricha-Graveolens-Risk-Assessment.pdf:

Isolated plants can be controlled by hand weeding or hoeing. The species could be difficult to control with herbicides, due to its oily leaves which reduce penetration by most chemicals. In some areas, it has been controlled with 2,4-D ester, but this product must be used with caution as it is liable to cause off-target damage. It cannot be used in restricted spraying areas. (More detailed information: Parsons, W. T., Cuthbertson, E. G. 1992: Noxious weeds of Australia. Inkata Press, Melbourne/Sydney. 692 pp.)

3.1.12. *Bidens frondosa*

http://dar.zrsvn.si/slike/ras/vpl/mrk/nav.html:

The extraction of smaller plants and its imidiate burning in barrels is recommended as the most sucessful action to remove the plant. But, you should be very careful for not causing the spread of seeds. Therefore, on seeding plants paper tubes should be placed (e.g. cement bags with cutting both edges). The tube should be firstly fixed on the bottom and thereafter on its top to prevent shaking the seeds from the bag. Then the plant is extracted and burned in a barrel together with the bags. Frequent mowing is also effective. Very young plants should be mowed at the ground, befor the sprouting of buds or the starting of blooming, while also mowed plants with buds could start to bloom and fruiting. Removed plants (*Bidens frondosa* and other plant species) should be burnt in barrels: brushwood is burnt in old petrol barrels with holes for air, and the plants (with bugs) are burnt on the embers. The fire should be weak, to prevent the dispersal the plant weeds around the firebox. Finally, the brushwood should be burnt again, to make sure that all plants have been burnt. At the end only the ash should remain, without any part of plants.

3.1.13. *Helianthus tuberosus*

Removal of the plant's tubers in spring and early summer (Bačič, 2008c).

3.1.14. *Rudbeckia laciniata*

Removing of the plants or mowing before the plants are blooming and frooting. This will be a long process because it takes a long time before rhizomes are exhausted from all stored nutrients. The effect of removing will be greater when, as much as possible, plants are removed together with rhizomes. But rhizomes needed to be dried out and burnt to prevent a further expansion of the species through remaining rhizomes. Such removals will be successful where the species inhabits isolated areas. It is also possible to remove the species with herbicides. But this should be carefully controlled to avoid contaminations of the environment, especially close to open waters and water-courses. It is further recommended to replant locations from which the species was removed, with native species from the surroundings (Frajman, 2008c).

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3.1.15. *Robinia pseudacacia*

http://www.issg.org/database/species/reference_files/robpse/robpseman.pdf; Sabo, 2000 (http://conservancy.umn.edu/bitstream/59729/1/6.3.Sabo.pdf):

Robinia pseudoacacia invasions need to be controlled because it has the ability to vary its growth patterns, thrive in many regions, and grow at very aggressive rates.

Mechanical control: Cutting *R. pseudacacia* stimulates sprouting and clonal spread. Therefore, some authors recommend against the simple cutting of stems. Mowing and burning may temporarily control spreading, but mowing seems to promote seed germination, and burning stimulates sprouting. Girdling is ineffective, because it kills the stem but does not prevent sucker formation. On disturbed lands, the most effective option to rid the site off *R. pseudacacia* may be to bulldoze the surface. Unfortunately, removing all vegetation will likely result in high rates of soil erosion (DeLoach, 1997). Burning is often a viable option for managing invasive species over large areas. In grassland ecosystems, annual haying may be able to control the spread of first year seedlings while their root systems are not very developed. However, if reproductively mature trees are present, mowing of small seedlings may promote seed germination (Heim, 2000), probably by scarifying the thick seed coats of previously dropped seeds. Roots that remain after top removal by mechanical methods often result in suckers and sprouts with increased vigor (Converse, 1984). Girdling which involves the cutting of the inner bark or phloem, but leaving the sapwood or xylem is a common method for killing trees as is the cutting near the tree's base (Solecki, 1997). Neither of these well-known methods are recommended for *R. pseudoacacia* though, since the killing of the main stem is often followed by the formation of suckers from the tree base.

