FACTORS INFLUENCING ABUNDANCE AND SPECIES RICHNESS OF OVERWINTERED WATERBIRDS IN PARISHAN INTERNATIONAL WETLAND IN IRAN

JAHANBAKHSH GANJEH, M.[1] – KHORASANI, N.[1*] – MORSHEDI, J.[2] – DANEHKAR, A.[3] – NADERI, M.[4]

[1]*Department of Environment, Science and Research Branch, Islamic Azad University Tehran, Iran; e-mail: mehdijahan59@yahoo.com*

[2]*Department of Geography, Ahvaz Branch, Islamic Azad University Ahvaz, Iran; e-mail: jafarmorshedi@gmail.com*

[3]*Department of Environmental Science, University of Tehran Tehran, Iran; e-mail: afdanehkar@gmail.com*

[4]*Department of Environmental Sciences, Faculty of Agriculture and Natural Resources Arak University, 38156-8-8349, Arak, Iran e-mail: m-naderi@araku.ac.ir*

**Corresponding author e-mail: mehdijahan59@yahoo.com, tel: +98-9-17-571-583*

(Received 7th Apr 2017; accepted 5th Jul 2017)

Abstract. Parishan International Wetland, an Iranian Ramsar Site in Fars Province, is one of the two demonstration sites for the UNDP/GEF Conservation of Iranian Wetlands Project. The aim of this study was to examine the factors influencing water bird abundance, density, the number of species, and species richness in Parishan wetland from 1991 to 2010. We used remote sensing techniques to study some environmental factors affecting waterbirds community. Spearman’s Correlation Coefficient and linear regression were also used to examine the impact of environmental factors on the community of waterbirds. The results showed that only the nearest wetland area was significantly correlated with abundance and density of species ($p < 0.01$). Also, the vegetation cover surface of wetland ($P < 0.01$); the deepest depth of wetland ($P < 0.01$); and the areas shallower than 1m ($P < 0.05$) were significantly correlated with the number and richness of species (Margalef Index). The Resulting models of the backward multiple regression test also indicated that the nearest wetland area was a good predictor of abundance (P value < 0.01) and density of waterbirds (P value < 0.05). Furthermore, the vegetation cover surface of wetland, was a good predictor of the number of species (P value<0.01) and of the richness species based on Margalef Index (P value<0.01). The area of the Parishan wetland has fallen very low in 2010 and reducing the area of the wetland has led to a sharp decrease in the number of birds in the wetland.
Keywords: *species richness, remote sensing, Fars province, wetland, bird abundance*

Introduction

Conservation of wetlands has become a frequent topic among wildlife managers (Kumar et al., 2007). Wetlands are important conservation sites due to their rich biodiversity; they are among the most productive ecosystems in the world and they harbor many globally threatened species (Casado and Montes, 1995; Green, 1996;

Petrie, 1998; Getzner, 2002; Kumar et al., 2007). Wetlands have one of the highest biodiversity and biological productivity in the world (Whittaker and Likens, 1973; Gibbs, 1993; Casado and Montes, 1995; Paracuellos and Tellería, 2004). One of the most important functions of wetlands is to protect biodiversity. In fact, biodiversity envelops all forms of life on the planet and includes all genes, ecosystems, species, and ecological processes in the world (Balton et al., 2002; Collwell and Dodd, 1995; Behrouzi-Rad, 1996). Preserving the genetic diversity of species and ecosystems guarantees continuity of the environment. So, for the continuation of the health of the environment, identification of species, their habitats, and also the study of their population dynamics based on scientific methods are required (Mori et al., 2001; Mehrjoo, 1992). The importance of aquatic habitats for dependent organisms as irreplaceable ecosystems and preservation of biodiversity of valuable plant and animal species, has attracted the attention of protective agencies to these areas (Balton et al., 2002; Collwell and Dodd, 1995). Aquatic birds are considered as the most significant animal species to detect ecological changes in the aquatic environment and mangroves (Bambang, 2008; Bayly and Gomez, 2008). Waterbirds are important biological indicators that play an important role for the determination of the health of the wetlands (Amat and Green, 2010; Hoyer and Canfield, 1994; Sonal et al., 2010). Therefore, studying changes in the populations of Waterbirds and the factors involved in these changes is essential for the management of wetlands. Understanding factors that determine population size is central to ecology, population genetics, and conservation biology (Backwell et al., 1998; Frankham et al., 2002; Taft et al., 2002). Water bird community dynamics are complex and influenced by many natural and anthropogenic factors (Mundava et al., 2012). Natural dynamics of water bird populations is mainly affected by rain or by having access to water (Paillisson et al., 2002). Other factors affecting the community composition and abundance of birds include migration, breeding, and moulting of birds along with human factors (hunting, Water Harvesting and Agricultural activities) (Caziani et al., 2001; van Niekerk, 2010; Mundava et al., 2012). The aim of this study is to assess the changes in waterbirds community and the factors affecting these changes in Parishan wetland in Fars province in Iran.

