ELSEVIER

Agriculture, Ecosystems and Environment 70 (1998) 119–128

Agriculture Ecosystems & Environment

Agricultural activities affecting the functions and values of Ramsar wetland sites of Greece

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Received 9 October 1997; accepted 16 April 1998

Abstract

Agricultural activities in the agroecosystems neighbouring wetland ecosystems are considered a major threat to the latter in all Mediterranean countries. This threat was investigated in thirteen internationally important wetland sites (Ramsar sites) of Greece. The effects of ten activities commonly practised in the surrounding agroecosystems on four wetland functions and four wetland values were evaluated. The functions were: nutrient removal/transformation, sediment/toxicant retention, flood flow alteration, and ground water discharge. The values were: biodiversity, fishing, hunting, and recreation. It was found that the Adamus' Wetland Evaluation Technique is useful even in the little studied Ramsar sites of Greece. Irrigation is the most decisive activity negatively influencing all functions and values, followed by cropland expansion and overgrazing. Coastal lagoons are the least affected by agricultural activities. It is concluded that in Greece the sustainability of wetland ecosystems depends to a significant degree on the sustainability of agroecosystems. The reverse is also true because wetlands provide irrigation water, crop pollinators, some frost protection, and predators of crop pests. The two ecosystem types are functionally closely linked. Therefore, a national policy for the sustainable development of the soil, water, and genetic resources of Greece must integratively consider both these ecosystems types.

Keywords: Wetland functions; Wetland values; Ramsar sites; Sustainable development; Greece

1. Introduction

About two thirds of the wetland area of Spain, France, Italy, and Greece have been drained during the last two generations (Commission of the European Communities, 1995). Losses in the other Mediterranean countries are thought to be equally high. Pearce and Crivelli (1994) estimate that there are about 28 500 km^2 of wetlands remaining in the Mediterranean basin, an area the size of Albania or Sicily. Greece hosts 378 wetland sites covering about 2000 km^2 (Zalidis and Mantzavelas, 1996). Nearly 90 of these sites are eligible for inclusion in the Natura 2000 Network of the European Union according to Directive 92/43/EEC (Dafis, 1996). Eleven wetland complexes (consisting of 59 sites) have been designated for the list of wetlands of international importance (Ramsar Convention Bureau, 1990) according to criteria (e.g. uniqueness, naturalness, representativity,

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0167-8809/98/$ – see front matter
PII: S0167-8809(98)00119-4

number of species, population size) adopted by the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention Bureau, 1996). This convention is more commonly known as the Ramsar Convention from its place of adoption in 1971 in Iran. Similarly, the wetland sites of international importance are commonly known as Ramsar sites. Human activities in the wetlands themselves (e.g. harvesting of wetland products) may be fairly readily related to alterations of wetlands. However, alterations may also be caused by activities in the wetland watersheds and, in the case of Greek Ramsar Sites, predominantly by agricultural ones, i.e. crop and livestock production (Kazantzidis et al., 1995; Zalidis et al., 1997). This cause is serious in many other Mediterranean wetlands too, as evidenced by the fact that the Mediterranean Wetlands Strategy, a document prepared and endorsed by the representatives of twenty two Mediterranean governments in Venice in 1996 (Italian Ministry of Environment, 1996), has included among its priority actions the development of sustainable agriculture in the Mediterranean watersheds hosting wetlands.

The attention in Greece on this matter has been so far focused on agrochemicals application (Gerakis et al., 1998) although other agricultural activities may be equally or more important. Identification of the relative importance of these activities for the sustainability of a particular wetland may be approached by assessing the functions and values of the wetland and the effects each activity may have on each function and value. The objective of this study was to test this approach in Ramsar sites of Greece. These sites are little studied in comparison with the Ramsar sites of west European countries.

2. Materials and methods

The study was based on: (a) The data archives of the Aristotle University and the Greek Biotope/Wetland Centre; (b) field visits to the sites during 1996 to update and/or supplement the information in the archives; (c) professional opinions from agronomists, ichthyologists, hydrologists, and land reclamation specialists mainly of the Ministry of Agriculture.

