VEGETATION MAPPING IN WETLANDS

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ABSTRACT - The current work examines the main aspects of wetland vegetation mapping, which can be summarized as analysis of the ecological-vegetational (ecotone) gradients; vegetation complexes; relationships between vegetation distribution and geomorphology; vegetation of the hydrographic basin to which the wetland in question belongs; vegetation monitoring with help of four vegetation maps: phytosociological map of the real and potential vegetation, map of vegetation dynamical tendencies, map of vegetation series.

KEY WORDS - Wetlands, vegetational gradients, ecotones, geomorphology, vegetation monitoring, synchorology of wetlands vegetation, vegetation mapping.

INTRODUCTION

This work examines the main aspects of wetland vegetation mapping. Wetlands are defined as transitional lands between terrestrial and aquatic systems where the water table is at or near the surface or the land is covered by shallow water. Wetland ecosystems have one or more of the following three attributes: 1) they support, at least periodically, hydrophytes; 2) the substrate is classified predominantly as an undrained hydric soil; 3) the substrate is saturated with water or covered by shallow water at some time during the growing season each year (Holland, Whigam and Gopal, 1990).

WETLAND ECOLOGY

Wetland ecology is very complex for the following reasons:

– the wetlands are subject to modifications due to natural causes, such as progressive silting and drying. The phenomenon can be observed particularly well in the case of the evolution of lakes in swamps and peatbogs. Some wetlands are characterized by an active dynamism of the substrate, which provokes rapid transformations of the vegetation; this is very evident in the case of waterways, which are

always characterized by great variations in their paths because of the hydric regime which provokes floods, erosion and deposits;

- they host an azonal vegetation very much subject to the hydric conditions, which man can alter very easily with drainage and other methods; this vegetation is stable as long as the substrate's hydric condition is maintained, otherwise it is very unstable (Pedrotti, 2003);
- the boundaries among the aquatic communities often are not well-defined, as in the case of floating vegetation; this is the case of the associations of the *Lemnetea* class, for example *Lemnetum trisulcae, Riccietum fluitantis, Ricciocarpetum natantis*, and *Stratiotetum aloidis* for Europe and analogous associations for other continents of the world, such as *Lemnetum valdivianae* of Lake Titicaca in South America (FIGURE 1);
- the wetlands host a very specialized and exclusive flora, above all submerged hydrophytes, floating hydrophytes, heliophytes, hemicriptophytes and phanerophytes;
- wetland typology is very extensive in relation to both origin (for example coastal lakes, volcanic lakes, temporary lakes, glacial lakes, etc.) and ecology (for example lotic, lentic, oligotrophic, eutrophic, etc. environments);
- the ecotones among the various types of wetlands and between the wetlands and the terrestrial environment are very different;
- as a consequence of all the above, the typology of the wetland vegetation units is very extensive on the level of associations, alliances, orders and classes: in Germany alone the vegetation units reported number 21 classes, 30 orders, 60 alliances and 235 associations (POTT, 1995).

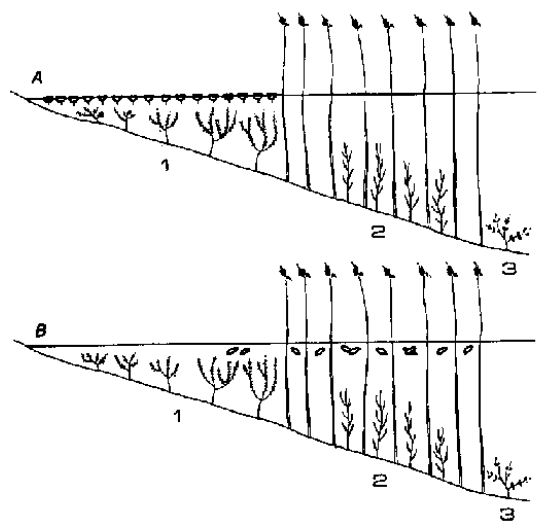

FIGURE 1 - Profile of the vegetation of the banks of Lake Titicaca, Bolivia; 1-*Myriophyllion elatinoidis*; 2-*Scirpion totorae*; 3-*Charetum* s.l.; A-*Lemno minusculae-Lemnetum gibbae*; B-*Lemnetum valdivianae* (from Liberman Cruz *et al.*, 1988).