Materials and methods

Study area

Lake Parishan, an Iranian Ramsar Site in Fars Province, is one of the two sites nominated for the UNDP/GEF Conservation of Iranian Wetlands Project. As a part of Arjan Parishan Protected Area, Parishan Lake was registered by UNESCO as a Biosphere Reserve (Department of Environment of Fars, 2010). This wetland is located in the eastern part of Kazeroun City surrounded by Parishan protected area (29˚ 34' 48" N and 51˚ 54' 36" E) with an area of about 60000 hectares in southwest Iran (*Fig. 1*). Parishan wetland with an arid and desert cold climate at an average elevation of 820 m above sea level receives an annual rainfall of about 430 mm (Department of Environment of Fars, 2010). The evaporation capacity in the area is high (2470 mm/yr on average) ranging between 1600-3350 mm/yr. The surface area of the water body changes

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

seasonally according to the hydrological condition and generally varies from more than 2500 to almost 5000 ha. The Lake does not have a natural outflow and its main source of water loss is through evaporation and consumption by vegetation cover. However, a large number of deep wells (more than 800) have been dug around the Lake exploiting significant volume of groundwater for agricultural uses resulting in wetland discharge (Fars DOE, 2010). The wetland is almost surrounded by agricultural farms in all directions; however, further on the northern elevations, there exists a semi-dry type of forest cover consisting mainly of scattered oak trees. The water body of the Lake as well as different patterns of vegetation cover around and inside the lake provides diverse habitats which supports the rich biodiversity of the wetland. The Lake hosts significant number of migratory waterbirds specially wintering population which breed there. At least, five globally threatened species such *as Pelecanus crispus*, *Marmaronetta angustirostris*, *Aythya nyroca*, *Oxyura leucocephala* and *Aquila heliaca* (Fars DOE, 2010) are usually present on the lake, occasionally in large population.

Figure 1. *Study area: Geographical location of Parishan Wetland in Fars Province, Iran (Fars DOE, 2010)*

Waterbird surveys

The avian characteristics monitored for each year are presented in *Table 1*. The Environmental Protection Agency of Iran is doing the mid-winter count of waterbirds in Parishan wetland every year. Information about the counting of waterbirds over the past years was obtained from the Environmental Protection Agency of Iran and Waterbird surveys were conducted from 1990 to 2015. To calculate the species richness the index of Margalef was used (*Table 1*).

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

Table 1. *The investigated characteristics of birds*

Avian characteristics	Abbreviation	Equation
The number of species in each year	S	
The density	D	average value of the number of individuals per ha
Total number of all birds in the wetland in each year	N	
Margalef species Richness	R	$R = \frac{s-1}{\ln N}$

S = the number of Species, N= Total size of population, Pi= Relative abundance of species i, ni= Number of species i

Environmental characteristics

All environmental factors monitored are shown in *Table 2*. Landsat satellite images were used to calculate the area of the wetland, shoreline length, the deepest depth of the wetland, coverage of water surface by vegetation and the area of the nearest wetland (Arjan wetland) in each year. Firstly, radiometric and geometric corrections were applied to all images using ENVI 5.1 Software. Then, the layers of the coverage of water surface by vegetation and water area were prepared using supervised classification method.

Table 2. *Environmental and human factor descriptions and abbreviations*

Factors	Abbreviation	Measuring unit
Wetland area	Wa	hectare
Open water area	OWa	hectare
Vegetation cover	Vc	hectare
Shoreline length	Sl	m
Area shalower than 1 meter	As	hectare
The nearest wetland area	Nw	hectare
Average temperatures	At	C0.
Shoreline Development Index	SDI	
Most depth	Md	m

To calculate the water areas with a depth of less than 1 m and the deepest depth of the wetland in each year, the bathymetric maps of the wetland in different years were obtained from the Environmental Protection Agency of Fars province and on the basis of bathymetry maps of the wetland, the DEM layers of the wetland area was prepared by the ARC gis 10.2 Software. Then, the DEM layers of the wetland were cropped for each year according to the water surface area of the wetland. Finally, these layers were entered into the ARC gis Software and the water areas with a depth of less than 1 m and the deepest depth of the wetland were calculated for each year.

Temperature data were obtained from the weather station of the Parishan wetland and average temperatures for the winter months (when counting birds) were calculated.

Shoreline development was calculated based on the following equation for each year (Margalef, 1983):

$$SDI = \frac{Sl}{2\sqrt{OWa \times \pi}} \quad \text{(Eq. 1)}$$

where SDI stands for Shoreline Development Index; Sl stand for Shoreline Length; and OWa stands for Open Water Area

Data analysis

Abundance data were first transformed into densities (number of birds per ha) to allow comparison of the wetland with different sizes in different years. Square-rooted densities were numerically transformed to down weight dominant species that could have given erratic counts over the replicated samples (Niu et al., 2013).

The Shapiro-Wilk test was used to test for normality on all variables analysed (SPSS 18.0); and if non-normal variables transformed logarithmically or trigonometrically (Jobson, 1992; Atmar and Patterson, 1993; Sokal and Rohlf, 1994). But transformations did not stabilize variance of some independent variables.

Therefore the Spearman's Correlation Coefficient (r) was used for simple relation analyses with the variables. Then, a backward multiple regression test was employed for modeling the relation between the number of species, the species density, total number of birds, and Margalef species Richness Index as the dependent variables and the characteristics of the wetland as the independent variables.

