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Presence of alien ligneous species in some plant associations from Danube Delta and their management

[1]Bogdan M. Negrea, [2]Mihai Doroftei, [3]Meike Grimm, and [1]Cătălin C. Roibu

[1] Faculty of Forestry, University "Ştefan cel Mare" Suceava, Suceava, Romania; [2] Danube Delta National Institute for Research and Development, Tulcea, Romania; [3] University of Leipzig, Faculty of Physics and Geosciences, Department of Geography, Leipzig, Germany. Corresponding author: B. M. Negrea, bogdannm@yahoo.com

Abstract. This paper presents a brief overview of the most important species of alien woody plants of the Danube Delta. Also presents the habitats where they are found. Stational conditions are studied and described of each habitat type apart, in order to study the affinity of species to certain environmental conditions. In the annex paper there is presented each habitat where woody alien plants appear. Also there is an overview and rehabilitation measures that are required of these habitats.
Key Words: vegetal associations, ligneous species, alien species, habitat restoration, basin area.

Rezumat. Lucrarea prezintă o trecere în revistă a celor mai importante specii de plante lemnoase alohtone din Delta Dunării, cât şi a habitatelor unde acestea se întâlnesc. De asemenea, sunt descrise condiţiile staţionale ale fiecărui tip de habitat în parte pentru a putea studia afinitatea unor specii pentru anumite condiţii de mediu. În anexa lucrării sunt prezentate habitatele unde plantele alohtone lemnoase apar. De asemenea sunt trecute în revistă şi măsurile ce se impugn pentru reabilitarea habitatelor afectate de aceste plante alohtone.
Cuvinte cheie: asociaţii vegetale, plante lemnoase, specii alohtone, reabilitarea habitatelor, zona depresionară.

Introduction. Growing number of naturalized alien species is perceived as an important indicator of global uniformization. It is shown the fact that the changes in distribution of a species are natural phenomena. The natural area of an species can extend or reduce.

Such species can colonize new regions outside the natural area. Nevertheless, such events are rare and often restricted by natural barriers (Wittenberg 2005). Globalization as an actual fenomena can lead to uniformity, without having the natural barriers as an important factor in maintaining biological diversity (Blossey & Notzold 1995; Anastasiu & Negrean 2005). Current perception over the invasion process in a distorted one. This fact is due to actions of monitoring and control are focused only on aggressive species, which eliminates the native ones or change the invaded ecosystem (Cogălniceanu 2007).

The main purpose of this paper is to establish the trends of vegetation evolution in some areas of Danube Delta. Pressure of alien species and all nowadays global changes also have an important role in our study.

Material and Method. The relevee and transect method was employed in the field (according to coverage – percentage method). The species have been recorded on an established surface (100 m^2) meant to reflect the average characteristics of the investigated areas.

General presentation of the areas were the research was conducted. In order to conduct the research were selected five different areas (Figure 1) of the two major sectors of Danube Delta (Covaliov et al 2012).

In the fluvial delta were selected three major areas:

1. Basin of Sontea – Fortuna,
2. Basin of Matita – Merhei,
3. Basin of Dranov.

In the fluvio-marine delta, were selected two major areas:

4. Coastal area; Sulina – Sfântu Gheorghe sector,
5. Caraorman sand bank.

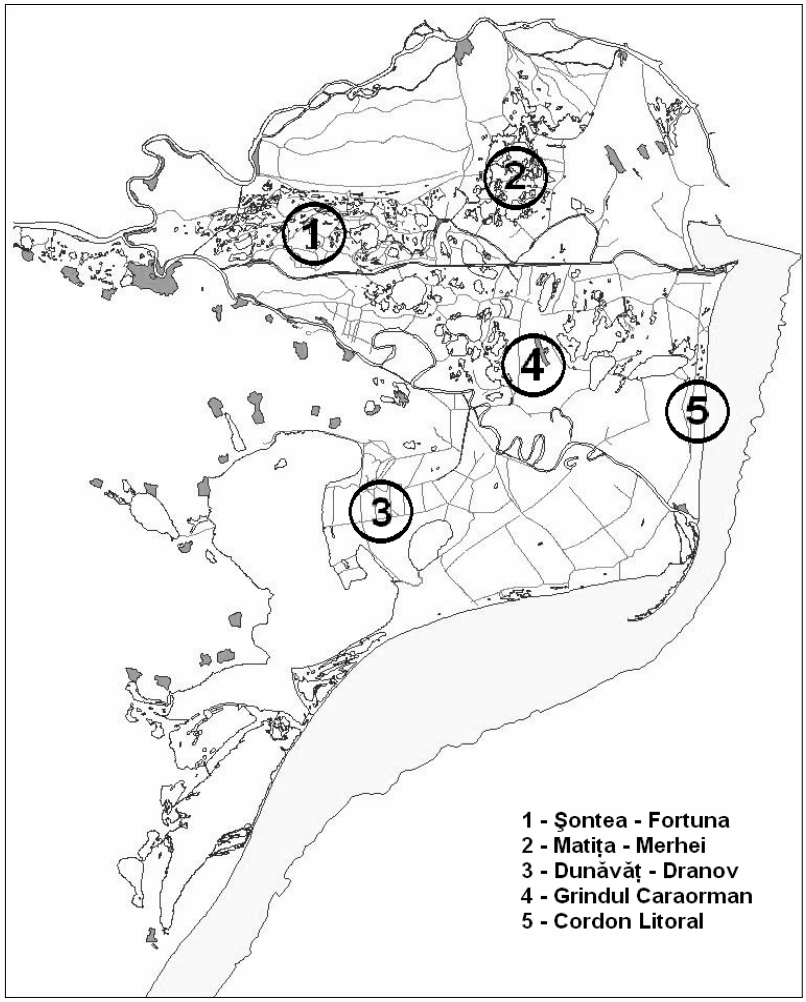

Figure 1. The areas of Danube Delta were the research was conducted.

In each area were studied the species *Elaeagnus angustifolia*, *Acer negundo*, *Amorpha fruticosa, Ailanthus altissima*, *Robinia pseudoacacia*, *Fraxinus pennsylvanica*, *Lycium barbarum* and *Gleditsia triacanthos* from different habitats, in order to observe the way species adapt and spread.

1. Basin of Sontea – Fortuna (Figure 2, Table 1) - is part of fluvial delta. The basin is located northern of the Sulina branch and southern of Stipoc sand bank between Sireasa and Matita-Merhei basins. Within this area there are a series of water areas (backwaters and channels, lakes and flood patches). The total surface of these is aprox. 2219 ha. There are also some embanked enclosures aprox. 14431 ha (Gomoescu 2002).

The basin is crossed by six main chanells: Sireasa channel, Mila 23 channel, Sontea channel, Stipoc channel, Sontea Noua channel and Papadia channel summing aprox. 106.3 km. From these main channels, furcate a number of 37 secondary channels

(aprox. 152.8 km). In order to monitor our research areas were chosen: Mila 35, Draghilea, Papadia Veche, Cranjala, Razboinita, Mitchina, Olguta, Baba Rada, Ligheanca, Trofilca, Sireasa, Papadia and Sontea. The last one crosses the entire basin and is perhaps the most circulated channel.

