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REHABILITATION AND EXTENSION OF WETLANDS WITHIN FLOODPLAINS OF EMBANKED RIVERS

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Abstract

Embankment works modify the river and floodplain hydrology by interrupting the transversal connectivity of the water bodies. The altered river flow regime affects riparian wetlands. This paper describes the rehabilitation possibilities of embanked areas by restoring connectivity of the river and topographically low zones on the floodplain (oxbows, backwaters, brooks). The following measures are proposed: refreshing inland waters from the river during droughts and evacuation of the excess at rains, controlling water level in drainage channels and, by it, the ground water table. Connecting pools to drainage canals, controlling the water level on these, assuring refreshing water from the rivers, quality of the environment will be improved. Applying rehabilitation proposals within the paper for Trifeşti Sculeni embanked Prut River floodplain better conditions for wet habitats (including Natura 2000 sites) of the zone will be assured.

Key words: embankment, floodplain, oxbows, rehabilitation, wetlands

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1. Introduction

In Romania, in order to provide flood protection, many rivers have been embanked with the Saligny technique (non-submersible dikes). In the lower sectors, the embankments, combined with other hydro-technical arrangements within embanked areas, have focused on an agricultural use of the flood protected area.

Some sectors of the floodplain in the natural flow regime (before embankments) were represented by wetlands. By various works, including the embanking of the river, erosion control on slopes, and by other hydro-technical works, the hydrological balance of the floodplain, has been altered, and, therefore the environmental balance (typical for wetlands) has also been changed. By leveling the ponds, the abandoned water beds, the oxbows and the backwaters, the number of wet and semi-wet areas has been drastically reduced. This paper describes the possibilities of rehabilitation for the Prut River's floodplain (Downs and Gregory, 2004), within the Trifeşti Sculeni embanked area, a zone where the history and the current conditions allow the extension of wet areas. A basic goal is to preserve the Natura 2000 sites of international importance within the studied area.

2. Case studies

The Trifeşti Sculeni embanked area is included in a series of hydro-technical works completed within the Prut hydrographic basin, in order to provide flood protection (Fig.1). The zone is located in the Iasi County, being limited to the north by the village Trifeşti, to the east by the protection

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embankment built along Prut River, to the west by the terrace and to the south by Sculeni village and the embanked Jijia River that connects the Prut river national embankment to the terrace protection embankment. The protection embankment built along Prut River has a length of 30 km, an average width at the top of 4 m, an average height of 3 m, the interior/exterior bank slopes being 1:2/1:3, and provides flood protection for an area of 8982 ha (ISPIF, 1976). In arrangement wetlands the following characteristics have to be analyzed (Sargent and Carter, 1999):

1. From a hydrological point of view: water availability, located at the ground surface or very close to it (during at least for a part of the vegetation growth season). The rehabilitation of wet areas has to commence with investigations focused on the modification of the hydrological parameters (Zedler, 2000);

2. Regarding the soils' hydro regime: there exist hydro soils in saturation condition developed. Hydro soils have the capability to retain water (at ground surface or in its proximity), at least during a part of the year.

3. As to the wet soil's vegetation: the plants adapted to wet soils. Hydro soils are formed over long periods and it is difficult to create the features of this type of soils. Therefore, the rehabilitation can take place where hydro soils exist, and where the hydrological regime and the vegetation have been altered.

In order to identify various methods for the rehabilitation of wetlands within the Trifeşti Sculeni area, the hydrological, hydric and ecological regimes of the area have been studied. Factors responsible for these changes have been identified (Darby and Sear, 2008).

