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# GIS MODELING FOR THE ECOLOGICAL RESTORATION OF A NATURE RESERVE: LEGII LAKE AND VALLEY (NW ROMANIA) - A CASE STUDY

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**Abstract:** The Legii Lake and Valley area has been a protected nature reserve for the conservation of wetland bird species since 1966, established in order to preserve one of the last remaining natural wetlands in the Fizes Basin. Nevertheless, hydro-technical constructions in the area resulted in the gradual shrinking of the lake. In present days, the entire area is covered by reed. GIS techniques were used in order to estimate the area and depth of the lake after ecological restoration of the wetland. The calculations were based on a DEM (Digital Elevation Model), obtained using contours extracted from the topographical maps (1:25000 scale). Historical maps of the area were also used in order to determine the evolution of the river system and slopes to evaluate the consequences of human intervention in the area. The result was a complex model that allows multiple scenario evaluation. The model was used to predict the changes in the ecosystem and how suitable the area would became for protected bird species.

**Key words:** Wetlands, water birds, habitat heterogeneity, predictability, restoration

## 1. INTRODUCTION

Wetlands, as natural ecosystems, have functions, derived from their hydrological, geological, chemical and biological characteristics, and values, derived from those functions, which are important or useful to people (Kent, 2001). The recognition of the importance of wetlands has continuously grown since the 1960s (Young, 1996). The wetlands function as habitat for wildlife community and species is considered a value in terms of preservation of flora and fauna and providing habitat for threatened, rare or endangered species (Richardson, 1994). Wetlands removal and drainage has been a common and highly rewarded practice, leading to increased profits, mainly by conversion in agricultural land (Biebighauser, 2007). As a result, more than half of the world wetlands have been completely destroyed, and the remaining have been degraded to a greater or lesser extent by human activities (Fraser & Keddy, 2005). Ecosystems, including protected areas, could have suffered previous degradation and/or are subject to constant pressure. The management of the protected areas, a crucial part of biodiversity conservation, has shifted in consequence from non-intervention to active management and restoration in order to successfully conserve biodiversity and ecosystem function (Keenleyside et al., 2012). Ecological restoration of protected areas will become more necessary with increasing environmental pressure and climate change (Keenleyside et al., 2012) and has been defined as the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.

We identified a nature reserve in the Fizes Plain (NW Romania), a pond that has been almost completely drained during several decades due to a single intervention of deepening the draining stream. The protected area has consequently lost the function as habitat for wetland bird species, which was the original goal of the nature reserve, and the

value for the local community. We propose relatively simple measures to assist the recovery of the ecosystem and we use GIS techniques to calculate the area of different habitats resulting after reconstruction. Our objectives are to predict the composition of wetland bird fauna after restoration and to estimate the abundance of several bird species.

The aim of this study is to provide the plan for re-establishing and maintaining the values of the Legii Lake and Valley protected area, especially to restore habitats for locally extinct bird species, by active intervention of restoring natural ecosystem structure, function and composition (Keenleyside et al., 2012). The ecosystem restoration of the Legii Lake and Valley aims to recover the ecological, cultural and socio-economic value of the protected area and its surroundings. The first step in restoring the species composition of the wetland ecosystem is to recover the hydrological function and re-establish the natural hydrology.

