MedWet

Volume I

Mediterranean Wetland Inventory: A Reference Manual

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9 Mapping wetlands

Mapping In this chapter a mapping procedure is proposed in order to spatial identify wetland habitats. The identification and delineation of wetland habitas are based on the MedWet Wetland Habitat Description System (Farinha *et al.* 1996) and detailed informaiton for its application are applied by standard conventions (Zalidis *et al.* 1996). The proposed method consists of 4 phases and is based on information captured from aerial photographs combined with ground data and pre-existing data. The final information for the wetland habitats is transferred onto a base map and, after quality control of the product, the final map is produced. The hierarchical structure of the MedWet Wetland Habitat Description System, the use of remotely sensed data and the field surveys allow us to gather, store and use detailed information for each wetland habitat and to potentially associate different levels of information.

9. Mapping wetlands

The gathering of data on the location, size and quality of wetlands, is a prerequisite to effective management and monitoring. Wetland inventory becomes more effective if it is carried out by methods which permit the identification and delineation of distinct wetland habitats and accommodate the spatial storage and presentation of the acquired information.

Because of the diversity and regional differences evident in wetlands, and because the boundaries between wetlands and other environments are often gradual, there has been no general agreement on their identification, description, or limits. Thus, spatial identification of wetland habitats is better to be based on their fundamental components such as vegetation types or life forms, substrate types, water regime and water salinity, than to use common terminology taken from existing classification systems. This requires that inventory data are organised at the wetland habitat level. This also, permits the reliable delineation of wetland habitats and consequently defines the boundaries between wetland and non-wetland, combining remotely sensed data and ground data. Following a specific monitoring procedure based on a random stratified sampling design, habitats trends can be recognised as a consequence of anthropogenic activities.

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Such an approach to wetland inventory has not so far been carried out at the European level (Zalidis & Mantzavelas 1994). For this reason it was decided to develop and test a wetland habitat mapping method. To apply this method the MedWet Wetland Habitat Description System was developed and tested based on Cowardin *et al.* (1979) classification system.

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Mediterranean Wetland Inventory. Photointerpretation and Carthographic Conventions

It is proposed to spatial identify wetland habitats using a mapping procedure. The objective of the proposed procedure is to develop a well-described method and the corresponding specification guidelines to implement it accurately. These specifications cover field investigations, photointerpretation and cartography. At the field investigation level the wetland identification criteria were developed; at the photointerpretation and cartographic levels conventions were developed to maintain consistency in the Mediterranean region.

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Chapter 5

The mapping method and its different phases

Today it is commonly accepted that remotely sensed data coupled with field surveys comprise the most timely, cost-effective and accurate way for mapping natural resources (Karteris 1992). In particular, aerial photographs have proved the best remotely sensed data for the identification and classification of wetlands (Federal Geographic Data Committee 1992). The proposed method is based on information captured from aerial photographs combined with ground data and pre-existing data. The final information for the wetland habitats is transferred onto a base map and, after quality control of the product, the final map is produced.

Maps produced by following the proposed methodology are useful tools for accurate determination of coverage and spatial distribution of wetland habitats, and being considered with other data sources in planning activities. In addition, digital wetland habitat data can be merged with other databases within a Geographical Information System (GIS) to support further analysis and modeling. The hierarchical structure of the MedWet Wetland Habitat Description System, the use of remotely sensed data and the field surveys allow the gathering, storage and use of detailed information for each wetland habitat and to potentially associate different levels of information.

The application of mapping in Mediterranean wetland sites will help to produce several tools to assist with identifying wetlands in the field (e.g. to prepare a list of wetland plants and divide them into categories based on a species' frequency of occurrence in wetlands, and to prepare a list of regional or national soils with actual or high potential for hydric conditions).

The objective of the proposed method is to organize systematically the mapping effort, which consists of the 4 following phases. The fourth phase concerns those who have the opportunity to produce a digital wetland map and integrate the information into a Geographical Information System (GIS).

