Environmental Monitoring of Spatio-temporal Changes Using Remote Sensing and GIS in a Mediterranean Wetland of Northern Greece

E. S. Papastergiadou · A. Retalis · A. Apostolakis · Th. Georgiadis

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Abstract Loss and degradation of terrestrial and aquatic habitats and degraded water quality are major environmental concerns worldwide. Especially wetlands are sensitive ecosystems that are subject to stress from human activities. Remote sensing techniques have been primarily used to generate information on land cover/use changes. Geographical Information Systems (GIS) and remote sensing can be used to provide a rapid or a large-scale understanding of lake change and in developing lake management strategies. The principal objectives of this study are to monitor and assess the spatial and temporal changes in land cover/use by using GIS, and to determine the main environmental factors affecting these changes. This paper presents a case study for the application of integrated remote sensing and GIS data for the classification and monitoring of the spatial and temporal changes in land use types. The study was conducted in a small natural wetland of Lake Cheimaditida, located in the East Mediterranean region of Northern Greece. Data analysis was conducted using GIS software. During the past several decades Lake Cheimaditida wetland has been influenced by many anthropogenic activities. The variables chosen for the assessment included condition of wetland and lake areas, present extent of wetlands relative to historic area, cover of natural habitat, wetland disturbances, etc. These variables address catchments properties that are important for maintaining and improving wetland habitats and water quality and assessment of trends useful for environmental monitoring. Land cover/land use patterns were assessed and compared using aerial photographs taken in 1945, 1969, 1982, and 1996. Over this period, reed beds enormously increased by 1,655.19%, while open-water areas and peat lands...
decreased by 74.05 and 99.5%, respectively. The significance of the changes in land cover distribution within the Lake Cheimaditida wetland are discussed in relation to the historical pattern of reed beds colonization, the importance of *Phragmites australis* in the process and the implications for strategic management of freshwater wetland resources.

**Keywords**  Aerial photographs · GIS · Greece · Land cover/use · Remote sensing · Reed beds

### 1 Introduction

Wetlands are amongst the Earth’s most productive ecosystems, providing a diverse array of important ecological functions and values, ranging from flood and flow control to groundwater recharge and discharge, water quality maintenance, habitat for flora and fauna species, biodiversity, carbon sequestration, and other life support functions (Mitsch and Gosselink 1993). However, despite the growing awareness of the values and benefits from wetlands, wetland loss and degradation continues in European countries. Historically, many wetlands have been treated as wastelands and drained or otherwise degraded (Barbier et al. 1997). In many European countries for example wetlands are under increasing pressure from anthropogenic activities, including conversion to intensive agricultural use and to other industrial and residential uses, their drainage as a result of excessive irrigation in agriculture; pollution as a result of nutrient run-off from intensive agricultural production and industry. Greece has lost about 70% of its wetlands between 1920 and 1991 (Gerakis 1992). Today Greece is a European Union (EU) member state and Ramsar convention partner, and, as result, is obliged to protect, sustainable manage, and conserve remaining wetlands. The EU Water Framework Directive (WFD 2000/60/EC 2000) clearly identifies the protection, restoration and enhancement of water needs of wetlands as a part of its purpose. WFD stresses the EU’s involvement in wetland protection, together with Birds Directive (79/409/EEC) and Habitats Directive (92/43/EEC), which aim to conserve several ecological functions and attributes that are provided by wetlands.

Land use changes and associated hydrological disturbances, mainly caused by human activities is a usual reason for the degradation of wetlands worldwide (Mitsch and Gosselink 1993; Barbier et al. 1997). Significant land cover changes have been reported during the last century both on spatial and temporal scale, mainly due to economic development and population growth (Mitsch and Gosselink 1993). Regarding the biotic and abiotic components of the ecosystems, land cover changes cause both direct and indirect impacts. Although these changes are most significant on the local scale, they can result in cumulative global environmental changes. For that reason, monitoring land cover/use changes and assessing their impacts is essential for sustainable environmental management and policy-making. Examining the historical pattern of an area’s land cover/use change provides the necessary context for framing modern ecological studies and designing conservation efforts (Boyle et al. 1997; Domotorfy et al. 2003).

