ESTABLISHMENT OF A HABITAT MONITORING SYSTEM IN AGRA WETLAND (PELLA, GREECE)

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ABSTRACT - The Agra wetland has been proposed for inclusion in the European Network of Protected Areas, known as "Natura 2000" (LIMNI AGRA, GR1240004), in accordance with the Habitat Directive 92/43/EEC and the Directive for Birds 79/409/EEC. The region can be divided into a core area, which is mainly covered by water and includes wetland communities, and a surrounding peripheral zone where terrestrial ecosystems primarily dominate. The habitats present in the core area are of great ecological significance not only because one is classified as a priority habitat (Calcareous fens with *Cladium mariscus* and *Carex davalliana*), but also because they are resting habitats for a large number of migratory birds. The purpose of this study is to establish a monitoring system for the significant vegetation types to assess the present conservation status and detect significant changes in the wetland. For this purpose the following vegetation types were selected for monitoring: Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation (3150), Mediterranean tall-herb and rush meadows (Molinio-Holoschoenion) (6420), Calcareous fens with *Cladium mariscus* and *Carex davalliana* (7210*), and Reed bed communities (72A0). Within these selected vegetation types permanent plots were established, plant samples collected and, where required, water and soil analyses conducted.

KEYWORDS - Wetland, habitat, biodiversity, monitoring system, vegetation type, Greece.

INTRODUCTION

During the 20th Century more than half (63%) of the Greek wetlands were destroyed by humans and mostly converted to agricultural land. The remaining wetlands are estimated to cover 190,000 hectares, of which about 100,000 hectares belong to the Ramsar Convention network (Finlayson *et al.*, 1991). The study area of Agra wetland is part of the European Natura 2000 Network (GR1240004) (Habitat Directive 92/43/EEC) and is also an area significant for birds (Directive 79/409/EEC) (Dafis *et al.*, 1996). The Agra wetland is part of the wetland ecosys-

tems of northern Greece and, according to the Ramsar classification system (Tsiouris & Gerakis, 1991; Zalidis & Mantzavelas, 1994), is an artificial wetland. Specifically, it is a semi-natural ecosystem because the Tiavos (also named Vrita) wetland previously existed there (springs of River Edesseos). It is well-known that wetlands are amongst the most productive natural ecosystems and have a number of important functions such as: water storage and filtration, flood prevention, positive contribution to the local climate, habitats of rare or endangered species, production of natural products etc.

The present study takes place within the scope of a European program called Life Nature (LIFE03 NAT/GR/000092) and aims to assess the present condition of the wetland with the aid of an environmental monitoring system. Using this monitoring system, significant changes in the ecosystem can be detected so that appropriate management measures can be taken.

Study Area

Agra wetland is located in the Prefecture of Pella (Macedonia) in northern Greece (Figure 1), at an altitude of 480 m and 40°47' N, 21°54' E.

According to Platis *et al.* (2000), the protected area of Agra comprises a total surface area of 4,738 ha and can be divided into two zones: zone A or core area (wetland ecosystem), and zone B or peripheral zone (terrestrial/mountainous ecosystem). The core area was formed after the Electric Power Corporation hydroelectric dam was built in 1955. The dam was built in the place of an older wetland (Tiavos) where the springs of Edesseos River are located. According to meteorological data of the area, the climate is characterized as sub-Mediterranean with an average annual rainfall of 850 mm and average annual temperatures between 5-14°C (Platis *et al.*, 2000). Geologically, the study area is located on the border of the Pelagonian zone with the old Vardar zone, presently called Almopia zone (Mountrakis, 1985). The study area comprises contemporary alluvial deposits of the Quaternary period (IGME, 1983), while in the surrounding area limestones and marbles belonging to the Triassic-Jurassic and Cretaceous periods can be found.

Material and Methods

The vegetation types present in the wetland ecosystem of Agra were identified based on their physiognomical characteristics (Zalidis & Mantzavelas, 1994; Platis *et al.*, 2000; Karagiannakidou *et al.*, 2003; Gounaris, 2004). From the distinguished vegetation types, priority habitats or habitats of significant species (mainly birds) were selected for monitoring. These are: Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation (Natura code 3150) 126.20 ha in area, Mediterranean tall-herb and rush meadows (Molinio-Holoschoenion) (Natura code 6420) 149.83 ha in area, Calcareous fens with *Cladium mariscus* and *Carex davalliana* (Natura code 7210* - a priority habitat) 74.23 ha in area, and Reed bed communities (Natura code 72A0) of 319.56 ha. The above vegetation types

cover a total of 669.82 ha. They comprise 57.46% of the core area (zone A), and 14.14% of the Special Protection Area (SPA).