The main sources used from the archives were delineation and/or management studies (Ministry of Environment, 1986; Kizilou, 1989; Kasioumis, 1991; Bonazountas and Kallindromitou, 1992; Sekliziotis and Papakonstantinou, 1992a, b; Skoullos, 1993, 1994; Tsirikos, 1992; Paraskevopoulos et al., 1993), and the original data forms of specific inventories (Dafis, 1996; Zalidis and Mantzavelas, 1996). Also, specific reports assisting in the description and evaluation of features, functions, values, and activities were used (only the main ones are cited, e.g. Mourkidis, 1986; Bonazountas et al., 1987; Pyrovetsi and Gerakis, 1987; Veresoglou et al., 1988; Hollis, 1989; Maltby et al., 1989; Gerakis, 1992a, b; Tsiouris et al., 1993; Georgoudis et al., 1994; Kazantzidis et al., 1995; Psychoudakis et al., 1995; Wurdinger and Jerrentrup, 1995; Koutrakis, 1996; Zalidis et al., 1997).

The study was conducted in three stages: (a) Assessment of functions and values of the wetland sites; (b) identification of the agricultural activities carried out in the watersheds with an evaluation of their negative effects on functions and values; (c) assessment of the intensity with which each activity is practised in each watershed.

Available information enabled the assessment of only four functions (nutrient removal/transformation, sediment/toxicant retention, flood flow alteration, ground water discharge) and four values (biodiversity, fishing, hunting, recreation). The assessment of the first three functions followed the wetland evaluation technique (WET) as described by Adamus et al. (1987). The adaptations of WET to Mediterranean wetlands were also taken into consideration (Maltby et al., 1989). WET evaluates functions using a series of predictors (variables) that are believed to correlate with the physical, chemical, and biological characteristics of the wetland and its surroundings. The predictors are analysed in a series of interpretation keys that reflect the relationship between predictors and functions. The keys lead the evaluator to a qualitative rating of 'high', 'moderate' or 'low' to each function (Adamus et al., 1987). In this study this rating signifies the 'high', 'moderate' or 'low' probability of a particular wetland to perform effectively a particular function. WET is considered a 'broad-brush' approach and the only alternative to specific long term field studies. The assessment of the ground water discharge function was based on the opinion of hydrologists and geologists.

The biodiversity value was assessed on the basis of nine criteria (2a-2d, 3a-3c, 4a, 4b) pertinent to species

as they are described by the Ramsar Convention Bureau (1996). Wetlands which were found to meet at least seven of these criteria were rated high, wetlands meeting four to six criteria were rated moderate and wetlands with less than four criteria were rated low.

The fishing value for the lakes and lagoons was assessed according to annual commercial fish catches (high: >5.0 t ha^{-1}, moderate: 1.6-4.9 t ha^{-1}, low: <1.5 t ha^{-1}). Information on catches was from statistics of the Ministry of Agriculture and, when appropriate, from personal interviews with local ichthyologists. It must be noted that the fishing value of the deltas, as opposed to that of the lakes and large lagoons, does not refer to the whole area of the delta but only to the narrow coastal zone of shallow sea water and small lagoon systems. Assessment of the hunting value was based on professional opinion regarding the number of hunters visiting annually the wetlands and their immediate perimetric zone. The recreation value was broadly related to landscape, history, archaeology, and ethnology.

Wetland functions are the physical, chemical, and biological processes performed by the wetland system. Wetland values are the wetland processes and features (or combination of them) which are valuable or beneficial to society.

Assessments pertain to thirteen sites (Fig. 1): Four deltas (Evros, Nestos, Axios, Arachthos), five lakes (Ismaris, Vistonis, Kerkini, Volvi, Koronia), and three of the largest coastal lagoons in Greece (Porto Lagos, Mesolonghi, Kotychi). For historical reasons the Ramsar Convention Bureau (1990) lists several of these sites as parts of much larger wetland complexes.

The potentially negative effects of the activities practised in the agroecosystems on the functions and values of the wetland ecosystems were identified and separated into predominantly direct and predominantly indirect effects.