Phase 1 Collection, screening and evaluation of existing data and integration of extracted information in photointerpretation procedure

Phase 2 Fieldwork

Phase 3 Photointerpretation and production of the final Wetland Habitat Description map

Phase 4 Digital Wetland Habitat Description map production using Geographical Information Systems (GIS)

The identification and delineation of wetland habitats based on the MedWet Wetland Habitat Description System and detailed information for its application is applied by standard conventions.

Phase One. Collection, screening and evaluation of existing data and integration of information

The first phase covers the collection, screening, and evaluation of required information and material. Aerial photography provides the raw material for constructing the wetland habitat maps and offers the bulk of the information for the classification of wetland habitats. All the other information, which is grouped under the heading "collateral data", supports the aerial photography interpretation. This stage includes preliminary photointerpretation. The integration of collateral data into this process helps clearly to determine the limitations due to lack of information.

Sources of information

Aerial photographs

Vertical aerial photographs are the main source of information and the main material for wetland habitat mapping. They can provide both a detailed picture of the real situation and synoptic viewing of the project area. These help the photointerpreter to make identifications and classifications and accurately draw the wetland habitat borders. The photo elements usually considered during the photointerpretation process are: colour and tone, texture, pattern, site and association.

The factors that affect the quantity and quality of derived information are the type of aerial photography film, the date and the time of acquisition and the scale. A suitable combination maximises the opportunity to discriminate between different wetland habitats. Furthermore, selection of the suitable aerial photography scale should depend not only on being able to detect required parameters but also on such factors as cost and organisational capabilities.

If there is no capability of designing an aerial photography survey it is important to use the most recent photographs in order to be as close as possible to the present situation of the wetland.

The information that can be extracted from aerial photographs for the identification and delineation of the wetland habitats as those are described by the proposed MedWet Wetland Habitat Description System is:

- The vegetation type of life form and its aereal coverage (successful photointerpretation of vegetation is achieved by matching the diagnostic phenological reflectance of plants of interest to the spectral sensitivity of the aerial photography film type to be used);
- The substrate-feature composition (sand, cobble-gravel, salt crust etc.)
- The water regime determination (hydrological conditions, like the relative soil moisture content of bare soil which can be used to determine the extent of flooding);

Collateral data

Many sources of data are often available in the following forms:

- Literature on the vegetation, hydrological conditions, soil characteristics, water quality and management activities of the wetland site and its catchment area.
- Topographic, vegetation, geology, land-use and other thematic maps, orthophotomaps.
- Records in tabular and graphic form (hydrological or land-use data collected by individuals or official agencies).
- Field surveys and laboratory measurements and analyses.

The acquisition and analysis of collateral data should be viewed as an essential element of photointerpretation, providing significant information in order to successfully interpret and classify wetland habitats. As such, it must be realised that these data have their own variance and, like the remotely sensed data, are subject to interpretation.

The supportive collateral data aids not only the interpretation of aerial photographs, but may also produce a better definition of the problems associated with the project area. An initial field reconnaissance visit is particularly useful if it is seen as a tool for screening and evaluating the collateral data. The nature, amount, timing and method of acquisition and integration of the collateral data must be thoroughly considered and planned depending on the individuality of each specific wetland area.

Preliminary Photointerpretation

'Photointerpretation has been defined as the act of examining photographs for the purposes of identifying objects and phenomena and judging their significance. In carrying out this task, an interpreter may use much more information (collateral data, field data) than that recorded on the photos he is to interpret.' (Reeves *et al.* 1975).

In this step all the photographs are thoroughly examined and only a sample part of the entire area is photointerpreted. Actually it is not practical to do a significant amount of photointerpretation before the fieldwork. The area to be interpreted represent the entire range of

wetland habitat types and covers about the 10% of the project area. By this preliminary photointerpretation, habitat identification and descriptions are made and relevant problems appear.

Specifically, the preliminary photointerpretation includes:

1. Preparing the aerial photo mosaic, so as to have a whole view of the site (it is important for the interpreter to possess the flightline maps of the photos);
2. Thorough examination of each photo in order to have an initial idea of the appearance of the wetland habitats;
3. Registration of transparent overlays on each photograph that is interpreted;
4. Determination of overlap area of each photograph with the adjacent photos and framing it into a polygon;
5. Performance of photointerpretation closest to the geometric centre of the photo, which assures minimum displacement;
6. Noting the doubtful or questionable interpretation decisions.