In this method, all variables are first entered into the model and then, the least important variable is removed according to removal criteria; this process continues until all the less important variables are gradually removed. Finally, the final model will be calculated based on the main variables. Therefore, all the remaining variables have an acceptable and significant correlation with each other. Models obtained by backward method are superior than those made by Enter and Stepwise methods in terms of the number of variables. That is to say, the number of variables is not as many as that in the Enter models and not as few as that in the Stepwise models. Also in these models, higher correlation between the calculated performance and actual performance is observed compared to the Stepwise model. Logistic regression is used for modeling the relation between binary dependent variable and one or more environmental predictor variables. In other words, logistic regression can be used to predict the dependent variable based on the predictor variables. Formula of Backward Model is given in *Equation 2*.

$$Yi = \beta 0i + \beta 1iX1i + \beta 2iX2i + \beta 3iX3i + \beta 4iX4i + \ldots + \beta(p-1)i\, X\,(p-1)i \quad \text{(Eq. 2)}$$

Yi= the linear predictor

β0i= Constant coefficient

β1i - β4i= the coefficients of the variables

X1i - X4i= Variable values

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

Results

Table 3 lists the dependent variables (characteristics of birds) measured and *Table 4* lists the independent variables (characteristics of Wetland) measured in different years and *Figs. 2* and *3* show the maps of vegetation cover and water surface of the wetland in different years.

Table 3. *Characteristics of birds in different years*

Year	N	D	S	R
1991	27126	6.93	39	3.72
1992	25500	6.51	54	5.22
1993	10171	2.32	38	4.01
1995	21275	5.17	57	5.61
1999	6076	1.36	26	2.86
2000	11142	2.48	36	3.75
2001	8591	2.02	47	5.07
2002	4172	1.03	25	2.87
2003	20970	6.11	35	3.41
2005	5000	1.22	32	3.63
2007	24561	7.01	37	3.56
2009	253	0.84	11	1.80

Table 4. *Characteristics of the wetland in different years*

Year	Wa(ha)	OWa(ha)	Vc(ha)	Sl(m)	As(ha)	Nw(ha)	At(C0)	SDI
1991	3909.06	3070.8	838.26	85740	491.04	1141.94	11.6	4.36
1992	3914.91	3021.12	893.79	88740	880.49	1245.51	9.9	4.55
1993	4383.09	3570.3	812.79	101340	876.95	1782.87	12.3	4.78
1995	4107.42	3166.47	940.95	98340	882.97	1444.76	13.9	4.93
1999	4444.38	3635.58	808.8	110700	858.58	1921.17	10.6	5.18
2000	4491.0	3526.83	964.17	112900	866.32	1729.99	12.9	5.36
2001	4249.26	3314.44	934.82	110250	778.8	1850.26	12.7	5.40
2002	4026.87	3232.48	794.39	97570	526.9	2012.03	12.3	4.84
2003	3428.1	2861.18	566.92	79360	507.89	1498.60	12.4	4.18
2005	4091.85	3220.14	871.71	97980	450.3	1980.79	13.7	4.87
2007	3503.79	2680.19	823.6	82460	423.85	1295.92	13.0	4.49
2009	299.16	111.69	187.47	14100	111.69	1300.46	11.5	3.76