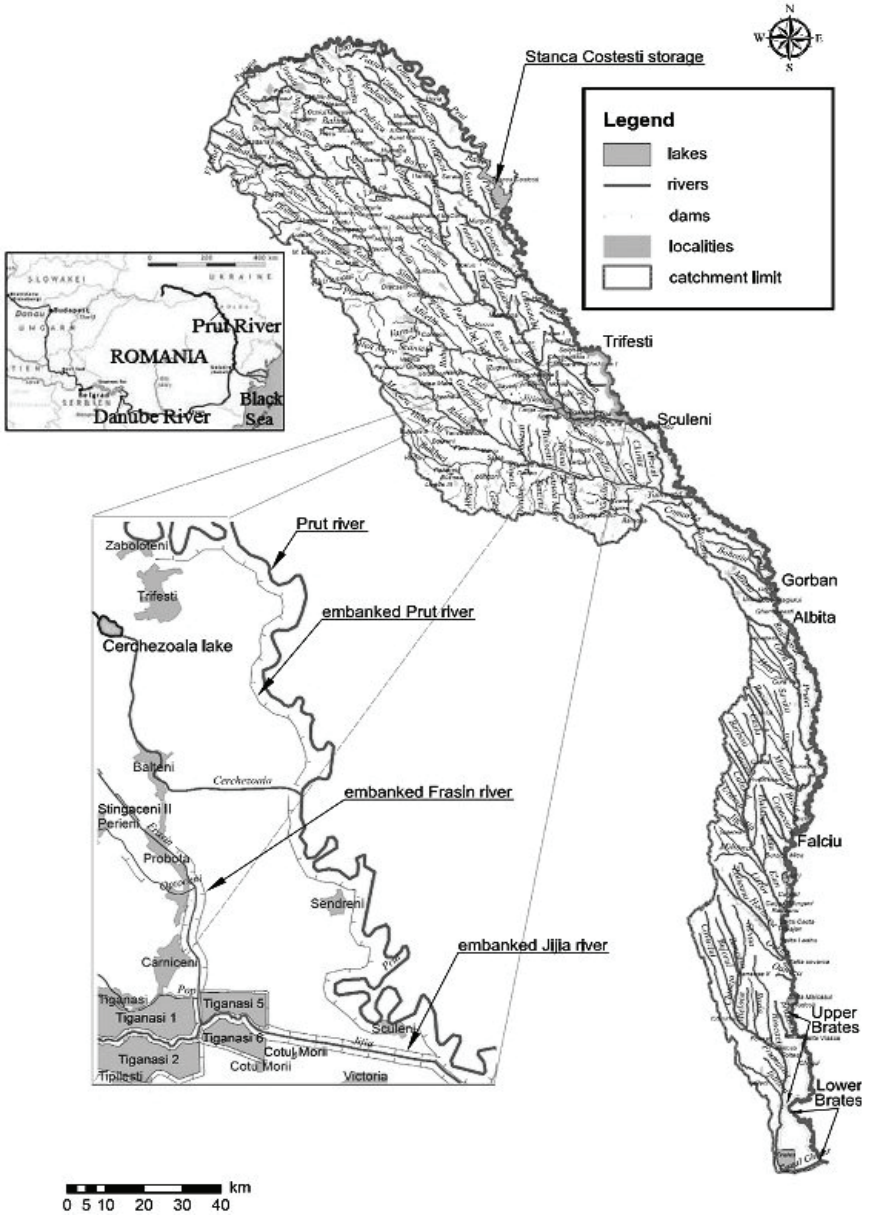

Fig. 1. The Prut hydrographic basin in Romania: the location of the Trifeşti Sculeni embanked area

2.1. Research on modifications of the hydrological regime within the Prut River and its floodplain

The hydrological regime within the Prut river floodplain has been anthropogenically modified by building protection hydro-technical works (longitudinal embankments and the Stânca Costesti reservoir) and also amelioration works (draining, irrigation). By these hydraulic arrangements protected and ameliorated agricultural area has increased. In addition to the hydro-technical works, the hydrological regime also depends on the terrain's morphology, the hydro-geological features, and the climate.

The Prut's floodable area, during a natural flow regime was a regulator of the river's hydrological regime. That is, it worked as a „safety valve" during floods and, at the same time, as a „storage tank" that was able to supplement the Prut's flows during low water periods.

The main part of the floodplain was formerly occupied by permanent ponds, swamps, pastures, wetland forests and agricultural lands on high-grounds, all these being at risk of flooding by the Prut River at high water. The pre-terrace area, which in general lacks natural drainage and which in several places was overlapping with the central area, (near ponds and oxbows next to the terrace)**,** was supplied from springs and other waters incoming from the Cerchezoaei, Frasin and Optoceni valleys. These water sources maintained a periodical water excess in the pre-terrace area feeding the micro-relief low areas (ISPIF, 1976).

Within the Prut floodplain there are many oxbows and old abandoned meanders of the rivers Prut, Frasin, Optoceni and Jijia. In maps from 1965 (before the construction of the national flood protection embankment) it is possible to identify the former river routes and the existence of backwaters and oxbows. This diversified relief has been created by the sudden enlargement of the floodplain downstream of Zaboleteni, and by the influence of the Jijia River, which, by backwaters generated during floods, has prolonged the water stagnation within the studied area. Flood protection within the Prut hydrographic basin (Prut Bârlad W.B.A., 2010a) has been ensured by Stânca-Costeşti artificial storage (Fig. 1) and by means of several embankments as Trifeşti-Sculeni-Gorban, Albiţa-Fălciu, Upper Brateş and Lower Brateş zones. The Stânca-Costeşti reservoir has been in operation since 1978 and the Trifeşti Sculeni area was embanked between 1972 and 1974 (ISPIF, 2000).

In order to describe the hydrological modifications of the Prut River and its floodplain, the hydrological data recorded at the Ungheni hydrometrical station have been used. Hydrograph of maximum historical flow from natural regime (till 1974) and between 1978 and 2010, after the Stânca-Costeşti reservoir and embankment operate are presented in Fig. 2. There has been an increase of maximum flows due to embankments, although the Stânca Costeşti reservoir attenuates it. After building of the hydraulic arrangements embanked area was not flooded at high water. Hydraulic works reduced the permanent water covered surface from 5% to 1% (ISPIF, 2000).

2.2. Stage of hydrotechnical works in the studied area

The drainage network (collecting-evacuating channels) and the drainage pumping plants have been completed between 1974 and 1975 (ISPIF, 1976). Part of the ponds that have been intercepted by the collecting channels became agricultural land. The open drainage channel network conveys the surface water (generated by rainfalls) and groundwater (generated by infiltration from terrace, river and rainfalls) to the warnambool.

These works have been carried out on a surface of 8130 ha, within two functionally independent systems: the Bălteni Northern system (3900 ha) and the Bălteni Southern system (4230 ha), together comprising a network of collecting channels with a total length of 153 km.

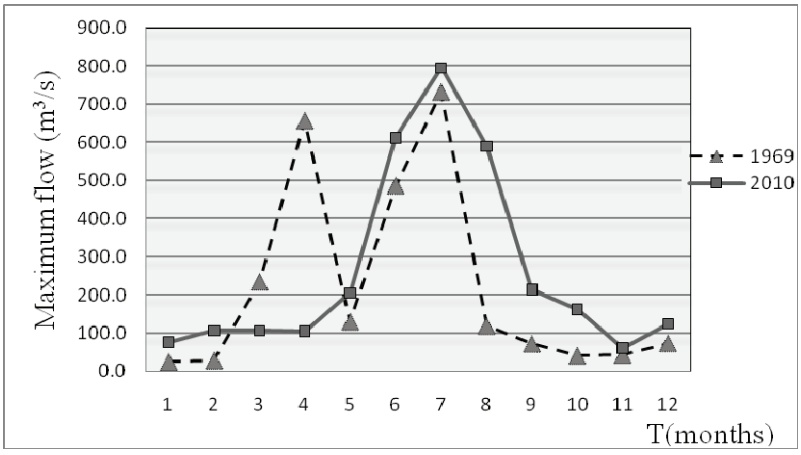

Fig. 2. Hydrograph of maximum historical flows at Ungheni hydrometric station for: natural regime (till 1974) and controlled embanked regime (between 1978 and 2010)

The drainage network is equipped with a central collector (transversally to the floodplain), nearby the village Bălteni, up to the Prut embankment - CC Bălteni North (Fig. 3). This collector conveys the waters generated at the northern part of the studied area, collected by the secondary channels, located at equidistance of 400 m between them. Collected waters are discharged to the Prut River via the Bălteni Pumping Station (PS).