The intensity with which each activity is practised was rated on factors such as agroecosystem area and slope, dominant crop species, inputs required by each species, available farm machinery, irrigated area and availability of irrigation water, species and population sizes of farm animals, animal production methods, etc.

3. Results

The three little polluted fresh water lakes (Kerkini, Volvi, and Mikri Prespa) are likely to be more effective in removing/transforming nutrients (Table 1) than Koronia lake (fresh water but grossly polluted) and Vistonis lake (seasonally brackish water). The reason the three lagoon sites were rated low is mainly because they have less emergent vegetation and their water is brackish-saline. The deltas were moderately rated.

The deltas have high probability to be effective in retaining sediments (Table 1). This is mainly because

Table 1
Probability rating[a] of four functions and four values of Ramsar wetlands of Greece

Wetland sites	Functions				Values			
	Nutrient removal/ transformation	Sediment/ toxicant retention	Flood flow alteration	Ground water discharge	Biodiversity	Fishing	Hunting	Recreation
Evros delta	M	H	L	L	M	M	H	M
Nestos delta	M	H	L	L	H	H	M	M
Axios delta	M	H	L	L	H	L	H	M
Arachthos delta	M	H	L	L	H	M	H	H
Ismaris lake	M	M	L	H	M	M	L	L
Vistonis lake	M	M	L	M	H	H	M	M
Kerkini lake	H	H	H	L	H	M	M	M
Volvi lake	H	M	M	H	H	M	L	L
Koronia lake	M	M	M	H	M	L	L	L
Mikri Prespa lake	H	M	M	M	M	L	M	H
Porto Lagos lagoon	L	M	L	L	H	H	M	M
Mesolonghi lagoon	L	M	L	L	H	H	L	H
Kotychi lagoon	L	L	L	L	M	H	L	M