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

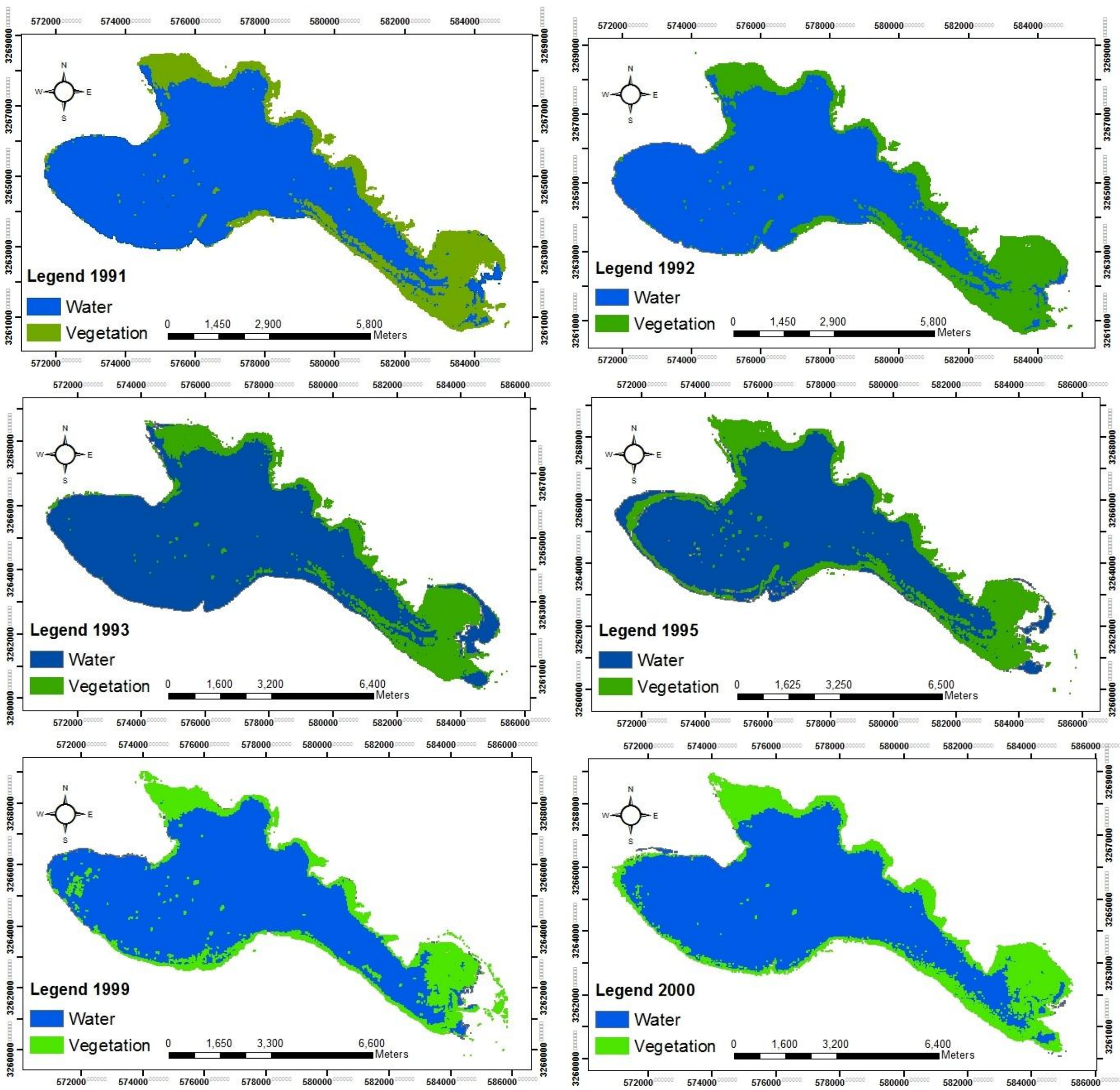

Figure 2. *Classes of water and vegetation of Parishan wetland during the different years*

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

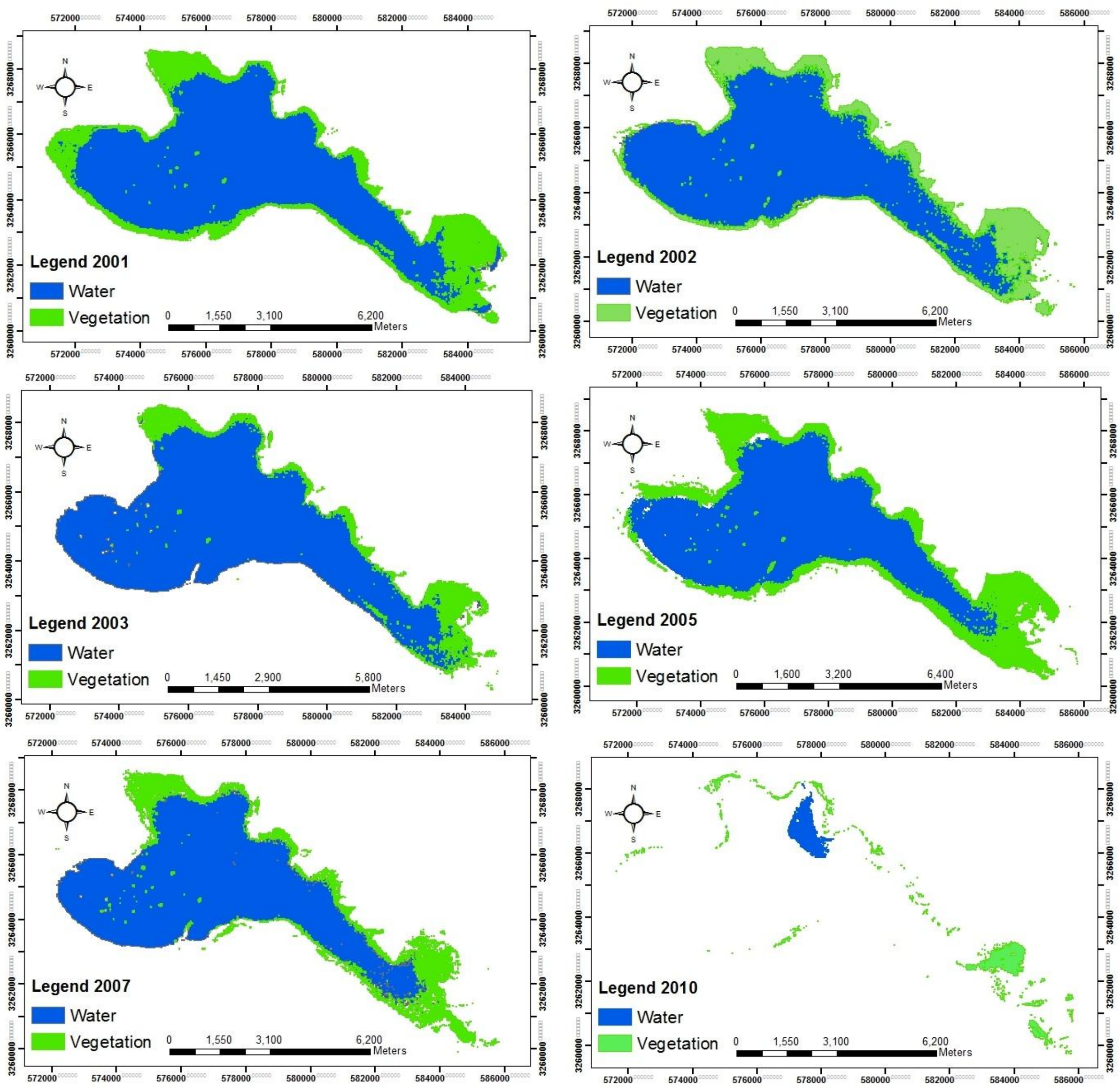

Figure 3. *Classes of water and vegetation of Parishan wetland during the different years*

Only one environmental variable was significantly correlated with the total members of species and the density (the number of waterbirds per ha) ($P < 0.01$) (*Table 5*). The correlation between these variables was negative. They were entered into backward multiple regression tests for modeling to predict the frequency and density of the waterbirds (*Table 6* and *7*).