The study of changes of surface area, structure and functions of the wetland is very important for the determination of causes and consequences of their degradation, and the provision of solutions for their protection and restoration. Aerial photographs are the most commonly used form of remote sensing data for mapping aquatic habitats (Lehmann et al. 1997). Remote sensing has been used for many years and has been prove to be an indispensable tool in mapping and assessing natural resources. GIS is a valuable tool for studying the nature of wetlands and the potential of their restoration (Gottgens et al. 1998). In order to accurately analyze the dynamic geographical phenomena related to wetlands it is
necessary to take into account their changes in space and time. Aerial and satellite photography can be used to detect coarse changes in wetland plant communities in response to anthropogenic disturbances e.g. eutrophication, terrestrialization process, etc (Jensen et al. 1995). Remote sensing techniques can detect changes in the aerial extent of wetlands, the percent cover of vegetation, as well as the replacement of one plant community by another (Tiner 2004). Remote sensing requires field verification, however, to calibrate plant community types with patterns discerned from aerial and satellite images.

Our purpose here is to report land cover and hydrological changes occurring as a result of human activities in the second half of 20th century in a small freshwater wetland of Northern Greece. This wetland is a designated protected area. This study has been conducted in an area where significant land cover changes have been occurring during the last decades and as a result, substantial degradation of the existing wetland habitats has occurred. This case study focuses on the Cheimaditida and Zazari wetland in Northern Greece, which provides several important ecological functions to the surrounding area. Lake Cheimaditida wetland has undergone significant changes in watershed characteristics and water quality over the last century. Its watershed has changed from peat land to farmland and pasture. For many years Cheimaditida wetland has been affected by human activities, resulting in a reduction of the water surface and degradation of wetland habitats. GIS was used to measure wetland area changes between the years for which photographic data were available.

The objectives of this study were to fulfill the need for baseline data of land cover and land use in the area by preparing a new accurate and up to date land cover/use map of the Lake Cheimaditida wetland and the adjacent Lake Zazari, using remote sensing techniques and GIS. More precisely, the aims of the study were (1) to demonstrate that historical vegetation-maps can be drawn up from cartographic archives using GIS methods (2) to demonstrate that by conforming each map to a common co-ordinate system, it is possible to quantify historical changes in land cover types and extents and (3) to indicate the significant land cover/use changes over time.

2 Materials and Methods

2.1 Study Area

Lake Cheimaditida is situated in Northern Greece (Prefecture of Florina, 21°34′E, 40°35′N) close to the borders of Yugoslavia (FYROM). The lake has been included in the European network of protected areas NATURA 2000 (Dafis et al. 1996). The importance of the area is derived from the presence of different habitat types and the numerous flora and fauna species, many of them are listed in the Directive 92/43/EEC (Papastergiadou et al. 2003). Lake Cheimaditida is very close to Lake Zazari. Both are part of a wetland complex that includes another two lakes Lake Petron and Lake Vegoritida. The maximum depth of the Lake Cheimaditida is 2.5 m and its mean depth is around 1 m. The surrounding land is intensively cultivated and also used as meadow and pasture. Lakes Cheimaditida and Zazari are used for irrigation purposes and commercial fishing. Stresses have impacted these wetlands during last century, mainly due to land use changes including extension of the agricultural land towards the lakeshore, and urbanization. The citizen’s population in the catchments’ areas is 5,500. The main economic activities comprise farming, stockbreeding, fishing and manufacturing of agricultural products. Due to significant water availability and soil fertility, agricultural land has substantially increased during the last century, however natural and wetland areas decreased simultaneously.
In the late 1960s early 1970s a series of drainage works for agricultural purposes, at the NE part of Lake Cheimaditida, were rounded off decreasing the water surface of the lake to its current size (Fig. 1). Among these works was the construction of a dyke at the NE boundary of the lake in order to protect the adjacent agricultural land from flooding (Fig. 1). Since the 1960s the two lakes are connected with a channel flowing from Lake Zazari (maximum water elevation 599.2 m) to Lake Cheimaditida (maximum water elevation 591.3 m). These modifications accompanied by the associated land use changes have caused significant impacts on the regional environmental parameters.

