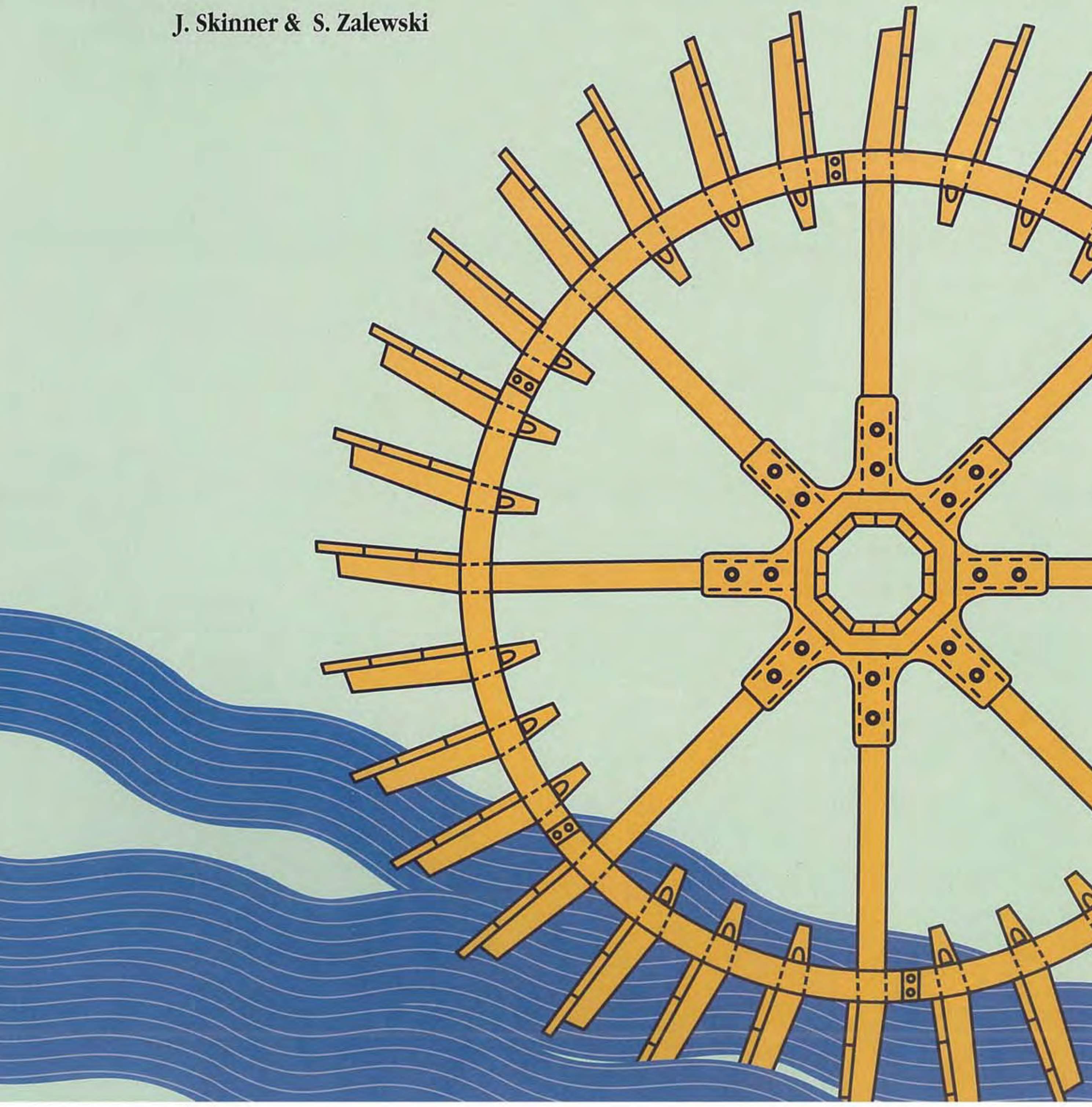
Conservation of Mediterranean Wetlands

MedWet

Functions and values of Mediterranean Wetlands

J. Skinner & S. Zalewski



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MedWet

The MedWet action

The Mediterranean basin is rich in wetlands of great ecological, social and economic value. Yet these important natural assets have been considerably degraded or destroyed, mainly during the 20th Century. To stop and reverse this loss, and to ensure the wise use of wetlands throughout the Mediterranean, a concerted long-term collaborative action has been initiated under the name of MedWet.

A three year preparatory project was launched in late 1992 by the European Commission, the Ramsar Convention on Wetlands of International Importance, the governments of Spain, France, Greece, Italy and Portugal, the World Wide Fund for Nature, the International Waterfowl and Wetlands Research Bureau (IWRB) and the Station Biologique de la Tour du Valat.

This project focuses on that part of the Mediterranean included within the European Union, with pilot activities in other countries such as Morocco and Tunisia. Two thirds of the funds are provided by the European Union under the ACNAT programme and the remainder by the other partners.

The concept of MedWet and its importance for the wise use of Mediterranean wetlands was unanimously endorsed by the Kushiro Conference of the Contracting Parties to the Ramsar Convention in june 1993.

The MedWet publication series

Wetlands are complex ecosystems which increasingly require to be managed in order to maintain their wide range of functions and values. The central aim of the MedWet publication series is to improve the understanding of Mediterranean wetlands and to make sound scientific and technical information available to those involved in their management.

Jamie Skinner and Sally Zalewski, 1995
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1. Characteristics of Mediterranean Wetlands.
2. Functions and values of Mediterranean Wetlands.

Conservation of Mediterranean Wetlands
MedWet

Functions and Values

of Mediterranean Wetlands

J. Skinner & S. Zalewski

Number 2

Series editors : J. Skinner and A. J. Crivelli

S. Zalewski/ BIOS

Preface

Only a small proportion of the original Mediterranean wetland resource remains and of that very little exists in anything like a pristine condition. Despite the growing strength of the nature conservation movement, important international treaties such as the Ramsar Convention, European Commission directives, national initiatives and an unprecedented effort on the part of non-governmental organizations and as many individuals, Mediterranean wetland loss and degradation continues. Scientific research is showing increasingly what our ancestors knew by experience – that wetlands are valuable.

Politicians and decision-makers, however, have often yet to recognize the full significance of wetland functioning providing economically important goods and services, as well as in enhancing or just maintaining environmental quality. Instead there has been a perpetuation of a traditional dichotomy between the needs of human economy and the conservation of wildlife and habitat. Such a division is both artificial and detrimental to the maintenance of precious natural resources. The natural functioning of wetland ecosystems has substantial economic as well as other values. Awareness and understanding of wetland functions and values is of paramount importance if society is to meet the challenges of conservation and wise use of wetlands.

An imaginative preparatory action of the European Commission DG XI laid the scientific groundwork for the present text. The work of the authors to present often complex scientific information in plain language follows a logical step in transferring important knowledge and concepts to non-scientists. It represents a vital step if Mediterranean wetlands are to survive into the next millennium.

Prof. Edward Maltby
Director, Royal Holloway Institute for Environmental Research
Chairman, IUCN Wetlands Programme Scientific Advisory Committee

Ruins of the 10th century basilica on the island of Agios Achillios in lake Mikri Prespa, Greece.

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Introduction

According to the Ramsar Convention wetlands are defined as: "...areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including marine water the depth of which at low tide does not exceed six metres".

Sadly misunderstood, and considered traditionally as wastelands, wetlands have for centuries been dismissed as noxious and unprofitable places, synonymous with disease and recommended for drainage at the earliest opportunity. It is only very recently that conservation groups have been able to persuade the general public that this is far from the truth. Wetlands are not only beautiful places that provide enjoyment for millions of people, through a range of recreational activities from birdwatching to swimming and sailing, they are among the most productive ecosystems in the world.

Wetlands are natural areas where water plays a dominant role for at least part of the year. Marshes, swamps, streams, rivers, lakes, ponds, wet meadows, estuaries, mudflats and even shallow parts of the sea are all included in this definition.

More than 5,000 years ago several modern civilizations came into being independently of each other. The fertility of the alluvial plains along the Nile, the Euphrates and the Tigris, the Indus and the Hwang Ho rivers was one of the factors contributing to the wealth of ancient Egypt and Mesopotamia, and of India and China.

Scientists and conservationists have long known of the importance of wetlands. Some wetlands can produce up to eight times more plant matter than an average wheat field and many wetlands support valuable fisheries. Although individual wetlands do not necessarily perform all functions, generally they help to maintain groundwater levels which provide vital water resources for domestic consumption, agriculture and industry. They play a vital role in flood control by absorbing heavy rainfall and reducing the risk of dangerous flooding downstream. By stabilizing the soil and sediment at the water's edge, wetlands maintain shorelines of lakes, rivers and seas. They are valuable for their timber production and for providing other natural resources, such as grazing. By removing nutrients, such as nitrogen and phosphorus, wetlands act as water purifiers and improve water quality. This helps prevent eutrophication and avoids the need to build costly water treatment plants. Wetlands also support populations of plants and animals, especially waterfowl, and make a major contribution to maintaining biodiversity.