In all the vegetation types selected for monitoring, 23 permanent sampling plots (relevés) were established from 15-21 July 2004, using the Braun-Blanquet method (1964). In a number of habitats soil profiles were established and soil and water samples collected for analysis (FIGURE 2). The sampling plots are placed in each representative vegetation type of the wetland ecosystem. They are square (5x5m) or circular in shape (5m radius, plots L1-L4, P1-P2) depending on the type of vegetation (wet meadows or water bodies, respectively). Four water samples (locations: P1, L2, L3, L4) were collected where hydrophytic vegetation was present. Three soil samples were also collected (locations: Y1, Y6, K1) from areas where wet meadows and marshes prevailed (Papamichos, 1979). Water (October 2004 and February 2005) and soil samples (September 2004) were transported to the laboratory for analysis. Water sample analysis included pH measurements, dissolved oxygen (D.O.), ion concentrations etc., while soil samples were analysed for pH (H_2O 1:1), presence of free carbonate ions ($CaCO_3$), organic carbon content (C%) (using the method of liquid acidity with acidic medium $K_2Cr_2O_7$), and total nitrogen content (N%) (following the Kjeldahl method).

Strid & Tan (1997; 2002), Greuter *et al.* (1984; 1986; 1989) and Tutin *et al.* (1968-1980; 1993) were used for taxa identification and nomenclature. Papastergiadou (1990), Grabherr & Mucina (1993), Mucina *et al.* (1993), Rodwell (1995), Dafis *et al.* (1996), and Mucina (1997) were used for syntaxa nomenclature.

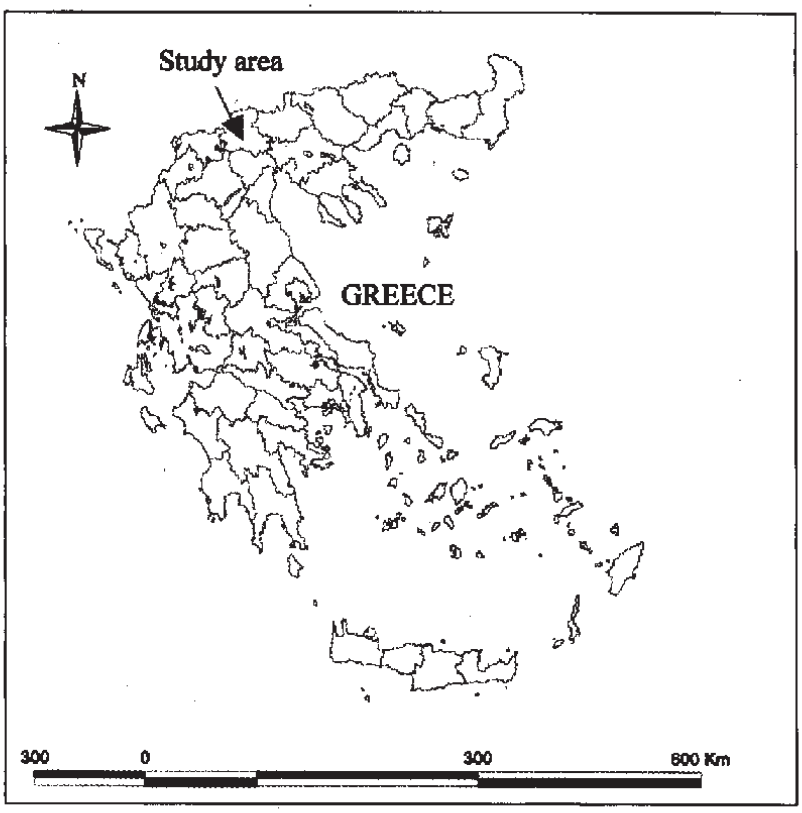

FIGURE 1 - The study area of Agra wetland in the Prefecture of Pella (Macedonia, N Greece).