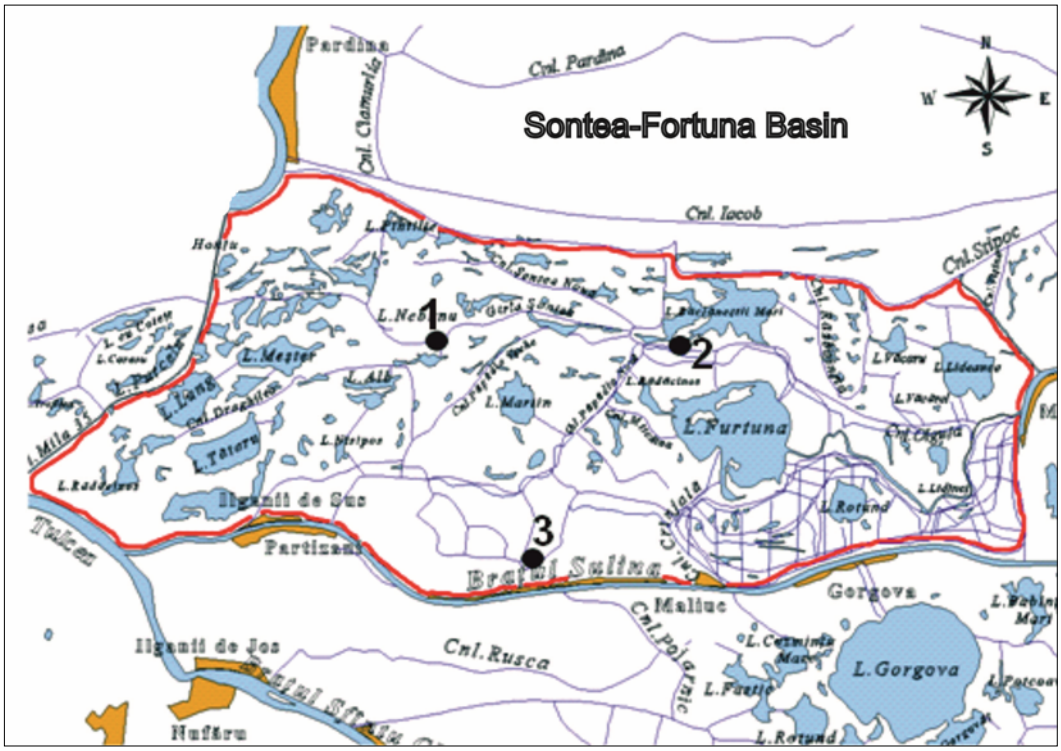

Figure 2. Sample areas location of Sontea–Fortuna study area (INCDD).

Table 1

Sample area characteristics of Sontea–Fortuna study area (Munteanu & Curelariu 1996)

Station	*Salinity*	*Drainage*	*Of surface deposit*
1	without salinity (< 4 dSm^{-1} at 25°C)	very poor (< 0.5 m)	peat from lowland with mineral stratifications
2	without salinity (< 4 dSm^{-1} at 25°C)	very poor (< 0.5 m)	silty loess
3	without salinity (< 4 dSm^{-1} at 25°C)	very poor (< 0.5 m)	sandy-clayey deposits fluvial and lacustrine

Hypsography of this basin indicates relatively small landfoms being configured sand banks and fluvial formations. These are covered with forest or paludous vegetation, aquatic depressions (lakes, ponds and small channels). The amplitude of these positive landforms varies decreasing from exterior fluvial sand banks throught inland. The area with the lowest altitude is the basin of Sireasa followed by Sontea area. Depending of Danube water level, water flow is carried through, over or among the these formations. The major tendency of drainage is from west to east on the natural slope (Diaconu & Nichiforov 1963).

2. Matita-Merhei basin (Figure 3, Table 2) - is characterized by presence of numerous lakes which occupy the central part of the basin. These are interconnected, taking part in the exchange of water, which generally, is done in good condition. Because low clogging of this basin there are almoust no soils present. Vegetation consists of homogeneous reed, well developed in the central area and mixture of reed, rush and cattail towards the edge. The area is placed between large sand banks of Chilia (western part) and Letea

(eastern part). It extends between Chilia branch (branches Cernovca and Campul Chiliei) in noth part and Dunarea Veche of the big „M" in south (Rudescu et al 1965).

The total surface of the Matita-Merhei waters is 5701.74 ha (106 lakes). Among lacustrine basins stands out: Merhei 1137.47 ha, Matita 641.83 ha, Trei Iezere 433.5 ha, Bogdaproste 400.19 ha, Babina 427.35 ha etc. (Romanescu 1996).

This area has a very low average altitude (+0.718 m), 40.25% of the total surface is under the sea level. This fact indicates that in the recent past was a marine lagoon, presently clogged (Romanescu 1996). Hydrological regime of this studied area is entirely dependent on level changes of Sulina branch (respectively on Dunarea Veche) (Gastescu et al 1983). Channels system through which the water flow include, mainly channels Eracle – Lopatna – Bogdaproste, Dovnica and Sulimanca – as evacuation channels; there are also some other small backwaters.

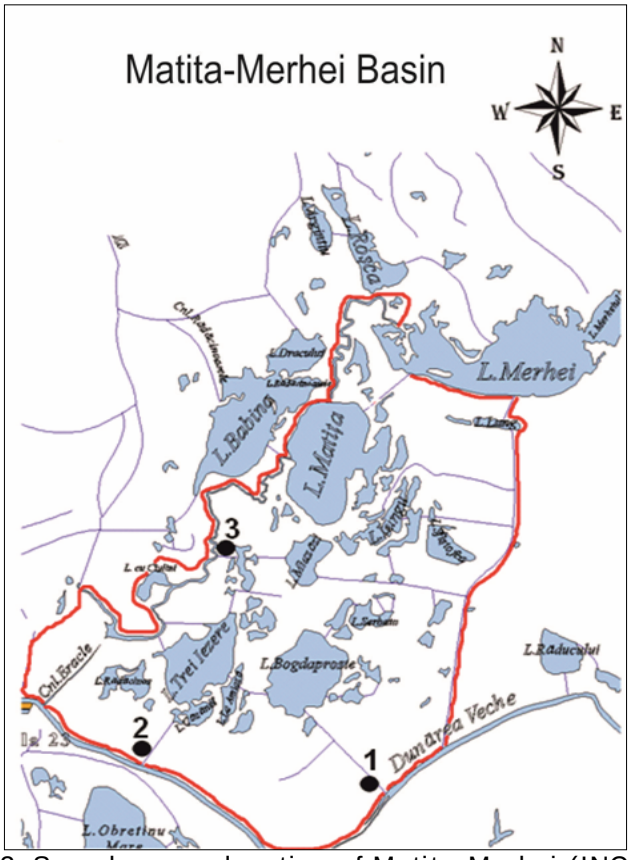

Figure 3. Sample areas location of Matita-Merhei (INCDD).

Table 2

Sample area characteristics of Matita – Merhei study area (Munteanu & Curelariu 1996)

Station	*Salinity*	*Drainage*	*Of surface deposit*
1	without salinity (< 4 dSm^{-1} at 25°C)	very poor (< 0.5 m)	silty loess
2	without salinity (< 4 dSm^{-1} at 25°C)	very poor (< 0.5 m)	sandy-clayey deposits fluvial and lacustrine
3	without salinity (< 4 dSm^{-1} at 25°C)	permanent water and floating reed islet	peat from lowland and floating reed islet 130 – 200 cm thickness

Most of those channels have reversible function, through them being done water supplying (on high waters), and also drainage (in low waters), to the Danube main branches. Eracle channel continues throught north with Iacub backwater and Baharova channel. This way it makes the connection to Dunarea Veche and Pardina basin, through

Batacu channel. Iacub backwater and Baharova channel have a total lenght of 4.5 km, 15-30 m wide and riverbed at –1.5 m (Diaconu & Nichiforov 1963).