The excess waters from the southern part (sector Bălteni South) are collected by the 2nd main channel – CC Bălteni South, which has a route parallel to the transversal terrace embankment, and conveys the waters from the secondary collectors. The discharge from the sector, over the embankment, towards the Jijia River, is achieved with the Sculeni Pumping Station (PS).

The Bălteni Pumping Station has the following specification (ISPIF, 2000): installed flow 58 m^3/s; pumping head H = 5.5 mH_2O; volume foreseen to be pumped on an average year (probability 50%) $Vp = 13.3 \cdot 10^6 m^3$. The Sculeni PS is located at the southern boundary of the Trifeşti Sculeni sector, on the left embankment of the Jijia River, at the downstream end of the Bălteni South main collector. The Pumping Station's characteristics are: installed flow Q = 4.2 m^3/s; pumping head H = 5.4 mH_2O; volume foreseen to be pumped on an average year (probability 50%) $Vp = 10 \cdot 10^6 m^3$. In order to diminish the flows from the terrace storage has been realized at the Cerchezoaia valley.

The CCS7 channel, located at the terrace base, in the Bălteni North sector, ensures the conveying towards the CC Bălteni North Channel of all flows coming from the Cerchezoaia reservoir. Over the period 1976-1988 irrigation systems have been implemented. These have been conditioned by previous drainage and rehabilitation of the soil's permeability conditions. Before 1972, when the construction of the national protection embankment commenced, in the Prut floodplain, corresponding to the Trifeşti Sculeni sector, between 1959 and 1969, some field works were performed including local irrigation, embankments, draining and soil protection. The embankments were built close to settlements, elsewhere the river was left unrestrained.

The irrigation systems were mainly located on high levees, close to the Prut River, in an area of ca. 2000 ha. When the Prut flooded, these systems were damaged at once. After the erection of the protection embankment all these lands have been included in the total area of 7800 ha that has been proposed to receive the irrigation system.

2.3. Research on the soils' hydric regimes

From a lithological point of view, the upper layer of the ground has a low permeability, with thicknesses ranging from 1.0 to 12.0 m, constituted of clays and clays with dust.

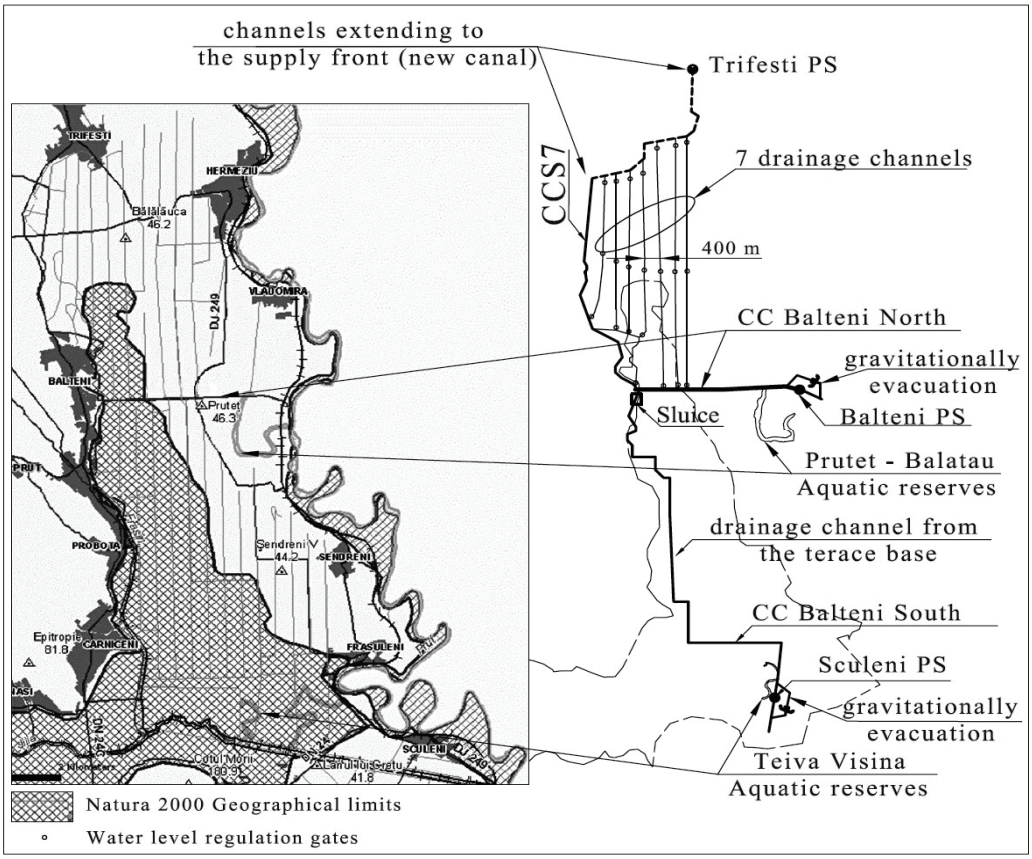

Fig. 3. The proposed solution for rehabilitation of wetlands within the Trifeşti Sculeni embanked area

The next layer is a complex of sands and sandy gravel and gravel, with high permeability, and thicknesses ranging from 1.0 to 15.0 m. At the bottom there is the base layer, made of Sarmatian clays and marls. In several isolated areas the more permeable layers of sand and/or fine sands with dust appear straight at the surface. The groundwater within the permeable horizons is pressurized.