## 2. METHODS

In order to calculate the volumes of the resulting pond after restoration, GIS techniques and field measurements were used. At first a DEM (digital elevation model) of the pond area was developed. This model is based on contours extracted from the Romanian Topographical map at 1:25000 scale and GPS measurements in the field, all data being integrated by using Topo to Raster function in ArcGIS 10.1. After the DEM development, the next step was to evaluate the height of the dam and the resulting water level. All calculations were performed using GRASS GIS 6.4.2. It is important to note that the spatial resolution of the DEM is 1m and the coordinate system used is Stereo 70 (the national coordinate system of Romania with meter as the liner unit). The DEM was imported into GRASS GIS and the r.lake module was used in order to obtain the area and volume of the resulting lake. R.lake is a module in GRASS GIS that fills a lake to a set water level by a given starting point. The result is a raster map with cell values representing water depth and NULL values for all other cells. The depth is reported relative to the specified water level. Basically the module uses a 3x3 moving window cell approach to find all cells that match the following criteria: cells are below the specified elevation; cells are connected with an initial cell called seed; cells are not NULL or masked. Important in this stage is to notice that the DEM units must be the same as the specified water level. For the purpose of the study and considering the fact that the actual water level measured in the field is 297m above sea level, an increase of just 1m in the water level was analyzed. The r.lake module was used several times in order to represent different water levels and in each case, the total water area and volume of the pond were determined. In order to calculate the specific depth area (areas with a depth varying from 0 to 0.5 meters; areas with a depth of 0.5 to 1m; areas with a depth of 0.8 to 1.2 meters and more that 1 meter depth) the module was used to calculate the area and volume for the following water levels (altitude in meters above sea level): 298 meters (the proposed dam altitude), 297.5 meters; 297.2 meters; 297 meters; 296.8 meters. The seed coordinates were considered the same in each case and represent the point where the depth is maximum. The coordinates were expressed in meters by using the national coordinate systems of Romania that is Stereo 1970.The resulting raster maps were exported from GRASS GIS and further analyzed in ARCGIS. The final stage was to convert the raster maps into vector layers in order to prepare the maps.

We used historical information about the area to document the evolution of the wetlands and the bird fauna as a guide to setting the goals of the restoration process and to predict the changes in the composition of bird communities. We compared the oldest systematic research on bird fauna (1966) with the newest published data (2008) and field surveys (2014) in relation with the habitat data to evaluate the changes. We used the simulated results to estimate the abundance of different bird species, based on areas of different wetland habitats created.

## 3. STUDY AREA

"Lacul si Valea Legiilor" is a nature reserve located in the Fizes River Basin, Transylvanian Plain, Romania (Fig. 1).

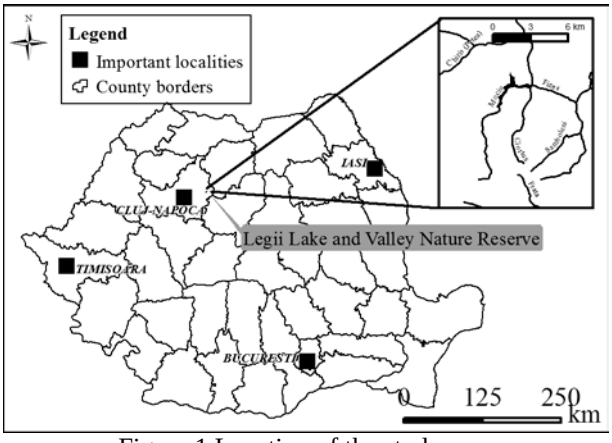

Figure 1 Location of the study area

The Legii pond is fed by the Mociu stream and drained by the Legii stream.

The wetlands of the Transylvanian Plain have suffered considerable changes during the decades, both from natural causes, like alluvial deposits or landslides, and from human interventions (Filipascu, 1968; Săndulache, 1968), which continue in the present. In the year 1900 there were 51 wetlands in the Fizes Basin, but in 1966, due to human intervention, only 13 remained. By that time, the largest four wetlands had already been changed into fish farms by flow and depth control, reed bed removal and shore modification. The authorities' plan was to change all existing wetlands in the area into fish farms, with the exception of Stiucilor Lake, already a natural reserve, and, for that moment, the Legii Pond, due to its location outside the main valley.

The ponds and wetland located on Mociu and Legii streams suffered significant changes during the decades, being created, modified and destroyed by human actions. The Josephine maps (1764-1785) show in the Legii (Mociu and Legii streams) area the existence of five different large ponds and several marshlands. On the 3rd Military Mapping Survey of Austria-Hungary (1868 – 1880) most of the former ponds are no longer present. The Mociu Pond, nearby the Legii Pond, was completely dried out in 1913 (Filipascu, 1968).