Combination of mechanical and chemical techniques: Due to the unsuccessfulness of mechanical methods alone, a common method of *R. pseudacacia* control involves both mechanical and chemical treatment. Firstly cutting or girdling the tree and then applying herbicides on the stump appears to be a viable option. Directions from the Roundup (glyphosate) manufacturer suggest that stumps should be treated with a 50-100% concentration but, according to Heim (2000), a 20% concentration is sufficient. Heim (2000) states that “the best success with herbicides has resulted from basal bark application of herbicides to live standing trees … when trees are small and thin-barked.” For this he recommends using a 2% solution of Remedy (a formulation of triclopyr) in diesel fuel. Heim (2000) discourages the use of picloram (Tordon, RTU) for stump treatments since robust sprouting occurs afterwards. Additionally, he states that picloram is both highly mobile and persistent in the soil, so it should not be used on sandy soils. Another herbicide, triclopyr, is manufactured for dilution with diesel fuel or mineral oil. Although mineral oil is more costly, it is likely to be less toxic to non-target organisms (Wisconsin DNR, 1999).

Chemical control: Because *R. pseudacacia* has an extensive root system over a broad area, widespread chemical application may be most feasible. Examples of herbicides used for removing *R. pseudacacia* include dicamba, fosamine, glyphosate, imazapyr, picloram, and triclopyr. Combinations that have been documented to be effective against *R. Pseudacacia.* Combinations which will be readily useable for land managers with little experience with herbicide application include fosamine plus imazapyr and glyphosate plus imazapyr. Glyphosate is a good choice as a primary ingredient in mixtures due to its effectiveness, the widespread familiarity with its activity and behavior in the

environment, availability, and low costs. Glyphosate, triclopyr diluted with water, or fisamine ammonium can be utilized as foliar sprays late in the growing season. Foliar sprays work best on thick patches under five feet high or in small isolated plants since all branches and stems need to be treated. This technique is not recommended in high quality natural areas. In particular glyphosate should not be sprayed on such sites because it is a nonselective herbicide (Wisconsin DNR, 1999). Runoff from triclopyr could also harm non-target species. Therefore, it should not be used if rain is forecasted within the next one to four days (Heim 2000). In addition to harming non-target organisms, inefficient spraying can damage water quality.

Biological control: *Megacyllene robinae* is a major insect pest of *R. pseudacacia* that often transmits the fungus *Phillinus rimosus* (syn. *Fomes rimosus*) which is causing rimosus root rot. Adult *M. robinae* feed on the pollen of *Solidago* spp. and lay eggs in the bark of *R. pseudoacacia*. In spring, larvae bore into the tree's wood, which results that the weakened tree is more susceptible to wind breakage and possible fungal rot (Hoffard, 1992). *M. robinae* has a wide distribution because it was inadvertently transported along with *R. pseudacacia*. J. Haarstad, CCNHA naturalist, doubts the practicality of biological control with *M. robinae*, at least in Minnesota, but he has noticed another insect pest, the leafhopper (*Thelia bimaculata*) which causes more damage to *R. pseudoacacia*.

For tree species, *Parthenocissus quinquefolia, Aster lanceolatus, Physocarpus opulifolius,* no data on their management and control could be found.

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4. Management implications

Changes in ecosystem structure and processes that allow the initiation and dispersal of alien plants should be addressed before effective control can be achieved (Hobbs & Humphries, 1995). Before choosing appropriate management tools, the following activities should be considered:

- management goals (conservation or restoration of ecosystems),
- evaluating of the extent and quality of the area which should be managed,
- the invasive target species affecting the area,
- the effects of management activities on native species and ecosystems,
- time schedule and costs.

A successful management plan for invasive species should include the following steps (Hobbs & Humphries, 1995; Wittenberg & Cock, 2001):

1. **The use of literature, databases, and other available information.**
2. **Analysis of the condition of ecosystems (conservation value of habitats, degradations).**
3. **Analysis of the extent of species and effects of alien species on ecosystems and native species (potential loss of native species).**

   I. Current and potential extent of the species:

   1. Species not yet on the site but which are present nearby.

   2. Species present on the site as new populations or outliers of larger infestations, especially if they are expanding rapidly.

   3. Species present on the site in large infestations that continue to expand.

   4. Species present on the site in large infestations, which are not expanding.

   II. Current and potential impacts of the species:

   1. Species that alter ecosystem processes such as fire frequency, sedimentation, nutrient cycling, or other ecosystem processes.