The groundwater in the upper soil complex is a result of direct infiltration from the surface. Within the clay with dust complex the capillary driven vertical infiltration is very slow, and the storage capacity is reduced.

In natural hydrological regimes (before the regulation) the floodplain was frequently inundated and the soils were washed, and thus the salts accumulated in the soil's upper layers (during drought periods) were removed. The soils presented weak or moderate salinization and were characterized by some reversible (salinization-desalinization) processes.

After the completion of surface embankments and drainage network the salinization processes depended on the balance of the humidity created within soils. This process has been under control by operation of the drainage network, the water volumes distributed within irrigation and other hydro-technical upgrading works (Table 1). After the collapse of irrigation salt accumulation process is possible (obtained by simulation (Vlad, 2009)).

2.4. The climate

The climate within the studied zone brings, in general, low rainfalls that have an uneven distribution throughout the year: most precipitation falls during the summer: 189.7 mm, 37.9% of the annual amount. Much precipitation also falls during spring: 118.9 mm, or 23.7% of the total yearly volumes. Little precipitation falls during winter (16.9%) and autumn (21.3%). The precipitation monthly averages show the highest amounts in June, with is 14.5% of one year's total.

The recordings from the Iasi meteorological station are characteristic of the main part of this area, the annual average being 499.8 mm.

In terms of temperature, the greatest part of the studied area is in compliance to the recordings from the Iasi meteorological station that is an annual average of 9.6ºC. The lowest monthly average temperature is -3.6^0C, as recorded in January and the highest average figure is 21.7^0C, as recorded in July. The climatic conditions in the Prut basin are generating water losses via evapotranspiration, losses that yearly range from 600 mm in the northern part of the basin up to 700 mm in the southern part. Therefore it results in an annual average water deficit that range from 100 mm in the northern sector of the basin, to 150 mm in its center and 250 mm in its southern part. The most severe humidity deficit occurs in July and August, when the crop water needs are at their peak.

2.5. Ecological research for rehabilitation and extension of wetlands

The Prut River is an entrance gate towards the Danube Delta Biosphere Reserve (Fig.4), located in three main migration corridors for birds that are hatching on Eurasian territory: the Elbic Eastern route, the Carpathian route and the Pontic route, towards northern Europe.

The Prut River route is in fact the birds' Eastern-Elbic route, one of the most important bird migration routes to and from northern Europe. The Prut is also an important area in terms of wild fauna and birds in Romania: here 225 bird species have been recorded, this being the equivalent of 60% of Romania's wild birds. The rest area is represented by the woody and herbaceous vegetation on the Prut floodplain. The hibernation area is the Stânca Costeşti reservoir that seldom freezes. Romania features five types of bio-geographical regions: the continental type, the steppe type, the pannonia type, the alpine type, and the pontic type regions that have a very rich biological diversity. Thus Romania is involved in the Natura 2000 European Ecological Network with a very rich natural asset.

Within the Trifeşti Sculeni studied area five "Natura 2000" and protected sites are geographically delimited (Fig. 3) (Table 2).

Table 1. Soils' salinization within the Trifeşti Sculeni area (ISPIF, 2000)

Soils and salinization status		***In natural regime (%)***	***In modified regime (%)***	
			Embankment and drainage	***Irrigation***
Proto-soils and alluvial soils				
-Non-salinized		49	45	63
-Non-salinized and swamped		17	-	-
	total	66	45	63
Salinized soils at various salinization degrees	Low	4	52	37
	Moderate	29		
	High and/or very high	1	3	
	total	34	55	37
Total		100	100	100

In the Teiva-Vişina Pond and the Pruteţ Bălătău lakes are present the species *Misgurnus fossilis* – eel, *Proterorhinus marmoratus* – tubenose goby, *Tinca tinca* – tench, species that are numerically decreased within most waters of Europe (REPAI, 2008). The Pruteţ Bălătău Lake, after embankment works, has become separated from the river, fact that has fostered the death of fish within (Iconomu, 2011). The two aquatic reservations have been assessed and therefore these two sites have been classed in the category of hyper-trophic lakes (Table 3) (Prut-Bârlad W.B.A., 2010a).

Table 2. „Natura 2000" sites within the embanked area of Trifeşti Sculeni (GD, 2007; MO, 2007; GEO, 2007; Law 73, 2000)