In 1966 the Legii Pond, surrounded by reed, covered an area of approx. 8 ha (Filipascu, 1968). The Subcommittee for the Conservation of Nature Monument Cluj (Romanian Academy of Science) proposed the designation of a regional important nature reserve in the area. The goal was to preserve the habitats for bird fauna: deep water for diving birds, marshlands for shore birds and several duck species, reed beds and other higrophyle vegetation for other aquatic species, and the forest and old willow trees for nesting *Ardeidae* species. The proposed protected area consisted of marshes, river meadows, the pond itself, reed beds, old willow trees along the valley, and the surrounding hills, including a small forest. The nature reserve named "Legii Lake and Valley" covered approx 300 ha, with 40 ha of reed beds, marshes, helm and open water (Decision no. 244/1966 of Cluj People's Council). In 1977 the area was again proposed for conservation under national legislation, under the name "Legii Lake and Valley", with an area of 26 ha, with 20 ha of reed beds and 6 ha of open water. An additional buffer area of 400 ha of meadow, marshes, wet grasslands and hills was proposed. The entire area was the last remaining pond in the Fizes Basin (apart from Stiucilor Lake) that maintained its natural aspect in a natural ambiance. By that time, the woody vegetation had already been largely destroyed by the locals, and it was expected that by protecting the area under national legislation, the vegetation will restore itself, without active management. Despite the conservation status, in the late 1970s the Legii stream draining the pond was channelized and deepened, in an attempt to "regain land for agriculture". As a result, the earth dam burst and water started to leak away from the pond, thus, starting with the early 1980s, the open water area diminished continuously and the basin was invaded by reed. In 2010 there was a marsh area 90% covered by vegetation (20 % *Typha sp.* and 80% *Phragmites australis*), with a small open water in center of the wetland (Stermin et al., 2011). In present days (spring 2014) there is no longer open water, only reed beds (12 ha).

The legislation regarding the management of national territory and the nature protected areas was passed only in the year 2000 (Law no 5/2000), and only 13.50 ha of the proposed protected area were designated as nature reserve under the name "Legii Valley". Four years later, the nature reserve was expanded to 125 ha (Governmental Decision no. 2151/2004 regarding the designation of new nature protected areas), but no conservation or restoration measures were implemented.

The current natural reserve contains the reed beds and open water, the Legii valley, including a portion of the Geaca Pond, but the Legii forest was completely excluded. (Fig. 2).

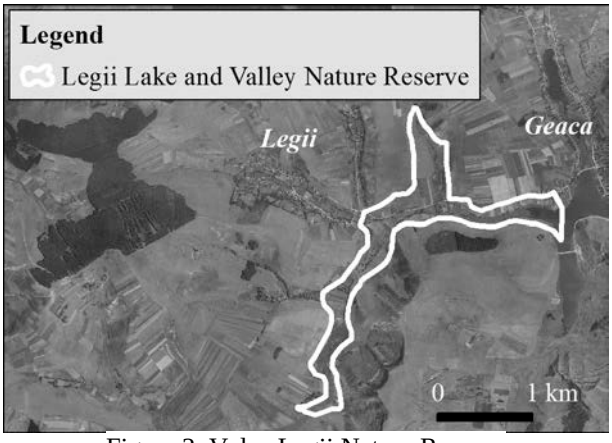

Figure 2. Valea Legii Nature Reserve

## 4. RESULTS

By using a dam level of 298 meters above sea level, the pond water level increases to the same altitude and the total area of water is 25.15 hectares with a volume of 318231.80 cubic meters. This is a rather dramatic change as the current pond area

(considering the altitude of 297m as the current water level) is 12.11 hectares.

The depth of the lake is of approximately 3 meters near the dam in the case of a 298-meter water level, obviously decreasing with the decrease in the water level. In order to obtain the areas with water depth between the above mentioned intervals we used the values calculated for each water level. To calculate the area of water with a depth between 0 and 0.5 meters the area at a level of 297.5 meters was subtracted from the total water area at the 298 meters above sea level.