Phase Two Fieldwork

In most Mediterranean countries specific information (collateral data) on wetlands, like national lists of wetland vegetation species, soil maps, and systematically collected hydrological data, is limited or scattered. This makes fieldwork a significant source of information for the identification and classification of wetland habitats. For this purpose the criteria for wetland identification (see Chapter 5) are primarily considered during this stage in order to support the identification process in the field and also the registration of vegetation and soil features. Field investigations aim to solve complications identified during the first stage and also to collect information for the completion of wetland habitat classification. Successful and fruitful fieldwork requires careful preparation.

Pre-fieldwork preparation

Fieldwork preparation is required in order to plan fieldwork and to determine the parameters that need to be investigated. It consists of:

a) Reviewing all the collected data and extracted information from the previous steps. Problems of wetland habitat description that have been faced are explicitly determined.

b) Selecting the field checksites. Most of the field cheksites should be located in marginal areas, since these are the most difficult to identify on the photos. Obvious wetland habitats are only visited to confirm the classification (e.g. water regime, salinity, etc.). The checksites are marked on photographs and topographic maps for route planning but are numbered during the fieldwork as the team gets to them. In addition to the preselected checksites, the field team may visit other areas which are identified as wetlands during the field visit. The choice of the field checksites is based on photo signatures of:

- commonly occurring habitats that characterise the area;
- habitats located in transitional zones where it is difficult to determine the wetland from non-wetland area by photointerpretation;

- unusual pattern of habitats but important because of their large coverage or of difficulties to describe them;
- hydrological conditions (correlating signatures with permanently flooded, seasonally flooded, temporarily flooded areas etc.);
- water or substrate salinity;
- specific problems related to the date and time of photography (e.g. clouds).

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c) *Gathering all the necessary material that will be used during the fieldwork. This must include:*

- topographic maps and/or other thematic maps
- aerial photographs
- inventory data sheets
- soil probe and soil spade/shovel
- list of soil indicators for hydric soil identification (see Chapter 5)
- munsell soil colour chart
- salinity meter
- plant identification books/keys
- magnifying glass in order to closely view the photo features in the field
- stereoscope in order to examine on photos the visited checksites (this is important to learn the subtle signature differences that often serve as identifiers for the description of wetland habitats).

Fieldwork

Fieldwork in this phase involves training the photo interpreters to recognise the aerial photo signatures of the wetland habitats in the project area and collection of detailed data on the vegetation communities, hydrological conditions, water salinity and soil/substrate characteristics, in order to solve classification problems that have arisen during the preliminary photointerpretation.

During the fieldwork the team examines: (1) representative wetland habitats to confirm the classification and improve the wetland habitat description (e.g. water regime, water salinity, dominant species, etc.) and (2) wetland habitats located in transition zones between wetlands and non-wetland areas. In these zones wetland habitats are not easily identified and classified by photointerpretation alone, and the team should implement the criteria for identification of wetlands in order to determine their borders. The team also visits areas where the information on photos is deficient.

The field trip is ideally done during the same season that the aerial photographs were taken and repeated at a different time in the season in order to see differences. Sometimes several field visits are required at different seasons in order properly to describe the wetland habitats (especially if there are few data regarding the water regime).

The objectives of the fieldwork are:

- The training of the photointerpreters. During field examinations, the photo interpreters are trained to identify and classify wetland habitats accurately. By continuously comparing the photo signatures with the ground observations, the field team is able to

describe the photoelements of each wetland habitat. Accurate identification and classification by aerial photographs, requires experience of photointerpretation techniques and knowledge of the wetland area and the Wetland Habitat Description System. It is also imperative that the photointerpreters are the same people who conduct the field examinations.


Simple Stereocopes
Photo of Wild Heerbrugg Inc.