No.	*Name of protected site/area*	*Type of protected site/area*	*Comments*
1.	Jijia and Miletin Ponds (ROSPA0042)	SPA*	Wetland proposed as a RAMSAR site and important fauna and flora area identified by Bird Life International (GD, 2007); Includes the natural reservation Teiva-Vişina Pond; This site is hosting numerous protected species (GD, 2007): a) species listed in Appendix 1 of Directive Birds: 37 species b) other migrating species, listed in the appendices of the Convention on migrating species (Bonn): 30 c) worldwide endangered species: 9 Shelters numerous ecologically protected birds species. Important for nesting birds belonging to the following species: *Falco vespertinus, Aytya nyroca, Platalea leucorodia, Ardea purpurea, Aedeola ralloides, Chlidonias niger, Egretta alba, Circus pygargus*. The ecological site is important during migration period for the next species: *Aytya nyroca, Anser anser, Anser erytropus, Aquila heliaca, Ciconia ciconia*. The site shelters ducks and geese during wintertime. During migration time the site shelters over 20.000 aquatic birds.
2.	Salt marshes of Jijia (ROSCI0222)	SCI*	Includes the aquatic reservation Teiva-Vişina and Pruteţ Bălătău Includes five types of typical wetland and salt marsh habitats (MO, 2007).
3.	Prut River (ROSCI0213)	SCI Aquatic reservation	Includes five types of specific aquatic and wetland habitats and includes fauna species which requires strict protection (MO, 2007); Are present flora and fauna species of Community interest, regulated by GEO (2007).
4.	Pruteţ Bălătău Lake	Aquatic reservation	Are present flora and fauna species of Community interest, regulated by GEO (2007). Flora species: *Carex hirta, Carex limosa* – sedge*, Carex paniculata, Carex riparia, Carex rostrata, Glyceria plicata, Salvinia natans, Phragmites sp., Salix sp.* Fauna species: Insects: belonging to ord. *Heteroptera, Homoptera, Coleoptera, Hymenoptera, Lepidoptera, Diptera.* Amphibians: marsh frog (*Rana ridibunda*) and small lake frog (*Rana esculenta*) Reptiles: the water snake (*Natrix tesselata*) and the pond turtle (*Emys orbicularis*) Fish: bream (*Abramis brama*), blacktail (*Acerina cernua*), big head carp (*Aristichthys nobilis*), carp (*Cyprinus carpio*), pike (*Esox lucius*), gudgeon (*Gobio gobio*), Danube gudgeon (*Gobio obtusirostris*), silver carp (*Hypophthalmichthys molitrix*), sun perch (*Lepomis gibbosus*), belica (*Leucaspius delineatus*), chub (*Leuciscus cephalus*), perch (*Perca fluviatilis*), zander (*Stizostedion lucioperca*), rudd (*Scardinius erythrophthalmus*), wels catfish (*Silurus glanis*), vimba bream (*Vimba vimba*). Birds: silver gull (*Larus argentatus*), pewit (*Larus ridibundus*), gray heron (*Ardea cinerea*), small egret (*Egretta garzetta*), little bittern (*Ixobrychus minutus*), teal (*Fulica atra*), great reed warbler (*Acrocephalus arundinaceus*) etc. Protected species**:** Amphibians: marsh frog (*Rana ridibunda*), small lake frog (*Rana esculenta*), Reptiles: pond turtle (*Emys orbicularis*), water snake *Natrix tesselata*; Fish: belica (*Leucaspius delineatus*), wels catfish (*Silurus glanis*); Birds: pewit (*Larus ridibundus*), gray heron (*Ardea cinerea*), teal (*Fulica atra*), great reed warbler (*Acrocephalus arundinaceus*). The area features good development conditions for the next species: wells catfish *(Silurus glanis),* bream *(Abramis brama brama),* carp *(Cyprinus carpio carpio),* goldfish *(Carassius auratus gibelio),* pike *(Esox lucius)* and gudgeon *(Gobio obtusirostris)* (REPAI, 2008).
5.	Teiva – Vişina Pond	Aquatic reservation	Flora species: *Carex hirta, Carex limosa* – sedge*, Carex paniculata, Carex riparia, Carex rostrata, Glyceria plicata, Phragmites sp., Salix sp.* Fauna species: Amphibians: marsh frog (*Rana ridibunda*) and small lake frog (*Rana esculenta*) Reptiles: water snake (*Natrix tesselata*) and the pond turtle (*Emys orbicularis*) Fish: bream (*Abramis brama*), blacktail (*Acerina cernua*), big head carp (*Aristichthys nobilis*), goldfish (*Carassius auratus gibelio*), carp (*Cyprinus carpio*), gudgeon (*Gobio gobio*), Danube gudgeon (*Gobio obtusirostris*), silver carp (*Hypophthalmichthys molitrix*), sun perch (*Lepomis gibbosus*), belica (*Leucaspius delineatus*), chub (*Leuciscus cephalus*), perch (*Perca fluviatilis*), zander (*Stizostedion lucioperca*), rudd (*Scardinius erythrophthalmus*), wels catfish (*Silurus glanis*), tench (*Tinca tinca*), vimba bream (*Vimba vimba*), pike (*Esox lucius*). Birds: mallard (*Anas platyrhynchos*), garganey (*Anas querquedula*), pochard (*Aythya ferina*), silver gull (*Larus argentatus*), gray heron (*Ardea cinerea*), small egret (*Egretta garzetta*), white stork (*Ciconia ciconia*), black stork (*Ciconia nigra*), little bittern (*Ixobrychus minutus*), teal (*Fulica atra*), great reed warbler (*Acrocephalus arundinaceus*) etc. Protected species: Birds: belica (*Leucaspius delineatus*), wels catfish (*Silurus glanis*); Reptiles: green lake frog (*Rana ridibunda*), small lake frog (*Rana esculenta*), pond turtle (*Emys orbicularis*), water snake *Natrix tesselata*; Birds: mallard Anas platyrhynchos, garganey (Anas querquedula), pochard Aythya ferina, pewit (Larus ridibundus), gray heron (Ardea cinerea), teal (Fulica atra), great reed warbler (Acrocephalus arundinaceus).