The Ebro delta near Barcelona is one of Spain's most important wetlands.

List of Ramsar sites

ALGERIA

1	B	Lac Oubeïra	2,200 ha
2	B	Lac Tonga	2,700 ha

CROATIA

1	Delta Neretve	11,500 ha

EGYPT

1	Lake Bardawil	59,500 ha
2	Lake Burullus	46,200 ha

FRANCE

1	Camargue	85,000 ha
2	Biguglia	1,450 ha

GREECE

1	Evros Delta	10,000 ha
2	Lake Vistonis and Porto Lagos Lagoons	10,000 ha
3	Lake Mitrikou & adjoining lagoons	3,800 ha
4	Nestos Delta and Gumburnou Lagoon	10,600 ha
5	Lakes Volvi and Langada (Koronia)	2,400 ha
6	Kerkini reservoir	9,000 ha
7	Axios, Loudias and Aliakmon Delta	11,000 ha
8	Lake Mikri Prespa	8,000 ha
9	Amvrakikos Gulf	25,000 ha
10	Messolonghi Lagoons	13,900 ha
11	Kotychi Lagoon	3,700 ha

ITALY

1		Pian di Spagna - Lago di Mezzola	1,740 ha
2		Vincheto di Cellarda	99 ha
3	E	Sacca di Bellóchio	223 ha
4	E	Valle Santa	261 ha
5	E	Punte Alberete	480 ha
6		Palude di Colfiorito	157 ha
7		Palude di Bolgheri	562 ha
8		Laguna di Orbetello	887 ha
9		Lago di Burano	410 ha
10		Lago di Nazzano	265 ha
11	C	Lago di Fogliano	395 ha
12	C	Lago dei Monaci	94 ha
13	C	Lago di Caprolace	229 ha
14	C	Lago di Sabaudia	1,474 ha
15		Lago di Barrea	303 ha
16	D	Stagno di s'Ena Arrubia	300 ha
17		Stagno di Molentargius	1,401 ha
18		Stagno di Cagliari	3,466 ha
19		Le Cesine	620 ha
20		Valle Cavanata	243 ha
21	D	Stagno di Cábras	3,575 ha
22	D	Stagno di Corru S'Ittiri, Stagni di San Giovanni e Marceddi	2,610 ha
23	D	Stagno di Pauli Maiori	287 ha
24	E	Valle Campotto e Bassarone	1,363 ha
25		Laguna di Marano : Foci dello Stella	1,400 ha
26		Saline di Margherita di Savoia	3,871 ha
27		Lago di Tovel	37 ha
28		Torre Guaceto	940 ha
29	E	Valle di Gorino	1,330 ha
30	E	Valle Bertuzzi	3,100 ha
31	E	Valli residue del comprensorio di Comácchi 1	3,500 ha
32	E	Piallassa della Baiona e Risega	1,630 ha
33	E	Ortazzo e Ortazzino	440 ha
34	E	Saline di Cervia	785 ha
35	D	Stagno di Sale Porcus	324 ha
36	D	Stagno di Mistras	680 ha
37		Valli del Mincio	1,081 ha
38		Torbiere d'Iseo	324 ha
39		Palude Brabbia	459 ha
40		Palude di Ostiglia	123 ha
41		Biviere di Gela	256 ha
42		Laguna di Venezia : Valle Averto	200 ha
43		Vendicari	1,450 ha
44		Isole Boscone	201 ha
45		Bacino dell'Angitola	875 ha
46		Palude della Diaccia Botrona	2,500 ha

MALTA

1	Ghadira	11 ha

MOROCCO

1	Merja Zerga	3,500 ha
2	Merja Sidi Boughaba	200 ha
3	Lac d'Afennourir	380 ha
4	Baie de Khnifiss	6,500 ha

PORTUGAL

1	Estuário do Tejo	14,563 ha
2	Ria Formosa	16,000 ha

SLOVENIA

1	Secoveljske soline (Secovlje salt pans)	650 ha

SPAIN

1		Doñana	50,720 ha
2		Las Tablas de Daimiel	1,928 ha
3		Laguna de Fuente de Piedra	1,364 ha
4		Lagunas de Cádiz (Laguna de Medina y Laguna Salada)	158 ha
5		Lagunas del sur de Córdoba (Zoñar, Rincón y Amarga)	86 ha
6		Marismas del Odiel	7,185 ha
7		Salinas del Cabo de Gata	300 ha
8		S'Albufera de Mallorca	1,700 ha
9		Laguna de la Vega (o del Pueblo)	34 ha
10		Laguna de Villafáfila	2,854 ha
11		Albufera de Valencia	21,000 ha
12	A	Pantano de El Hondo	2,387 ha
13	A	Lagunas de la Mata y Torrevieja	3,700 ha
14	A	Salinas de Santa Pola	2,496 ha
15		Prat de Cabanes - Torreblanca	812 ha
16		Aiguamolls de l'Emporda	4,784 ha
17		Delta del Ebro	7,736 ha
18		Laguna de Manjavacas	231 ha
19		Lagunas de Alcàzar de San Juan	160 ha
20		Laguna del Prado	52 ha
21		Embalse de Orellana	5,500 ha
22		Salinas de Ibiza y Formentera	550 ha
23		Laguna de Chiprana	162 ha
24		Laguna de Gallocanta	6,720 ha
25		Embalses de Cordobilla y Malpasillo	1,972 ha
26		Albufera de Adra	75 ha
27		Mar Menor	14,933 ha
28		Marjal de Pego-Oliva	1,290 ha

TUNISIA

1	Ichkeul	12,600 ha

TURKEY

1	Göksu Deltasi	8,650 ha
2	Burdur Gölü	12,600 ha
3	Kus Gölü	10,200 ha

Klein Hubert/ BIOS

The wealth between land and water

There are many different types of wetland spread across the globe, covering about 6 per cent of the earth's surface. They are found everywhere, in all climates and countries, from the Arctic tundra to mangroves in the tropics. In the Mediterranean region, the most familiar wet places are temporary marshes, deltas and lagoons.

It is now generally recognized just how economically important wetlands are to man, as well as being a resource of cultural, scientific and recreational value. In spite of this, many wetlands have already been irretrievably lost and more continue to be drained for agricultural or development programmes.
The presence of malaria-carrying mosquitos in the Mediterranean has been used to justify drainage programmes dating back to Roman times.

But attitudes are changing, albeit slowly. Although the pace of wetland destruction has slowed, draining, filling and channelling remain chronic threats. By some estimates, this has already led to the destruction of half the world's wetlands. Some areas of the Mediterranean have lost over 60 per cent of their wetlands during the 20th century.

Reedbeds occur throughout the Mediterranean region.

The Ramsar Convention

The recognition of the importance of wetlands led to a conference in 1971, in the Iranian city of Ramsar. It was here that one of the very first worldwide treaties for environmental protection was agreed upon: the Convention on Wetlands of International Importance.
The signatory states pledged to enter their wetlands of international importance on a list of "Ramsar sites" and generally to protect and conserve wetlands.
The principal actions of Contracting Parties to the Ramsar Convention are:

S. Zalewski/ BIOS

1. To designate wetlands for the List of Wetlands of International Importance using criteria internationally adopted; to formulate and implement planning so as to promote conservation of listed sites and to advise the Ramsar Bureau of any change in their ecological character; and to compensate for any loss of wetland resources;

2. To formulate and implement planning so as to promote the wise use of wetlands; to make environmental impact assessments before transformations of wetlands; and to make national wetland inventories;

3. To establish nature reserves on wetlands and provide adequately for their wardening, and through management to increase waterfowl populations on appropriate wetlands;

4. To train personnel competent in wetland research, management and wardening;

5. To promote conservation of wetlands by combining far-sighted national policies with coordinated international action; and to consult with other Contracting Parties about implementing obligations arising from the Convention, especially on shared wetlands and water systems;

6. To promote wetland conservation concerns with development aid agencies;

7. To encourage research and exchange of data.

13 Mediterranean countries have designated 100 wetlands as Ramsar sites covering 544,431 hectares in the Mediterranean region.