2.2 Image Preparation

A data set of black and white aerial photographs pairs suitable for stereoscopic observation acquired from the Hellenic Army Geographical Service (HAGS) for the years 1945, 1969, 1982 and from the Hellenic Ministry of Rural Development and Food (HMRDF) for the year 1996 was used to assess land cover data of the area. The original aerial photographs were acquired at varying scales: 1:42,000 (1945), 1:40,000 (1969), 1:15,000 (1982) and 1:40,000 (1996). All aerial photographs were taken during the summer period (August), which allows for a reliable comparison of the specific land cover types. The cover types of the area exhibited a distinctive spectral response in these summer photos. The absence of moisture surplus or humidity during the photo acquisition time and season secured this issue (Kalivas et al. 2003). Prior to analysis, all photographs were scanned using a constant standard exposure setting and a resolution of 400 dpi (dots per inch). Once scanned, all photographic images were processed using Erdas IMAGINE software (ERDAS 2003). All images were converted into IMAGINE image files.

Then images were rectified and projected to the Greek Geodetic Reference System (EGSA87) using the nearest neighbor re-sampling method using ERDAS Imagine 8.7 and Leica Photogrammetric Suite. Geometric correction was carried out using standard techniques with ground control points and a second order polynomial fit (Mather 1999). Once corrected an assessment was made to validate the accuracy of checkpoints. Next, all

Fig. 1 Location of the case study area, Lake Cheimaditida wetland, Northern Greece

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images for each year were geo-referenced, overlapping images were merged together, using the Erdas Imagine Mosaic Tool (ERDAS 2003) to provide continuous coverage of each target area for each year of analysis.

From the aerial photographs specific land cover types (see also Table 1) were recognized by stereoscopic observation and photo-interpretation, and the borders of these areas were defined. Wetland vegetation types were classified by structural type as emergent’s separated in reed beds, wet meadows, and peat lands (Davies et al. 2004). Individual emergent species were identified and verified with field data during samplings of spring and summer 2002. Submerged species (aquatic macrophytes growing below water surface) were not found during this study (Papastergiadou, unpublished data). Based on the interpreted aerial photographs, land cover/use maps of wetland were produced. Then the geo-referenced aerial photographs were stored in a GIS spatial database. Conducted land surveys of the area were used for the ground-trusting of the photo interpretation results. Spatial analysis techniques were applied using ArcGIS 8.3 software (ESRI 2002), for change detection analysis. This defined procedure that has been applied to derive land cover/use maps and respective changes on spatial and temporal basis with the contribution of remotely sensed data is widely adopted by the scientific community (Weng 2001).

Only the eligible protected area was used in this study. The outer perimeter boundary of the lake’s catchment’s area polygon is used to identify the protected area proposed to be included to the European network NATURA 2000 (Dafis et al. 1996).

2.3 The GIS Development

Geographic Information Systems (GIS) are widely used for lake studies providing a powerful tool for capturing, storing, checking, manipulating, merging, analyzing and, displaying data. GIS is particularly useful for analyzing spatial data related to lakes and to their catchment’s areas (De Mers 1997; Baban 1999). Building a database is the first step in interfacing models with GIS. For any GIS application, the completeness and accuracy of