3. Dranov basin (Figure 4, Table 10) - constitutes a major part of delta south of Sfantu Gheorghe branch. It is an area more evenly clogged than other lowlands of river delta. Nevertheless the degree of advanced clogging was made at a lower basic level than the actual level. So nowdays at 3 hydrogrades whole basin is under water.

The natural hydrographical network is largely clogged and replaced by a network of artificial channels. These channels fail to provide a good water exchange.

Figure 4. Sample areas location in Dranov (INCDD).

The expansion of wetlands limit the presence of soil only to marginal areas (sand banks) where are swampy poor salty soils.

Vegetation consists of homogeneous reed, and mixtures of reed, rush and cattail interwoven in large patches. These patches also contain complex mixtures of paludous vegetation (Diaconu & Nichiforov 1963; Hanganu et al 2002).

Table 3

Sample area characteristics Dunavat – Dranov study area (Munteanu & Curelariu 1996)

Station	*Salinity*	*Drainage*	*Of surface deposit*
1	moderate (8–15 dSm^{-1} at 25°C)	very poor (< 0.5 m)	peat from lowland and floating reed islet 50–1300 cm thickness
2	moderate (8-15 dSm^{-1} at 25°C)	poor (0.5–1.5 m)	sandy-clayey deposits fluvial and lacustrine
3	poor (4–8 dSm^{-1} at 25°C)	very poor (< 0.5 m)	clay carbonatic deposits fluvial and lacustrine

4. Caraorman sand bank (Figure 5, Table 4) - is part of the fluvio-marine delta southern of Sulina branch, between lowlands of eastern Litcov, Rosu-Puiu and Erenciuc. It is a complex formation basically made from superposed strips of sand. The north half is sandy with active dunes or in different stages of stabilization. Nude sands are interposed with sandy soils with a different content of humus in salty small basins. Nude surfaces

are interleaved with forest strips and meadow vegetation (Leandru 1970). Caraorman sand bank is crossed by Crisan channel. Much of channel length is located within Caraorman sand bank (Diaconu & Nichiforov 1963).

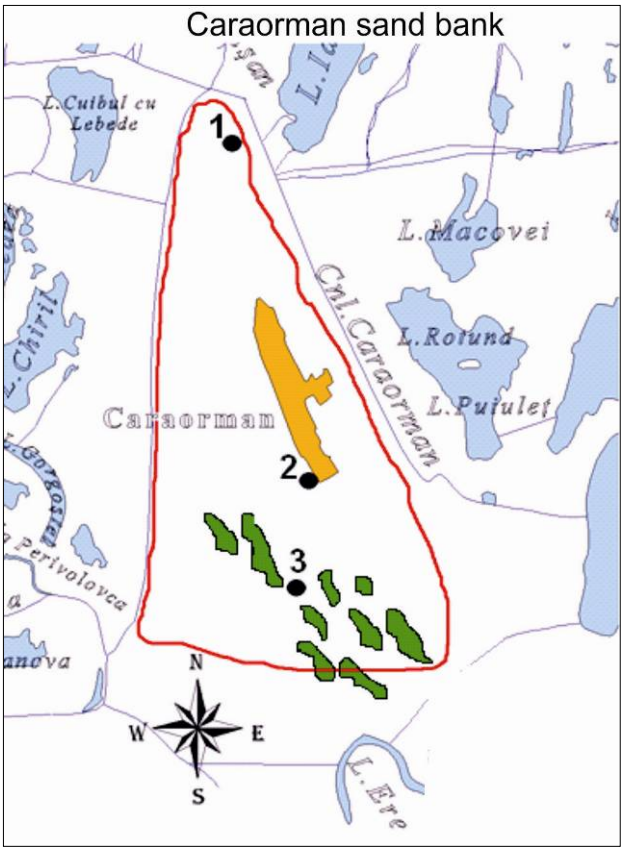

Figure 5. Sample areas location in Caraorman sand bank (INCDD).

Table 4

Sample area characteristics Caraorman sand bank study area (Munteanu & Curelariu 1996)

Station	*Salinity*	*Drainage*	*Of surface deposit*
1	poor (4–8 dSm^{-1} at 25°C)	poor (0.5–1.5 m)	marine rough sandy poor carbonated deposits
2	poor (4–8 dSm^{-1} at 25°C)	good (> 3 m)	
3	without (< 4 dSm^{-1} at 25°C)	moderate (1.5–3 m)	

5. Littoral sand bank area Sulina – Sfantu Gheorghe section (Figure 6, Table 5) it is characterized of a weaker influence of the Danube waters.

Table 5

Sample area characteristics along littoral sand bank area (Sulina – Sfantu Gheorghe section) (Munteanu & Curelariu 1996)

Station	*Salinity*	*Drainage*	*Of surface deposit*
1	moderate (8–15 dSm^{-1} at 25°C)	poor (0.5–1.5 m)	marine fine sandy rich carbonated deposits; also contain aloat of micas, (phyllosilicate) minerals
2	poor (4–8 dSm^{-1} at 25°C)	very poor (< 0.5 m)	
3	strong (< 15 dSm^{-1} at 25°C)	very poor (< 0.5 m)	

The main influence factor are a series of close to shore strong marine currents on the north-south direction. Those currents determine an erosion of the bank. This fact leads in time to sea advancing in the main deltaic region (Diaconu & Nichiforov 1963).

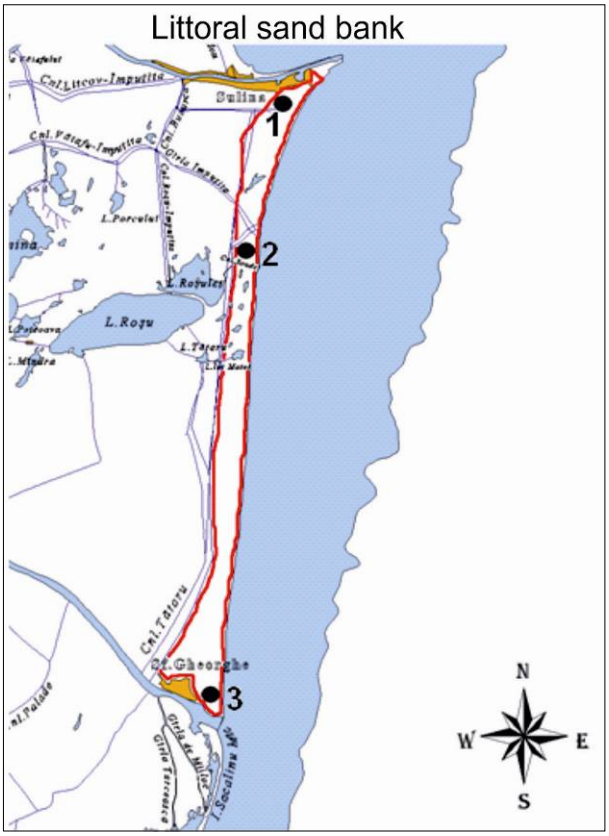

Figure 6. Sample location along littoral sand bank area
(Sulina – Sfantu Gheorghe section) (INCDD).