The formula can be presented in the following form:

Ahl =Ah-Al where:

Ahl-area with water between a higher and a lower water level

Ah-area higher water level

Al-area lower water level

The formula was used by considering 298 always a higher water level; 297.5 and 297.2 as higher water level but also lower water level and the values for 297.2 and 296.8 always as lower water level. The results are presented in table 1.

Table 1. The resulting water depth and corresponding areas

| Water depth (in meters) | Area (hectares) |
|---|---|
| 0-0.5 | 10.07 |
| 0.5-1 | 2.96 |
| 0.8-1.2 | 2.53 |
| More than 1 | 13.04 |

## 5. DISCUSSIONS

The analysis of historical data showed a dramatic reduction of the wetland area and of the area covered by open water, which was 7 ha in 1967, with 45 ha of reed beds (Filipascu, 1968), and only 2.314 ha with 16.77 ha of reed beds (David, 2008). The destruction of wetland habitat caused the local extinction of several wetland bird species in the last decades. The number of bird species breeding in the Legii wetland dropped from 24 (Filipascu, 1968) to 13 (David, 2008) and to only 10 in the present (Table 2). Recent studies showed that the size of the pond is the most important variable in relation to the number and density of wetland birds (Sebastián-González & Green 2014).

In the wetlands, the microstructure of the habitats is strongly correlated with the water level and dictates the composition and complexity of bird communities, being an important factor in determining the number of bird species present. The development of the aquatic vegetation influences the repartition of fish and crustaceans (Adopo et al., 2014), an important food source for wetland birds. The establishment of fauna (including bird species) and flora when restoring or creating wetlands can be strongly linked with size, depth of water and isolation of the site (Sebastián-González & Green 2014).

Our results showed that by using active management for ecological restoration, we would obtain significant areas with different water levels, resulting in a wetland with a complex microhabitat structure, a key factor in habitat selection, even within the same bird foraging guild (Yuan et al., 2014).

Table 2.Temporal changes in the composition of nesting bird fauna

| | Species | 1967 | 2004 | 2014 |
|---|---|---|---|---|
| *1* | *Podiceps cristatus* | *P* | - | - |
| *2* | *Podiceps grisegena* | *P* | - | - |
| *3* | *Podiceps nigricollis* | *P* | - | - |
| *4* | *Ardea purpurea* | *P* | - | - |
| *5* | *Ixobrycus minutus* | *P* | *P* | *P* |
| *6* | *Botaurus stellaris* | - | *P* | *P* |
| *7* | *Anas plathyrhinchos* | *P* | *P* | *P* |
| *8* | *Anas querquedula* | *P* | - | - |
| *9* | *Anas strepera* | *P* | - | - |
| *10* | *Aythya nyroca* | *P* | - | - |
| *11* | *Aythya ferina* | *P* | - | - |
| *12* | *Anas clypeata* | *P* | - | - |
| *13* | *Fulica atra* | *P* | *P* | - |
| *14* | *Locustella naevia* | *P* | - | - |
| *15* | *Locustela luscinioides* | *P* | *P* | *P* |
| *16* | *Locustella fluviatilis* | *P* | - | - |
| *17* | *Acrocephalus arundinaceus* | *P* | *P* | *P* |
| *18* | *Acrocephalus scirpaceus* | *P* | *P* | *P* |
| *19* | *Acrocephalus palustris* | *P* | - | - |
| *20* | *Acrocephalus schoenobaenus* | *P* | *P* | *P* |
| *21* | *Gallinulla chloropus* | *P* | *P* | - |
| *22* | *Rallus aquaticus* | *P* | *P* | *P* |
| *23* | *Porzana porzana* | *P* | *P* | - |
| *24* | *Porzana parva* | *P* | - | - |
| *25* | *Emberiza schoeniclus* | *P* | *P* | *P* |
| *26* | *Circus aeruginosus* | - | *P* | *P* |

*P* – present

We would expect around 10 hectares of reed beds (a specific habitat dominated by *Phragmites australis*), 6 hectares of cattail habitat (dominated by *Typha latifolia*), with different conformations

(compact and fragmented cattail habitats) and more than 10 hectares of open water (Fig. 3).