The wealth between land and water

Mediterranean wetlands

Most wetlands in the Mediterranean basin are at low altitudes and are predominantly coastal. A number of large river deltas are well known in the Mediterranean. They include the Camargue at the mouth of the Rhône in France, the Po delta in Italy, the Ebro delta in Spain, the combined delta of the rivers Axios-Aliakmon-Loudias near Thessaloniki, the Nestos delta in Northwest Greece, the Evros delta on the border between Greece and Turkey, the Menderes delta in Western Turkey, the Medjerda delta in Tunisia and, of course, the enormous Nile delta in Egypt.

Wetlands are found where water and land meet. They are among the most fertile ecosystems on our planet and are found in all the earth's climate zones. They provide a habitat for innumerable animal and plant species. There are more than 30 different types of wetland. The common factor is their dependence on water. Wetlands are fed by rivers, lakes, groundwater, oceans, rain or snow.

There are high mountain ranges all around the Mediterranean basin. To the north lie the Alps, the Dinaric Alps of former Yugoslavia, the Pindos range of Greece and the Taurus mountains of Turkey. In the Southwest lie the Atlas mountains which have high plateau lands to their south, particularly in Algeria. The rate of erosion is high on all the mountains around the Mediterranean, resulting in the transportation of high sediment loads to the coast. This, together with the largely tideless nature of the Mediterranean Sea has created complex delta mosaics and coastal wetlands, which are constantly fed by sediment inflows from the hills. This can be a rapid process. A lagoon of over 2,000 hectares near the famous Roman ruins at Ampurias in Catalonia is drawn on maps as recently as the 17th century. This has since been completely filled in by sediments, and is now agricultural land. Ancient Anatolian coastal sites such as Priene and Milet or Ephesus are now more than 10 kilometres inland as the river deltas extend seawards.

The impact of man on the river deltas of the Mediterranean basin has modified the natural wetlands, creating complexes of lagoons, marshes, lakes, temporary pools, river channels, irrigated agriculture and shallow coastal zones. But it is the natural elements of the hydrological cycle, such as precipitation and evapotranspiration, that have the greatest influence on wetlands, since these elements determine the amount of water available to wetlands throughout the year.

The Mediterranean climate is mild and humid in the winter with plentiful rainfall, followed by several hot, dry summer months of maximum sunshine. The Mediterranean coastal strip from Morocco to Tunisia and parts of southern Turkey receives on average between 500 and 1,000 millimetres of rainfall. The coast of north

J.J. Alcalay/ BIOS

Summer storms in Corsica rapidly swell rivers, transporting soil from the mountains to the coastal plain.

Africa, from central Tunisia to southern Israel and then inland through Jordan is the driest part of the region with 250 millimetres of annual rainfall, or less.
Rainfall is irregular during the year and varies substantially from one year to the next. This is particularly true of the southern Mediterranean. Storms can be violent and produce flash floods in a few hours, washing away precious topsoil. In 1981 in Larnaka (Cyprus), 192 millimetres of rain fell in just 4 hours leading to a loss of soil from erosion that was 25 times higher than during the whole of the previous year.

The Mediterranean Sea is virtually enclosed and is subject to high rates of evaporation of more than 2 metres per year, which is not fully offset by inputs from rain and rivers. This accounts for its relatively high salinity, 35 grammes per litre compared to 33 grammes per litre in the Atlantic. Its level is maintained by an inflowing current from the Atlantic Ocean through the straights of Gibraltar.

Because it is a small sea, the Mediterranean has practically no tides. There are only two tidal areas, one in the Gulf of Gabès, Tunisia, where tides reach 1.5 metres, and the other in the north Adriatic, where the movement is 20–30 centimetres at the most. This means that water level and wetland processes are influenced more by storms and wind direction than by tidal cycles. Winter storms can breach the sand bars separating lagoons from the adjacent sea, dramatically increasing the salt concentration in the lagoons.

Wetland loss in the Mediterranean

Wetlands provide a range of different goods and services and the wise use of these natural resources provides the basis for their long-term conservation. The Ramsar Convention adopts the following definition of wise use: "The wise use of wetlands is their sustainable utilization for the benefit of mankind, in a way compatible with the maintenance of the natural properties of the ecosystem".

Since before recorded history man has settled by water to fish or to farm rich wetland soils. Many early civilizations were founded upon wetlands, and millions of people are still dependent on them today. Numerous remaining wetlands in the developing world, and indeed in the less developed regions of industrialized countries, retain a wide range of their natural functions upon which rural communities still rely heavily.

However, in spite of research clearly showing that the chemical, biological and physical functions of wetlands provide society with valuable goods and services, their destruction continues. Contrary to the position in the United States, procedures for the assessment of functions and values have not yet been developed formally for Mediterranean wetlands.

A large proportion of Europe's wetland area has already been drained or converted to agricultural, industrial or recreational uses. Many of the remaining wetlands are still threatened by pollution, water extraction, eutrophication and sedimentation.

Loss of Greek Wetlands

The area of irrigated land in Greece today is 1,200,000 hectares (32 per cent of total land under crops) up from 178,000 hectares in 1929. At the same time, Greece's water requirements were radically expanding for industry, domestic use, tourism, livestock breeding, aquaculture and for the production of power. Land reclamation by draining wetlands was carried out in all parts of the country. In just five years from 1960 to 1964, 24,600 hectares of wetlands were destroyed; 120,000 hectares of land were drained, while flood protection was provided for 108,000 hectares. During this century in Macedonia alone, 62 per cent of the wetlands have been destroyed.

Immense wetland areas have been destroyed by the increasing need for land and energy. In Italy alone only 190,000 hectares of wetlands remain from the 3 million hectares which existed in Roman times. About half of all the wetlands around the world have fallen victim to conversion to agricultural lands. In Europe wetlands are still being destroyed for agricultural purposes despite an enormous agricultural surplus.

Tunisia has lost 28 per cent of its wetlands over the last 100 years. The catchment of the Mejerdah river has suffered the most, losing 84 per cent of its wetland area. Spain has lost more than 60 per cent of its historical wetland surface, most of it during the past four decades.

Wetland destruction has been relentless since the 1960s; many projects tried to develop the rural economy by converting wetlands without regard for their sensitive nature and the natural functions they perform. All too frequently, it was only after the wetland had been destroyed that the value of its natural resources was fully realised.

G. Boutin/ EXPLORER

Canalised water transfer programmes, such as this one on Cap Bon, Tunisia, have affected the hydrology of river systems and wetlands.

Giving the Hula Valley wetland a second lease of life

In the 1950s, Lake Hula (Israel) and the surrounding swampland were drained to create arable land and to reduce the risk of malaria and bilharzia (schistosomiasis) recurring in the area. The lake and surrounding swampland once occupied some 10,000 hectares of the Hula valley, just south of the source of the River Jordan.

Although the drainage programme had set aside 300 hectares of the swamps as a nature reserve, most of the local species disappeared. Scientists at the Hebrew University of Jerusalem fear that some of Hula's endemic species, such as the frog *Discoglossus nigriventer*, a fish *Acanthobrama hulensis* and two dragonflies, may now be extinct. Hula is also the most northern location of Papyrus swamp.

However the draining of the wetland did not provide all the benefits that had been hoped for. While the lake bed provided profitable harvests, the surrounding peatlands of the swamp were difficult to cultivate and of poor quality, limiting yields of crops such as wheat and cotton. Furthermore, oxidation of the peat caused spontaneous underground fires and the land began to subside, sinking three metres in the 35 years since it was drained.

As the land became unproductive, farmers from the surrounding agricultural settlements gradually ceased to work it. Each year more and more areas lay fallow until the community decided that action had to be taken.

In 1992 it was decided that the area should be partly restored to its original wetland state and that the River Jordan and nearby springs should be diverted to reflood the swamplands. A new lake of 100 hectares will be fed by 12 million cubic metres of fresh spring water. Hopefully the newly flooded area will attract tourists and generate income for the local farmers, who have fallen deeply into debt over recent years.

Environmentalists see the reflooding as a chance to recreate the original ecosystem. They believe that many species will repopulate the Hula, while others will need to be reintroduced once the former water system has been recreated.

Government agencies, local communities and conservation groups agree that the restored area of 800 hectares should be set aside for conservation and tourism. Attitudes at a neighbouring kibbutz are positive.
Although they have lost some of their cultivated land, they feel that the area will prove to be highly successful for tourism, and profitable for the communities in the area.

This is the first phase of a US$25 million restoration programme which shows that the fundamental principle for sustainable utilization is the management of wetlands as part of a complex system. The wise use of wetlands turns them into an asset, rather than an obstacle to sustainable development.

What are wetlands worth ?

Wetlands provide the world with many important natural resources and services. Far from being a constraint to development, they offer free economic services. The trend towards recognition of the natural values of wetlands coincides with a whole series of policy initiatives linking environment and development. The Earth Summit, held in Rio de Janeiro in 1992, the implementation of "polluter pays" policies, and attempts to assess market failures (where the true value of resources can never be established by a free market system) are all indications that the assimilation of environmental components into the art, or science, of economic valuation is under way.