[a] H: High, M: Moderate, L: Low

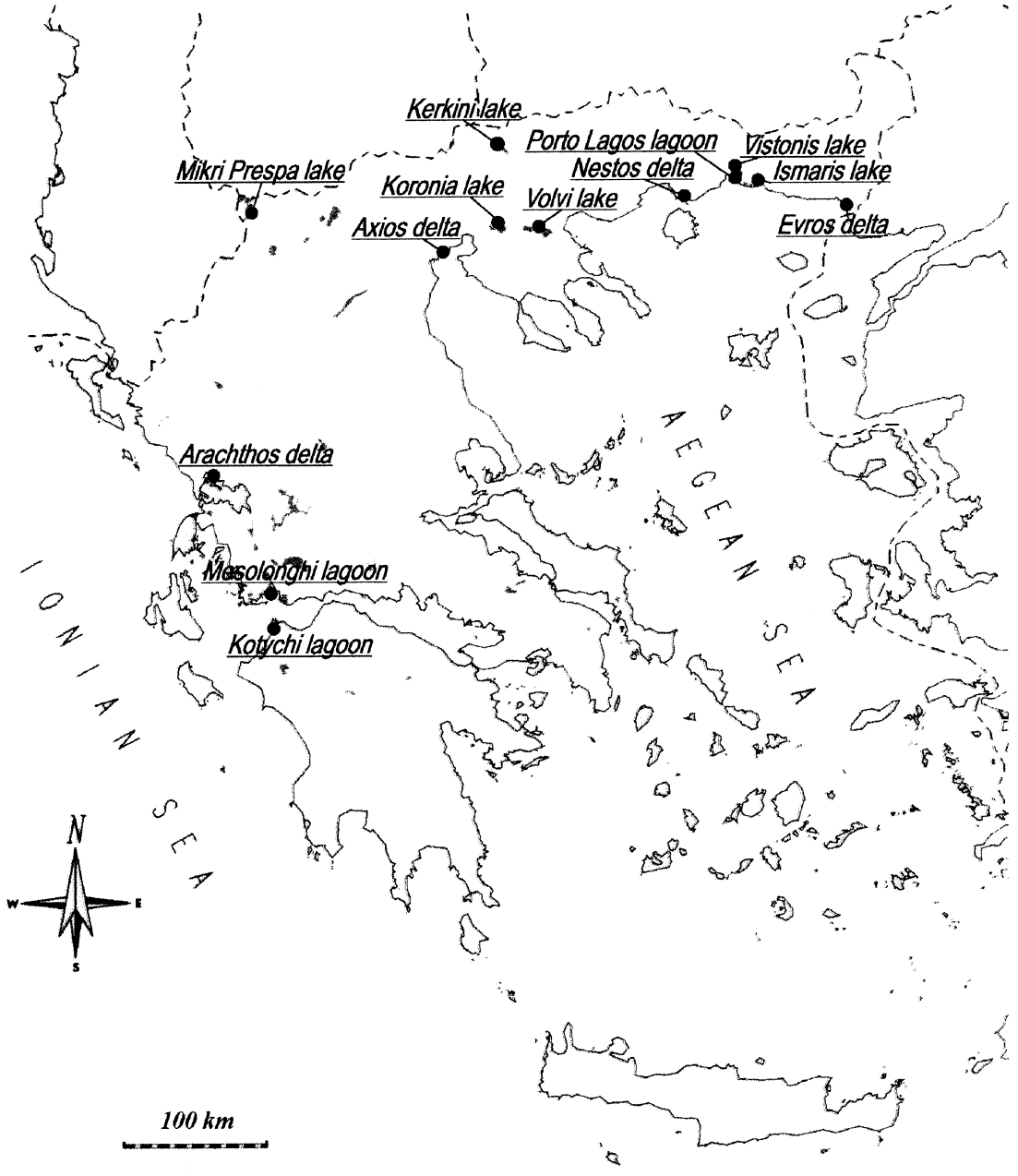

Fig. 1. The internationally important wetland sites (Ramsar sites) of Greece which have been included in this study.

of the dominance of emergent macrophytes and the presence of brackish waters favouring flocculation (Maltby et al., 1989). Kerkini lake is also highly rated because it has been formed by damming Strymon river.

The deltas and the lagoons are unlikely to be effective in buffering adjacent land from serious flooding because of their coastal location. The probability of Vistonis lake altering flood flows is low although its elevation is higher than that of the deltas and lagoons.

Table 2
Activities in the agroecosystems of the watersheds of Greece hosting Ramsar wetland sites and predominantly direct and indirect negative effects on functions and values of wetland ecosystems[a]

Activities	Wetland functions and values affected							
	Functions				Values			
	Nutrient removal/ transformation	Sediment/toxicant retention	Flood flow alteration	Ground water discharge	Biodiversity	Fishing	Hunting	Recreation
Cropland expansion	D	D	D	I	D	D	D	I
Ploughing across contours	I	D	I	NE	I	I	I	I
Fertiliser application	D	NE	NE	NE	I	I	I	I
Pesticide application	I	NE	NE	NE	D	D	I	I
Monoculture	NE	NE	NE	NE	D	NE	I	I
Irrigation	D	D	D	D	D	D	D	D
Crop residue burning	D	D	I	NE	D	I	D	D
Overgrazing	D	D	D	I	D	I	I	D
Livestock changes	NE	NE	NE	NE	D	NE	NE	I
Livestock feedlots	I	NE	NE	NE	D	D	D	D

[a] D: Direct negative, I: Indirect negative, NE: No established effect

A moderate rating is probable for Volvi, Koronia, and Mikri Prespa lakes. Kerkini lake was primarily designed to perform this function hence its high rating. Yet, silting threatens its ability to keep performing this function unless prompt sustainable water management measures are taken (Skordas and Anagnostopoulou, 1995).

Only three sites (lakes Ismaris, Volvi and Koronia) have high probability to discharge ground water (Table 1).

The biodiversity value of Evros, Ismaris, Koronia, Mikri Prespa, and Kotychi is lower than the value of the other Ramsar sites (Table 1). Arachthos delta and the neighbouring wetlands of the Amvrakikos gulf wetland complex has been long considered the most important wetland area in terms of the number of waterfowl species.