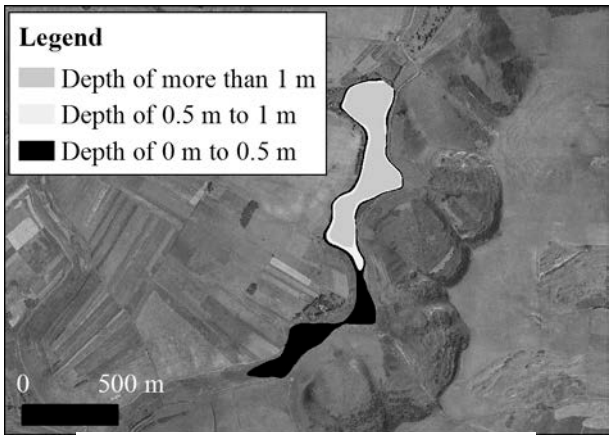


Figure 3. Areas with different water depths

Almost all protected wetland bird species depend on one or the other of these habitat microstructures for breeding, feeding and finding shelter (Table 3), although only few restoration plans attempt to optimize water depth for focal bird species (Nadeau & Conway, 2015). High habitat heterogeneity is important not only in nest site selection and in food availability, but in seasonal movements and reducing inter- and intraspecific competition for resources. Naturally fluctuating water and seasonal hydroperiods are expected to attract waterfowl and wading birds (Cheek et al., 2014). By increasing the overall water area with and without vegetation, and by creating muddy shorelines with gentle slopes, we could expect 49 different species of birds to use the nature reserve habitats: 33 nesting species and 16 species visiting the area for feeding, wintering and during migration (Table 3). The shoreline structure is especially important for wading birds, and it is particularly exposed to human pressure and prone to alteration (Boromisza et al., 2014).

Table 3. Bird species that would benefit from the restoration of the wetland habitat