   2. Species that kill, parasitise, hybridise or outcompete natives and dominate otherwise undisturbed native communities.

   3. Species that do not out-compete dominant natives but:

   - - prevent or depress recruitment or regeneration of native species;

- - reduce or eliminate resources (e.g. food, cover, nesting sites) used by native species;
- - promote populations of invasive non-native animals by providing them with resources otherwise unavailable in the area;
- -significantly increase seed distribution of non-native plants or enhance non-native plants in some other way.

4. Species that overtake and exclude natives following natural disturbances such as fires, floods, or hurricanes, thereby altering natural succession, or that hinder restoration of natural communities.

III. Value of the habitats/areas the species actually or potentially infests:

1. Infestations that occur in the most highly valued habitats or areas – especially areas that contain rare or highly valued species or communities and areas which provide vital resources.

2. Infestations that occur in less highly valued areas. Areas already badly infested with other pests may be given low priority unless the species in question will make the situation significantly worse.

IV. Difficulty of control and establishing replacement species:

1. Species likely to be controlled or eradicated with available technology and resources and which desirable native species will replace with little further input.

2. Species likely to be controlled but will not be replaced by desirable natives without an active restoration programme requiring substantial resources.

3. Species difficult to control with available technology and resources and/or whose control will likely result in substantial damage to other, desirable species and/or enhance other non-indigenous species.

4. Species unlikely to be controlled with available technology and resources. Finally, pest species whose populations are decreasing or those that colonize only disturbed areas and do not move into (relatively) undisturbed habitats or affect recovery from the disturbance can be assigned the lowest priorities.

(Wittenberg & Cock, 2001)

4. **Analysis of past control actions, their success/failure, and their ecological risks.**
5. **Identifying the species of higher priority for management (extent, impact, ecological value of habitats invaded, difficulty of control).**

As species of highest priority are considered those that are known or suspected to be invasive but which are still present in small numbers, species which can alter ecosystem processes, species that

occur in areas of high conservation value, and non-indiginuous species for which a successful control is expected (Wittenberg & Cock, 2001).

6. Identifying optimal management tools.

Control

The control of invasive plant species means the long-term reduction of its densities and abundances below a pre-set acceptable threshold. Control and removal methods may be effective in areas of lower density and when the population is limited to a small area. Because in the short-term control seems to be a cheaper option than eradication, it is often the preferred method (Wittenberg & Cock, 2001).

Mechanical control includes mowing, manual removing or can be used in eradication programs. In many cases combined cutting of the plant and painting the stem with a herbicide proves to be more efficient. Mowing of herbs and grasses may lead to the same result, when the plants are not adapted to heavy grazing. Annuals are especially susceptible to mowing shortly before setting flowers, because they will have used up most of their root reserves to produce the buds. Girdling can kill trees; cutting with a knife through the cambium of a tree trunk and removing 5 cm of bark will interrupt the flow of nutrients and kill the plant. Girdling alone may not suffice for rapidly killing those species where the water and nutrient movement are not restricted to the outermost layer of the trunk, but an application of herbicide will speed up the process (Hobbs & Humphries, 1995; Wittenberg & Cock, 2001).

Chemical control involves use of herbicides and other pesticides and has therefore the most negative effects on the environment (water, soil organisms). Widely used application methods for herbicides include treatments of the bark of young trees or applying herbicide into the wounds created by girdling or cutting. Herbicides can also be applied directly to the leaves of the invasive species by using a sponge or wick, but a less specific method is foliar spraying of infested areas (Hobbs & Humphries, 1995; Wittenberg & Cock, 2001).

Biocontrol is the intentional use of predators or pathogens that control populations of invading species. Organisms attacking the plant at various life-cycle stages have to be considered and tested, as well as their impacts to whole ecosystems (Hobbs & Humphries, 1995).