<table>
<thead>
<tr>
<th>Land cover/use types</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban areas/villages</td>
<td>Villages, lignite mine of Amyntaio</td>
</tr>
<tr>
<td>Rocks</td>
<td>Rocks</td>
</tr>
<tr>
<td>Arable land</td>
<td>Agricultural land presently cultivated by crops, mainly irrigated from the lake</td>
</tr>
<tr>
<td>Open water areas/lakes</td>
<td>Lakes open water area possibly containing aquatic plants of Potametea or Lemnetea class close to the littoral zone</td>
</tr>
<tr>
<td>Peat lands/fen</td>
<td>Usually communities of Magnocariccion elatae and in spring areas communities of Chara species</td>
</tr>
<tr>
<td>Wet meadows/marshes</td>
<td>Areas periodically inundated which are characterized by vegetation that requires saturated soils for growth. Usually communities of Molinio–Holoschoenion, Magnocaricetea or in some wetter places different associations of Phragmitetalia</td>
</tr>
<tr>
<td>Reed beds</td>
<td>Usually reed-dominant associations of Phragmitetalia</td>
</tr>
<tr>
<td>Pastures</td>
<td>Land covered by annual vegetation, grasses, herbs, etc. that can be used for grazing.</td>
</tr>
<tr>
<td>Scrubs and trees</td>
<td>Wet forested land of <em>Salix alba</em> and residual alluvial forests of <em>Alnus glutinosa</em></td>
</tr>
<tr>
<td>Forests</td>
<td>Oak forests of the surroundings mainly of <em>Quercus frainetto</em> woods</td>
</tr>
</tbody>
</table>
the database determines the quality of the analysis and the final product. In designing the database, the boundary of the study area, the coordinate system, the necessary data layers (coverage’s/shape files), and the coding and organization of the attributes was done first as Tsihrintzis et al. (1997) suggested.

2.3.1 The Data Base Structure

For the purposes of this study, ArcGIS 8.3 software (ESRI 2002) has been used for the storage, organization, analysis and visualization of spatial-temporal datasets. Changes of the geometric and thematic attributes of the spatial objects through time are accommodated, by creating separate shape files. Each shape file shows the state of the spatial objects at discrete times, without explicit temporal relations among the shape files. However, for this study, appropriate arrangements were made in the attribute files so as to incorporate the spatial-temporal variation in one shape file. For example the temporal information is stored, relative to specific spatial objects and topologically defined elements, which makeup the objects. Therefore the time characteristics are presented as attributes. All the changes of the individual objects through time are stored in the same coverage. The coverage is a temporal composite built from accumulated geometric and thematic changes. Each change causes the changed portion of the coverage to break from the initial object to become a discrete object with its own distinct history. This method of temporal decomposition was originally suggested by Chrisman (1983) and allows the integrity of individual spatial objects, components of those objects and their spatial interrelationships to be explicitly maintained over time (Kalivas et al. 2003). The thematic information was stored in different database files for each time period and in the temporal database file.

2.3.2 Remotely-sensed Ecological Assessment

To assess the overall ecological condition of watersheds a set of largely remotely sensed indices were used. To be most useful for environmental monitoring, these variables had to meet the following requirements: (1) be derived from remotely sensed data (aerial photos or satellite images) for contemporary data and from maps for historical data, (2) be suitable for frequent updating and rapid assessment, (3) consist of metrics that could efficiently and cost effectively be updated for large geographical areas, (4) present a broad view of the extent of natural habitat, and (5) provide a historic perspective on the extent of wetlands and open water bodies.

The variables chosen for the assessment of the wetland areas included condition of wetland and lake areas, present extent of wetlands relative to historic area, cover of natural habitat, amount of wetland disturbance (e.g. drained, excavated, impounded, and farmed wetland areas), extent of canalization and habitat fragmentation by roads. These variables address catchments properties that are important for maintaining and improving wildlife habitat and water quality.

3 Results and Discussion

A series of maps were prepared using the collected and analyzed data. These features include open water areas, extent of different wetland habitat types, agricultural land, scrubs and trees, forests, etc. A classification system of ten land cover/use types was developed for the purposes of the study and the identified and delineated boundaries of the polygons of...
the categories were transferred from the aerial photographs on to the base maps. The descriptions of these types are shown in Table 1.

3.1 Land Cover/use Changes

In order to fulfill the need for baseline data of land cover and land uses in the area we produced a new accurate and up to date land cover/use map of the Lake Cheimaditida wetland and the adjacent Lake Zazari, by using remote sensing techniques and GIS. These maps provide a set of baseline conditions for comparing long-term changes. Also the maps can help identify potential landscape-level threats to parts of the watershed. The prepared thematic map from the 1996 aerial photographs was ground verified, so that each area represented most closely to the conditions occurring in 2002. The most current land cover/use data (at minimum) were displayed in these maps. Although land use patterns do not completely describe disturbance levels, they are usually highly correlated with landscape and wetland condition (O’Connell et al. 1998).