| Species | Shore | | | Reedbed habitat (depth 0-0.5 m) | | | Cattail habitat (depth 0.5-1 m) | | | Open water (depth > 1 m) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | B | W | M | B | W | M | B | W | M | B | W |
| *Gavia arctica* | | | | | | | | | | * | | |
| *Gavia stellate* | | | | | | | | | | * | | |
| *Podiceps cristatus* | | | | | | | | * | | * | * | * |
| *Podiceps grisegena* | | | | | | | | * | | * | * | |
| *Podiceps nigricollis* | | | | | | | | * | | * | * | * |
| *Tachybaptus ruficollis* | | | | | * | | | * | | * | * | * |
| *Phalacrocorax carbo* | | | | | | | | | | * | | |
| *Botaurus stellaris* | | | | * | | | | | | | | |
| *Ixobrychus minutus* | | | | * | * | | | | | | | |
| *Egretta alba* | | | | * | * | | | | | | | |
| *Ardea cinerea* | | | | * | * | | | * | | | | |
| *Ardea purpurea* | | | | | * | | * | * | | | | |
| *Nycticorax nyctycorax* | | | | * | | | | | | | | |
| *Cygnus olor* | | | | | | | | * | | * | * | * |
| *Anas platyrhyncos* | | | | | * | | | | | * | * | * |
| *Anas strepera* | | | | | | | | | | * | | * |
| *Anas crecca* | | | | | * | | | | | * | * | * |
| *Anas querquedula* | | | | | * | | | | | * | * | * |
| *Anas clypeata* | | | | * | | | * | | | * | | |
| *Aythya ferina* | | | | | * | | | * | | * | * | * |
| *Aythya nyroca* | | | | | * | | * | * | | * | * | |
| *Circus aeruginosus* | * | | | * | * | | * | * | | | | |
| *Rallus aquaticus* | | | | * | * | * | | | | | | |
| *Porzana porzana* | * | * | | * | * | | | | | | | |
| *Porzana parva* | | | | * | * | | * | * | | | | |
| *Porzana pusilla* | | | | * | * | | | | | | | |
| *Gallinula chloropus* | | | | * | * | | * | * | | * | * | |
| *Fulica atra* | | * | | | | | * | * | | * | * | |
| *Vanellus vanellus* | * | * | | | | | | | | | | |
| *Charadrius dubius* | * | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Calidris alpine* | * | | | | | | | | | | | |
| *Actitis hypoleucos* | * | | | | | | | | | | | |
| *Tringa ochropus* | * | | | | | | | | | | | |
| *Tringa glareola* | * | | | | | | | | | | | |
| *Tringa tetanus* | * | | | | | | | | | | | |
| *Phylomacus pugnas* | * | | | | | | | | | | | |
| *Himantopus himantopus* | * | | | | | | | | | | | |
| *Larus ridibundus* | | | | | | | | | | * | * | * |
| *Chlidonias niger* | | | | | | | | | | * | * | |
| *Chlidonias leucopterus* | | | | | | | | | | * | * | |
| *Chlidonias hybridus* | | | | | | | | | | * | * | |
| *Sterna hirundo* | | | | | | | | | | * | * | |
| *Locustella luscinioides* | | | | * | * | | * | * | | | | |
| *Acricephalus schoenobaenus* | | | | * | * | | | | | | | |
| *Acrocephalus palustris* | | | | * | * | | | | | | | |
| *Acrocephalus scirpacaeus* | | | | * | * | | | | | | | |
| *Acrocephalus arundinacaeus* | | | | * | * | | | | | | | |
| *Panurus biarmicus* | | | | * | * | * | * | * | * | | | |
| *Emberiza schoeniclus* | | | | * | * | | * | * | | | | |

Legend
*M – migratory*
*B - breeding*
*W – wintering*

It is especially important that the wetland restoration and management would provide nesting habitat for the Purple Heron (*Ardea purpurea*). The species had been reported as common and breeding among tall reeds in the Fizes Basin in 1874 (Danford & Brown, 1875). By the year 1956 the species was already rare, with only a couple of pairs breeding (Munteanu & Mătieş, 1968), and extinct from the area 10 years later (Filipascu, 1968). In present times, the species does not breed in any of the Fizes Basin wetlands, but juveniles have been spotted in the Legii area several times. We hope that by providing the specific habitat (fragmented Cattail habitat) the species will once again find a nesting place in the Fizes Basin.

Little crake (*Porzana parva*) is a species that in recent years has nested only in two other wetlands in the Fizes Basin (Stermin et al., 2011), but we expect the species to recolonize the Legii nature reserve after the ecological restoration. Taking into account its ecological needs and density in the other wetlands with similar habitats type from the Fizes Basin (Stermin et al., 2012), we would expect a number of 3 to 6 breeding pairs.

The ecological restoration of the wetland will dramatically increase the probability of nesting for one of the most elusive bird species, Baillon's Crake (*Porzana pusilla*). This typical wetland bird was reported as present in the Fizes Basin in the 19$^{th}$ century (Herman, 1871) and again in 2005 (nest) and 2010 (song), but with no nest and eggs measurements and no song recordings, the species cannot be listed as a sure presence in current days (Stermin & Pripon, 2011).

An important species of conservation concern is the Ferruginous Duck (*Aythya nyroca*). In the last four years, only one pair of Ferruginous Duck has nested in the Fizeş Bazin, in Sucutard pond. This species prefers heterogeneous habitat dominated mainly by *Typha* sp. (Green, 1998; Robinson, 2003). The habitat types and areas expected to be formed in the target zone overlap with the species ecological requirements. In this context, we expect a minimum number of two breeding pairs in the area.