Studies in the United States have indicated that some wetlands are worth 150 times more when left intact (water supply, flood prevention, pollution reduction, recreation and amenity) than if drained for development. Furthermore, the United States Fish and Wildlife Service estimated that 55 million people spent almost US$10 billion visiting, observing and photographing waterfowl and other wetland-dependent birds. Similar studies are urgently needed in the Mediterranean.

Economists and policy-makers are beginning to understand the wisdom of letting wetlands provide their free natural services, rather than draining the land for agriculture, housing or other development.

Wetlands supply the community with clean drinking water, fish, shellfish and other foods, and invaluable services such as flood control and filtration of contaminants. Destroy the wetland and all these services vital to the community will disappear, only to be recreated artificially by expensive technical innovations.

Efforts to convince people of the worth of the world's wetlands by actually calculating the economic values of wetland goods and services have shown that they more than earn their keep and their place on the planet. Wetlands are not just elements of the landscape; invisible processes are constantly taking place to cycle and recycle water and nutrients. Nothing is static. Plants grow and die, water flows constantly downhill either through the soil and rocks, or in streams and rivers. It is only when a wet area suddenly dries up in the summer that the natural phenomena of evaporation becomes apparent; or during periods of heavy rainfall and floods when the true impact of dykes and drainage (or lack of them) is realized. More often than not wetlands are only fully appreciated once they have disappeared.

The success of a development project affecting wetlands is usually calculated by cost-benefit analysis, with markets and economics dictating resource use. But wetlands are not marketed except when water is sold to a consumer. When water is extracted from a river or aquifer it is assumed to have a zero opportunity cost: that

The wealth between land and water

D. Simeonidis / BIOS

Many coastal wetlands support important fisheries.

is to say that diverting the water is considered not to lead to loss of value elsewhere. This is clearly untrue, since if left in the river the water would support fisheries, floodplains, grazing land, aquifer recharge, landscape values and so on.

All over the world, people are dependent on the productivity of wetlands. Many commercially valuable marine fish species depend on coastal wetlands for part of their life cycle.

The time has now come to assess more widely the natural cultural and heritage value of our wetlands, particularly in the richer Mediterranean countries of the European Community. The task is a challenging one, for while it is relatively straightforward to quantify the value of 3,000 hectares of sunflowers, it is considerably more difficult to assess how much 3,000 hectares of natural wetland is worth.

The approaches currently being developed to address this issue are discussed in the last chapter on the economics and pricing of wetland values.

Wetland functions

Wetlands are often the only places where certain natural functions take place; destroy the wetland and these precious services will be lost. How a wetland works depends on its particular biological and physical characteristics; these include nutrient recycling and groundwater protection and its ability to store floodwaters. Few wetlands possess all of the functions, and not all wetlands will perform them with equal efficiency. However a given wetland will usually have a range of different functions.

Of the 154,000 million cubic metres drawn off each year in the Mediterranean, 72 per cent (110,000 million cubic metres) is used for irrigation, 10 per cent for drinking-water and 16 per cent for industries not linked to the water supply.

A wetland acts essentially as a "store" in the hydrological cycle, and is linked to other stores by a series of transfer processes. Water is never lost from the global system and is constantly being cycled. The water storage in a wetland reflects the balance between the inputs (from rainfall, river run-off and, perhaps, groundwater or the sea) and outputs (evapotranspiration, river run-off and transfer to groundwater).

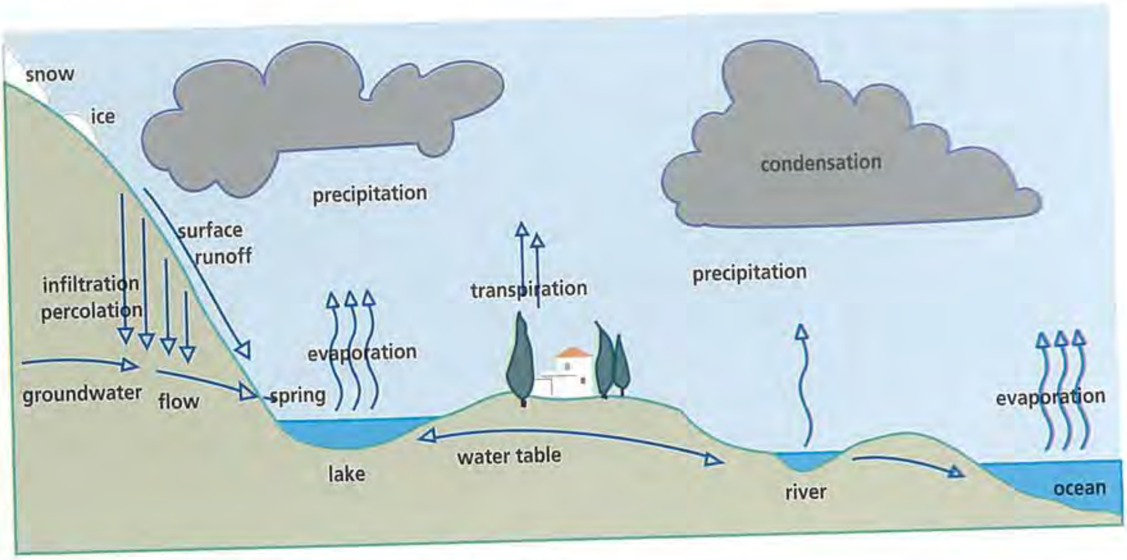
Coastal wetlands form an interface between marine and terrestrial systems.

A wetland is part of a wider hydrological system, and so the hydrological mechanisms of a wetland cannot be understood in isolation from its drainage basin. Wetlands are dependent on processes operating in

The Hydrological Cycle

Water is constantly moving in and out of the wetland system. However, if sustainability is to be achieved, the amount of water being removed for use in industry, agriculture or drinking-water supply cannot exceed the replenishment rate of the aquifer. High exploitation rates in most countries imply low levels of future availability, or even nil future availability in extreme cases. For example, in Israel and Libya exploitation rates already exceed 100 per cent, meaning that extraction exceeds replenishment and the water will eventually be exhausted.

In the coastal area to the south-east of Mesaria (Cyprus), draw-off from the aquifer amounts to 25–27 million cubic metres per year, whereas natural renewal amounts to 14 million cubic metres.
This over- exploitation produced a drop in the water level and the seepage of seawater into the aquifer. In this case the expensive solution envisaged is to import "surplus" water from other regions through a 15 kilometre tunnel, to ensure the future water supplies to Limassol, Larnaca, Famagusta and Nicosia.



Source : Todd (1959), Ground-water Hydrology, Wiley & Sons, U S.

the upper reaches of the basin or in the higher recharge zone for an aquifer-controlled wetland. The zone downstream and the coastal zone depend upon wetland processes for their hydrological regime and water quality.

Wetlands are composed of a number of physical, chemical and biological components. Processes linking these components allow wetlands to perform certain functions, such as flood control, and to generate products, such as fisheries.

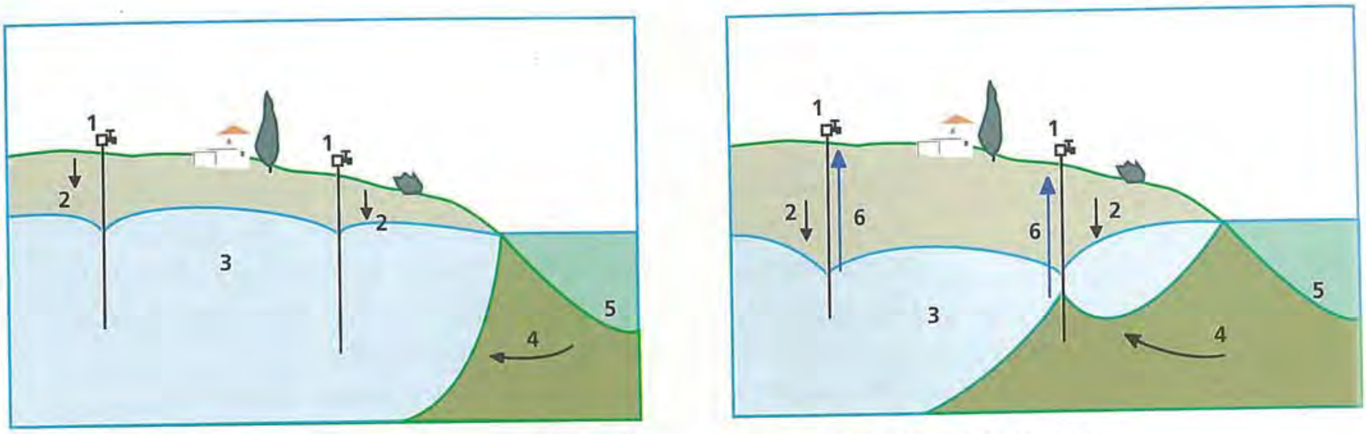
Groundwater recharge and protection

Wetlands can play an important role in replenishing or "recharging" groundwater supplies. Recharge of groundwater occurs when water percolates through the topsoil to the underlying aquifer, the layers of rock or deeper soil which can hold water.
The layers of upper soil act as a filter retaining nutrients and pollutants. Thus groundwater is often cleaner than its surface water source. Aquifers provide an important source of water for domestic and industrial use. Groundwater is not always static and may flow through the aquifer to return to the surface as a spring.