The most valuable sites for commercial fishing are the three large lagoons, Nestos delta, and, perhaps, Vistonis lake (Table 1). The less valuable are Axios delta, Koronia lake and Mikri Prespa lake.

Evros delta, Arachthos delta with the neighbouring wetlands, and Axios delta because of their large area and large populations of waterfowl game species are the most valued sites by hunters.

Mikri Prespa lake is the most valued site for recreation because of its small islets, very diverse landscape, and rich historical and archaeological features (Table 1). The fact that it is in the centre of a National Park markedly enhances this value (Pyrovetsi, 1984; Tsalikidis, 1993). At the other end is Ismaris lake whose recreation value is the lowest due to its small size and to the fact that it presently receives municipal effluents. The Mesolonghi lagoon owes much of its recreation value to its outstanding historical and poetic background and Arachthos delta to its very diverse landscape.

Ten activities related to agroecosystem management were identified to be quite common in the watersheds of Greek Ramsar sites (Table 2). Activities differ in their potential predominant effects on functions and values, i.e., one may have a direct effect on one function or value, an indirect on another, and no effect on a third one. Seasonal cropland expansion to the adjacent reedbeds and wet meadows of fresh water systems in years of drought adversely affects all functions and values. Biodiversity may also be adversely affected because some wetland bird species (e.g. pelicans) avoid disturbed habitats even after the disturbance ceases.

Table 2 also shows that ploughing across contours mainly affects sediment/toxicant retention, agrochemicals affect nutrient removal/ transformation and all values especially biodiversity, and monoculture is important only with regard to biodiversity. Irrigation is the activity with the most profound and long term

effects on all functions and values. The destruction of the vegetative cover of the soil by both crop residue burning and overgrazing is expected to cause adverse effects to almost all functions and values although the former is a more serious cause because residue fires often become uncontrolled and burn neighbouring wetland forests, reedbeds, and wet meadows. Changing the germplasm of the livestock which graze in a wetland or in its perimetric zone seldom has any detectable effects on functions. However, the replacement of local breeds by genetically improved ones may be a direct loss of biodiversity and, therefore, an indirect degradation of the passive aspects of recreation. Finally, Table 2 shows that livestock feedlots when discharging their untreated effluents into wetlands, a common practice in Greece, lower the effectiveness of the wetland to perform the nutrient removal/transformation function and degrade all four values by altering wetland species composition and making the landscape less natural.

Table 3 shows that all ten activities listed in Table 2 are not practised with equal intensity at all sites and that some activities are negligible in some sites. Cropland expansion into reedbeds and wet meadows is serious only in Koronia and Mikri Prespa. Sloping agroecosystems cover an appreciable percentage in the watersheds of four lakes (Koronia, Mikri Prespa, Vistonis and Volvi) and therefore, it is only for those lakes that ploughing across contours is of importance. Fertilisers and pesticides are used in all watersheds but the insensity of their use is higher in the agroecosystems close to Koronia (intensive vegetable production). Monoculture is most dominant in the watershed of Mikri Prespa, where in more than half of the cultivated area beans are grown year after year and is less dominant north of Vistonis. Large irrigation schemes operate in three deltas (Evros, Nestos, Axios). The waters of Kerkini, Volvi, Koronia, and Mikri Prespa lakes are intensively used for irrigation. Koronia's water quality for irrigation is very low but it is still used. Burning, rather than soil incorporation, is the preferred way to manage residues of cereals in Greece and frequent fires of natural wetland vegetation are observed in one delta and four lakes.

Table 3 also shows that intense overgrazing is common in the deltas of Axios and Evros. The wet meadows of Mikri Prespa are less and less grazed, a trend which already has caused changes in plant species composition which may affect wildlife. Changes in livestock germplasm which were intense in 1950–1970 are presently negligible. However, socioeconomic factors threaten with extinction the only herds of water buffaloes bred today in Greece, i.e. in Axios, Vistonis, Kerkini, and Volvi (Georgoudis et al., 1994), and the indigenous small sized cattle breed of the wider area of Mikri Prespa. Finally, Table 3 shows that livestock production is intensively practised in Arachthos delta followed by Koronia. It is negligible for all three large lagoons.