* *SPA- Special Protection Areas; SCI- Sites of Community Importance*

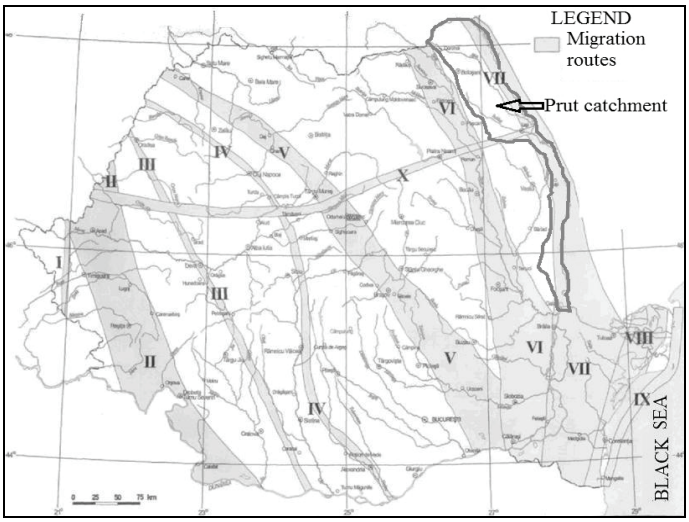

Fig. 4. Bird migration routes on Romanian territory: I The Pannonia-Adriatic route; II The Pannonia-Bulgarian route; III,IV,V The Central-European-Bulgarian route; VI The Carpathian route; VII The Elbic Eastern route; VIII The Pontic route; IX The Sarmatia route; X The Russian-Adriatic route (Stânca Costeşti Administration, 2011)

Table 3. The assessment of trophic condition (in compliance to MO 161 (2006)

No.	*Protected area*	*Trophic status*			
		2007	*2008*	*2009*	*2010*
1	Teiva Vişina Pond	H	H	H	M
2	Pruteţ Bălătău Lake	H	H	E	E

M-mesotrophic, E-eutrophic, H-hypertrophic

Waters' quality has been influenced also by the droughts that occured in 2007 and 2009. In the natural flow regime of the Prut River, in springtime, when the area was flooded, a part of the meadow became a water body and migratory birds used this territory for nesting and feeding.

In summertime, the water level receded, but lots of wetlands still remained, these wetlands being favorable to the development of aquatic fauna. In this zone existed areas covered with water, reed, clumps of wetland typical trees and large pasture areas. The major bed was separated from the minor bed by higher natural levees. In the depression areas ponds often appeared which an adequate area for fish natural spawning became.

In times of flood, mature fish entered in these still water areas where, during floods, brood developed. Floods were an essential phenomenon for the development of fish.

Due to the hydraulic and agricultural developments, the natural ecosystems and territories have been replaced with anthropogenic systems, mainly dedicated to agriculture (Table 4). In natural conditions, the major floodplain area was sheltering massive deciduous forests (oaks and durmasts), with typical grassy elements, like xerophile herbaceous vegetation, xero-mesophyle vegetation (pastures), aquatic vegetation, tall swamp herbs, segetal and ruderal vegetation (widespread in agricultural cultures, along roads and trodden fields). After the developing works, the area was planted with crops, and the forests and grasslands receded.

Table 4. Evolution of land use (ISPIF, 1976)

Type	*Surface (%)*	
	Before embankment	*After embankment and arrangement works*
Arable	40	84
Pasture	22	5
Meadow	15	2
Vineyards	-	-
Orchards	-	-
Total agricultural	77	91
Forest	9	1
Waters	5	1
Reed	7	-
Constructions	1	1
Roads, channels, agricultural constructions	-	4
Unproductive	1	1
Total non-agricultural	23	9
Grand Total	100	100

Nowadays, the aquatic vegetation could meet only sporadically, on small areas with permanent still water or in channels. The vegetation of halophil grasslands is spread on small surfaces affected by salinization. The agro-ecosystems have replaced the floodable wet specific areas, becoming important due to their size. This includes mainly the agricultural crops (straw cereals, maize, sunflower, vegetables, but also important industrial plants as flax, rape, hemp) and, as well, the orchards and vineyards. These are ecosystems that are featuring low habitat diversity. The change of uses due to the human interventions (developments) is shown in (Table 4).

Anthrophic interventions over the environment leads to widelife changes (NRC US, 2005; Sargent and Carter, 1999).

After the completion of embankment works, the distribution of birds in embanked enclosure

changed. Example: Due to the disappearance of reed areas, the number of brooding of aquatic birds decreased (by example the red heron - *Ardea purpurea*, which is nesting in large area reed zones). Many birds have the status of rare bird or regressing birds (Threatened species: the white egret *Egretta garzetta* monuments of nature, *Circus pygargus*; Vulnerable species: *Plegadis falcinellus*; Critical threatened species: *Anser erytropus*.). In addition, the interruption of the transversal connectivity resulted in a change in the ichthyofauna (REPAI, 2004): some species have disappeared and others have now the status of rare or endangered species. Regarding extinct fish species: Sturgeons have virtually disappeared from the Prut River and are severely endangered throughout the Danube basin, (Umbra krameri) mudminnow, (*Carassius Carassius*) froth. Endangered species are: (*Acipenser ruthenus*) sterlet, (*Pelecus cultratus*) zige, (*Tinca tinca*) tench, (*Zingel zingel*) zingel, (*Zingel streber*) streber. Vulnerable species (*Aspius aspius*) asp, (*Barbus Barbus*) barbel, (*Chondrostoma nasus*) common nase, (*Cyprinus carpio*) wild carp, (*Leuciscus idus*) ide, (*Lota*) burbot, (*Misgurnus fossilis*) eel, (*Vimba Vimba*) vimba bream.

Some species of vulnerable aquatic invertebrates have been directly threatened (*Unio Crassus, Astacus astacus, Paramysis ber bispinos, Velia goat Aphelocheirus aestivalis, Cercion Linden syn. Coenagrion linden*) by eutrophication and the use of fertilizers.

3. Rehabilitation proposals

In eutrophic conditions the wetlands have a tendency to be dominated by aggressive and frequently invasive species (Boers et al., 2006). An increase of nutrients within a wetland contributes to the replacement of indigenous with unwanted flora (Example: *Aphenizomenon, Microcystis, Anabaena, Coeloshorium)*.

In the context of the above mentioned, taking into account the history of the studied area and also the current conditions (the existence of drainage systems, the existence of Natura 2000 sites and the identified natural reservations within the area), we propose the upgrading and the extension of wetlands in this studied area (Fig. 3). This can be done by rehabilitation of the channel close to the terrace area, the creation of specific wetland ecological conditions on drainage channels, their connection to the oxbows**,** the old abandoned meanders of the Prut, Cerchezoiaia, Frasin Rivers. Low level micro-relief forms will be flooded by their connection to drainage network.