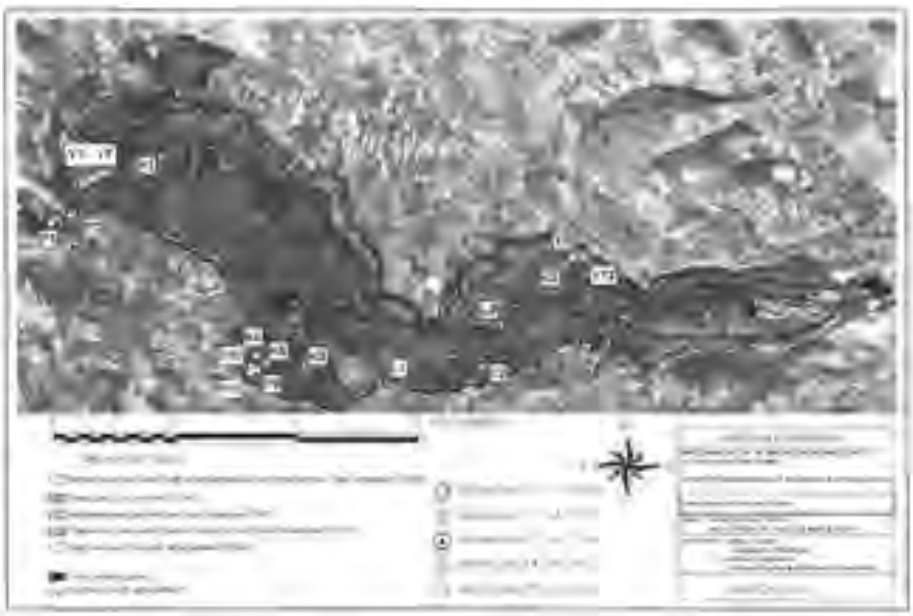

FIGURE 2 - The study area of Agra wetland showing its vegetation types and sample plots.

RESULTS

Habitat type: Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation (3150).

Location: Springs of Edesseos River, water bodies and hydroelectric dam.

Vegetation type: Two associations were identified from the relevés, namely, the *Potamo-Vallisnerietum* Br.-Bl. 1931, and *Potametum crispi* Soó 1927. Furthermore, within Lake Agra another association appears, that of *Nymphaeetum albae*, which however, is not developed enough in order to establish sampling plots. In such cases of partially developed plant communities, transects (5x30 m^2) were established. The results of these transects are not presented in this study.

This habitat includes aquatic vegetation of low biodiversity (3-4 species, average 3.5) that comprises submerged, emerged and floating-leaved macrophytes, such as *Potamogeton pectinatus*, *P. crispus*, *Myriophyllum verticillatum*, *Vallisneria spiralis*, *Chara vulgaris*, *Ceratophyllum demersum*, etc.

The first plant association in which a monitoring sample plot was established (L4) appears to be limited to a depth of 200 cm. The total cover of the herbaceous layer is 100%, with a height of 150 cm, while algae appear with cover of c. 20%. The second association, within which five monitoring sample plots were set up (P1, P2, L1, L2, L3), is well developed in the study area. Here, the herbaceous layer has a cover of <5-80% and height up to 300 cm. Within the water, which has depths of 45-600 cm, algae are frequenfly observed with covers of 0-70%. The third community has limited presence along the lake's shores and in locations protected from wind. The latter is not of sufficient size to be monitored using permanent sampling plots.

It should be noted that the sampling plot L2 might be reassigned into the Natura 2000 code: 3140 - Hard oligo-mesotrophic waters with benthic vegetation of *Chara* formations, with the following syntaxonomy:

Charetea fragilis Fukarek ex Krausch 1964
Charetalia hispidae Sauer ex Krausch 1964
Charion vulgaris (Krause et Lang 1977) Krause 1981
Charetum vulgaris Corillion 1957

The presence of the *Potamo-Vallisnerietum* was recorded in the area by Pavlides (1989), who noted that *Nymphaea alba*, which appears in equal contribution with *Myriophyllum verticillatum*, comprises the *Myriophyllo-Potametum* Soó 1934. The same scientist also recorded the *Potametum lucentis* Hueck 1931, *Potamogeton pectinatus* comm. and *Myriophyllum verticillatum-Potamogeton nodosus* comm. Papastergiadou (1990) identified the presence of the *Potametum natantis* (Soó 1927) Eggler 1933 in the area.

Syntaxonomical synopsis

Potametea Klika in Klika et Novák 1941
Nupharo-Potametalia Schaminee, Lanjouw et Schipper 1990 (= *Potametalia* W. Koch 1926)
Parvopotamion (Vollmar 1947) Den Hartog et Segal 1964 (= *Eu-Potamion* (W. Koch 1926) Oberd. 1957)
Potamo-Vallisnerietum Br.-Bl. 1931, (L4), (315037)
Potametum crispi Soó 1927, (P1, P2, L1, L2, L3), (3150??)
Nymphaeion albae Oberd. 1957
Nymphaeetum albae Oberd. & Mitarb. 1967, (without relevés), (315042)

TABLE 1 - Hydrological characteristics of Lake Agra (O=October 2004, F=February 2005).

LOCATION	PERIOD	pH	D.O. mg/l	EC_{25} mS/cm	K^+ meq/L	Na^+ meq/L	Ca^{2+} meq/L	Mg^{2+} meq/L	SAR	Cl^- meq/L	HCO_3^- meq/L	SO_4^{2-} meq/L	NO_3^- meq/L
Springs of R. Edesseos	O	6.9	5.55	0.78	0.08	0.37	5.2	4.8	0.17	0.4	8.2	0.31	0.11
	F	6.9	4.95	0.69	0.07	0.40	5.4	3.4	0.19	0.4	6.8	0.31	0.11
Middle of Lake Agra (north)	O	7.8	8.35	0.64	0.07	0.32	3.4	4.2	0.16	0.3	7.0	0.30	0.01
	F	7.9	13.25	0.65	0.08	0.37	4.0	4.2	0.18	0.3	7.0	0.25	0.06
Middle of Lake Agra (south)	O	7.4	10.40	0.75	0.08	0.39	5.0	3.0	0.20	0.4	4.8	0.36	0.04
	F	8.2	11.10	0.71	0.07	0.41	3.6	3.4	0.22	0.3	5.6	0.29	0.07
Dam	O	7.3	7.60	0.71	0.07	0.36	4.4	3.6	0.18	0.4	7.0	0.22	0.03
	F	7.4	15.65	0.65	0.07	0.36	4.0	2.4	0.20	0.3	5.0	0.30	0.06