Alternatively water may flow laterally underground until it rises to the surface in another wetland as groundwater discharge. In this process the recharge from one wetland is directly linked to the discharge into another. This recharge function is also important in regulating river flows. During the wet season, floodwater recharges the aquifers and is thus temporarily stored underground, reducing the risk of unwanted inundation downstream. The construction of embankments along river-banks restricts the spread of floodwater and thus reduces the ground area over which recharge is possible.

Fresh groundwater flowing seawards also prevents seawater incursions which are liable to harm drinking and irrigation water supplies. Saline incursion into the groundwater is increasing in the Nile delta because of reduced flows in the river as a result of water stored in the Aswan dam. In Algeria, Tunisia and southern France saline incursion into the groundwater is a consequence of overpumping. Groundwater levels in Thessaly, Greece, have dropped by up to 10 metres due to overpumping.
This unsustainable use of water resources has pushed the engineers into proposing a huge diversion scheme from the Acheloos river, in order to provide adequate irrigation water and replenish the aquifer.

As an indication of the relatively small volumes stored in wetlands at any one time, it is estimated in the Emilia-Romagna region in Italy that from a total of 9 billion cubic metres of precipitation, 49 per cent becomes surface flow in rivers and streams, 25 per cent is lost to evaporation, 25 per cent percolates into the ground (with 10 per cent reaching deep aquifers) and only a fraction is retained by surface ponding, soil and plants.



Intrusion of salt water replaces fresh water, along the coast.

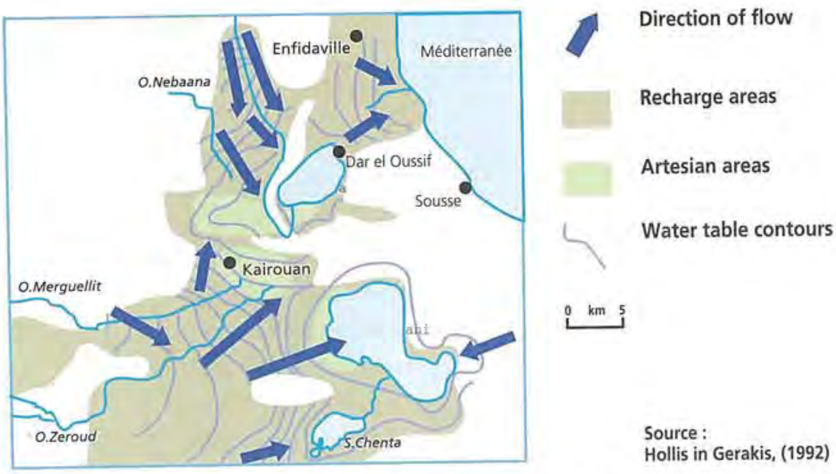
Normal situation

Overexploitation of aquifer by boreholes.

1 : Pumping
2 : Infiltration
3 : Fresh groundwater aquifer
4 : Salt wateraquifer
5 : Sea floor
6 : excessive pumping

Source : Miller (1990)

In central Tunisia, the rivers Zeroud, Merguellil and Nebaana flow across the extensive plain of Kairouan and recharge the aquifer with water during floods. Although the rivers subsequently dry up completely, the groundwater is exploited by wells for irrigation and finally surfaces at Kairouan under artesian pressure, where it provides the city with its drinking-water. Without this recharge, wells would run dry.



Groundwater contours and flows in the plain of Kairouan, Tunisia.

Source : Hollis in Gerakis, (1992)

At the Tablas de Daimiel wetland in Spain, overpumping of the underlying aquifer for irrigation has made the wetland a recharge rather than a discharge wetland. The natural flows in the river have diminished dramatically because they now lose water to the aquifer instead of being supplied by it. Abstractions were 100 million cubic metres a year greater than inflow, the water-table was dropping and the whole area was becoming desiccated. Efforts to restore the water balance of this Ramsar site are currently under way.

Groundwater discharge

Groundwater discharge occurs when water that has been stored underground comes up into a wetland and becomes surface water. This process is particularly common when the wetlands are located at low points in the landscape. For example, the S'Albufera wetland in Majorca (Spain), is fed partially by strong springs which keep the extensive reedbeds wet throughout the year. In Azraq, Jordan, two powerful springs used to maintain rich freshwater marshes between the infrequent inputs of water from the surrounding wadis. Today, however, heavy pumping has virtually dried up these springs.

The regular groundwater flow from the plain of the Crau, in the south of France, supplies coastal wetlands with a steady supply of clear, thermically stable, nutrient-poor water which promotes the formation of peat-like conditions and supports plant communities, dominated by *Molinia caerulea* and *Cladium mariscus*, unusual in this region.

Wetlands receiving their water from groundwater discharge are often able to support more stable biological communities. This is because water levels and temperatures fluctuate less in underground storage than they do when stored as surface water. Wetlands fed by groundwater discharge also have a direct influence on maintaining stream-flow during the dry summer months. Some wetlands fulfil a dual role. At one time of the year they are sites of groundwater discharge; at another they act as sites of recharge to the groundwater, depending on the rise and fall of the local groundwater table. In this way they act as a buffer within the hydrological cycle.

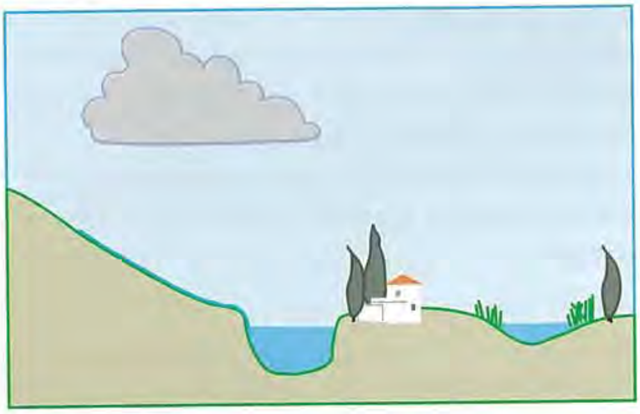
The main functions of selected Mediterranean wetlands :

Groundwater recharge	Garaet Haouria (Tunisia)
Groundwater discharge	La Vera (Spain), Azraq (Jordan)
Flood storage	Lac Fetzara (Algeria)
Shoreline anchoring and reduction of erosion	Göksu river and delta (Turkey)
Sediment trapping	Sebket Kelbia (Tunisia), Axios delta (Greece)
Nutrient retention/removal	Tablas de Daimiel (Spain)
Habitat for fisheries	Lake Kastoria (Greece), Lake Kinneret (Israel) Etang de l'Or (France)
Habitat for wildlife	Göksu delta (Turkey) Albufera de Valencia (Spain) Camargue (France)
Recreation and heritage value	Mekhada marshes (Algeria) Camargue (France)

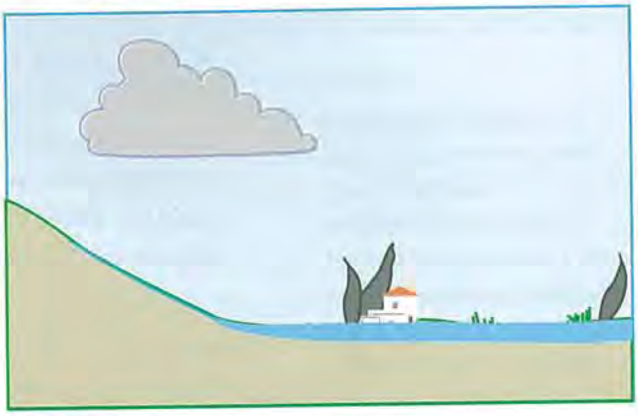
Flood control

About a quarter of the 100,000 cubic kilometres of rainwater falling each year on the earth runs off as flood flow. Floods are a regular feature of Mediterranean rivers and major protection works have cost billions of dollars. Natural wetlands can play a role in reducing damage from floods.