4. Discussion

The Adamus approach (Adamus et al., 1987) has been based on North American literature which may not be readily applicable for European countries especially those of the Mediterranean region (Maltby et al., 1989). In Greece, as well as in most Mediterranean countries, wetland research has been traditionally focused on bird fauna. There are less data on other biotic and abiotic wetland features and little experience in using the approach. Nevertheless, this study and the two previous ones made in Greece, i.e. Maltby et al. (1989) for Evros delta and Zalidis and A. Gerakis (unpublished) for Karla lake, indicate that the approach is applicable to Greece and worthy of further testing and improvement.

Various specific factors have been identified to constrain the assessment of the functions of Greek Ramsar sites, in addition to the general paucity of data. Firstly, full information on the watersheds of the Evros, Nestos, and Axios deltas, and of the Kerkini and Mikri Prespa lakes is not available because Greece shares these watersheds with other countries. Therefore, the continually improving transboundary cooperation must be extended to the exchange of information on soil and water resources. Secondly, overall assessments in large and complex sites are of limited practical usefulness because these sites include more or less distinct wetland units. These units must be identified and separately assessed keeping, however, in mind the functional relationships among them. Thirdly, hydrogeological data, sufficient enough to assess the ground water recharge and discharge functions, are, with few exceptions, inadequate. Given the immense economic and ecological

Table 3
Rating of the intensity with which various activities are practised in the agroecosystems of the watersheds of Ramsar sites of Greece[a]

Activities	Agroecosystems in the watersheds of Ramsar sites												
	Evros delta	Nestos delta	Axios delta	Aracthos delta	Ismaris lake	Vistonis lake	Kerkini lake	Volvi lake	Koronia lake	Mikri Prespa lake	Porto Lagos lagoon	Mesolonghi lagoon	Kotychi lagoon
Cropland expansion	2	2	0	1	0	1	1	2	3	3	0	0	0
Ploughing across contours	0	0	0	0	0	2	1	2	3	2	0	0	1
Fertiliser application	2	2	3	3	2	3	3	3	3	3	1	2	2
Pesticide application	1	2	2	2	1	2	1	2	3	2	1	2	1
Monoculture	2	2	2	2	2	1	2	2	2	3	2	2	2
Irrigation	3	3	3	2	1	2	3	3	3	3	1	1	1
Crop residue burning	1	2	3	2	2	1	3	3	3	3	1	1	1
Overgrazing	3	1	3	1	1	2	1	1	2	0	1	1	1
Livestock changes	0	0	2	0	0	2	2	2	0	1	0	0	0
Livestock feedlots	1	1	1	3	0	1	1	1	2	0	0	0	0

[a] Rating scale: 3, High intensity; 2, Medium intensity; 1, Low intensity; 0, Activity negligible or absent.

importance of ground water resources and the serious problems already caused by their unsustainable development in Greece (Zalidis et al., 1998), extreme caution must be exercised in assessing these functions. Poor assessments may threaten the very existence of the wetland, as shown in the case of the drained lake Karla (Koutseris, 1989) and Acheloos delta (Pergantis, 1995, pers. commun.).

The fishing value of Koronia lake is becoming lower and lower because of the dramatic drop of its water level (low rainfall coupled by increased pumping of water for irrigation) and pollution from municipal and industrial effluents. The Greek deltas are important for fishing for an area far larger than the strictly deltaic one because they are nurseries for fish populations living in a wide marine zone which is adjacent to the delta (Koutrakis, 1996, pers. commun.).

Wetland values may be interrelated. Recreation is a 'composite' value depending not only on the other three but also on the cultural features of the wetland (e.g. history, archaeology, literature, social anthropology). There are only two studies on the cultural features of Greek wetlands (Papayiannis, 1992; Lilimbaki and Papangelos, 1995).