Also, three environmental variables (vegetation cover surface of the wetland ($P < 0.01$); the deepest depth of the wetland ($P < 0.01$); and the areas shallower than 1m ($P < 0.05$)) were significantly correlated with the number of species (*Table 5*). They were entered into backward multiple regression tests for modeling to predict the number of species (*Table 8*).

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

Also, three environmental variables (vegetation cover surface of the wetland (P < 0.01); the deepest depth of the wetland (P < 0.01); and the areas shallower than 1m (P < 0.05)) were significantly correlated with the Margalef species Richness index. (*Table 5*). They were entered into backward multiple regression tests for modeling to predict the Margalef species Richness index (*Table 10*).

Table 5. *Statistical relationships (r) between the environmental characteristics and the characteristics of water bird species in different years in Parishan wetland. Level of significance: * P < 0.05, ** P < 0.01.*

Variables	N		S		D		R	
	r	P	r	P	r	P	r	P
Wa	0.133	0.681	0.189	0.557	0.196	0.542	0.378	0.226
OWa	-0.266	0.404	0.014	0.966	-0.322	0.308	0.182	0.572
Vc	0.434	0.159	0.713**	0.009	0.343	0.276	0.825**	0.001
Sl	-0.140	0.665	0.203	0.527	-0.203	0.527	0.385	0.217
As	0.294	0.354	0.601*	0.039	0.168	0.602	0.706*	0.010
Nw	-0.748**	0.005	-0.469	0.124	-0.720**	0.008	-0.245	0.443
At	0.049	0.880	0.217	0.498	0.119	0.712	0.315	0.318
SDI	-0.189	.557	0.224	0.484	-0.238	0.457	0.399	0.199
Md	0.371	0.235	0.760**	0.004	0.249	0.436	0.816**	0.001

Table 6. *The models obtained by the backward multiple regression test using the number of water bird species as dependent variables and the area of the nearest wetland as the independent variables*

Parameters included in the model	r2	F	Coefficient	P
Model	0.509	10.381		
Constant			48412.324	0.001
Nw			-21.668	0.009

Table 7. *The models obtained by the backward multiple regression test using the density of water bird species per hectare as the dependent variables and the area of nearest wetland as the independent variables*

Parameters included in the model	r2	F	Coefficient	P
Model	0.466	8.713		
Constant			3.808	0.003
Nw			-0.002	0.014

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

Table 8. *The models obtained by the backward multiple regression test using the number of species as the dependent variables and the area of vegetation cover of the wetland areas shallower than 1 meter and the deepest depth of the wetland as the independent variables*

Parameters included in the model	r2	F	Coefficient	P	Excluded Variables	P
Model	0.521	10.868				
Constant			3.019	.779		
Vc			0.042	.008		
					As	0.223
					Md	0.441

Table 9. *The models obtained by the backward multiple regression test using the Margalef species richness index as the dependent variables and the area of vegetation cover surface of the wetland areas shallower than 1 meter and the deepest depth of the wetland as the independent variables*

Parameters included in the model	r2	F	Coefficient	P	Excluded Variables	P
Model	0.517	10.705				
Constant			0.946	0.318		
Vc			0.004	0.008		
					As	0.305
					Md	0.830

Discussion

Our results showed the importance of the nearest wetland area in explaining the frequency and density of waterfowl in Parishan wetland. Our results showed that when the nearest wetland area attracted an abundant number of birds, the Parishan wetland area decreased. It means there is no rise in competition, i.e. the birds occupy both wetlands to prevent increased competition for food, shelter, nesting, etc. But, when a wetland area decreased they migrated to nearby wetlands to satisfy their biological needs. Many studies were conducted on the effect of isolation (distance to the nearest wetland) as a variable affecting the abundance of waterbirds (Brown and Dinsmore, 1986; Craig and Beal, 1992; Andrén, 1994; Rosenberg et al., 1997; Tellería and Santos, 2001), but we did not find any report on the impact of the nearest wetland area on the frequency and density of waterfowl.

At the beginning of our study, we assumed that the area of wetland had a significant impact on the abundance of birds, but the results showed that wetland size had no significant effect on the bird abundance. The results of this study performed on the effect of wetland area on the abundance of birds were consistent with those obtained by Sulaiman et al. in 2015. But, other studies showed a significant relation between an increase in the number of birds and that in the size of wetlands (He and Legendre, 1996).

The models obtained by the backward multiple regression test indicated that the nearest wetland area was a good predictor of frequency (P value < 0.01) and density of waterbirds (P value < 0.05).