Results and Discussion

Stationary conditions in which alien species are present

<u>*Sontea–Fortuna basin*</u> - compared to other studied areas, this one has a larger diversity of vegetation, soils and higher altitude. Vegetation of the inner basin is predominantly composed of reed and meadows. Near the channels there are natural floodplain forests (Figure 7).

There are also exceptions represented of the area between Papadia, Dunarea Veche and Sulina channels. This large area is covered by cultivated forest vegetation. Drainage is poor on the whole surface of the area, which is beneficial in terms of the development of alien species. About the altitude of the area it can say that Sontea–Fortuna basin has over their banks:

- between 0 and 1 m, Olguta and Războinita channels;
- between 1 and 2 m, Garla Sontea, Papadia Noua, Papadia Veche, Mitchina, Cranjeală and Mila 35 channels (northern part);
- between 2 and 3 m, Dunarea Veche, Papadia and Mila 35 (Sulina channel area).

Investigated vegetation units in Şontea–Fortuna basin are (Sanda et al 1983; Popescu & Sanda 1977; Sanda & Arcus 1999; Hanganu et al 2002):

a) Dunarea Veche area:

- natural floodplain forests: S*alicetum albae* 1924 s.l., *Salicetum cinereae* Zolyomi 1931, *Populetum marylandicae* Mititelu 1970 (cultivated);

- meadows on high embankments: *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.

b) Sontea channel area:

- mixed vegetation of reeds and cattail 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 vegetation of reed an cattail on mineral soils: *Scirpo-Phragmitetum* W. Koch 1926, *Typhetum angustifoliae* (All. 1922) Pign. 1934;
- natural floodplain forests: S*alicetum albae* 1924 s.l., *Salicetum cinereae* Zolyomi 1931.

c) Olguta channel area:

- mixed vegetation of reed and cattail on mineral soils: *Scirpo-Phragmitetum* W. Koch 1926, *Typhetum angustifoliae* (All. 1922) Pign. 1934;
- mixed vegetation of reeds and cattail on organic soils: *Typhetum angustifoliae* (All. 1922) Pign. 1934, *Scirpo-Phragmitetum* W. Koch 1926;
- natural floodplain forests: *Salicetum albae* 1924 s.l., *Salicetum cinereae* Zolyomi 1931.

d) Papadia channel area:

- *Salix sp., Populus sp., Fraxinus pennsylvanica, Robinia pseudoacacia* plantations;
- natural floodplain forests: *Salicetum albae* 1924 s.l. *Salicetum cinereae* Zolyomi 1931;
- mixed vegetation of reed on mineral soils: *Scirpo-Phragmitetum* W. Koch 1926.

e) Cranjala channel area:

- natural floodplain forests: *Salicetum albae* 1924 s.l., *Salicetum cinereae* Zolyomi 1931, *Salicetum triandrae* Malciut 1929;
- mixed vegetation of reed an cattail on mineral soils: *Scirpo-Phragmitetum* W. Koch 1926, *Typhetum angustifoliae* (All. 1922) Pign. 1934.

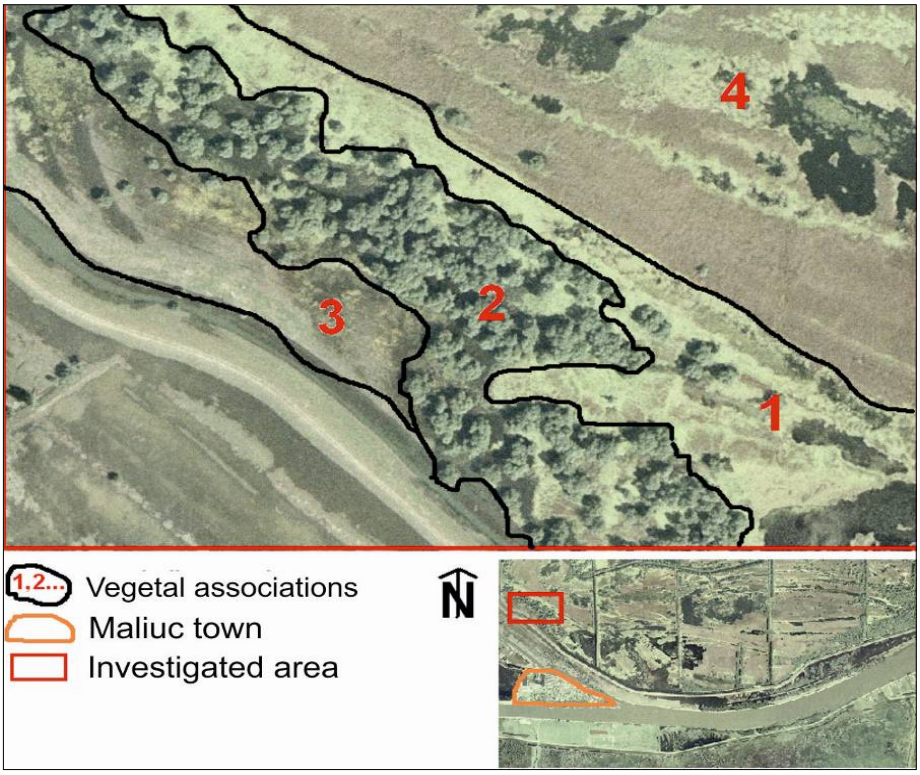

Figure 7. Vegetation profile of Dunarea Veche area (Sontea–Fortuna basin) (Google Earth): 1 - *Cynodonto–Poetum angustifoliae*, 2 - *Salicetum albae*, 3 - *Bassietum sedoidis,* 4 - *Scirpo-Phragmitetum.*

Matita–Merhei basin - dominant vegetation in this area is composed of reed associations (70%) (Figure 8). The area is low with an altitude between o and 1 m in central part, and 1-2 m in southern and western parts. Drainage is poor on the entire surface of the basin. This aspect in conjunction with low heights, facilitate the development of reed vegetation. Poor salinity, is common to all basins of the river delta.

Investigated vegetation units in Matita–Merhei basin are (Sanda et al 1983; Popescu & Sanda 1977; Sanda & Arcus 1999; Hanganu et al 2002):

a) Lopatna backwater area:

- reed vegetation and shrubs on compactly floating reed islet: *Thelyptero–Phragmitetum* Stefan et al 1995;
- natural floodplain forests: *Salicetum albae* 1924 s.l., *Calamagrostio-Salicetum cinereae* Soo et Zolyomi (1934) 1955.

b) Bogdaproste channel area:

- reed vegetation and shrubs on compactly floating reed islet: *Thelyptero – Phragmitetum* Ştefan et al 1995; *Scirpo-Phragmitetum* W. Koch 1926.

c) Dunarea Veche area:

- natural floodplain forests: *Salicetum albae* 1924 s.l., *Calamagrostio-Salicetum cinereae* Soo et Zolyomi (1934) 1955, *Salicetum triandrae* Malciut 1929.

d) Canalul Eracle area:

- reed vegetation and shrubs on compactly floating reed islet: *Thelyptero–Phragmitetum* Ştefan et al 1995; *Scirpo-Phragmitetum* W. Koch 1926.