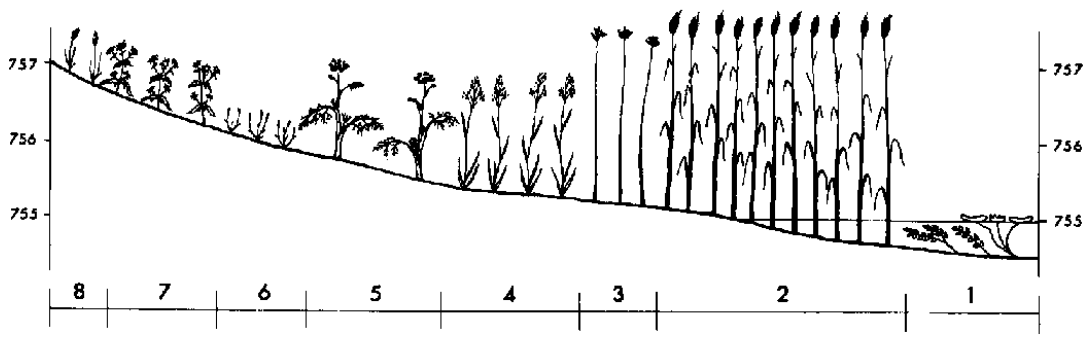

FIGURE 2 - Profile of the vegetation of the banks of Colfiorito Lake, central Apennines: 1-*Potamogetonetum lucentis nymphaeetosum*; 2-*Phragmitetum vulgaris*; 3-*Scirpetum lacustris*; 4-*Glycerietum aquaticae*; 5-*Oenantho-Rorippetum*; 6-*Rumici-Alopecuretum geniculati*; 7-Community of *Bidens tripartita*; 8 Community of *Bromus erectus* (from Pedrotti, 1982).

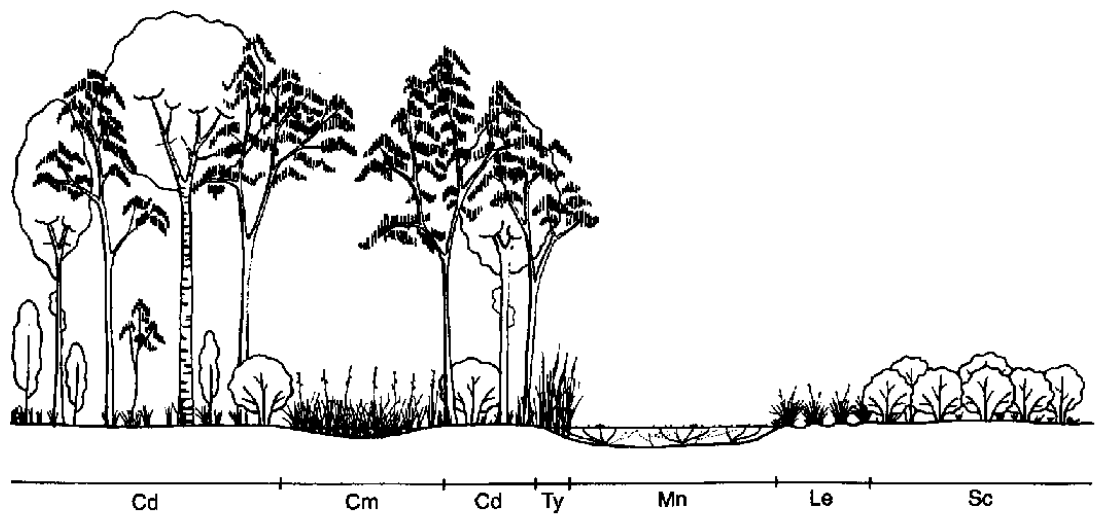

FIGURE 3 - Profile of the vegetation of the Valle Mandriole swamp, Po delta: Cd-*Cladio-Fraxinetum oxycarpae*; Cm-*Mariscetum serrati*; Ty-*Typhetum angustifoliae*; Mn-*Nymphaeetum albo-luteae*; Le-*Leucojo-Caricetum elatae*; Sc-*Salicetum cinereae* (from Merloni and Piccoli, 2001).