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

The results also showed that three environmental factors (area of vegetation cover of the wetland; the deepest depth of the wetland; and the areas with depths less than one meter) had significant relation with the number of species. Number of bird species may increase as a result of an increase in habitat heterogeneity (He and Legendre, 1996; Elmberg et al., 1994; Sulaiman et al., 2015). A more heterogeneous range of habitats allows the co-occurrence of more species because they meet the habitat requirements of more species (Sulaiman et al., 2015). Also, more species may occur in areas of more diverse habitat because of spatial segregation that reduces competition (Sulaiman et al., 2015) and these three factors can increase heterogeneity of the wetlands. Other studies conducted in wetland ecosystems have demonstrated the importance of habitat heterogeneity (Svingen and Anderson 1998; Fairbairn and Dinsmore 2001; Riffel et al. 2001; Gonzalea-Gajardo et al., 2009).

Furthermore, the results of this study showed a significant relation between the Margalef species richness index and three environmental factors (area of vegetation cover of the wetland; the deepest depth of the wetland; and the areas with depths less than one meter). Increasing the richness species index as well as increasing the number of species may increase as a result of an increase in habitat heterogeneity; these three factors can increase heterogeneity of the wetlands.

Other studies have shown a significant relation between the size of habitats, the number of species, and richness species (Sillén and Solbreck 1977; Brown and Dinsmore 1986; Opdam 1991; Andrén 1994; Turner 1996; Tellería and Santos 2001), but this study found that the wetland size had no significant effect on the number of species and richness species index.

The models obtained by the backward multiple regression test indicated that among these three variables, the vegetation cover surface of the wetlandwas a good predictor of the number of species (P value<0.01) and the richness species index of Margalef (P value<0.01).

Conclusion

The result showed that abundance was fundamentally affected by the nearest wetland area which required integrated management of adjacent wetlands.

Also, the results showed that the number of species had a significant relation with the vegetation cover surface of the wetland, the deepest depth of the wetland, and the areas shallower than 1m. These 3 factors play a major role in habitat heterogeneity. So, to increase biodiversity, habitat heterogeneity should be managed at an appropriate level.

Wetlands provide ecological functions such as protective nursery habitat for fish and shellfish, erosion prevention, flood protection, and water filtration (Dahl, 2005; Behrouzi-Rad, 2014). They also provide vital feeding, resting, and breeding habitat for resident and migrating birds. Seabirds and colonial waterbirds face threats to their habitats and sites on which they depend (Behrouzi-Rad, 2014); conservation of seabirds and colonial waterbirds is a local matter. Nesting and roosting seabirds and colonial waterbirds are particularly affected by local conditions (Behrouzi-Rad, 2014). Parishan wetland is one of the two demonstration sites for the UNDP/GEF Conservation of Iranian Wetlands Project. The water body of the Lake as well as different patterns of vegetation cover around and inside the lake provides diverse habitats which supports the rich biodiversity of the wetland. The

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

Lake hosts significant number of migratory waterbirds which use it for wintering, feeding, breeding, and stationing. The higher records of waterbirds population in the Lake exceed 120,000 (1970s and 1980s). (DOI, 2010). In 7 out of 17 years of accessible records since 1990, the annual counts of waterbirds in Lake Parishan have exceeded the 20,000 Ramsar threshold for internationally important wetlands. Also, *Podiceps cristatus*, Great Crested Grebe, *Phalacrocorax pygmaeus* Pygmy Cormorant, *Anser anser*, Greylag Goose, *Oxyura leucocephala* White headed Duck, *Larus ridibundus* Black Headed Gull, and *Tadorna ferruginea* Ruddy Shelduck have been recorded in numbers exceeding %1 of their bio-geographical population. At least, five threatened species are usually present in the lake and occasionally in noticeable population. These are *Pelecanus crispus*, *Marmaronetta angustirostris, Aythya nyroca, Oxyura leucocephala*, and *Aquila heliaca* (DOI, 2010). Unfortunately, the Parishan wetland has completely dried up since 2011.

The wetland is almost surrounded by agricultural farms in all directions. Water for irrigation is supplied from groundwater wells. Now, there are more than 940 water wells around the wetland and the water extracted from these wells is used in agriculture (DOI, 2015). Excess exploitation of water wells has brought about a drop in underground water level by 15.11 meters between 1990 and 2015 (WAOI, 2015). As long as the resources of underground water are not restored, there is no chance of restoring the wetland because all the water entering the wetland, penetrates into the ground.

Agricultural sector imposes agreat pressure on the wetland due to excessive withdrawals of water from the wells, digging water wells, and excess use of fertilizers and pesticides to increase productivity. Therefore, until rigorous and scientific management is not practiced in agricultural land around the wetland, it is not possible to manage the wetland and protect its ecological benefits.

Therefore, drying up of springs, reduction of the level of underground water, an increase in organic and inorganic contaminants, and finally drying up of the wetland are all resulted from uncertain effects of land use changes along with climate changes.

As shown in *Figure 3*, the area of the Parishan wetland has fallen very low in 2010 and reducing the area of the wetland has led to a sharp decrease in the number of birds in the wetland.

Parishan wetland has completely dried up from 2011 onwards. Along with the increased discharge of water from wells surrounding wetlands, the underground water level and the volume wetland water also have declined and the wetland has completely dried up in 2011. Most of wetland water is supplied through precipitation and spring water and a portion is supplied through groundwater flow; this is while the amount of annual precipitation in the region is very small compared to the rate of evaporation from free surface of the wetland. The average evaporation in the study area during the studied period has been equal to 2731.8 mm; and considering the coefficient of evaporation pan (0.7) (Zamin Ara Consulting Engineers of Fars, 2011), evaporation from the wetland surface has been equal to 1912.26 mm. Now, given that the average area of wetland during the studied period was 24 square kilometers, it follows that the average annual evaporation from the wetland surface has been equal to 38.245 million cubic meters, while the average rainfall has been equal to 8.892 million cubic meters. On the other hand, the water of springs around the wetlands is consumed by farmlands before reaching the wetland; and in recent years, most springs have dried up due to drought and low levels of underground water. Meanwhile,

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

digging a large number of wells around the wetlands and depletion of groundwater have caused the groundwater level go down 13.68 meters; and now, there is no possibility of providing water of wetland by underground water flows (Jahanbakhsh Ganjeh et al, 2017).