Hydrological characteristics

The chemical composition of the water from different parts of the wetland is presented in TABLE 1. Data indicate that the pH of the water is neutral to slightly alkaline. In addition, data indicate that Ca^{2+} and Mg^{2+} concentrations are moderate, Cl^- concentration is low, and nitrate (NO_3^-) concentration in the springs of River Edesseos is high. In addition, low SAR (Sodium absorption ration) values were recorded.

Monitoring sample plots						
Relevé number	**L4**	**P2**	**P1**	**L1**	**L2**	**L3**
Total cover (%)	100	45	85	80	70	80
Herb cover (%)	100	<5	10	80	<5	80
Moss cover (%)	0	0	70	0	0	0
Algae cover (%)	20	45	15	0	70	0
Water cover (%)	100	100	100	100	100	100
Water depth (cm)	200	600	45	180	230	145
Max height of herbs (cm)	150	300	200	180	230	160
Total species number	3	3	4	4	4	3
Diagnostic species of *Potametea* Klika in Klika et Novák 1941						
Vallisneria spiralis	4	.	.	.	.	.
Potamogeton crispus	.	1	.	4	r	3
Potamogeton pectinatus	3	.	1	1	1	2
Myriophyllum verticillatum	.	.	.	r	r	1
Potamogeton lucens	.	1	.	.	.	.
Ceratophyllum demersum	.	.	.	r	.	.
Diagnostic species of *Charetea fragilis* Fukarek ex Krausch 1964						
Chara vulgaris	.	.	.	.	4	.
Diagnostic species of *Montio-Cardaminetea* Br.-Bl. et R. Tx. ex Klika 1948						
Cratoneurum commutatum	.	.	4	.	.	.
Diagnostic species of *Phragmito-Magnocaricetea* Klika in Klika et Novák 1941						
Berula erecta	.	.	2	.	.	.
Other species						
Algae (= *Cladophora* sp.)	2	3	2	.	.	.

Habitat type: *Mediterranean tall-herb and rush meadows* (*Molinio-Holoschoenion*) (*6420*).

Location: Wet meadows.

Landscape: Level areas and small elevated areas due to the presence of root systems (*Carex* spp., *Juncus* spp., *Cyperus longus*).

Drainage: Poor, with seasonal fluctuation of the groundwater level. Groundwater level is >90 cm (November 2004).

Vegetation type: Three plant communities were distinguished from our relevés. The first, *Carex distans-Trifolium resupinatum* comm. (6420??) better represents

this particular habitat (6420) as it includes most diagnostic species of the class *Molinio-Arrhenatheretea*. The second, *Carex distans-Lythrum salicaria*, and third, *Juncus articulatus-Carex paniculata*, communities include several diagnostic taxa that belong to other classes, particularly the *Phragmito-Magnocaricetea*, which forms extensive reed beds in the area. The sampling plots Y1 to Y7 show the successive appearance of the three communities (FIGURE 2).

This habitat type is a wet meadow with moderate plant biodiversity (6-18 species, average 13.3) and with dominant species: *Carex distans*, *C. paniculata*, *C.* cf. *vulpina*, *Juncus articulatus*, *J. inflexus*, *Cyperus longus*, *Cirsium palustre*, *Trifolium resupinatum*, *Mentha aquatica* etc. The herbaceous layer has a cover of 40-100%, whereas in small sites there is water with depths of 10-20 cm. The ground flora height range is (5-)60-160 cm.

Syntaxonomical synopsis

Molinio-Arrhenatheretea Tx. 1937
Trifolio-Hordeetalia Horvatic 1963
Trifolion resupinati Micevski 1957
Carex distans-Trifolium resupinatum comm., (Y1, Y2, Y3), (6420??)
Carex distans-Lythrum salicaria comm., (Y4, Y5, Y9, Y10), (6420??)
Juncus articulatus-Carex paniculata comm., (Y6, Y7, Y8, Y11, Y12), (6420??)

Soil type: Humic-gley soil

Soil profile description (Y1)

Of: 1(-2) cm. Plant litter decomposed (f).