VEGETATION MAPPING

The principal topics that regard vegetation mapping of wetlands are:

- analysis of the ecological-vegetational (ecotone) gradients of the banks of lakes, lagoons, swamps etc., through execution of transects and profiles. In these cases the vegetation forms a distinct ecotone in concentric bands, each of which is characterized by a certain association; this zonation of the vegetation is found in all wetlands, such as lakeshores (FIGURE 2), swamps (FIGURE 3) and peatbogs (FIGURE 4); the analysis of basin bottom vegetation through sounding in noted points completes the gradient mapping;
- analysis of the vegetation complexes in the cases of intermingled types of vegetation belonging to different biological types, for example floating vegetation, helophytes rooted in the bottom and emerging, hydrophytes rooted in the bottom with floating leaves, completely submerged hydrophytes, etc. and analyses of the complex and interpenetrating vegetational mosaics of the bogs and wet meadows and swamps; the mapping can be done using different methods, according to the scale, and precisely, using only vegetation units (FIGURE 5) or vegetation units and symbols (FIGURE 6)
- analyses of the relationships between vegetation distribution and geomorphology; among the many examples examined, reference is made to an area with wet and swampy meadows and a river with riverbank vegetation; the Pian Grande is a vast basin of karst origin interrupted by numerous dolines; the bottom of the basin is occupied by hygrophilous meadows of *Nardo-Agrostion*, the dolines by *Magnocaricion* vegetation (FIGURE 7); along the Cervaro River (Puglia) the different types of riverbank vegetation (*Populetum albae*, *Salicetum albae*, *Salicetum triandrae*, etc.) are distributed according to the substratum such as alluvial plain, active riverbed, abandoned riverbed, etc. (FIGURE 8) and find a correspondence on the vegetation map. (FIGURE 9);
- analyses of the synchorology of associations of particular floristic and phytogeographic interest; synchorological mapping has become indispensible today for conservationistic uses, because of the progressive reduction of the areals fo the different association, some of which are by now limited to very few locations;
- analysis of the vegetation of the hydrographic basin to which the wetland in question belongs; vegetation mapping of the hydrographic basin is indispensable for territorial planning and management in order to protect all the wetlands and above all lakes, swamps and peatbogs (Orsomando and Catorci, 1991);
- monitoring of changes wrought by man on the level of flora and vegetation, following phenomena of eutrophytization, pollution and other anthropic activities. In the Trentino wetland research program about vegetation monitoring, four vegetation maps are prepared for every wetland: a phytosociological map of the real vegetation, a map of vegetation dynamical tendencies, an integrated phytosociological map (map of vegetation series) and a phytosociological map of the potential vegetation (Pedrotti, 1998 and 2001).

These topics are examined by referring to the vegetation mapping of various wetlands of Italy and of other parts of the world, including fresh water lakes (Trasimeno, Levico, Caldonazzo, Tovel); lagoons with briny water (Comacchio, Burano, Orbetello and Punte Alberete); swamps (Colfiorito); bogs (Vedes, Fiavé, Val Bighera, Regole); karst plains (Montelago, Pian Grande, Rascino, Quarto di S. Chiara, Voltigno, Pescopennataro, Montenero Valcocchiara); river-beds of waterways and surrounding areas (Incoronata, San Rossore) and others.