Red-necked Grebe (*Podiceps grisegena*) is another species with a strong dependence on open water surrounded by heterogeneous habitats (dominated by *Typha* sp.) (Fjeldså, 1982, 2004). In the last years, this species has not bred constantly in the Fizes Bazin. Correlating our results with the species ecological needs, we aspect a number of 2 - 3 nesting pairs.

Almost 10 hectares of reed beds will provide breeding habitat for around 20 breeding pairs of Little Bittern (*Ixobrychus minutus*), and for 2-4 Bittern territorial males (*Botaurus stellaris*). These species of special conservation concern strongly depend on marsh vegetation with constant water level.

## 6. CONCLUSIONS

The ecological restoration of the Legii Lake and Valley nature reserve would restore a wetland with high heterogeneous habitats that will improve the ecological value of the entire Fizeş Bazin

wetlands network. Numerous bird species of special conservation concern under European legislation (Council Directive 2009/147/EC) would greatly benefit from the reestablishment of the natural functions and of the wetland. At least one locally extinct bird species could potentially reoccupy the area and breed in the nature reserve. The value of the entire area would increase, not only for the locals, but also for the scientific community.

**REFERENCES**


**Adopo K.L., Romanescu G., N'Guessan A.I. & Stoleriu C.** 2014. *Relations between man and nature and environmental dynamics at the mouth of the Komoé River, Grand-Bassam (Ivory Coast).* Carpathian Journal of Earth and Environmental Sciences, 9 (**4**):137-148.

**Biebighauser, T. R**. 2007. *Wetland Drainage, Restoration and Repair*. Lexington: University of Kentucky, 241pp.

**Boromisza, Z., Pádárné Török, E. & Ács, T.** 2014. *Lakeshore-restoration - landscape ecology - land use: assessment of shore-sections, being suitable for restoration, by the example of Lake Velence (Hungary).* Carpathian Journal of Earth and Environmental Sciences, February 2014, 9 (1): 179 - 188.

**Cheek, M.D., Williams, G.E., Bousquin, S.G., Colee, J. & Melvin, S.L.** 2014. *Interim response of wading birds (Pelecaniformes and Ciconiiformes) and waterfowl 204 D.H. Catlin et al. / Biological Conservation 180 (2014) 196–205 (Anseriformes) to the Kissimmee River restoration project, Florida, USA.* Restoration Ecology 22: 426–434.

**Danford, C. G. & Brown, J. A. H**. 1875. *The Birds of Transylvania*. The Ibis, **II**: 188-199, 412-434

**David, A**. 2008. *The ecology of bird populations of the Fizeş Basin* (Ecologia populatiilor de pasari din Campia Fizesului). Cluj, Presa Universitara Clujeana, 148pp.

**Filipascu, Al**. 1968. *Ornithological fauna of the Geaca Lakes (Transylvanian Plain) after 100 years*. (Fauna ornitologica a lacurilor de la Geaca (Cimpia Transilvaniei) dupa 100 de ani), Ocrotirea Naturii **12**, 1: 21-41

**Fjeldså, J**. 1982. *The adaptive significance of local variations in the bill and jaw anatomy of North European red-necked grebes Podiceps grisegena*. Ornis Fennica **59**:84–98.

**Fjeldså, J.** 2004. *The Grebes-Podicipedidae*. Oxford University Press, Oxford, 264pp.

**Fraser, L. H. & Keddy P.A** (eds.). 2005. *The World's Largest Wetlands: Ecology and Conservation*. Cambridge University Press, Cambridge, UK. 488pp.

**Green, A. J.** 1998. *Habitat selection by the Marbled Teal Marmaronetta angustirostris, Ferruginous duck Aythya nyroca and other ducks in the Göksu Delta, Turkey, in summer.* Revue Ecologie (Terre et Vie) **53**: 225–243.

**Herman, O**. 1871. *A Mezöség. I. A Hodos Vagy Szarvasto és Környeke. Természetrajzi, jelesen állatani syempontból táryalva.* (The Transylvanian Plain. Environmental and Zoological Description) Az Erdély Muzeum - Egylet Evkönyvei **V:** 8 - 21.