Ao (H1o): Depth 0-30 cm. A horizon rich in organic matter (14.46%), black colour, with crumby structure and silty-clay texture. Alluvial deposits with numerous fine roots originating from ground-level vegetation (*Carex* spp., *Juncus* spp., *Cirsium palustre*, *Cyperus longus* etc). Rich in nitrogen (0.48%) and moderate degree of decomposition (C/N= 30). The horizon properties are affected by the drainage conditions and the upward movement of water (capillary action). The high pH value (pH= 7.9) can be attributed to the high $CaCO_3$ concentration (carbonate). Horizon limit is gradual.

Cgr (H2gr): Depth 30-90 cm. Organic horizon (organic matter 25.1%), moist, without structure, consisting mainly of plant litter with low degree of decomposition mainly due to redox conditions (C/N= 98). In its mass grey colour spots are observed. The pH is moderately alkaline (pH= 7.9) and the total nitrogen is 0.26%.

Soil profile description (Y6)

Of: 2(-3) cm. Plant litter decomposed (f), with greater amount of plant litter in the outcrops due to the root systems present.

Ao (H1o): Depth 0-20 cm. A horizon rich in organic matter (16.5%), with crumby structure, silty-loam-clay texture, moist, brown-black colour, with numerous fine roots, absence of rocks and gravels and presence of free carbonate ions (pH= 7.5, slightly alkaline). Rich in nitrogen (total nitrogen 0.38%) and moderate degree of decomposition (C/N= 43). Horizon limit is gradual.

Cgr (H2gr): Depth 20-40 cm. A horizon rich in organic matter (12.4%), without structure, with clay-loam texture, moist-saturated, brown-black colour and with many fine roots. Low degree of decomposition (C/N= 94, total nitrogen 0.13%) and appearance of redox spots. The high pH value (pH= 7.6, slightly alkaline) can be attributed to the high carbonate ion concentration ($CaCO_3$). Horizon limit is gradual.

Cgr (H3gr): Depth 40-80 cm. A horizon rich in organic matter (10.4%), cohesive, without structure, plastic, with silty-clay texture, brown-black colour, moist. Absence of roots, limited decomposition (C/N= 31, total nitrogen 0.33%) and appearance of redox spots. The high pH value (pH= 7.7, slightly alkaline) can be attributed to the high free carbonate ($CaCO_3$). Horizon limit is gradual.

C (H4): Depth >80 cm. A horizon rich in organic matter (19.8%). It is comprised of organic litter with no cohesion, saturated, brown in colour. Rich in nitrogen (total nitrogen 0.94%), moderate degree of decomposition (C/N= 21). Carbonate ions are present and the pH is slightly alkaline (pH= 7.5, slightly alkaline).