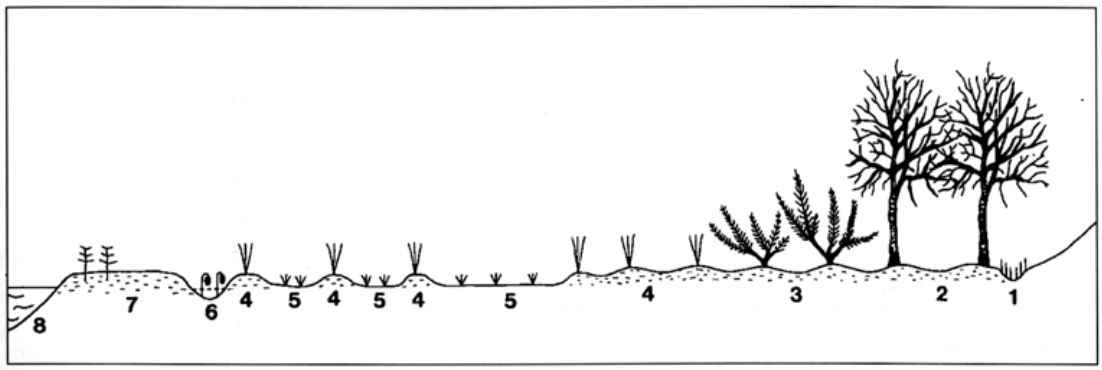

FIGURE 4 - Profile of the vegetation of the peatbog of Vedes, Trentino; 1-*Caricetum rostratae*; 2-*Vaccinio uliginosi-Betuletum pubescentis*; 3-*Sphagno-Pinetum mugo*; 4-*Sphagnetum magellanici*; 5-*Rhynchosporetum albae*; 6-*Caricetum limosae*; 7-Community of *Sphagnum* sp. and *Scheuchzeria palustris*; 8-little lake in the center of the peatbog (from Pedrotti, 1980).

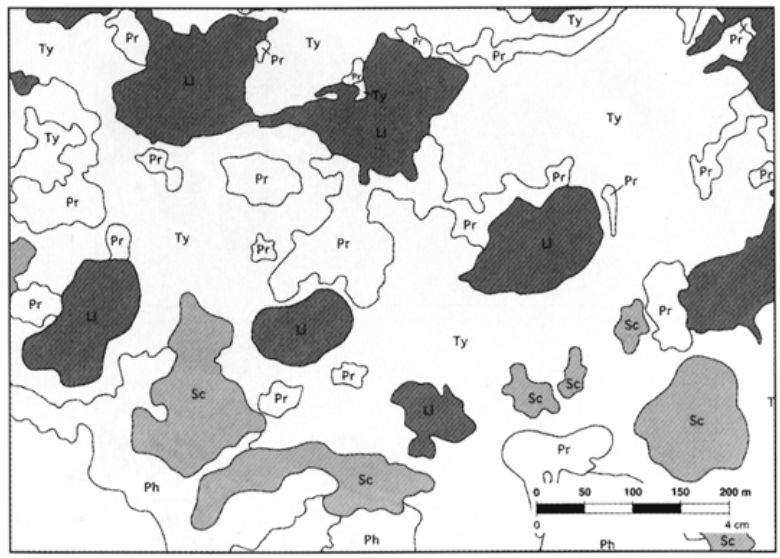

FIGURE 5 - Vegetation complex of the Valle Mandriole swamp; the vegetation complex is mapped using vegetation units; Ty-*Typhetum angustifoliae*; Pr-*Phragmitetum vulgaris*; Sc-*Salicetum cinereae*; Li-Communities of *Lemnetalia minoris* (from Merloni and Piccoli, 2001).

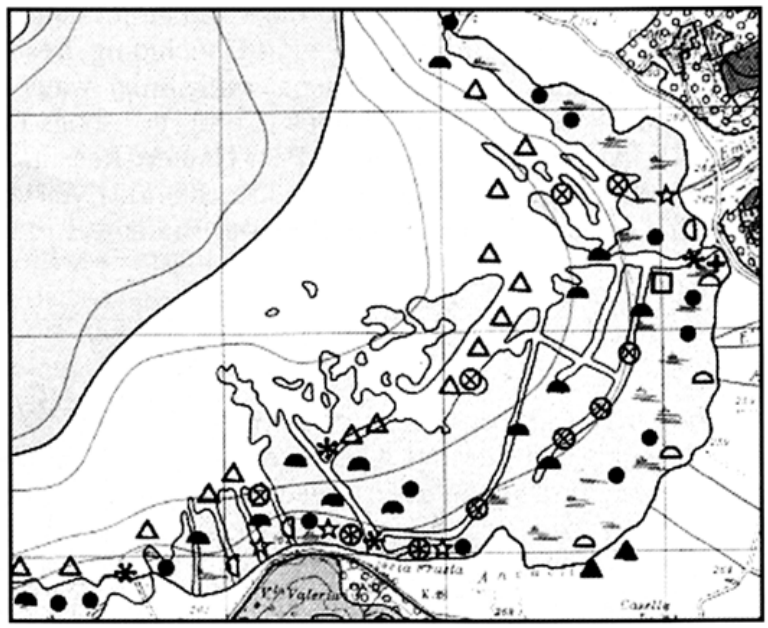

FIGURE 6 - Vegetation complex of a part of Lake Trasimeno, Umbria; the vegetation complex is composed of *Phragmitetum vulgaris*, in the midst of which are found numerous other associations (*Hydrocharitetetum*, *Potamogetonetum lucentis*, *Typhetum angustifoliae*, *Caricetum ripariae*), indicated with different symbols (from Orsomando and Pedrotti, 1985).