FLOW REGULATION
Runoff fills wetlands and flooding is avoided.



Wetlands present



Wetlands absent

Wetlands are able to diminish flooding in several ways. They store potential floodwaters, at least temporarily, and then release run-off evenly; wetlands in the upper catchment reduce floodwater peaks by ensuring that floodwaters from tributaries do not all reach the main river at the same time.
Flood control is a vitally important function of wetlands. Their preservation, along with that of their natural storage function, can avoid the costly construction of dams and reservoirs. The value of these wetland functions in protecting lives, property and crops is particularly crucial around cities, where development has meant that large areas of the land surface are impervious to water. For example, roads, roofs and pavements are often drained to water courses via pipes and culverts, which eliminates losses to the soil, and increases the volume and speed of run-off and the risk of floods. The flat fertile land of river floodplains, with nearby water and easy transport and communications, has always been very attractive to settlers. Such settlements have required the drainage of floodplain wetlands and the costly construction of flood control structures in their place. Yet in many places, flooding continues to put such investment at risk.
Recent and past policies have attempted to control and master the principal rivers of the Mediterranean region, without due consideration for the overall functioning of the river basin. It is technically feasible to plan to store all flood waters in dams, and to dyke a river throughout its length, hence protecting the floodplain. All structures have a design standard such that they will only be

overtopped once on average, for example, every one hundred years. However, when this rare event occurs, the embankments prevent water returning to the river and thus prolong the flooding. Since many people perceive that the embankment provides permanent protection, they invest in building property, infrastructure and agriculture (particularly if a flood has not occurred for a long time). Any consequent flooding may then have disastrous economic, human and psychological consequences. Sebkhet Kelbia, near Kairouan in Tunisia, used to overflow rarely into the sea because of its huge storage capacity. Heavy sedimentation from accelerated soil erosion in the catchment and some erosion of the lake's overflow sill have reduced its capacity by two-thirds since 1933. As a result, the enormous floods of the late 1960s and early 1970s swept through the Sebkhet cutting off all road, rail and telephone communications, killing many people and causing extensive damage to Kairouan.

Not only are investments in high-risk zones expensive, but they increase the risk of flooding elsewhere in the system. Many countries are only now refusing to provide insurance for constructions built in known flood zones, or are putting such zones out of bounds for construction. Long-term strategies for the sustainable management of flood risks inevitably include a balance between flood control works (dams, dykes) and natural floodplains (wetland).

The wise use of Lake Fetzara

Lake Fetzara (Algeria), a shallow 13,700 hectares depression in the floodplain of the Oued Seybouse, was completely drained in 1937.

In the early 1980s heavy floods caused considerable damage downstream as the lake no longer played its role of water storage. Since then the sluice gate on the outflow canal has been closed in the winter to retain flood water. Water is then released steadily in the spring and summer for downstream crops, hence inadvertently recreating and restoring some of the other wetland services, including substantial summer grazing areas and habitat for waterfowl.The present hydrological management of Lake Fetzara is in accordance with the "wise use" of wetlands, as set out by the Ramsar Convention.

Conservation has also benefited as a result of decisions taken primarily for economic purposes of flood control, grazing management and the supply of irrigation water.

Shoreline and delta dynamics

The semi-arid nature of much of the Mediterranean, combined with significant storm events and deforestation of the catchment area, promotes soil erosion in many countries. Transport of topsoil towards the sea is a major function of river systems and has both advantages and disadvantages. In Tunisia, erosion rates vary from 700 to 6,000 tonnes/square kilometres per year.

In 1950 there were 212 million people living in the countries of the Mediterranean basin. There will be a projected 433 million by the year 2000. Over 130 million people live on the coast and 50 coastal cities already have populations of more than 100,000. An additional 100 million tourists visit the region annually. Coastal countries make substantial investments to stabilize eroding coastlines and beaches.

Almost all important rivers in the Mediterranean have been dammed, resulting in a reduction of the amount of freshwater and precious sediments reaching their deltas. For example, the amount of sediment carried in the Nile and the Ebro has been reduced by over 95 per cent; for the Po the reduction is about 75 per cent and for the Rhône around 50 per cent. The quantities involved are enormous. In spite of being dammed, the Rhône carries 5 million tonnes of sediment to the sea every year. In the Ebro river basin, the construction of the irrigation system during the first half of this century and the building of a large number of dams have caused a drastic change in the natural cycle of sediment delivery and deposition in the delta.

During the first half of the century there were still big floods in the Ebro river, the last one in 1937. Since the mid-1960s the sediment inputs to the delta have decreased dramatically, from 4,000,000 tonnes a year before 1965 to less than 400,000 tonnes a year today. These lost sediments now accumulate in the Ribarroja-Mequinença dam system. At present, accretion over most of the delta is very small and probably lower than the relative sea-level rise. Scientific studies estimate that subsidence in the delta is between 3 and 7 millimetres a year.

The period of strong accretion up until the 1950s has probably so far prevented major erosion of the shoreline. It has long been known that dams restrict sediment transport, but the cost of coastal defences to replace the previously natural functions of sediment-bearing rivers has never been included in dam building costs, even though it is a clear and predictable consequence of their construction.

Sediment and toxicant retention

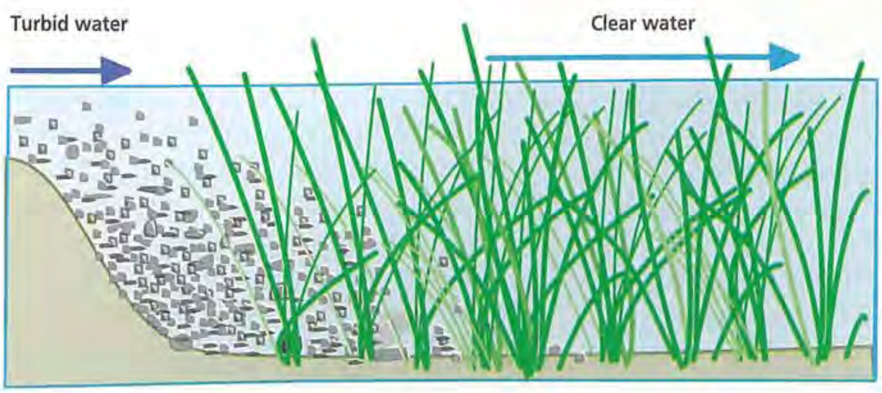
Sedimentation is important to the existence of wetlands along the coast of the Mediterranean, serving to stabilize them and counteract erosion along the shoreline. Sediment trapping is the process by which particles of any size are retained and deposited within a wetland. As the plant life of a wetland increases, flow velocity is reduced and sediment settles out as the slower-running water carries less suspended material.

Man has been influencing the Mediterranean ecosystem for more than 8,000 years. Where trees have been cut down or grazing pressure has intensified, erosion has greatly speeded up. Ancient Troy was strategically placed on a natural harbour at the mouth of the Dardanelles. Today its ruins overlook a land-locked plain. In only about 1,000 years, sediments from the deforested catchment area have cut Troy off from the sea.

Sediment brought down by rivers builds up rich and fertile deltas and is important in balancing coastal land loss. However, too much man-induced sediment brought down by rivers, from soil erosion or the destruction of nearby marshes acting as sediment filters, will cause lakes to fill up and interfere with other important natural functions such as flood control.

All of the dams in the Mediterranean are slowly filling with sediment. It is not technically or financially feasible to remove it and during the next century the storage capacity of existing schemes will be severely reduced.

The fisheries of the eastern Mediterranean have lost their vital source of annual fertilization due to the reduction of the Nile river's annual flood-load of rich silt. As the coastal delta erodes at a rate of up to 100 metres a year in some places, a new Nile delta is in the process of being formed by the 100 million cubic metres deposited annually at the entrance of the Aswan Dam, some 1,500 kilometres upstream.



SEDIMENT TRAPPING

When water flows through a wetland the current slows and sediments are deposited. Toxic substances adsorbed by the sediments may therefore accumulate. Some of these are taken up by plants.

Water stored in the aquifer is still drawn from traditional wells in many parts of the Mediterranean basin.

F. Didillon/ BIOS

But too much sediment, due to the influence of changing land-uses in the catchment, can also be considered a major water pollutant in many river systems. Large sediment loads can quickly silt up rivers and reservoirs, dramatically shortening the lives of hydro-electric installations and reducing the capacity of irrigation networks.

The mixing of saltwater with freshwater in estuaries, as in periods of flooding, causes the sediment to form in clumps and settle. Where land is subsiding, as in the Nile delta, sediment deposition is essential to maintain the coastal marshlands. Sediment generally builds up at 2–4 millimetres per year in areas with established vegetation, but on bare mudflats build-up can be as great as 45 millimetres per year.