Zoom Stereoscope
Photo of M. karteris

- The collection of ground data regarding the wetland habitat description. Simultaneously with training on photo signatures of the sample areas, which represent the entire range of wetland habitat variability, the team confirms or completes the preliminary classification, in order to fill in the wetland habitat description data sheets of all representative habitats of the project wetland site. The fieldwork data that are collected concern:
  - the dominant species of the upper stratum (not more than 3 codominants) of each wetland habitat;
  - hydrological signs for supporting the determination of water regime: current conditions, evidence of surface inundation if dry conditions exist during the field visit;
  - measurements of water salinity
  - hydric soil indicators; these observations are used in combination with vegetation and hydrological condition data, to support examinations of transitional zones between wetlands and non-wetlands and identify an area as wetland.

Upon completion of the field trip, the team delineates representative wetland habitat boundaries and prepares a general trip summary report which provides: (1) a description of the area, (2) descriptions of wetland habitats, (3) relations between vegetation, water regime salinity and soil characteristics, (4) a discussion of photointerpretation signatures and (5) specific problems faced during the field trip.

Phase Three
Photointerpretation and production of the final map

This phase results in the production of the wetland habitat map. The quality of the final photointerpretation results depends primarily on the quality and quantity of the data collected during the previous stages and also on the photointerpreter's skills and experience. After completion of the final photointerpretation and quality control, the final map is almost ready. Transferring the final information to a base map locates it planimetrically. The final step of the map production is the cartographic design.

Final Photointerpretation

Before performing of the photointerpretation the minimum mapping unit is decided. This depends mainly on the photo scale, the size of the project area, the study objectives and the available budget. This decision is crucial because wetland habitats with a smaller aerial extent than the minimum photointerpreted unit, are represented either as lines or points.

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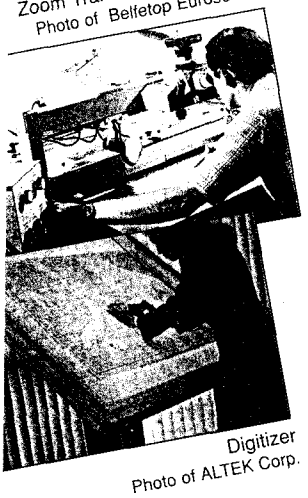
At this step, all the photographs are interpreted. The initial photointerpretation results are corrected and final photointerpretation and classification of the entire area is carried out. Information gained from fieldwork combined with the collateral data and the photointerpreter's skills and experience, will result in the successful completion of this step.

The photographs are visually interpreted under a stereoscope. The various wetland habitats are delineated on transparent overlays that are registered on the photographs. For each photograph, the area of overlap with the adjacent photos is determined and area closest to the geometric centre of the photo is interpreted, assuring minimum displacement. The photointerpretation is based on MedWet wetland habitat description system and according to photointerpretation conventions.

In addition to the identification and classification of wetland habitats, the interpreter identifies on the photos important man-made features (e.g. roads, trails). These are delineated only in cases where they are not displayed on the base map (e.g. topographic map) and according to the interpreter's decision whether or not to include them in the final map. Delineation of these is done on different transparencies.


Zoom Transfer Stereoscope
Photo of Belfetop Eurosense

Digitizer
Photo of ALTEK Corp.

Transferring the interpreted information to a base map

The photointerpreted information constitutes the basic part of the final map. Topographic maps are used as base maps onto which the interpreted information is transferred in order to be positioned planimetrically. This procedure is accomplished with the Zoom Transfer Stereoscope, which enables the operator to view the photograph and the map simultaneously. Selected control points are located on the topographic map and are fitted to the same points on the photos, in order to transfer the delineation with reasonable accuracy. Through this procedure the distortions of vertical aerial photographs are corrected to a certain extent.

Quality control

Quality control of the output product follows. The map is reviewed by scientists or agencies that are working in the project area. Considering their experience, the photointerpreter's decisions on wetland habitat descriptions and classifications are tested.