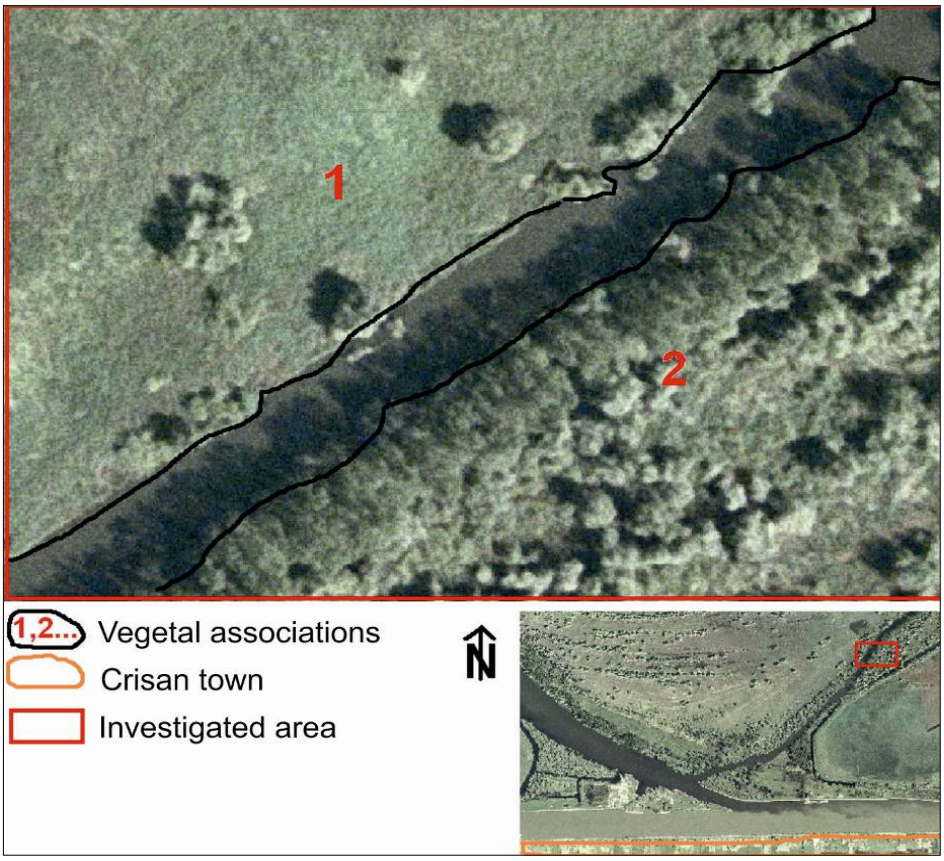

Figure 8. Vegetation profile of Dunarea Veche (Matita–Merhei basin) (Google Earth): 1 - *Scirpo-Phragmitetum*, 2 - *Salicetum albae.*

Dunavat–Dranov basin - this area is dominated by reef vegetation. Along channels vegetation consist of natural floodplain forests (Figure 9). Drainage is poor. The area is low, 0-1 m, rarely 2 m.

Vegetation units investigated in Dranov Basin and on main channels (Mustaca, Dunavat, Dranov and Lipovenilor) (Popescu & Sanda 1977; Hanganu et al 2002) are:

- reed vegetation and shrubs on compactly floating reed islet *Thelyptero–Phragmitetum* Stefan et al 1995; *Typhetum angustifoliae* (All. 1922) Pign. 1943; *Scirpo-Phragmitetum* W. Koch 1926;
- meadows on high embankments: *Hordeetum murini* Libbert 1923 emend. Pass. 1964; *Cardarietum drabae* Timar 1950;
- natural floodplain forests: S*alicetum albae* 1924 s.l., *Calamagrostio-Salicetum cinereae* Soo et Zolyomi (1934) 1955, *Salicetum triandrae* Malciut 1929.

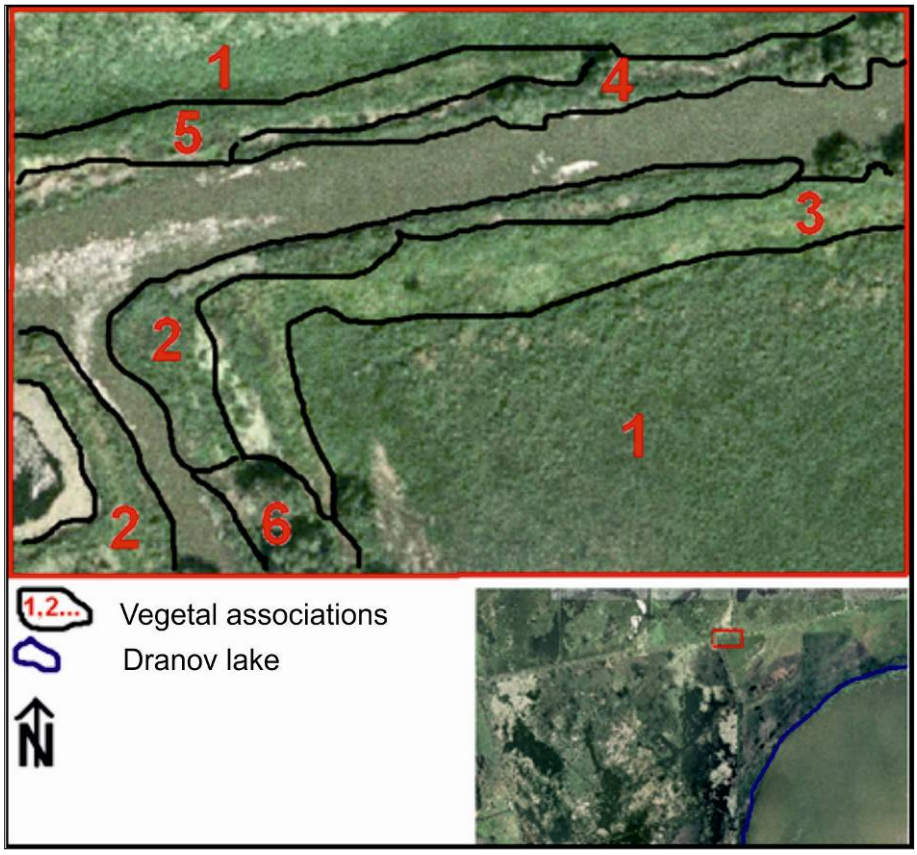

Figure 9.
Vegetation profile of Mustaca channel (Dunavat–Dranov area) (Google Earth):
1 - *Scirpo phragmitetum,* 2 - *Typhaetum angustifoliae,* 3 - *Hordeetum murini,*
4 - *Salicetum triandrae,* 5 - *Cardarietum drabae,* 6 - *Salicetum albae.*

Caraorman sand bank - The relief is structured with dunes of different heights and interdunal areas of variable heights, dimensions and forms. This kind of landscape affect the arrangement of Caraorman sand bank vegetation (Figure 10).

This arrangement is dependent also by the ecological gradients (humidity, salinity, insolation). Distribution of vegetation is according to the height of land, soil granulometry, depth of underground water. Also, in some cases the slope and exposition of dunes is important. The most important role is played by the hydric regime. The ecological conditions reflect very well distribution of ligneous vegetation in so-called forest corridors.