Eradication

For controlling invasive plant species through eradication mechanical, chemical and biological methods, as well as habitat management may be appropriate. All methods are most effective during initial stages of invasion and for small populations which are limited to small areas, but hopeless and waste of time and resources for those invasive species that have any obvious environmental impacts (Rejmánek & Pitcairn, 2002; Wittenberg & Cock, 2001). In eradication programmes all stakeholders and the public should be integrated. Eradication programmes have to be preceded by an analysis of costs, the likelihood of success, and predictions of possible consequences for the ecosystem. Eradication should be only considered if it appears to be feasible. When the eradication of invasive species is successful, it constitutes the most cost-effective method of long-term control. Most plants

will be best eradicated by a combination of mechanical and chemical treatments, e.g. cutting of woody weeds and the application of herbicides to cut stems (Wittenberg & Cock, 2001).

Containment

Containment is a special form of control. It means the restriction of an invasive species to a limited geographical range (Wittenberg & Cock, 2001). Containment programmes need to be designed with clearly defined goals: barriers beyond which the invasive species should not spread, habitats that are not to be colonized and invaded, etc. The nearest suitable habitat for the species should be separated by a natural barrier or an effective artificial barrier. This method is particularly suitable for species that are spreading slowly and over short distances (Wittenberg & Cock, 2001).

Mitigation

Mitigation measures aim to reduce the density and abundance of non-native species. This method affects alien species not directly. It focuses on native species which are affected by non-indigenuous plant species. The method is most commonly used for the conservation of endangered species. An extreme form of this method constitutes the translocation of viable populations of endangered species to ecosystems where competing invasive species are not occurring (Wittenberg & Cock, 2001).

Acceptance

Acceptance is recommended in cases where neophytes do not cause negative effects on native flora, fauna and ecosystems (Wittenberg & Cock, 2001).

Preventive actions

Preventive actions include the raising of public awareness, building regulations, and similar activities.

7. **Habitat restoration by using native plant species.**

8. **Monitoring and researches.**

Monitoring and early warning are crucial elements of any system aiming at the identification of risks. Monitoring programmes of alien plant species have to include activities to obtain information on:

- effects of neophytes on ecosystems and native species;
- distribution, ecology, and dispersal patterns of invasive plants;
- the response of invasive species to management activities.

On the basis of monitoring data it is possible to make decisions on the most appropriate management tool for a particular plant species in a specific site. Scientific analysis further provides a stronger scientific basis for decision-making (Shine & Genovesi, 2001).

9. **Public awareness, education, developing information systems (databases) with neighbouring regions.**

10. **Cooperation between different sectors (nature conservation, forestry, agriculture).**
11. **Stakeholder involvement.**
12. **More rigorous implementation of existing laws that restrict the transport and import of species that are likely to be invasive, and rigorous implementation of legal acts considering the removal of building materials and planting with native plants.**
13. **Evaluation of management plan (methods and actions, by which managing of alien species will be evaluated).**

5. Monitoring actions for nature conservation

By assessment of habitat quality invasive alien species as monitoring indicators could be taken into consideration. With the registration of “low quality”-indicators, such as invasibility indicators, the monitoring of unwanted disturbances (effects) should be possible (Godefroid & Koedam, 2003). A preventive control policy of non-native taxa could be made also by locating stands having a high risk of invasion with the help of native flora. In that way, it will be possible to obtain a precise view of risk areas needing inspection and management in order to minimize risks for the establishment of non-native flora. This type of preventive control will be more efficient than a curative policy, because restoration measures often produce poor results (Godefroid & Koedam, 2003).

The monitoring and survey of vulnerable sites and frequent eliminations of the seedlings of non-native species, before they spread, has been stressed by many authors as the most cost effective way to prevent the invasion of non-native species (Godefroid & Koedam, 2003; Vitousek et al., 1997).

Further monitoring and research are needed in Triglav National Park to find out which processes favour the invasion of non-indigenous plants, which traits of non-native species (life strategies), environmental conditions and which vegetation types (species composition!) are responsible, most vulnerable or may enhance the invasion of non-native species in mountain areas. Furthermore, a monitoring program should include the effects of the removal of alien species: vegetation development and soil characteristics after cleaning, possible effects of soil erosion and sedimentation, the success of selected management tools and the time of removal.