REFERENCES

[1] Amat, J. A., Green, A. J. (2010): Waterbirds as Bioindicators of environmental conditions. – In: Hurford, C., Schneider, M. Cown, I. (eds.) Conservation monitoring in freshwater habitat, a practical guide and case studies. Springer Dordrecht Heidelberg London New York, 187.

[2] Andrén, H. (1994): Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. – Oikos 71: 355-366.

[3] Atmar, W., Patterson, B. D. (1993): The measure of order and disorder in the distribution of species in fragmented habitat. – Oecologia 96: 373-382.

[4] Backwell, P. R. Y., Hara, P. D. O., Christy, J. H. (1998): Prey availability and selective foraging in shorebirds. – Anim. Behav. 55: 1659-1667.

[5] Baltonn, L. V., Ghasaian, M. G., Adamin, M. S., Klemjir, D. (2002): Chang in the waterbirds community of the lake seven lake Gilliarea. – J. Biol. Conserv. 106: 157-163

[6] Bambang, D. H. (2008): Jakarta birding: surabaya mangrove. – Retrieved 16, November, 2009, from http://jakartabirding.blogspot.com/2008/08/surabaya-mangrove.html.

[7] Bayly, N. J., Gomez, C. (2008): Bird communities in black mangrove and other mangrove types – with particular reference to neotropical migratory birds. – Final report of evaluating a stepping stone for neotropical migratory birds the Belizean NE biological corridor, Belizean Forestry Department, Belmopan, Belize.

[8] Behrouzi-Rad, B. (1996): The bird community of Iranian mangrove forests. – Journal of Environmental Science 8: 8-70. (In Persian).

[9] Behrouzi-Rad, B. (2014): Effect of some environmental factors on wintering waterbirds population in Zangi and Ahmad creeks in Persian Gulf. – International Conference on Chemistry, Biomedical and Environment Engineering. Oct 7-8, 2014 Antalya (Turkey).

[10] Brown, M., Dinsmore, J. J. (1986): Implications of marsh size and isolation for marsh bird management. – Journal of Wildlife Management 50: 392-397.

[11] Casado, S., Montes, C. (1995): Guía de los Lagos y Humedales de España. – J. M. Reyero Editor, Madrid.

[12] Caziani, S. M., Derlindati, E. J., Talamo, A., Sureda, A. L., Trucco, C. E., Nicolossi, G. (2001):Waterbird richness in Altiplano wetlands of northwestern Argentina. – Waterbirds 4: 103-117.

[13] Collwell, M. A., Dodd, A. (1995): Waterbirds communities and habital relationship in coastal pastures of northern California. – J. Biol. Conserv. 21: 75-84.

[14] Craig R. J., Beal, K. G. (1992): The influence of habitat variables on marsh bird communities of the Connecticut River Estuary. – Wilson Bulletin 104: 295-311.

[15] Dahl, T. E. (2005): Status and trends of wetlands in theconterminous United States 1998 to 2004. – United States Department of the Interior; Fish and Wildlife ServiceWashington D.C., USA.

[16] Department of Environment of Fars province of Iran. (2010). Lake Parishan Management Plan. 46 p.

[17] Department of Environment of Fars province of Iran. (2015): Annual report of the wetlands of Fars province.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