Vegetation units investigated along Caraorman sand bank (Sanda et al 1983; Doltu et al 1983; Hanganu et al 2002) are:

- shrubs: *Calamagrostio epigei-Hippophaetum rhamnoides* Popescu, Sanda, Nedelcu 1968;

- high dune vegetation: *Caricetum divisae* Slavnic 1948, *Saliceto (rosmarinifoliae)–Holoschoenetum vulgaris* Mititelu et al 1973; *Cynodonto–Poetum angustifoliae* (Rapaics 1926) Soo 1957;

- grassland 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);

- ash-oak mixed forests: *Fraxino pallisae-angustifoliae–Quercetum roboris* Popescu et al 1997 (Figure10).

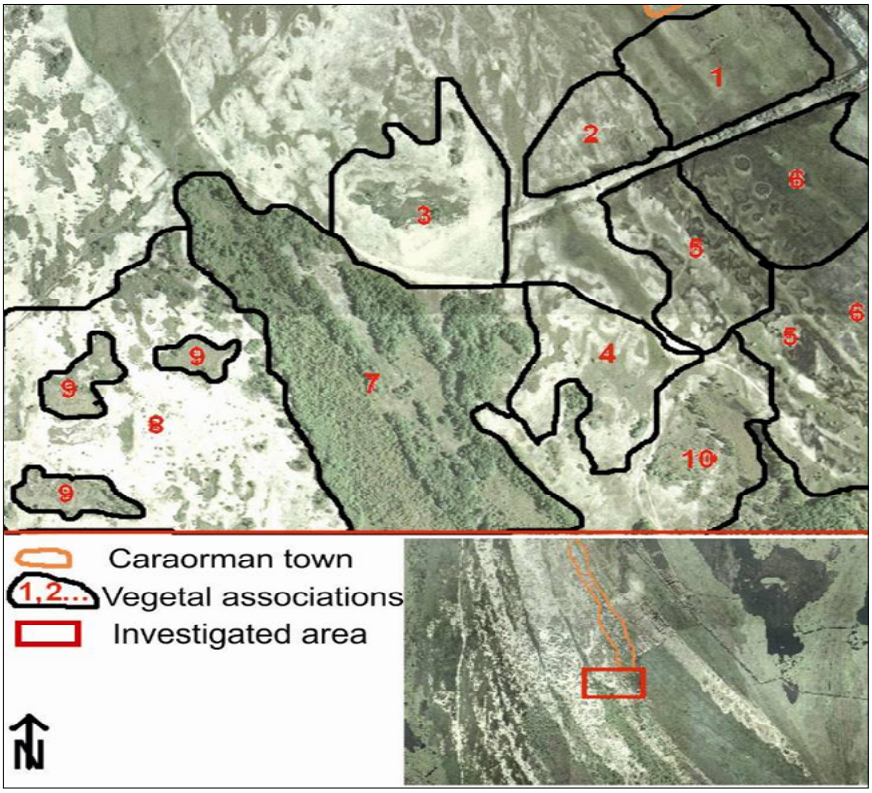

Figure 10. Vegetation profile southern of Caraorman village; Caraorman sand bank (Google Earth): 1 – *Plantaginetum arenarie,* 2 - *Cynodonto–Poetum angustifoliae,* 3-4 – *Calamagrostio epigei-Hippophaetum rhamnoides*, 5-6 - *Scirpo-Phragmitetum*, 7 - *Fraxino palisae-angustifoliae-Quercetum roboris*,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

A large part of Crisan channel is situated on the Caraorman sand bank. The vegetation along the channel alternates in height and composition. In northern part there is a vegetation particular to river delta. Sothern to Caraorman village it becomes particular to river-sea delta.

Vegetation units investigated along Crisan channel (Sanda et al 1983; Doltu et al 1983; Popescu & Sanda 1977; Sanda & Arcus 1999; Hanganu et al 2002):

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

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

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

- meadows on high embankments: *Cynodonto–Poetum angustifoliae* (Rapaics 1926) Soo 1957 (figura 44); *Bassietum sedoidis* (Ubrizsy 1949) Soo 1964; *Hordeetum murini* Libbert 1923 emend. Pass. 1964;

- high dune vegetation: *Secaletum sylvestre, Ephedro–Caricetum colchicae*, *Artemisietum arenariae* Popescu et Sanda 1977.

Littoral sand bank **-** littoral sands may have widths between tens to hundred of meters. There are parts of a particular relief. These „strips" are parallel to the line that separates the land from sea (Figures 11 and 12):

- scrambled beach front, permanently wet, no vegetation;
- scrambled beach, off waves, unsolidified sand, moist under surface, occupied by pioneer vegetation, poor in species;
- high sand dunes, poorly fixed and unsolidified, easily blew by the wind;
- medium sized dunes with sand partially fixed;
- low dunes with fixed sand and advanced soil formation processes, among salinated sandy lowlands, moist, often gleyed; in this sector are usually woody plant associations and this depends on the level of salinity and soil moisture;
- swamps gradually passing to permanent waters.

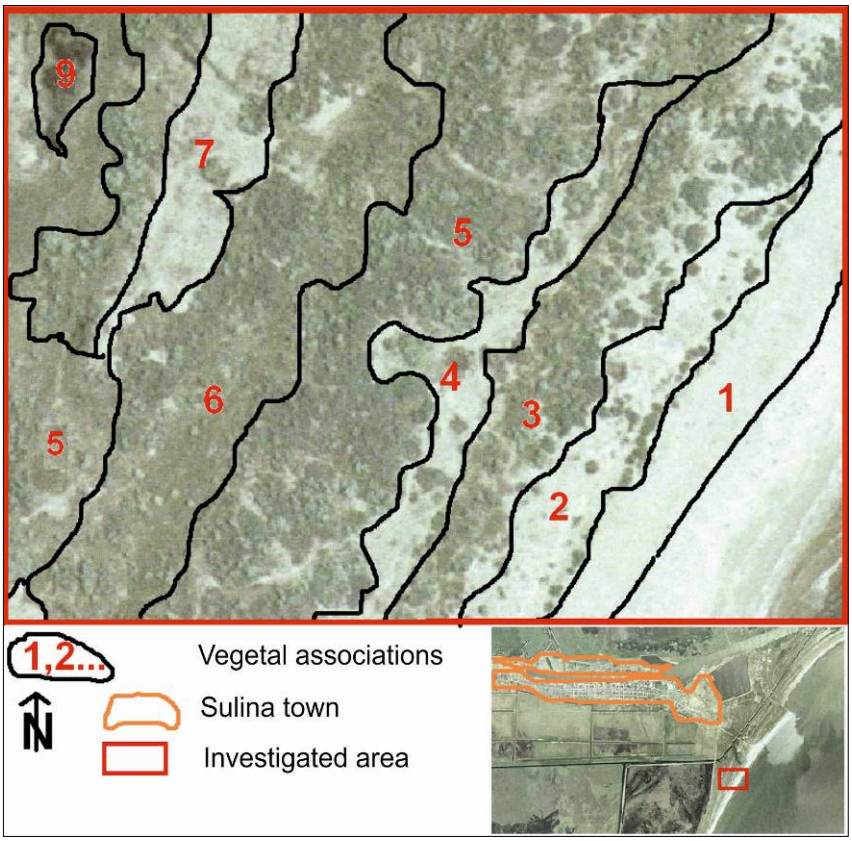

Figure 11. Vegetation profile Sulina area (Google Earth): 1 - *Atripliceto hastatae–Cakiletum euxinae,* 2 - *Elymetum sabulosi,* 3 - *Calamagrostio epigei-Hippophaetum rhamnoides*, 4 - *Brometum tectori,* 5 - *Calamagrostio-Tamaricetum ramosissimae,* 6 - *Junceum maritimi,* 7 - *Plantaginetum coronopi,* 8 - *Scirpo prhagmitetum.*