Monitoring sample plots													
Relevé number	**Y1**	**Y2**	**Y3**	**Y4**	**Y9**	**Y10**	**Y5**	**Y6**	**Y7**	**Y8**	**Y11**	**Y12**	
Herb cover (%)	100	100	90	60	100	80	40	60	85	100	100	100	
Water cover (%)	0	0	0	5	0	0	5	100	100	0	0	0	
Water depth (cm)	0	0	0	10	0	0	10	18	15	0	0	0	
Max height of herbs (cm)	80	80	5	100	80	60	120	150	110	150	160	150	
Total species number	18	17	11	16	12	13	17	11	16	6	11	12	
Diagnostic species of *Molinio-Arrhenatheretea* Tx. 1937													
Cirsium palustre	2	2	2	1	1	r	.	.	.	+	r	1	
Mentha aquatica	+	.	+	+	1	2	+	1	+	.	+	.	
Potentilla reptans	+	1	.	r	+	r	r	r	.	.	+	.	
Ranunculus sardous	r	r	+	r	.	.	r	.	+	.	.	.	
Trifolium resupinatum	2	2	+	.	.	.	.	.	.	.	.	.	
Plantago lanceolata	1	1	+	.	.	.	.	.	.	.	.	.	
Trifolium repens	1	1	.	.	.	.	.	.	.	.	.	.	
Achillea millefolium	+	r	.	.	.	.	.	.	.	.	.	.	
Cerastium fontanum	+	.	.	.	.	.	.	.	.	.	.	.	
Poa pratensis	+	+	+	.	1	r	+	.	.	.	.	.	
Festuca pratensis	+	+	+	.	1	r	r	.	.	.	.	.	
Lolium perenne	+	1	1	+	.	.	+	.	.	.	.	.	
Plantago major	1	1	+	+	.	.	.	.	.	.	.	.	
Teucrium scordium	+	.	+	.	.	.	+	.	.	.	.	.	
Lythrum salicaria	.	.	.	.	+	r	+	.	.	.	.	.	
Carex cf. *vulpina*	.	.	.	+	r	.	+	1	4	.	2	.	
Juncus inflexus	.	.	.	.	5	1	.	.	1	.	1	.	
Poa trivialis ssp. *sylvicola*	.	.	.	.	r	r	.	.	.	.	r	.	
Equisetum palustre	.	.	.	r	.	.	.	.	.	.	r	.	
Ranunculus acris	.	.	.	.	.	.	.	.	+	.	.	1	
Lysimachia vulgaris	.	.	.	.	.	.	.	.	.	+	.	1	
Agrostis stolonifera	.	.	.	.	.	.	.	.	.	+	.	r	
Juncus conglomeratus	.	.	.	.	.	.	.	.	.	.	.	1	
Diagnostic species of *Phragmito-Magnocaricetea* Klika in Klika et Novák 1941													
Lycopus europaeus	.	.	.	r	1	r	+	+	r	.	r	.	
Schoenoplectus lacustris	.	.	.	+	.	.	1	r	+	.	.	.	
Carex paniculata	.	.	.	.	.	.	.	.	.	5	.	2	
Phragmites australis	.	.	.	.	.	.	.	.	.	.	.	1	
Cladium mariscus	.	.	.	.	.	.	.	.	.	.	.	+	
Iris pseudacorus	.	.	.	.	.	.	.	.	+	.	.	.	
Carex riparia	.	.	.	.	.	.	+	.	.	.	.	.	
Diagnostic species of *Isoëto-Nanojuncetea* Br.-Bl. et R. Tx. ex Westhoff et al. 1946													
Juncus articulatus	.	.	.	.	.	3	.	3	2	.	.	5	
Lotus angustissimus	.	+	.	.	.	.	.	.	.	.	.	.	
Diagnostic species of *Galio-Urticetea* Passarge ex Kopecky 1969													
Calystegia sepium	.	.	.	r	.	.	1	+	+	1	.	1	
Epilobium hirsutum	.	.	.	.	.	.	.	.	.	.	1	r	
Galium aparine	.	.	.	.	.	.	.	.	.	.	+	.	
Other species													
Carex distans	4	4	4	2	1	1	1	.	.	.	.	.	
Euphorbia amygdaloides	+	.	.	.	.	.	.	.	.	.	.	.	
Eryngium creticum	+	.	.	.	.	.	.	.	.	.	.	.	
Crepis hellenica	.	+	.	.	.	.	.	.	.	.	.	.	
Clematis vitalba	+	.	.	.	.	.	.	.	.	.	.	.	
Trifolium campestre	.	r	.	.	.	.	.	.	.	.	.	.	
Sporobolus pungens	.	r	.	.	.	.	.	.	.	.	.	.	
Galium verum	.	r	.	.	.	.	.	.	.	.	.	.	
Juncus squarrosus	.	.	.	1	.	.	2	.	.	.	.	.	
Carex spec.	.	.	.	2	.	.	.	.	.	.	.	.	
Orchis palustris	.	.	.	+	+	1	+	r	r	.	.	.	
Samolus valerandi	.	.	.	+	.	.	+	1	.	.	.	.	
Cyperus longus	.	.	.	.	.	1	.	.	.	.	5	.	
Hydrocotyle vulgaris	.	.	.	.	.	.	.	1	r	.	.	.	
Potamogeton nodosus	.	.	.	.	.	.	.	.	1	.	.	.	
Arctium lappa	.	.	.	.	.	.	.	.	+	.	.	.	
Juncus subnodulosus	.	.	.	.	.	.	.	+	.	.	.	.	
Chara vulgaris	.	.	.	.	.	.	.	.	r	.	.	.	
Eupatorium cannabinum	.	.	.	.	.	.	.	.	.	r	.	.	
Epipactis palustris	.	.	.	.	.	.	.	.	.	.	.	r	
Ranunculus trichophyllus	.	.	.	.	.	.	.	.	r	.	.	.	
Lotus uliginosus	.	.	.	.	.	.	.	.	.	.	.	r	

Habitat type: Calcareous fens with Cladium mariscus and Carex davalliana (7210; * = priority habitat).*

Location: Tall wet meadows.

Landscape: Generally the landscape is flat, however, outcrops (20-40 cm) are present in some areas. On these outcrops dense root systems of dominant plant species such as *Cladium mariscus*, *Cirsium palustre* occur.

Drainage: Poor with seasonal flooding (spring to early summer) due to the operation of the dam. Groundwater level is >90 cm.

Vegetation type: The association *Cladietum marisci* was found here, with *Cladium mariscus* being the dominant species, while a small number of other species are present with low cover (%). This is the habitat of calcareous fens with *Cladium mariscus*, *Cirsium palustre*, *Calystegia sepium* etc. (7210*), which has low plant biodiversity (5-6 species; average 5.5) in the study area. The herbaceous layer has a cover of 95-100% and height of up to 250 cm. In a few places water depths of 1 cm are observed.