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6. Literature review on alien species

ALIEN SPECIES DATABASE

- GLOBAL INVASIVE SPECIES DATABASE: http://www.issg.org/database/species/List.asp
- DAISIE-project: http://www.europe-aliens.org/
- European Weed Research Society Invasive Plants: http://www.google.si/imgres?imgurl=http://www.ewrs.org/IW/images/Ambrosia_artemisiifolia_plant_in_fielda.jpg&imgrefurl=http://www.ewrs.org/IW/photos_ambrosia.asp&usg=__ZeLhY1kagJzeJykAMwN2RVxT0ZY=&h=400&w=535&sz=231&hl=sl&start=21&zoom=1&tbnid=6fzfqCwWcPlruM:&tbnh=99&tbnw=132&ei=Ah1NToDiJMHm-gbWwsTpBg&prev=/search%3Fq%3DAMBROSIA%2BARTEMISIIFOLIA%26um%3D1%26hl%3Dsl%26sa%3DX%26tbm%3Disch&um=1&itbs=1
- http://www.corpi.ku.lt/nemo/
- FloraWeb (www.floraweb.de) - details of taxonomy, biology, ecology, habitat, distribution, threat, protection and use, as well as photos and distribution maps for all of the approximately 3 500 native and alien plant species growing wild in Germany.
- The NeoFlora Web site (www.neophyten.de) - general information about alien species and data sheets for 30 invasive plant species whose biology, distribution, introduction history, impacts on nature and land use are outlined as well as possible control measures.
- INVASIVE SPECIES IN BELGIUM: http://ias.biodiversity.be/species/show/42

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- ALIEN PLANT SPECIES BIOLOGY AND DISTRIBUTION (POSTERS): http://www.emapi.us.edu.pl/pdf_lecture/posters_a.pdf
- Plans for Managing Invasive Plants: http://www.fws.gov/invasives/staffTrainingModule/planning/plans.html
- http://www.nps.gov/yose/parkmgmt/upload/Yosemite%20Inv%20Plant%20EA%205_19_08.pdf
- management tools: http://tncweeds.ucdavis.edu/tools.html

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- Managing Invasive Plants: http://www.fws.gov/invasives/staffTrainingModule/planning/plans.html
- Biocontrol: http://www.fws.gov/invasives/staffTrainingModule/methods/biological/practice.html
- Monitoring and Evaluation: http://www.dcnr.state.pa.us/forestry/invasivetutorial/Monitoring.htm
- INVASIVE ALIEN PLANT RESEARCH PROGRAMME PROPOSAL: http://www.sanparks.org/parks/kruger/conservation/scientific/ff/alien_biota/reports/intern%20report-%20aliens%20research%20.pdf

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7. Literature – Triglav National Park

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APPENDIX – Triglav National Park

Table 7: Explanation of Ellenberg indicator values (Ellenberg et al., 2001).

L		T		M		N		R		C	
1	deeply shadowy plants	1	indicator for cold (alpine and nival altitudinal belt)	1	indicator for total dryness	1	very poor with nitrogen content	1	indicator for heavy acidic	1	eu-oceanic
2	between 1 and 3	2	between 1 and 3 (alpine altitudinal belt)	2	indicator for dryness	2	between 1 and 3	2	between 1 and 3	2	oceanic
3	shadowy plants	3	indicator for cool (prevailing sub-alpine altitudinal belt)	3	indicator for drought	3	poor nitrogen content	3	indicator for acidic	3	between 2 and 4
4	between 3 and 5	4	between 3 and 5 (high montane, montane altitudinal belt)	4	between 3 and 5	4	between 3 and 5	4	between 3 and 5	4	sub-oceanic
5	half-shadowy plants	5	moderate thermophilous (planar to montane altitudinal belt)	5	indicator for freshness	5	moderate nitrogen content	5	moderate acidic	5	between condition
6	between 5 and 7	6	between 5 and 7	6	between 5 and 7	6	between 5 and 7	6	between 5 and 7	6	sub-continental
7	half-light plants	7	thermophilous	7	indicator for humidity	7	high nitrogen content	7	poorly acidic	7	between 6 and 8
8	light plants	8	between 7 and 9 (sub-mediterran)	8	between 7 and 9	8	indicator for nitrogen content	8	between 7 and 9	8	continental
9	full-light plants	9	extrem thermophilous (warmest sites for Mediterran)	9	indicator for wetness	9	excessive nitrogen content	9	basic (limestone ground)	9	eu-continentaln
				10	amphibious water plants						
x	indifferent data			11	under-water plants						
?	unknown data			12							