Vegetation units investigated along this area (Doltu et al 1983; Popescu & Sanda 1977; Hanganu et al 2002) are:

- shrubs: *Calamagrostio epigei-Hippophaetum rhamnoides* Popescu, Sanda, Nedelcu 1968; *Calamagrostio-Tamaricetum ramosissimae* Simon et Dihoru (1962)1963;
- loose sands coastal vegetation: *Atripliceto hastatae–Cakiletum euxinae* Sanda et Popescu 1999; *Argusietum (Tournefortietum) sibiricae* Popescu et Sanda 1975; *Plantaginetum arenariae* (Buia et al 1960) Popescu, Sandala; *Juncetum acuti-maritimi* Popescu et Sanda 1972, *Elymetum sabulosi* Morariu 1957.

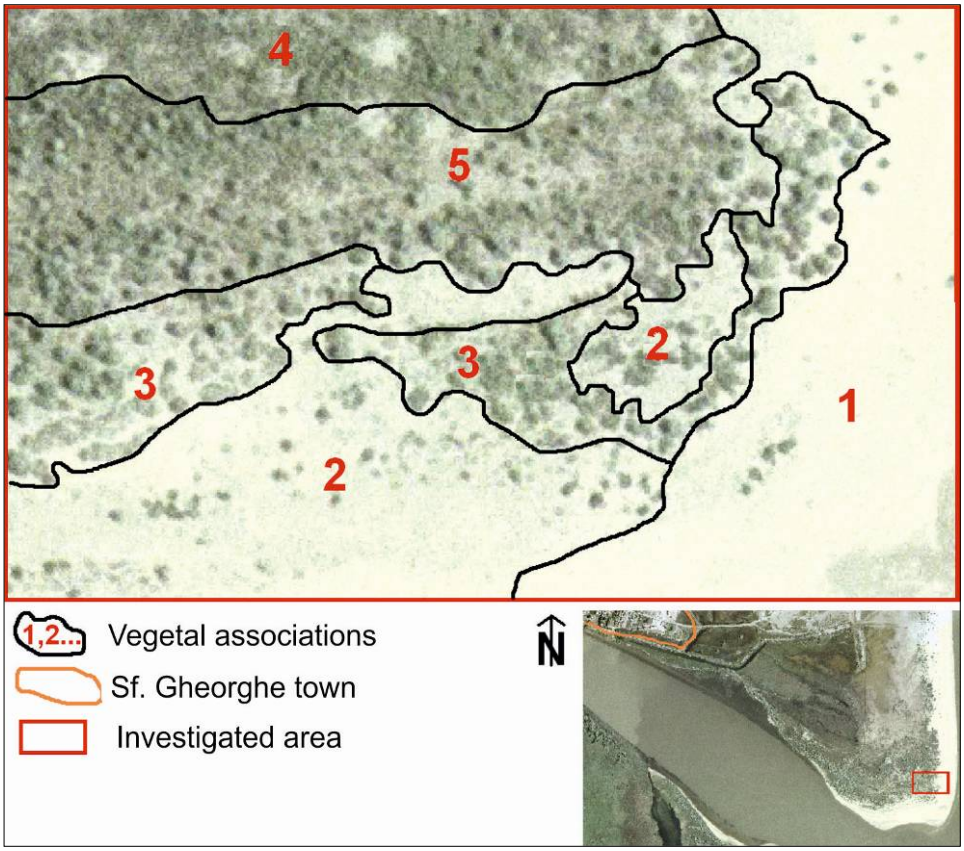

Figure 12. Vegetation profile Sf. Gheorghe area (Google Earth):
1 - *Atripliceto hastatae–Cakiletum euxinae*, 2 - *Argusietum sibiricae*, 3 - *Calamagrostio-Tamaricetum ramosissimae,* 4 - *Juncetum acuti-maritimi*, 5 - *Calamagrostio epigei–Hippophaetum rhamnoides*

Of allochthonous woody plant species, most widespread in the Danube Delta is *Amorpha fruticosa* (the river delta) and *Elaeagnus angustifolia* (in the fluvio-marine delta).

Because it was frequently cultivated along regularized/dredged channel banks *Amorpha fruticosa* species is very frecvent in the river delta, especially in Dranov and Sontea-Fortuna basins (Doroftei 2009).

Although present in almost all types of habitats from Danube Delta, its frequency significantly decreases in the fluvio-marine delta. In the following we present the specter of some vegetal associations where this species was found (Table 6).

We consider that this species is an exponent of adaptation on alien woody plants in the Danube Delta.

The highest incidence of *Robinia pseudoacacia* species is in the poor drainage and poor salinity areas. The species is found in the fluvio-maritime delta along channels banks. It is less frequent in the sandy substrate areas as Sulina, Sf. Gheorghe and littoral sand bank.

The allochthonous woody species *Gleditsia triacanthos* has a lower incidence in most habitats of Danube Delta. This is due to its poor resistance to drought conditions. Drainage and salinity, in conjunction with the hydrological regime, influence spreading of the species in natural habitats.

Elaeagnus angustifolia was identified predominantly in the fluvio-maritime delta. It is also present in the fluvial (river) delta, but less frequent. Beside other species *E. angustifolia* has an adaptive capacity under good drainage conditions and moderate salinity. Those factors determine a high incidende of this species in Danube Delta, ascending from East towards West.

Table 6

Specter of some vegetal associations were *Amorpha fruticosa* species was found
Salicetea purpureae Moor 1958
Salicetalia purpuraeae Moor 1958
Salicion albae Soó 1930
Ass. *Salicetum albae* Issler 1926 Sontea-Fortuna area

Relevee number	1	2	3	4	5	6
Coverage (%)	95	100	90	85	95	100
Studied surface m²	400	400	400	400	400	400
Caract. ass.						
Salix alba	3	2	3	3	3	3
Salicion albae						
Calystetia sepium	-	-	-	+	-	+
Humulus lupulus	-	-	+	-	-	-
Amorpha fruticosa	2	1	1	2	2	2
Populus alba	-	+	-	+	+	-
Vitis sylvestris	-	+	+	-	-	1
Symphytum officinale	+	-	+	-	+	+
Salicetalia purpuraeae et Salicetea purpuraeae						
Salix fragilis	1	+	1	2	1	1
Salix pentandra	+	-	-	-	-	-
Rubus caesius	-	+	+	+	+	+
Urtica dioica	+	+	-	+	+	-
Phragmitetea australis						
Carex acutiformis	+	-	+	-	-	+
Iris pseudacorus	-	+	+	+	+	-
Phragmites australis	-	+	-	-	+	-
Polygonum hydropiper	+	+	+	+	+	+
Solanum dulcamara	-	-	+	-	-	-
Mentha aquatica	-	-	-	+	-	+
Lythrum salicaria	+	+	-	+	+	-
Galio-Urticetea						
Arctium lappa	-	+	-	-	-	-
Eupatorium cannabinum						
Lamium purpureum						
Aristolochia clematitis						
Molinio-Arrhenatheretea						
Rorippa sylvestris	+	+	+	-	+	-
Plantago major	+	+	-	+	-	-
Carex hirta	-	-	+	-	-	-
Ranunculus repens	-	-	-	-	+	-
Trifolium repens	-	-	-	+	-	-
Trifloium fragiferum	-	+	-	+	-	-
Glechoma hederacea	-	+	+	+	+	-
Alopecurus pratensis	+	-	-	-	-	-
Attendant						
Fraxinus ornus	+	-	+	+	-	-
Fraxinus pennsylvanica	-	+	-	+	-	+
Elaeagnus angustifolia	-	-	-	-	-	+
Acer negundo	-	+	-	+	+	+
Viscum album	-	-	+	+	-	-
Morus alba	+	+	+	-	-	+
Crataegus monogyna	+	-	+	-	+	+
Tanacetum vulgare	-	-	+	-	-	+
Cynodon dactylon	-	-	+	-	-	-
Melilotus albus	-	-	+	-	+	-
Robinia pseudoacacia	-	-	+	+	+	+
Cardaria draba	+	-	-	-	-	-