The analysis and elaboration of the aerial photographs and the existing land cover data for the years 1945, 1969, 1982 and 1996 provided the land cover/use types and their respective changes within the examined time period (Table 2).

The most significant estimated change of Cheimaditida wetland during these five decades is the decrease of the open water areas that have been seriously reduced from their initial extent (74.05%), and covered by reed beds, as well as the drainage of peat lands for cultivation (99.5%), and the increase of agricultural land (63.21%, Table 3). The changes since 1945 extended mainly throughout the north eastern part of the lake where there were drastic decreases of peat lands/fen and the corresponding increase of arable land and reed beds (Figs. 3, 4, 5). The rest of the land cover/use types were not significantly altered. It should be noted that the above estimations include also the error derived from the geo-reference procedure of the aerial photographs. This explains, for example, the small increase in forest cover area (Table 2).

From the quantitative analysis (Table 3), the extent of coverage of the open water area was reduced from the 74.05% of total to 61.38% in 1982 and to 26.02% in 1996 as the water level was lowered. Of particular interest is that in the 1996 data the large open water area, that was previously occupied the whole lake, had already full covered by reed beds

<table>
<thead>
<tr>
<th>Land use</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arable land</td>
<td>740.40</td>
</tr>
<tr>
<td>Forest</td>
<td>1,452.12</td>
</tr>
<tr>
<td>Open water areas/lake</td>
<td>1,255.53</td>
</tr>
<tr>
<td>Pastures</td>
<td>56.84</td>
</tr>
<tr>
<td>Peat lands/fen</td>
<td>477.16</td>
</tr>
<tr>
<td>Reed beds</td>
<td>52.91</td>
</tr>
<tr>
<td>Rocks</td>
<td>1.30</td>
</tr>
<tr>
<td>Scrubs and trees</td>
<td>2.54</td>
</tr>
<tr>
<td>Urban</td>
<td>12.82</td>
</tr>
<tr>
<td>Wet meadows/marshes</td>
<td>13.12</td>
</tr>
</tbody>
</table>

Table 2  Land cover/use area (ha) for the time period 1945–1996, in the study area
Open water areas decreases from 30.89% in 1945 to 28.06% in 1969 and 10.84% in 1982, as well as 8.02% in 1996 (Fig. 2a,b).

The total area of reed beds increased mainly between both 1945–1969 and 1969–1982 periods. The wetland vegetation mainly occupied by reed beds increases from 1.3% in 1945.
to 19.77% in 1982 and 22.85% 1996 (Figs. 2a,b and 4). Reed bed development was almost 14 times faster in the second than in the first period (50.93 ha yr\(^{-1}\), compared to 3.69 ha yr\(^{-1}\), Table 3), and six times faster than in the third period (8.93 ha yr\(^{-1}\), Table 3).

Over the period covered by the four surveys, the area of land used for agriculture in the Lake Cheimaditida wetland increased significantly, as a result of proliferation of drainage-channels, land-reclamation and drying and shrinkage of peat layers (Figs. 2a,b and 3a,b). The arable land development was almost nine times faster in the first period (1945–1969: 16.53 ha yr\(^{-1}\), Table 3), than in the second period (1969–1982: 1.77 ha yr\(^{-1}\), Table 3) and almost five times faster than the third period (1982–1996: 3.45 ha yr\(^{-1}\), Table 3). From 1945–1969, this arable land development was due to an increase of available area from drying and shrinkage of peat layers and the construction of the dyke (Figs. 3 and 4). However, between 1969 and 1982 and the following years up to 1996, there was a slower increase in the area of arable land (1,137.14 ha in 1969 to 1,160.16 ha in 1982 and 1,208.39 ha in 1996). Pasture was created from drained marshland and areas, which had been wet or moist. The areas of peat land consequently decreased (Fig. 3).