Although the build-up of too much sediment in a wetland may affect its biological functions, floodwater storage and groundwater exchange, the quality of ecosystems downstream will be maintained if suspended sediment is retained in the headwaters. Toxicants, such as pesticides, or heavy metals often adhere to suspended sediment, and they therefore settle out along with the particulate matter. Retaining sediment in headwater wetlands will lengthen the lifespan of downstream reservoirs and channels, reducing the need for costly removal of accumulated sediment from dams, locks and power stations.
Research in Tunisia shows that the expected life of any dam in the country is 100 years or less and that there are enormous quantities of sediment in transit, caused by erosion following deforestation. The dating of sediments in Lake Ichkeul has shown that the rate of sedimentation is up to 6 millimetres/year and is increasing rapidly, because of both land degradation and the channelling of rivers directly into the lake.

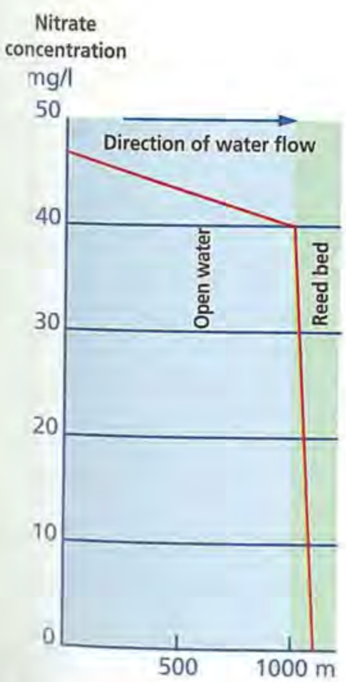
Nutrient retention and recycling

One of the functions of wetlands is their ability to retain nutrients from water entering the wetland system. These nutrients, which come from sewage effluent and the use of fertilizers on agricultural land, are a growing problem in many parts of the Mediterranean. They cause the eutrophication of inland and coastal waters and contaminate groundwater. As water passes through wetlands, and especially when it interacts with oxygenated wetland soils, nitrates and phosphates are fixed by the plants, by sedimentation and partially recycled by bacteria.

Eutrophication occurs when water is rich in nutrients; this eventually leads to excessive growth of suspended algae and phytoplankton, which, when they die, kills animal life by deprivation of oxygen.

Around 48 per cent of the estimated 450 tonnes of nitrate entering the Etang de l'Or (south of France) each year, comes from fertilizers carried from the catchment into the lagoon by groundwater.

The use of excessive fertilizers for market gardening in the basin of the river Vistre in the Gard (France) has been responsible for the groundwater containing 100 milligrammes/litre of nitrate, double the EC recommended level for drinking-water. Although wetland plants are able to absorb nutrients, this in itself would not ensure their eventual removal from the wetland. Moist low-oxygen wetland soils favour "denitrification" by certain bacteria. This means transforming nitrites or nitrates into molecular nitrogen or a gaseous oxide, which is circulated back into the atmosphere. This mechanism, which depends on alternate aerobic and anaerobic conditions (flooding and drying out), can remove between 40 per cent and 98 per cent of nitrogen from wetlands.The soil in the rice fields of the Camargue, which are really man-made wetlands, is excellent for denitrification. It has been estimated that 80 per cent of the nitrate fertilizer used by farmers is lost through denitrification one week after application. This rapid conversion rate obliges farmers to apply higher doses in order to supply the crop with the nitrogen it requires. Wetlands remove phosphorus and other nutrients in different ways. Plants taking up phosphorus store it only temporarily, releasing it when they decompose. No micro-organisms can transform phosphorus into a gas and phosphate levels do not therefore decline naturally in a eutrophicated wetland. However, not all phosphates are in a chemical form directly available to plants. Large amounts of phosphorus are inactivated by chemical bonding to inorganic ions in soils and sediments, mainly aluminium and iron. So, while wetlands are very efficient at cycling and removing nitrogen, phosphate is inactivated and stored. Although phosphate cannot be cycled in the same way and accumulation is permanent, it can be lost by exporting wetland products (for example through fishing, grazing, reed cutting or the removal of algae). In conclusion, wetlands are complex systems. Tampering with one part of the system can easily lead to unforeseen consequences.



REEDBEDS REDUCE NITRATE CONCENTRATION OF WATER FLOWING THROUGH.

Wetland resources and their uses

Although wetlands continue to be abused by drainage and poor management, left alone they supply local communities with many valuable assets. They provide a range of values and services that local people benefit from at no cost, as well as contributing to regional and national economies. Wetlands are the backdrop for recreational and cultural activities and are also habitats for a range of domestic and wildlife species.

Wetlands provide many opportunities for active outdoor recreation, but if not carefully managed serious damage can be caused to the other functions of the wetland. Swimming, sailing, windsurfing, angling, water-skiing, powerboating and hunting are all highly popular activities. With them comes the development of houses, hotels, roads and related infrastructure. More passive leisure activities that draw people to enjoy wetlands include birdwatching, hiking and horse riding.

Teal *(Anas crecca)* wintering in the Camargue. Wetlands are highly productive habitats and support many species of birds, often in impressive numbers.

M. Gunther/ BIOS

30 per cent of the world's tourists head for the Mediterranean coast where many camp on unauthorised sites. Beauduc, Camargue.

Tourism and recreation

The Mediterranean is the most important tourist destination in the world, attracting 100 million visitors annually; between 70 per cent and 80 per cent visit Spain, France and Italy. Tourism represents 10 per cent of GNP in Spain and Italy, and between 12 per cent and 15 per cent in Malta, Cyprus and Israel. Israel estimates that jobs in tourism employ 10 per cent of the workforce.

Many visitors to wetlands find them to be a source of inspiration for the creative arts, such as writing, painting or photography; others come simply to enjoy the beauty of the landscape, the natural habitats and the wildlife. A number of Mediterranean countries attract "green" tourists to their national parks; Ichkeul in Tunisia, for instance, receives as many as 1,000 visitors on some days. Visitor pressure is so high in Doñana (Spain) that numbers are restricted to 250 a day in the core area of the National Park.

Although these "ecological" visitors cause less damage to the environment than mass tourism, sound infrastructure still needs to be provided to avoid degradation of wetland tourist sites.

During the summer months, considerable numbers of northern Europeans invade the shores of the Mediterranean basin, placing heavy demands on water supplies during the driest months of the year. Water consumption by tourists in 1984 was calculated at 569 million cubic metres, which by some estimates could increase by 50 per cent by the year 2000, and double by 2025.

Sewage outflows into lagoons or the sea are frequently the low-cost solutions used to deal with waste-water disposal, particularly in summer resorts where the short holiday season does not justify major investment in sewage plants. This has led to marine pollution problems in places such as the Gulf of Thessaloniki, Greece, and eutrophication of lagoon systems in Etang de l'Or, France, and Laguna di Orbetello, Italy. An EC Directive now requires that all towns of over 10,000 people be equipped with a sewage treatment plant by 1998, and EC funds are available to support its implementation.

While the principal attraction remains the sun and the beaches, there is increasing diversification of the tourist package. The trend seems to be moving away from the traditional "roasting-on-the-beach" vacation and turning towards a "greener" tourism, making the beauty of the scenery and the quality of the surroundings of equal importance to the size and colour of the sand grains.

A more discreet type of "green" tourism is now becoming popular amongst photographers, painters and hikers.

D. Bringard/ BIOS

Tourists, wildlife or both ?

In southern Spain lies a beach resort named Matalascañas, meaning "kill the reeds", and this is unfortunately exactly what has happened. Over the past 25 years, seven kilometres of this exquisitely beautiful coastline have seen its reeds and rushes replaced by a tourist development originally planned to house 32,000 people.
It is now estimated to absorb over 200,000 tourists during weekends in the summer months.

There is only a small road separating Matalascañas from the boundary of the Doñana National Park. Established in 1969, the park is one of Europe's most important wetland and wildlife reserves. Over half of Europe's bird species live, breed or stop-over during migratory flights in the marshes of the Doñana. However, the national park only attracts a fraction of the tourists who flock to the Matalascañas beach resort.

Until the early 1960s, the marshes of Doñana had been the hunting grounds of both the rich and privileged and the poorer rural inhabitants of an under-developed and thinly populated land. With the eradication of malaria from the area, a government policy of large-scale tourist development and the exploitation of groundwater resources, life changed radically. The Doñana suddenly prospered. Wetlands were drained for agricultural purposes and groundwater pumped up to irrigate fields of wheat, rice, strawberries and asparagus. Of the 200,000 hectares of flooded marshes in the Doñana a century ago, only between 30,000 and 40,000 hectares are left today. While development pressures on the park have not increased since the construction of Matalascañas, there are always projects in preparation.
One such project is the Costa Doñana development, a projected US$100 million extension of Matalascañas which would provide construction and hotel jobs. However, a recent report by the European Commission on sustainable socio-economic development of the Coto Doñana suggested that more environment-friendly schemes could also provide jobs.