Ailanthus altissima species was identiffied also but it has a low vitality. The adaptation component of the species is due to drainage conditions, salinity and soil texture. It was frequently encountered in Dranov, Sontea-Fortuna basins.

Acer negundo species was encountered frequently in fluvial delta, especially along the channels. Inundability, hydrological regime and the conditions offered by the areas with woody vegetation, affect positively the development of this species. In fluvio-maritime delta this species is not commonly found, but it has a good vitality. This fact is due to the groundwater level, near the surface, as if Caraorman forest.

Morus alba is a common species in Danube Delta, due to its planting in forest culture (crops). Into cultural conditions, the species proved to be resistant to hygienisation, while continuing to fructify each year. Throughout the Danube Delta, this species is frequent because of its adaptation to local conditions (drainage, soil) and resistance to drought.

Determinant factors in the occurrence of *Lycium barbarum* species are its resistance to drought and adaptation to the light textured soils. The occurence of this species grows from west (meadows and floodplain forests) to east (sand dunes and littoral sand bank).

The occurrence of *Fraxinus pennsylvanica* species is due to its preference to forestry plantations of the Danube Delta. Although it has a reduced occurrence compared to other species, it is found in the fluvial delta, frequently along channels. Its occurrence drops a lot in the fluvio-marine delta due to salinity, high drainage and light soil texture. Into the flooding conditions as in Sontea and Gorgova-Uzlina basins, the species adapts much easier.

Conclusions. There were made researches in five areas: Sontea-Fortuna, Dunavat-Dranov and Matita-Merhei basins, and Caraorman and littoralsand banks.

The main reason of choosing these areas were the various environnment conditions (differences in salinity, drainage, vegetation texture and hydrological regime).

In Danube Delta Biosphere Reserve were identified 65 alien ligneous species belonging to 32 families (Doroftei & Covaliov 2009). Most belong to the *Rosaceae* and *Fabaceae* families. Some of these taxa have an increased frequency.

Some of them are present in the natural habitats and also in anthropogenic habitats. Some of these examples are: *Amorpha fruticosa, Robinia pseudoacacia, Acer negundo, Morus alba, Fraxinus pennsylvanica, Ailanthus altissima, Lycium barbarum, Gleditsia triacanthos* and *Elaeagnus angustifolia.*

Nowdays only 9 taxa are considered invasive species. Of them only *Amorpha fruticosa, Robinia pseudoacacia* and *Ailanthus altissima* are considered aggressive-invasive species.

The only viable measures to be taken where natural habitat restoration is intended are mecanical ones. The alien species can only be wrenched off. Their place must be taken by native fast growing species.

Another action would be to monitor and to prevent introduction of new alien species. This would be made in some key-zones were observations over vegetation succession can be easily made.

In the annex paper (Annex 1) it is presented each habitat where woody alien plants appear. Also there is an overview and rehabilitation measures that are required of these habitats.

Although all human interventions of the past years, it found that Delta territory yet preserves an amazing diversity of habitats and characteristic wetland species in a relatively limited area.

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Authors:
Bogdan-Mihai Negrea, Faculty of Forestry, University "Stefan cel Mare" Suceava, University Street no. 13, 720229, Suceava, Romania, e-mail: bogdannm@yahoo.com
Mihai Doroftei, ”Danube Delta” National Institute for Research and Development, Biodiversity Conservation Department, Babadag Street 165, Tulcea, Romania, e-mail: doroftei@ indd.tim.ro
Grimm Meike, Faculty of Physics and Geosciences, Department of Geography, University of Leipzig, Leipzig, Germany
Cătălin-Constantin Roibu, Faculty of Forestry, University "Stefan cel Mare" Suceava, University Street no. 13, 720229, Suceava, Romania, e-mail: catalin_roibu@yahoo.com;

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Annex 1

Assessment matrix of some management measures according to species representativity in the habitats

Habitat type	*Representativity of invasive species*			*Conservation phase of the habitat in which species is present*			*Management*		
	B	*C*	*D*	*Identified allochthonous species*	*Conservation degree of the structure*	*Possibility of rehabilitation*	Eradication	Isolation	Control
				1. Sontea – Fortuna basin					
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
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
				2. Matita – Merhei basin					
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
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 imposible rehabilitation		x	
			x	*Xanthium strumarium*					x
			x	*Robinia pseudoacacia*					x

				3. Dunavat – Dranov basin					
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	
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
				4. Caraorman sand bank					
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
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	

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
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
	x		*Robinia pseudoacacia*			x	
	x		*Amorpha fruticosa*			x	
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
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
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
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. Littoral sand bank, Sf. Gheorghe – Sulina sector									
beach exposed to waves, with not solified sand, permanently wet, without vegetation		x	x	*Amorpha fruticosa* *Elaeagnus angustifolia*	well preserved structure	possible rehabilitation with minimum effort		x	x
high dunes with weakly fixed and not solified sand, slightly exposed to wind					well preserved structure				
middunes with sand partly fixed, where solification process has begun			x	*Amaranthus albus*	well preserved structure				x
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	x	x x x x x	*Amorpha fruticosa* *Amaranthus albus* *Artemisia annua* *Elaeagnus angustifolia* *Cuscuta campestris* *Conyza canadensis* *Fraxinus pennsylvanica*	structure medium or partially degraded	possible rehabilitation with medium effort	x	x	x x x x x
depressions with permanently wet sand, very strongly salinized, *Salicornietum europeae*, *Suaedetum maritimae*. *Aeluropetum littoralis* (Prodan 1939) Şerbănescu 1965					well preserved structure				
shrubbery: *Calamagrostio epigei-Hippophaetum rhamnoides* Popescu, Sanda, Nedelcu 1968; *Calamagrostio-Tamaricetum ramosissimae* Simon et Dihoru (1962) 1963			x x x x x	*Acer negundo* *Ailanthus altissima* *Amorpha fruticosa* *Gleditsia triacanthos* *Lycium barbarum*	well preserved structure	possible rehabilitation with minimum effort			x x x x x

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	*Artemisia annua*				x
		x	*Iva xanthifolia*				x
		x	*Paspalum paspalodes*				x
		x	*Robinia pseudoacacia*				x
	x		*Xanthium strumarium*			x	
		x	*Xanthium spinosum*				x