The major causes of wetland degradation were altered natural hydrologic regimes and especially in Lake Cheimaditida wetland, changes to water quantity, water level fluctuation, and water quality (Lazaridou et al. 2001), and habitat modification that have serious impacts on composition of plant communities (Ehrenfeld 1983; 2000). The main responses by the plant communities that occur in Lake Cheimaditida wetland, as a result of hydrologic change include the decrease in species richness, the increase in the dominance of one plant species e.g. Typha angustifolia and P. australis or one structural type (Figs. 4 and 6), the absence of species that are sensitive to human disturbance (Cladium mariscus) and the presence of very dense stands of reed bed vegetation (Galatowitsch et al. 1999; Ehrenfeld 2000). Water table and vegetation have changed throughout the entire period as a result of environmental changes and human intervention. Ground water recharge and water storage were found degraded due to water abstraction for agricultural purposes (Lazaridou et al. 2001). Cut-sedge C. mariscus seems that was the main emergent vegetation in peat land areas of the wetland in 1945, but it has been gradually replaced by reed P. australis and in

<table>
<thead>
<tr>
<th>Land use</th>
<th>Change (%)</th>
<th>Annual change (ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arable land</td>
<td>53.58</td>
<td>2.02</td>
</tr>
<tr>
<td>Forest</td>
<td>0.52</td>
<td>2.95</td>
</tr>
<tr>
<td>Open water areas/lake</td>
<td>−9.15</td>
<td>−61.38</td>
</tr>
<tr>
<td>Pastures</td>
<td>14.59</td>
<td>30.07</td>
</tr>
<tr>
<td>Peat lands/fen</td>
<td>−81.80</td>
<td>−58.92</td>
</tr>
<tr>
<td>Reed beds</td>
<td>167.42</td>
<td>467.96</td>
</tr>
<tr>
<td>Rocks</td>
<td>0.00</td>
<td>1.17</td>
</tr>
<tr>
<td>Scrubs and trees</td>
<td>43.63</td>
<td>−15.23</td>
</tr>
<tr>
<td>Urban areas</td>
<td>22.14</td>
<td>23.22</td>
</tr>
<tr>
<td>Wet meadows/marshes</td>
<td>1.99</td>
<td>1.83</td>
</tr>
</tbody>
</table>
deeper places by *T. angustifolia* (Figs. 3 and 4). Reeds appeared to respond very rapidly to environmental changes (Fig. 4).

It is well documented that *Phragmites* and *Typha* species invade in response to eutrophication process as well as to other anthropogenic alterations like changes in hydroperiod and soil disturbance (Galatowitsch et al. 1999). *T. angustifolia*, for example,
encroaches on and colonizes areas that have undergone soil disturbance, nutrient enrichment, and hydrology alteration (Urban et al. 1993), and eventually can become the dominant species in areas that receive large loadings of P, the primary limiting nutrient. Another species that may invade in response to increased nutrients is Phragmites (Chambers et al. 1999; Galatowitsch et al. 1999). *C. mariscus* are adapted to low nutrient or oligotrophic conditions but are replaced by *Typha* and other species in eutrophic areas.

Fig. 4  Open water areas/lake and reed beds changes during 1945–1996
The disappearance of submerged aquatic vegetation also may be a useful indicator of nutrient enrichment.

Furthermore, there was a decrease in the number of land cover types and cut-sedge cover declined (Fig. 6), such a decline being much more important in the 1990s, with a dramatic increase in reed and cattail and a decrease in open water areas (Fig. 6, Table 2). Cut-sedge has been reported to need water throughout its life cycle, whereas reed can withstand long dry periods (Haslam 1970) and high nutrient content (Alvarez-Cobelas et al. 2001).

Modern environmental management recognizes that effective integrated systems need an understanding of the baseline natural conditions. In many cases this is difficult, but by examining the historical record, a series of temporal indicators of an environment can help to illuminate how the natural system worked, how it responded to change and how we can use this information in terms of habitat rehabilitation and reconstruction. Detecting change from historical photos provide us with indicators.

From the analysis of the aerial photographs data set and the spatial information presented in the digital maps (Figs. 3, 4, 5 and 6), it could be concluded that Lake Cheimaditida wetland has lost much of its historical surface, structure and functions. Transformation of the wetland was influenced by a number of factors acting over a period of decades including modifications in the catchments hydrology, geology, biology and geochemistry. The evident change is the observed changes to the shallow swamp areas of the littoral zone and land cultivations around the lake.