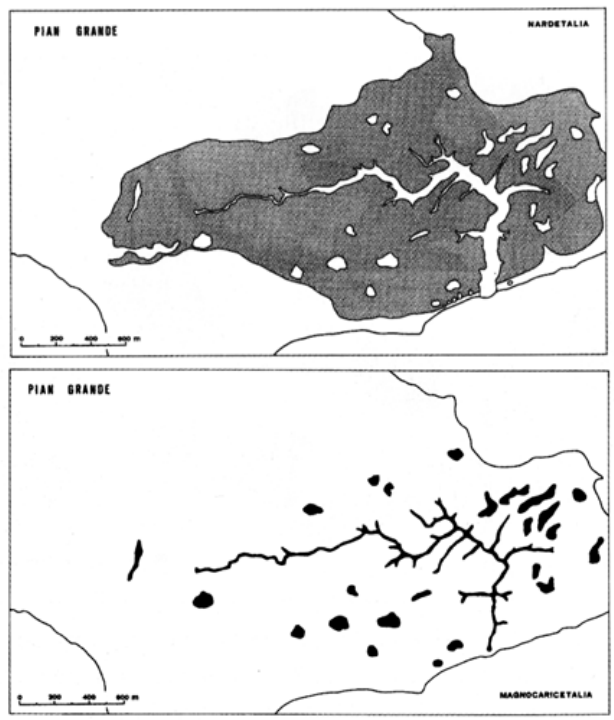

FIGURE 7 - Pian Grande (central Apennines); the plain area is occupied by meadows of the *Nardetalia* order (above), the dolines and the ditches of the meadows of the *Magnocaricetalia* order (below) (from Pedrotti, 1985).

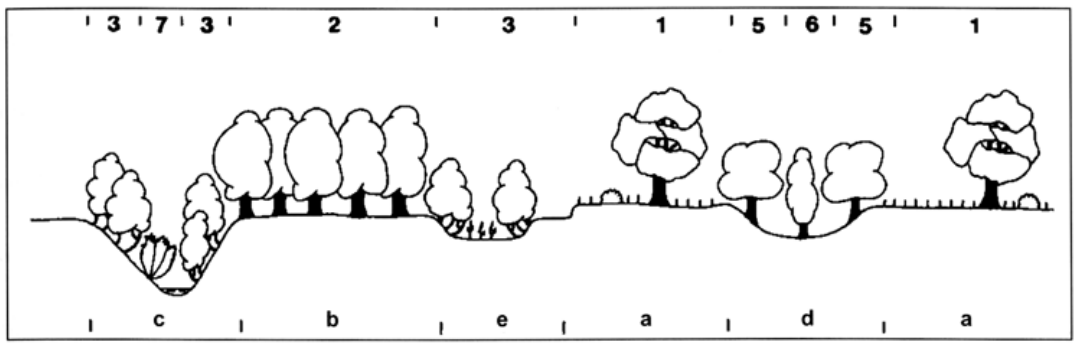

FIGURE 8 - Profile of the vegetation of the Cervaro River, Puglia; a-alluvial plain; b-terrace; c-current riverbed; d-abandoned riverbed; and-abandoned riverbed where a small lake has formed with *Phragmitetum vulgaris*; 1-forest of *Quercus pubescens*; 2-*Poo bulbosae-Plantaginetum serrariae*; 3-*Salicetum albae*; 5-*Aro italici-Ulmetum minoris*; 6-*Ranunculo-Fraxinetum oxycarpae*; 7-*Salicetum triandrae* (from Pedrotti and Gafta, 1996).