Syntaxonomical synopsis

Phragmito-Magnocaricetea Klika in Klika et Novák 1941
Phragmitetalia Koch 1926
Magnocaricion elatae Koch 1926
Cladietum marisci Zöbrist 1933 emend. Pfeiffer 1961, (K4, K5), (721021)

Soil type: Humic-gley soil.

Monitoring sample plots		
Relevé number	**K4**	**K5**
Herb cover (%)	95	100
Water cover (%)	10	0
Water depth (cm)	1	0
Max height of herbs (cm)	250	250
Total species number	6	5
Diagnostic species of *Phragmito-Magnocaricetea* Klika in Klika et Novák 1941		
Cladium mariscus	5	5
Lycopus europaeus	.	r
Diagnostic species of *Molinio-Arrhenatheretea* Tx. 1937		
Cirsium palustre	r	1
Mentha aquatica	+	.
Lysimachia vulgaris	.	+
Diagnostic species of *Galio-Urticetea* Passarge ex Kopecky 1969		
Calystegia sepium	+	r
Other species		
Bidens tripartita	+	.
Samolus valerandi	r	.

Habitat-type: *Reed bed communities (72A0).*

Location: Reed bed communities.

Landscape: Generally the landscape is flat with small, elevated areas of dense reed root systems (*Phragmites australis*) and to a lesser extent *Carex* cf. *vulpina*, *Agrostis stolonifera*, *Typha latifolia*, etc.

Drainage: Very poor. Permanent or seasonal flooding is observed due to the operation of the dam. The flooding that occurs here lasts longer than that observed in the wet meadows. The groundwater level is near the surface.

Vegetation type: Marsh vegetation with moderate degree of plant biodiversity (6-11 species; average 9.3). The dominant taxon here is *Phragmites australis* (72A010). Some species with lower heights and significant cover (%) appear together mainly from the class *Molinio-Arrhenatheretea*. Species that appear with high or low cover (%) are: *Phragmites australis*, *Carex* cf. *vulpina*, *Agrostis stolonifera*, *Typha latifolia*, *Cirsium palustre*, *Thelypteris palustris*, *Lysimachia vulgaris*, etc. This habitat occupies the largest part of the study area and is the most adapted vegetation type in the wetland. The herb layer cover is 90-100%, while at various locations the water depth reaches 20 cm. The height of the reed beds ranges from 80 to 250 cm.

Lavrentiades (1956) indicates that the wetland of Vrita (prior to the construction of the hydroelectric dam and the formation of the Agra lake wetland), was covered by 33% stagnant water or small rivers, and 66% by the halophytes: *Phragmites australis*, *Typha angustifolia* and *Schoenoplectus tabernaemontani*. These halophytes

constituted pure communities in the form of scattered stands, with *Phragmites australis* as the dominant taxon.

Syntaxonomical synopsis

Phragmito-Magnocaricetea Klika in Klika et Novák 1941
Phragmitetalia Koch 1926
Phragmition australis Koch 1926
Phragmitetum australis (Gams 1927) Schmale 1939 (?1, ?2, ?3), (72AO15)

Soil type: Humic-gley soil.

Soil profile description (K1)

Of: 2-5 cm. Organic litter (mainly from reeds) decomposed (f), with higher amounts in areas with elevated soil-root systems.

H1: Depth 0-40 cm. A horizon rich in organic matter (9.5%), without structure, viscous, with loam texture, brown in colour, numerous fine roots and some thicker ones (alive). Low degree of decomposition (C/N= 102, total nitrogen 0.09%), free carbonate present and pH slightly alkaline (pH= 7.7). Horizon limit is gradual.

H2: Depth 40-80 cm. A horizon rich in organic matter (9.5%), with clay-loam texture, saturated, of grey-brownish yellow (dark) colour. Roots abundant (dead and alive) with scattered root systems present. The pH is very strongly alkaline (pH= 9.8).

Monitoring sample plots			
Relevé number	**K1**	**K2**	**K3**
Herb cover (%)	100	100	90
Water cover (%)	0	10	100
Water depth (cm)	0	20	1
Max height of herbs (cm)	80	250	250
Total species number	6	11	11
Diagnostic species of *Phragmito-Magnocaricetea* Klika in Klika et Novák 1941			
Phragmites australis	4	4	4
Lycopus europaeus	.	r	r
Typha latifolia	.	.	2
Cladium mariscus	.	1	.
Scutellaria galericulata	.	.	+
Diagnostic species of *Molinio-Arrhenatheretea* Tx. 1937			
Cirsium palustre	+	1	1
Carex cf. *vulpina*	4	3	.
Agrostis stolonifera	.	3	2
Lysimachia vulgaris	+	1	.
Mentha aquatica	.	1	.
Teucrium scordium	.	.	+
Diagnostic species of *Galio-Urticetea* Passarge ex Kopecky 1969			
Calystegia sepium	1	1	.
Galium aparine	.	.	+
Other species			
Thelypteris palustris	.	3	2
Salix cinerea	.	1	+
Juncus articulatus	.	.	1
Rorippa thracica	r	.	.