[18] Elmberg, J., Nummi, P., Poise, H., Sjoberg, K. (1994): Relationship between species number, lake size and resource diversity in assemblages of breeding waterfowl. – Journal of Biogeography 21: 75-84.
[19] Fairbairn, S., Dinsmore, J. (2001): Local and landscapelevel influences of wetland bird communities of the Praire Pothole region of Iowa, USA. – Wetlands 21: 41-47.
[20] Frankham, R., Briscoe, D. A., Ballou, J. D. (2002): Introduction to conservation genetics. – Cambridge Univ. Press, Cambridge, UK.
[21] Getzner, M. (2002): Investigating public decision about protecting wetlands. – Environmental Management 64:237-246.
[22] Gibbs, J. P. (1993): The importance of small wetlands for the persistence of local populations of wetland-associated animals. – Wetlands 13: 25-31.
[23] Gonzalea-Gajardo, A., Sepúlveda, P. V., Schlatter, R. (2009): Waterbird Assemblages and Habitat Characteristics in Wetlands: Influence of Temporal Variability on Species-Habitat Relationships. – Waterbirds 32(2): 225-233.
[24] Green, A. J. (1996): Analyses of globally threatened Anatidae in relation to threats, distribution, migration patterns and habitat use. – Conservation Biology 10:1435-1445.
[25] He, F., Legendre, P. (1996): On species-area relations. – American Naturalist 148: 719-37.
[26] Hoyer, M. V., Canfield. D. E. (1994): Bird abundance and species richness on Florida lakes: influence of trophic status, lake morphology and aquatic macrophytes. – Hydrobiologia 280: 1-14.
[27] Jahanbakhsh Ganjeh, M., Khorasani, N., Morshedi, J., Danehkar, A., Naderi, M. (2017): An Investigation On Spatial Changes Of Parishan International Wetland Using Remote Sensing Methods. – Applied Ecology And Environmental Research 15(3): 549-562.
[28] Jobson, J. D. (1992): Applied Multivariate Data Analysis. Volume II: Categorical and Multivariate Methods. – Springer-Verlag, New York.
[29] Kumar, N. J. I., Soni, H., Kumar, R. N. (2007): Patterns of seasonal abundance and diversity in the waterbird community of Nal Lake bird sanctuary, Gujarat, India. – Journal of Bird Populations 8: 1-20.
[30] Margalef, R. (1983): Limnología. – Ediciones Omega S.A., Barcelona, Spain.
[31] Mehrjoo, A. (1992): The study of diversity, density and distribution of migratory birds in the Gomishan wetland. – Master thesis. Department of Natural Resources, Tehran University. (In Persian):
[32] Mori, Y. N., Sodhi, S., Kawanishi, S., Amagishi, S. Y. (2001): The effect of human disturbance and flock composition on the flight distances of water Flow species. – J. Ethol 19: 115-119.
[33] Mundava, J., Caron, A., Gaidet, N., Couto, F. M., Couto, J. T., De Garine-Wichatitsky, M., Mundy, P. J. (2012): Factors influencing long-term and seasonal waterbird abundance and composition at two adjacent lakes in Zimbabwe. – Ostrich 83 (2): 69-77.
[34] Niu, J. Y., Zou, Y. A., Yuan, X., Zhang, B., Wang, T. H. (2013): waterbird distribution patterns and environmentally impacted factors in reclaimed coastal wetlands of the eastern end of Nanhui County, Shanghai, China. – Acta Zoologica Academiae Scientiarum Hungaricae 59(2): 171-185.
[35] Opdam, P. (1991): Metapopulation theory and habitat fragmentation: a review of holartic breeding bird studies. – Landscape Ecology 5: 93-106.
[36] Paillisson, J. M., Reeber, S., Marion, L. (2002): Bird assemblages as bio-indicators of water regime management and hunting disturbance in natural wet grasslands. – Biological Conservation 106: 115-127.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579

[37] Paracuellos M., Tellería, J. L. (2004): Factors Affecting the Distribution of a Waterbird Community: The Role of Habitat Configuration and Bird Abundance. – Waterbirds 27(4): 446-453.
[38] Petrie, S. A. (1998): Nutrient reserve dynamics, foraging strategies, molt patterns and movements of Whitefaced Whistling Ducks in South Africa. – Ph.D. dissertation, University of the Witwatersrand, Johannesburg, South Africa.
[39] Riffel, S. K., Keas, B. E., Burton, T. M. (2001): Area and habitat relationships of birds in great lakes coastal wet meadows. – Wetlands 21: 492-507.
[40] Rosenberg, D. K., Noon, B. R., Meslow, E. C. (1997): Biological corridors: Form, function, and efficacy. – BioScience 47: 677-687.
[41] Sillén, B., Solbreck, B. (1977): Effects of area and habitat diversity on bird species richness in lakes. – Ornis Scandinavica 8: 185-192.
[42] Sokal, R. R., Rohlf, F. J. (1994): Biometry. – W. H. Freeman and Co., San Francisco.
[43] Sonal, D., Jagruti, R. Geeta, P. (2010): Avifaunal Diversity and water quality analysis of an inland. – Journal of Wetlands Ecology 4: 1-32.
[44] Sulaiman, I. M., Abubakar, M. M., Ringim, A. S., Apeverga, P. T., Dikwa, M. A. (2015): Effects of Wetlands Type and Size on Bird Diversity and Abundance at the Hadejia – Nguru Wetlands, Nigeria. – International Journal of Research Studies in Zoology (IJRSZ) 1(1): 15-21.
[45] Svingen, D. N., Anderson, S. H. (1998): Waterfowl management on grass-sage stock ponds. – Wetlands 18: 84-89.
[46] Taft, O. W., Colwell, M. A., Isola, C. R., Safran, R. J. (2002): Waterbird responses to experimental drawdown: implications for the multispecies management of wetland mosaics. – J. Appl. Ecol. 39: 987-1001.
[47] Tellería, J. L., Santos, T. (2001): Fragmentación de hábitats forestales y sus consecuencias. Pages – In. Zamora, R., Pugnaire, F. I. (eds.) Ecosistemas mediterráneos. Análisis functional, Colección Textos Universitarios 32. Consejo Superior de Investigaciones Científicas, Asociación Española de Ecología Terrestre, Granada, 293-317
[48] Turner, I. M. (1996): Species loss in fragments of tropical rain forest: a review of the evidence. – Journal of Applied Ecology 33: 200-209.
[49] Van Niekerk, J. H. (2010): Assemblages and movements of waterfowl at cattle feedlots across Gauteng, South Africa. – Ostrich 81: 31-37.
[50] WAOI (Water Affairs Organization of Iran) (2015). Annual report of Water Resources of Fars province.
[51] Whittaker, R. H., Likens, G. E. (1973): Primary production: the biosphere and man. – Human Ecology 1: 357-369.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1504_15651579