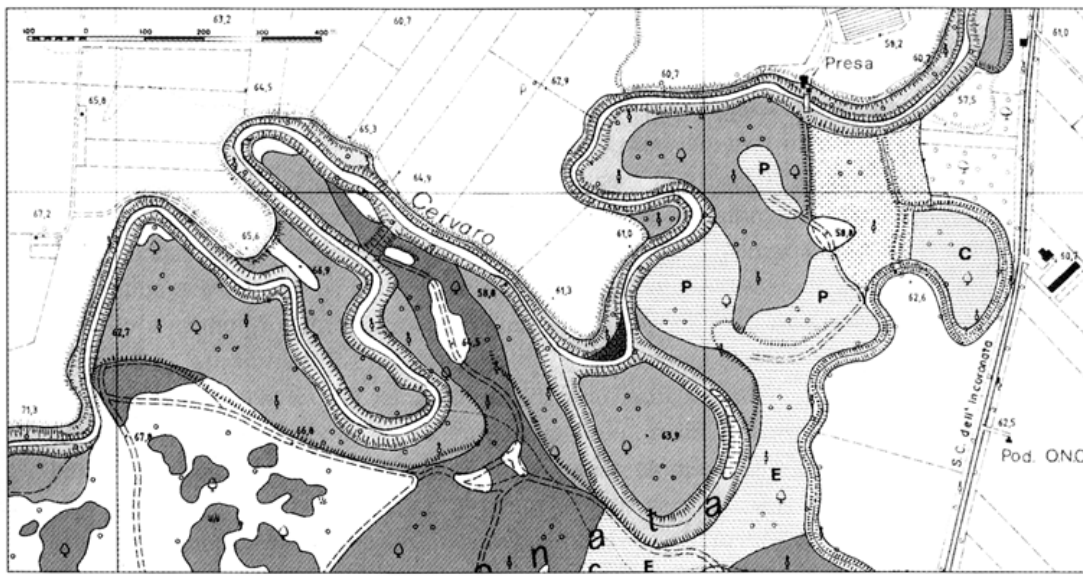

FIGURE 9 - Vegetation Map of the Cervaro River, with the associations *Salicetum albae* (light grey), *Populetum albae* (dark grey) and *Salicetum triandrae* (black); the other tones of grey indicate different associations of the alluvial plain (from Pedrotti and Venanzoni, 1994).

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MULTIFUNCTIONAL AND MULTIMEDIA GIS SYSTEM FOR THE INVENTORY AND THE MANAGEMENT OF THE WETLANDS OF PUGLIA REGION (SOUTHERN ITALY)

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ABSTRACT - The Puglia region is characterised by an homogeneous calcareous basement, affected by karst processes, so as to have a noticeable water reservoir. Its wetlands are the result of the complex interaction of geo-hydrological, climatic and biogeographical factors. The conservation of these remnant wetlands is menaced by human activity: land reclamation, pumping of water table, loading of pollutants, tourism and poaching. In order to conserve these habitats a two phases project was carried out. In the first phase the wetlands were identified and mapped in a GIS system. In this way 36 wetlands were mapped. These areas were grouped into the following categories: ponds and marshes (15), artificial basins and saltpans (6), meanders (5), lakes (3), swamps (3), estuaries (2), lagoon (1), gulf (1). A description has been hot linked to each area: physical and biological characteristics, previous land uses, environmental perturbations; level of protection; restoration activities to be undertaken. In the second phase three sample areas were chosen to develop a method for their characterisation. The areas are: 1-Torre Guaceto, a brackish marsh bounded by sand-banks, 2-Frattarolo swamp, a salt swamp characterised by grasslands mainly composed by halophytes. 3-Lago Salso, an artificial basin created for agricultural and hunting purposes, characterised by a mosaic of vegetation, mainly composed of hydrophytes and hygrophilous species, and of sheets of water, which represent an idoneous nesting and roosting area for many bird species. A spatio-temporal GIS database was developed using 19 digital ortophotos in order to analyse the changes that have occured in the last fifthy years. Then the efficiency of a quantitative evaluation index was verified. This index was calculated using a GIS extension named Wetlands Rapid Assessment Procedure (WRAP). This procedure is based on the ranking of the ecological factors chosen for the evaluation: wildlife, vegetation, buffer area, hydrology and water quality. Multimedia information such as graphics, tables, ground photographs and digital video was used to highlight the more interesting characteristics of those wetlands and the GIS systems was modified to develop a more suitable user-interface for an easy access to both the spatial dataset and the multimedia information.

KEY WORDS - GIS, GPS, Puglia, wetland, WRAP.