**Keenleyside, K.A., Dudley, N. Cairns, S., Hall, C.M. & Stolton, S.** 2012. *Ecological Restoration for Protected Areas: Principles, Guidelines and Best Practices*. Gland, Switzerland: IUCN. 120pp.

**Kent, D. M.** 2001. *Applied wetlands science and technology*. Boca Raton, FL: Lewis Publishers, 388 pp.

**Munteanu, D. & Mătieș, M.** 1968. *Aperçu sur l'avifaune des Étangs de Geaca.* (Contributions on the ornithology of the lakes around Geaca). Stejarul **2**: 185-199.

**Nadeau, C. P. & Conway, C. J.** 2015. *Optimizing water depth for wetland-dependent wildlife could increase wetland restoration success, water efficiency, and water security.* Restoration Ecology, 23 (**3**): 292-300.

**Richardson, C. J**. 1994. *Ecological functions and human values in wetlands: a framework for assessing forestry impacts.* Wetlands, **14**, 1: 1-9

**Robinson, J. A.** 2003. *A global overview of the ecology of the Ferruginous Duck*. In: Petkov N, Hughes B, Gallo-Orsi U., editors. *Ferruginous Duck: From Research to Conservation*. Sofia, Bulgaria: Birdlife International, BSPB and TWSG, pp. 114–121.

**Săndulache, Al.** 1968. *Contribuții la studiul lacurilor dulci din Câmpia Transilvaniei* (Contributions to the study of the lakes of the Transylvanian Plain, In Romanian). Lucrări științifice. Oradea **2**: 75-85.

**Sebastián-González, E. & Green, A. J.** 2014. *Habitat Use by Waterbirds in Relation to Pond Size, Water Depth, and Isolation: Lessons from a Restoration in Southern Spain.* Restoration Ecology 22 (**3**): 311-318.

**Stermin, A.N. & Pripon L.R.** 2011. *Baillon's Crake (Porzana pusilla intermedia, Hermann 1804) geographical and historical distribution in Romania.* Brukenthal Acta Muzei, **VI (3)**: 493-498.

**Stermin, A.N., Pripon, L.R. & David, A**., 2012. *The importance of homogenous vs. heterogenous wetlands in rallid (Rallidae) phenological seasons*. Brukenthal Acta Musei, VII (**3**): 549-554.

**Stermin, A.N., Pripon, L.R., David, A. & Coroiu, I.** 2011. *Wetlands management for Little Crake (Porzana parva) conservation in a "Natura 2000" site.* 2nd International Conference on Environmental Science and Development, Singapore, IPCBEE.**4**: 91-94.

**Young, P.** 1996. *The "New Science" of Wetland Restoration*. Environmental Science & Technology News, **30**, 7; 292-296.

**Yuan, Y., Zeng, G., Liang, J., Li, X., Li, Z., Zhang, C.,**

**Huang, L., Lai, X., Lu, L., Wu, H. & Yu, X.** 2014. *Effects of landscape structure, habitat and human disturbance on birds: a case study in East Dongting Lake wetland*. Ecol. Eng. **67**: 67-75.

***Council Directive 2009/147/EC on the conservation of wild birds.

***Decision no. 244/1966, republished and added by Decision no. 447/16 May 1967 of the Cluj People's Council (Decizia nr. 244/1966, republicata si completata prin Decizia 447/16 mai 1967 al Sfatului Popular Cluj)

***Governmental Decision no. 2151/2004 regarding the designation of new nature protected areas (Hotărârea nr. 2151/2004 privind instituirea regimului de arie naturală protejată pentru noi zone)

***Law no. 5/2000 regarding the approval of the Plan for the management of national territory, section III – protected areas (Legea nr. 5 din 6 martie 2000 privind aprobarea Planului de amenajare a teritoriului naţional - Secţiunea a III-a - zone protejate).

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