In order to achieve this, it is necessary to provide a sufficient water exchange during drought periods in all drainage channels proposed in wetland rehabilitation and extension (north and south terrace based channel and seven collectors in north) (Fig. 3). The water supply of the area can be achieved from the Prut River, by means of a pumping station (PS) that is to be installed near the village Trifeşti (Fig. 3), PS having an installed flow of 890 l/s and a head of 8.5 mH_2O – depending on the topographic features and the Prut River level in the Trifeşti area. In order to ensure a water change flow, the drainage channels that exist in the studied area are to be extended up to the supply front (new channel).

Excess water from the drainage channels have to be evacuated in a controlled manner, during the period of water excess, via the Bălteni pumping station towards Prut River and the Sculeni pumping station towards the Jijia River. Drainage channels reshaping is required because of their silting (Fig. 5). This involves deepening, correction of bottom width and slopes of the channel sides in order to achieve the following dimensions: h = 2.5 m, b = 0.6 m, m = 1.5.

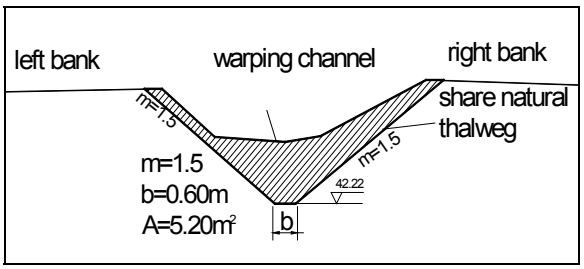

Fig. 5. Cross section showing reshaping of drainage channels

The water flow ensures water circulation in the area that will diminish the eutrophication process. If water exchange is ensured for the existing water within a system, the normal evolution of land and water ecosystems can be provided (URBANPROIECT, 2007). The Prut River water, that features the quality parameters given in Table 5 (2nd class quality), is able to provide dilution of water within drainage channel network, in the abandoned branches (e.g. Pruteţ), in the Pruteţ Bălătău and Teiva - Vişina aquatic reservations, respectively, in order to maintain life conditions demanded by aquatic, flora and fauna. Rehabilitations in the Danube Delta recommends (URBANPROIECT, 2007) quantity of water supply up to 10% of the water volume existing in the area.

The calculation of the renewal flow was started from the average volume set to be pumped in a year (50% probability) at Bălteni PS ($V_{pB}=13.3\cdot10^6$ m^3) and Sculeni PS ($V_{pS}=10\cdot10^6$ m^3). The renewal monthly volume (V_p) consists of 10% (URBANPROIECT, 2007) of the total average volume expected to be evacuated from the enclosure (Eq. 1):

$$V_p = \frac{V_{pB}+V_{pS}}{10} = \frac{(13.3+10)\cdot10^6}{10} = 2.33\cdot10^6\ m^3 \qquad (1)$$

The monthly water change flow is (Eq. 2):

$$Q_p = \frac{V_p}{t} \approx 0.90\ m^3/s = 900\ l/s \qquad (2)$$

This flow will be pumped from the Prut River and distributed to the seven drainage channels on the Bălteni North sector (20 L/s for each), the rest of 760 L/s will be conveyed by the channel along the terrace and divided over the Bălteni main channel 375 L/s and the Bălteni South sector 385 L/s.

Table 5. Physical and chemical parameters of Prut River at Ungheni hydrometric station – 2010 (Prut-Bârlad W.B.A, 2010b)

Physical and chemical parameters	***Mean values***
Average monthly flow (m^3/sec)	134.09
TSM- Total suspended matter (mg/L)	48.85
Dissolved Oxygen (mg/L)	9.74
Dissolved oxygen saturation degree (%)	88.78
BOD5 (mg/L)	4.12
COD-Mn (mg/L)	3.05
COD-Cr (mg/L)	14.55
Conductivity (µS/cm)	580.76
Fixed residue (mg/L)	390.06
pH (pH unit.)	8.10
Alcalinity (mg/L)	3.71
Total phosphorous (mg/L)	0.099
PO_4 (mg/L)	0.039
Total nitrogen (mg/L)	2.097
Chlorophyll (µg/L)	2.878

On the channel along the terrace from Bălteni South sector, near the village of Probota a sluice (Fig. 3) will be placed to ensure the controlled conveyance of water towards in Bălteni South sector (Fig. 3). Supplying and outflow gates will be provided for each drainage channels, and for Pruteţ Bălătău Lake. Maintaining the water level within water covered areas drainage channels division in water races is necessary. These may be achieved by level regulator gates building.

The evacuation of water towards warnambool shall be provided for the Bălteni north sector via the Bălteni PS (discharging in Prut River) and for Bălteni southern sector via the Sculeni PS (discharging in Jijia River). The outflow towards Prut and Jijia Rivers can be carried by means of pumping or via gravity, depending on the water levels within Prut and Jijia Rivers.

Forest protection curtains around the existing marshes, pools (Pruteţ Bălătău), along drainage channels and earth roads are necessary.

4. Conclusions

This paper proposes some solutions for the natural re-instatement and extension of the wetlands within the Prut River's floodplain that is in the embanked study area of Trifeşti Sculeni. In order to achieve this, the history of the area has been studied, as well as the current conditions in terms of hydrological and ecological regimes.

The proposed solutions consist in:

1. extension of wetland on small ground depression with low elevation;
2. reshaping of drainage channels cross section by removing alluviums;
3. connecting pools, oxbows, low depressions to drainage network;
4. refreshment of water in the studied wet area from Prut River (joining drainage channels and the channel at the terrace limit with the proposed new supplying channel);
5. rising water table by regulating water level in draining channels using gates and on the channel at the terrace limit a sluice;
6. setting up forest protection curtains.