Discussion

According to the international system of soil classification, FAO/UNESCO, the soils in the area are classified as organic (gley soils) because they were formed under hydromorphic conditions (Misopolinos & Silleos, 1984; Brady & Weil, 2002). The American Classification System classifies these soils as halfbogs, bog soils or histosoils and their various subcategories (saprists-hemists-fibrists), depending on the degree of decomposition of the organic litter (>2/3, 1/2, <2/3). The determining factor for the formation of the above soils is the frequent to permanent presence of water and the poor aerobic conditions (anaerobic) together with the appearance of redoximorphic features and gley horizons (gleization or gleying).

Analyses of the hydrological parameters do not indicate any threshold values. Furthermore, data from this study did not show significant deviations from those of previous studies even though it was not possible to completely match their locations and sampling methods (Papastergiadou, 1990; Platis *et al.*, 2000).

Results produced from this study so far point to the significant role of the Electric Power Corporation as regulator of the seasonal hydrological conditions of Lake Agra due to the operation of the dam. The consequences of these seasonal conditions on the formation or decomposition of peat as well as the habitat types,

including the priority habitat 7210*, is evident. The priority habitat type is stressed when groundwater level drops significantly i.e. more than 15 cm (Gregarek & Vogel, 2000). This is probably why this unique habitat is absent or has scattered distribution in areas of the wetland that have large fluctuations in groundwater level (e.g. near the dam), while in areas with stable water levels it forms dense stands such as the ones found near the village of Vrita.

Phytosociologically, typical vegetation units such as the associations of *Cladietum marisci*, *Phragmitetum australis* were described, in which the dominant species identify the association. Other vegetation units were described at the level of association or community for which, however, the determination of their syntaxonomy and ecology proved to be generally difficult. This can be attributed to the fact that in neighbouring vegetation units, dominant or co-dominant diagnostic species of different classes often mix.

Thus associations such as the *Potamo-Vallisnerietum*, *Potametum crispi*, as well as communities of *Molinio-Arrhenatheretea*, are often difficult to distinguish or it is questionable whether they belong to specific units when species such as *Chara vulgaris*, *Cratoneurum commutatum* or algae (e.g. *Cladophora* spp.) dominate and diagnostic species are low in number and cover (%). In such cases, more significant factors play a role in vegetation unit identification other than structure and plant composition. These factors include the ecology and direction of unit evolution (positive or negative). It is therefore imperative, apart from the permanent sampling plots in locations where typical vegetation units appear, to also establish transects in areas where transitional vegetation exists. Within these transects, identification of flora and mapping and analysis of the ecological growth conditions should be conducted during a twelve-month period as well as from one year to the next.

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Riassunto

Installazione di un sistema per il monitoraggio di habitat naturali nella zona acquatica di Agra (Pella, Grecia).

La zona acquatica di Agra è stata proposta per integrare la rete europea di Aree Protette, nota anche come "Natura 2000" (LIMNI AGRA, GR 1240004), secondo la Direttiva sulla conservazione degli habitat naturali e seminaturali e della flora e fauna selvatiche per il mantenimento della biodiversità (92/43/CEE), nonchè la Direttiva sulla conservazione degli uccelli selvatici (79/409/CEE). L'area comprende il nucleo, costituito soprattutto da superfici d'acqua e formazioni di igrofite, e la zona periferica, dove predominano gli ecosistemi terrestri. Gli habitat naturali del nucleo sono di grande importanza ecologica, non solo perchè uno di loro è un habitat naturale di alta priorità (paludi calcaree con *Cladium mariscus* e *Carex davalliana*), ma anche perchè sono l'habitat di un'avifauna migratoria molto importante. Lo scopo della ricerca è l'installazione di un sistema di monitoraggio dei più importanti tipi di vegetazione, perchè si possa arrivare a una estimazione della situazione e, nello

stesso tempo, il reperimento dei cambi più importanti della zona acquatica. Quindi, è stata stimata necessaria l'installazione di un sistema di monitoraggio ambientale (monitoring) in questa zona acquatica, che include il monitoraggio dei tipi più importanti di vegetazione. A questo scopo sono stati selezionati i seguenti tipi di vegetazione: laghi naturali eutrofici con vegetazione tipo Magnopotamion o Hydrocharition (3150), prati mediterranei con alte erbe e giunchi (Molinio - Holoschoenion) (6420), paludi calcaree con Cladium mariscus e Carex davalliana (7210*) e canneti (72A0). Nei tipi di vegetazione della zona acquatica selezionati sono state installate delle superfici permanenti di campionatura e, dove necessario, sono state effettuate l'analisi dell'acqua e del suolo.

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