The map accuracy is also verified. Two major types of map error have been identified, attribute error and location error. Attribute error (also called thematic or descriptor error) occurs when a thematic attribute or class name is incorrect, but the boundaries are correct. Location error, which has also been termed cartographic or position error, is the error in the geographic location of cartographic features such as points, lines, and polygons. In reality, both types of error occur together, making them difficult to separate. Error checking cannot be done in all wetland habitats on the ground due to time and cost constraint. Therefore, by developing a formal sampling scheme, efficient testing of each map attribute at each level can be achieved (Karteris 1990).

Cartographic presentation of the map

The wetland habitat description map is composed of the identified delineated and properly classified wetland habitats and the necessary base map elements.

The wetland habitats are displayed as polygons, lines and points associated with their attributes. All these cartographic elements are drawn with the same pen colour and width.

- Dot wetland habitats are represented by points;
- Linear wetland habitats are represented by dashed lines with uniform type;
- Polygon wetland habitats are represented by continuous lines and are displayed with different patterns. Five different patterns are used in order to indicate the corresponding Systems.

Base map elements are added to the wetland habitat map in order to produce a more reliable representation of the wetland site. They include: (1) topographic elements (contour lines, altitude points, trigonometric points); (2) stream network: when the catchment area is also depicted on the map, streams are displayed as linear features and coded by the proper wetland habitat according the proposed Wetland Habitat Description System; (3) primary or secondary roads, paths or tracks: all these are represented as linear features; (4) dams, canals and other infrastructure which is related to the wetland site; (5) administrative and catchment area boundaries; (6) location and/or extent of residential areas.

In cases where, the base map (topographic maps or orthophotomaps) do not reflect the present configuration and do not include elements which should be depicted on the wetland habitat map, they are photointerpreted by the aerial photographs and transferred to the base map using the Zoom Transfer Scope.

In addition each map should contain: a) a location map depicting the geographical position of the wetland site; b) the north symbol; c) the base map legend, and; d) the diagram of the MedWet Wetland Habitat Description system.

Phase Four
Digital wetland habitat description map production using GIS

This phase is for those who have the capability to produce a digital wetland map and integrate the information into a Geographical Information System (GIS). In very general terms, the procedure is completed in three steps: (1) Data input to the geographical information system, (2) Geographic database development, (3) Outputs. The basic concepts and functions of the procedure are described below.

Data input to the Geographical Information System

Data are input to a geographical information system both by digitising and scanning methods depending on the equipment available and user's skills. Digital data are categorised in three different types: polygons, lines or points. Polygons represent geographic aereal phenomena or objects, lines represent geographic linear features and points represent data with no length or area such as dot wetlands, wells, and cultural features (e.g. discontinuous urban areas, archaeological sites etc.) that are of interest only for their location. The type of data is dependent on the minimum mapping unit. This means that geographical features that have been mapped as lines on a given mapping scale, will be represented by polygons if a greater scale is used.

The information to be digitised comes from the final wetland habitat map. In order to accurately and rapidly transform the analogue wetland habitat map into digital form the data are traced on clear separate transparencies. For the wetland habitats two transparencies are used,

one for their spatial distribution and the other for their description codes. Base map elements are grouped and traced on different transparencies according to their intensity and complexity.

Finally, if further spatial analysis of the relationships between wetland habitats and other factors affecting the wetland site (e.g. abiotic, biotic, anthropogenic) is carried out, then thematic maps may be used as a source of information.

Geographic database development

The geographical database is the core of a GIS. Spatial data and their associated attributes are the two components of a geographical database and are linked together by a common identifier. Spatial data is translated into simple objects like points, lines and areas. Attribute data records a description of spatial data like the wetland system, subsystem, class, subclass, water regime, water salinity, and description of base map elements (e.g. names of residential areas, administrative boundaries etc.).

Data input is followed by automated procedures which build the topology of all the features stored in the database. Standard columns of the geographical database are created containing spatial data (e.g. an identifier for each feature, the length of lines, the area of polygons, etc.). After the topology is built the user can add to the database other descriptive data (attribute data) related to the features.

Outputs

With the use of a GIS, spatial and attribute data are associated to support map display of wetland habitats and their descriptions.