After solutions application a positive impact on the biodiversity within Prut river floodplain is expected.

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References

Boers A., Frieswyk C., Verhoeven J., Zedler J., (2006), *Contrasting Approaches to the Restoration of Diverse Vegetation in Herbaceous Wetlands,* In: *Ecological Studies: Wetlands: Functioning, Biodiversity Conservation, and Restoration,* Bobbink R., Beltman B., Verhoeven J.T.A., Whigham D.F. (Eds.) **191**, Springer-Verlag Berlin Heidelberg, 225-246.

Darby S., Sear D., (2008), *Diver Restoration: Managing the Uncertainty in Restoring Physical Habitat,* Wiley, Chichester.

Downs P.W., Gregory K.J., (2004), *River channel management, Towards Sustainable Catchment Hydrosystems,* Routledge, London.

GD, (2007), Governmental Decision no. 1284/2007 regarding the declaration of bird special protected areas as an integrant part of the European Ecological Network Natura 2000 in Romania, *Romanian Official Monitor*, Part I, No. 739, 31st of October, 2007.

GEO, (2007), Governmental Decision no. 57/2007 regarding the regime of natural protected areas, conservation of natural habitats and of wild fauna and flora, *Romanian Official Monitor*, Part I, No. 442, 29th of June, 2007

Iconomu L., (2011), *Biodiversity conservation and specific problems of biodiversity conservation in Iasi County,* (in Romania), Regional Environmental Protection Agency Iasi, Romania, 16, On line at: http://biodiversitatecbc-apmis.ro/new/down/APM_suport%20de%20curs.pdf

ISPIF, (1976), Irrigation and drainage in Trifesti Sculeni area*,* Iasi County, Project no. 3189/1 (in Romanian), National Institute of Research and Development for Land Reclamation "ISPIF" Iasi, Romania.

ISPIF, (2000), Refurnish and upgrading of Sculeni and Balteni pumping stations from inside Trifesti Sculeni dammed and drained enclosure, Iasi county, Project no.167/1 (in Romanian), National Institute of Research and Development for Land Reclamation "ISPIF" Iasi, Romania.

Law 73, (2000) Law 73/2000, on the Enviroment Fund, *Romanian Official Monitor* No. 207 the 11th of May 2000

MO 161, (2006), Order. 161 of 16 February 2006 for approval of the Norms on surface water quality classification in order to establish ecological status of water bodies, *Romanian Official Monitor*, Part I, Nr. 511/13 June 2006.

MO, (2007), Ministerial Order No. 1964/2007 regarding the establishment of the protected natural area regime for the sites of Community interest, as integral part of European ecological network *Natura 2000* in Romania, (in Romanian), *Romanian Official Monitor*, Part I, No. 98, 7th of February, 2007.

NRC US, (2005), Endangered and Threatened Species of the Platte River, National Research Council (U.S.), National Academies Press Washington, D.C.

Prut-Bârlad W.B.A., (2010a), The regulation of exploitation of Prut-Bârlad catchment, (in Romanian), Report, Prut-Bârlad Water Basin Administration, National AdministrationRomanian Waters, Bucharest, Romania.

Prut-Bârlad W.B.A., (2010b), Bulletins (in Romania), On line at: http://www.rowater.ro/daprut/Sinteza%20de%20calitate%20a%20apelor/2010/Buletin_calitatea_apei.pdf

REPAI, (2004), Mutual management Romania – Republic of Moldova for biodiversity conservation on the border between the two countries, Phare Project, CBC RO2004/016.941.01.01.02, (in Romania), Regional Environmental Protection Agency Iasi, Romania, 15, On line at: http://biodiversitatecbcapmis.ro/new/down/starea%20de%20conservare/APM_BOOK_Starea_de_conservare_Interior_ART.pdf.

REPAI, (2008), Natural protected areas from Botosani, Iasi, Vaslui, Galati counties, Mutual management Romania–Republic of Moldova for biodiversity conservation on the border between the two countries, (in Romania), Regional Environmental Protection Agency Iasi, Romania, 6, On line at: http://biodiversitatecbc-apmis.ro/new/down/Buletin_informativ_2.pdf.

Sargent M., Carter K., (1999), *Managing Michigan Wildlife: A Landowners Guide*, Michigan Department of Natural Resources (eds.), Michigan United Conservation Clubs, East Lansing, MI., 297, On line at: http://www.michigandnr.com/publications/pdfs/huntingwildlifehabitat/Landowners_Guide/Resource_Dir/Acrobat/Wetlands_Intro.PDF

Stânca Costeşti Administration, (2011), Report on environmental impact study for the project *Rehabilitation of Stanca Costesti storage, Botosani County* (in Romanian), National Administration Romanian Waters, Stânca Costeşti Administration, Iasi, Romania.

URBANPROIECT, (2007), Zonal Spatial Plan for Danube Delta**,** Vol. I, Project No. 308/2007, (in Romanian), National Institute for Research and Development in Urban and Spatial Planning – URBANPROIECT Bucharest, Ministry of Public Works and Territorial Planning, 96, On line at: http://www.mdrl.ro/_documente/dezvoltare_teritoriala/amenajarea_teritoriului/patz_delta_dunarii/2009_06_12_Tulcea.pdf.

Vlad L., (2009), *Contributions to the study of changes of hydric and ecological regime in floodplains,* (in Romania), PhD Thesis, Faculty of Hydrotechnical Engineering, Geodesy and Environmental Engineering, Iaşi, Romania.

Zedler J.B., (2000), Progress in wetland restoration ecology, *Trend in Ecology and Evolution,* **15,** 402-407.