Most activities act on the functions and values independently of others. However, interesting synergisms may also be identified. A cardinal example is irrigation. Until the mid-1920s the agroecosystems of Greece were predominantly rainfed (Zalidis et al., 1998). The expansion of irrigation, especially since the mid-1950s, enabled the use of more and larger subsidiary energy inputs in terms of fertilisers, pesticides, heavy machinery, improved crop varieties and livestock breeds, etc. Moreover, mismanagement of irrigation schemes may lead to excessive irrigation return flow which results in an increase of nutrient, sediment, and toxicant inputs into the wetland (Turner et al., 1980). On the other hand, the semi-arid climate of most of Greece makes winter cereal monoculture in the rainfed agroecosystems inevitable. A positive effect of irrigation would therefore be a marked increase in crop diversity. Although the irrigated agroecosystems of Greece are more diversified than the rainfed ones, economic subsidies to farm products, market forces, and other factors favour monoculture even in the former.

Seasonal cropland expansion intensifies agrochemicals use. However, this synergism is immaterial compared with the direct effects of this practice. Few Greek farmers are aware that the relatively narrow wetland zone with persistent emergents and wet meadows which they cut, burn, and cultivate in years of drought is the one which mainly removes/transforms nutrients and therefore, maintains the quality of the wetland's water (Baker and Maltby, 1995). It is this water that the same farmers pump for irrigation (Pyrovetsi and Gerakis, 1987).

Changes in the livestock germplasm may, depending on the type and magnitude of the changes and on the agroecosystem features, increase or decrease the intensity of grazing pressure (Papanastasis, 1992).

Clearly, the most heavily stressed wetland functions and values are at the sites of Koronia lake, Mikri Prespa lake, Volvi lake, and Axios delta. Pressures from other activities within the wetland (e.g. fishing) and in its watershed (e.g. industry) may interact with the pressures from agriculture (Zalidis et al., 1997). Although there is no quantitative data, it is postulated that it is only in Koronia that point pollution from industrial and municipal effluents may exceed non-point pollution from agricultural activities. Another factor which must be considered in studying the effects of human activities is the functional relationships among Greek Ramsar sites. For example, Arachthos delta (with the other wetlands of the Amvrakikos gulf complex) and the Mesolonghi and Kotychi lagoons commonly support some migrating bird populations. The same is true of the sites of northwestern Greece (Evros delta, Ismaris lake, Vistonis lake, Porto Lagos lagoon, and Nestos delta). This means that the importance of a wetland to the biodiversity of a region is reflected not only on the number of species it hosts but also on its relationship with other wetlands, e.g. its position in a north-south chain of wetlands used by migratory birds.

Functional assessment of wetlands, despite its limitations when applied to little studied sites, has been shown by this study to be a useful tool for better understanding of the potential effects of agroecosystems on wetland ecosystems. The World Conservation Union (IUCN) lists among its twelve priorities for wetland conservation the promotion of such tools that contribute to sustainable development. The sustainability of wetland ecosystems depends on the sustainability of agroecosystems. The reverse is also true, e.g. wetlands provide irrigation water and crop pollinators,

decrease frost damages to crops, host predators of crop pests, etc. The two ecosystem types are closely linked functionally. Therefore, a national policy for the sustainable development of the soil, water, and genetic resources of Greece must integratively approach these two types of ecosystems as well as other types (e.g. forests). This approach is implicit in the European Union's policy on sustainable development of natural resources and on wetland conservation (Commission of the European Communities, 1993, 1995). However, the planning and implementation of sustainable policy measures which are suitable for the ecological and social conditions of Greece may benefit from a comprehensive review of the more than twenty five projects on the sustainable management of Greek watershed resources which have been conducted since 1980. Such a review is planned by the Greek Biotope/Wetland Centre, Thermi, Greece.

Acknowledgements

Appreciation is expressed to the Greek Biotope/Wetland Centre for providing information and the map and to Drs. D.S. Veresoglou, E.T. Koutrakis, Eva Papastergiadou and Ms. Eleni Fitoka for their useful comments on an earlier manuscript. The authors also thank the anonymous referees and the Editor-in-chief for improvements to an earlier version of this paper.

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