The poor performance of the wetland functions resulted in (a) drop of the groundwater level, (b) shortage of irrigation water, (c) loss of wetland habitats, and (d) gradual decrease
of biodiversity (Papastergiadou et al. 2003). The reasons for the wetland’s degradation are mainly the expansion of the farming land, the construction of the artificial canal (1960s) that outflows water from Lake Zazari to Lake Cheimaditida, which was also used for irrigation purposes, and the progressive lowering of the lake’s water level. The water level regime is a key factor regulating the establishment and expansion of littoral stands of
emergent vegetation. Depending on the shoreline slope low water levels in summer provide suitable conditions for down slope germination and seedling growth of helophyte species, as well as for vegetative expansion (Coops et al. 2004).

Lake Cheimaditida is highly affected by human interventions, resulting in alteration of typical species composition and vegetation structure and in the formation of species – poor plant communities (Papastergiadou et al. 2003). The most serious interventions, especially the last few years are over-exploitation of the lakes water for irrigation, the encroachment of the fields in protected wetland habitats, as well as burning and/or harvesting of emergent vegetation. This resulted in an extension of the reed beds dominated by *T. angustifolia* and *P. australis* over most of the wetland area (Figs. 4, 5 and 6), which led to partial loss of the biodiversity and fishing values. Clearly, one way to restrict the reed bed zone to what it was 50 years ago is to raise the water level by restricting the extraction of water out of this lake and facilitating the flow of water into the lake (Coops and Hosper 2002; Coops et al. 2004). Changes over the past decades have been attributed to increased eutrophication, and a serious decline of submerged macrophytes during the last years (Papastergiadou et al. 2002). One expects that the increase of open water areas, especially if coupled with an increase in water transparency, will favor several species of aquatic flora, which are presently rare or absent. In Cheimaditida fen, lowering of the water table resulted in subsidence of the peat surface. In addition, the intense cultivation caused the loss of the surface peat layer as a result of oxidation and self-ignition (with peat thickness up to 3.5 m, Bouzinos et al. 1997). Also fragmentation of remaining habitat by roads and other development creates significant problems for maintaining biological diversity (Saunders et al. 1991; Tiner 2004).

4 Conclusions

Human alteration of the landscape is a major force adversely impacting aquatic and other wildlife habitat through outright destruction and degradation. The amount, type, and extent of natural habitat are important environmental indicators for natural resource managers and conservationists. Fragmentation of remaining habitat by roads and other development creates significant problems for maintaining biological diversity.

A prerequisite for an effective conservation strategy is a continuous and consistent monitoring program on the state and spatial extent of fragile habitats with a cost efficient way. The analysis of the aerial photographs provides valuable information regarding the ecological processes of land cover/uses development within the Lake Cheimaditida wetland and enables the current distribution of reed bed communities to be interpreted in relation to previous changes in community distribution. This approach is simple and cost-effective to implement, has sufficient rigor to be used as a planning tool to help prioritize wetland habitats for further investigations, in order to propose conservation measures or restoration projects.

Managing the water level fluctuations may therefore be an effective tool for lake restoration. One of the key research and monitoring priorities identified by this research for future conservation strategy as being essential in influencing integrated management of the protected Natura 2000 area has been the role of *P. australis* and *T. angustifolia* in colonization process. The significant role of aquatic species to degradation process of the wetland derived from evidence of surface overgrowth by reed bed species, evidence of overgrowth within water column by plant species, as well as, the bottom accumulated dead organic matter or peat.
The assessment of the overall biological integrity of the wetland monitoring of water quality with respect to water level changes, as well as other structural indicators, such as species dominance, richness, biomass, stem height, widespread change in plant community composition over time, and the presence of rare and invasive species should consist a major target for further research and investigation.

Use of the remotely sensed data for monitoring purposes requires periodic updates of two basic sources of information on land cover/use data and wetland habitats. These data represent useful information for resource managers to support their efforts to conserve the natural resources and to advice the local community on the changing status of natural wetlands. Remotely sensed data of natural habitat integrity provide a framework for large-scale environmental assessments. This landscape assessment can be readily updated and therefore can serve as an effective monitoring tool for natural resource management.

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