For several years rice and strawberry farmers in the area have been under pressure from conservation groups. They are accused of using too much water, and excessive amounts of pesticides and fertilizers. The immediate impact on the environment is not yet apparent as data for the Doñana are sketchy, and the water balance of the aquifer is not adequately known.
This is not helped by the presence of a complex range of agencies involved with the water regime of the park.

M. Gunther/ BIOS

The national park in the Coto Donana, Spain, is coming under serious threat from neighbouring holiday developments.

Simulations of the groundwater level paint a bleak picture for the next century. They show that with average rainfall and the pumping of 52.2 million cubic metres/year water to irrigate 6,900 hectares, the water-table beneath the dunes on the western side of the park will fall between one and five metres by 2005. The Rocina stream will become a major source of recharge as the water-table falls by about 3.5 metres under certain parts of the stream.

The effect of pollution from fertilizers and pesticides is not yet known as they have not so far been detected in large quantities. However, it is feared that pollution of the water-table is inevitable if their use in agriculture continues at its present rate, with long-term effects not fully felt for maybe another ten years.

The real danger for Doñana would be the construction of a second tourist village. With nearly 200,000 people already using 350 litres of water daily in the summer season, any additional demand may compete with the wetlands of the national park for already scarce sources.

Biodiversity

Wetlands shelter a rich and diverse collection of plants and animals. Only a very small portion of this vast genetic resource has been studied, and an even smaller portion is actually used for human consumption. Many rare and endangered plants and animals either live in wetlands or depend on them for survival. Some need a certain type of wetland while others spend only part of their life cycle in water, visiting for specific purposes such as resting, spawning or feeding.

Eight of the 29 globally threatened species of birds occurring in the Mediterranean are wetland species. They include marbled teal, *(Marmaronetta angustirostris)*, white-headed duck, *(Oxyura leucocephala)* and Dalmatian pelican *(Pelecanus crispus)*.

Of approximately 50 species of amphibian occurring in the Mediterranean region, 27 are endemic, i.e. restricted to this region. Reptiles such as grass snakes, vipers and terrapins are abundant. The rare soft-shelled Nile turtle *(Trionyx triunguis)* nests in Turkey's Göksu delta.

Although mammal species are not numerous throughout the Mediterranean, wetlands offer shelter to animals from the hot dry summers. The Doñana is the last haunt of the rare Spanish pardel lynx *(Lynx pardellus)*, while the Daimiel National Park and other Mediterranean wetlands are still a refuge to otters *(Lutra lutra)*.

Over 80 per cent of the species listed for protection under the 1992 Habitats Directive of the European Union are of Mediterranean distribution, many of them linked to wetlands.

Other species, mostly waterfowl, move from one wetland to another in a set migratory pattern. The Mediterranean region lies on major migration routes and twice yearly millions of birds cross the Mediterranean Sea – northwards in the spring to their European breeding grounds, and southwards to their African wintering quarters in the autumn.
The autumn migration occurs at a time when many temporary wetlands have dried up. Species such as herons, reed warblers, waders, terns and ducks which require wetland habitats depend on the few remaining permanent wetlands for a few days of rest and feeding before continuing their journey. This network of wetland staging sites provides essential stepping stones for waterbirds, particularly in arid North Africa where southward-bound migrants must face thousands of kilometres of the Sahara Desert before reaching the wetlands of the Sahel.
Wetlands also offer havens for breeding and wintering birds. The Evros delta, once one of the most important European

Waterfowl populations and the loss and degradation of wetlands in Egypt

J.C. Munoz/ BIOS

Populations of shovelers are endangered by untreated waste being dumped into the lakes and delta of the Nile.

In the winter of 1989–90 a study was carried out to determine the ornithological value of Egyptian wetlands. They are among the most important wintering areas for waterfowl in the Mediterranean region and are used as a stop-over area by thousands of waders.
Despite their importance, Egypt's wetlands are falling victim to land reclamation, pollution, uncontrolled bird hunting and coastal erosion.
Land reclamation for agriculture and housing is now a major threat, and the dumping of raw sewage and industrial waste is seriously affecting the water quality in the lakes of the Nile delta.
In some of the lakes the aquatic vegetation is disappearing. These ecological changes to the wetland habitats are reflected in recent bird counts. The most significant decreases were observed amongst the two previously most numerous species, coot (*Fulica atra*) down by 83 per cent, and shoveler (*Anas clypeata*) down by 44 per cent.

The construction of the Aswan Dam has been beneficial for irrigation. However, downstream at the delta, saline groundwater now extends 30 kilometres inland from the coast, as there is reduced freshwater flow into the aquifer.
Egyptian hydrologists have declared it their objective to reduce to an absolute minimum the "loss" of Nile flow to the sea.
Most of the Nile water is used for agricultural purposes and this has led to two contrasting side-effects on wetlands.
Firstly, there has been a four to five fold increase in the inflow of agricultural drainage water to the lakes in the delta, which has changed them from brackish to almost fresh water. Secondly, the constant run-off of slightly saline water from irrigation schemes has transformed one of the lakes (Lake Qarun) from a freshwater to a highly saline lake through evaporation and consequent concentration of salts. Fish species previously found in the lake have completely disappeared.

The lake is now used for aquaculture to breed marine species of fish and shrimp. Waterfowl populations on the lake have decreased by between 75 per cent and 90 per cent. Among the species to suffer the most are great crested grebe (*Podiceps cristatus*), black-necked grebe (*Podiceps nigricollis*) and tufted duck (*Aythya fuligula*).


R. Seitre/ BIOS

Every year 12 000 pairs of flamingo raise their young in the Camargue.

breeding areas for birds, still supports up to 300 bird species despite massive drainage. White-tailed eagles *(Haliaetus albicilla)* nest there, Dalmatian pelicans winter and white pelicans rest during their migration.
The Doñana's saltmarsh can host as many as 150,000 waterbirds in the winter and the Camargue supports 12,000 pairs of breeding flamingos *(Phoenicopterus ruber)*, many of which move down to the Gulf of Gabès in Tunisia for the winter.

Conservationists have adopted the guideline that any wetland which supports over 1 per cent of a given waterfowl population is of international importance for the maintenance of the species. In the case of the white-headed duck, 75 per cent of the world population winters in some years on one lake – Turkey's Lake Burdur.

Because of the diversity of fauna and flora supported by wetlands, it is important to conserve all these sites.
The health and conservation of wetlands is vital for the productivity of economically important populations, for example of fish, shellfish and grazing animals, as well as the well-being of human communities. And this is quite apart from any scientific, cultural or recreational values associated with wildlife and the wetland ecosystem.

Hunting

There are some 9 million hunters registered in Europe, at least half of them in the Mediterranean region. Hunting is seen by some as a degradation of wetland values through the killing of wildlife, and by others as a sustainable and wise use of wetland resources. Conservationists and hunters should, however, have a common goal – maintenance of wetlands and their waterfowl populations.

Wetland habitat loss through destruction, degradation and disturbance causes declines in wintering waterfowl. It is in the interests of hunters to maintain the network of wetland sites on which the waterfowl depend.

The Mediterranean region holds nearly 50 per cent of the wintering Western Palearctic populations of ducks and coot. However, the populations of these species show a general decline of 46 per cent in the last 15 to 20 years, according to a study carried out on 295 sites in 15 countries. The total number of the most important waterfowl species on these sites was estimated at 2.8 million during the early 1970s, and at 1.5 million in 1989. The species most severely affected was the ferruginous duck *(Aythya nyroca)* whose population dropped by 93 per cent.

A further hazard faced by birds is lead shot, used almost universally by hunters in the Mediterranean region, which causes lead poisoning in waterfowl that ingest it. Large numbers of birds also die as an indirect result of lead poisoning as their weakened state makes them vulnerable to predators. Research suggests that hunting in the Mediterranean exposes birds to a much higher risk of lead poisoning than in northern Europe. Shot densities of up to 2 millions per hectare have been recorded in the sediments of heavily hunted marshes in the Camargue delta.

However, the problem of lead poisoning in waterfowl can be overcome by the use of non-toxic shot such as steel. Following the Mediterranean wetland management meeting in Grado, Italy, early in 1991, it was recommended that the use of lead shot for hunting bird species should be banned immediately on all Mediterranean wetlands that attract wintering, migrating or breeding waterbirds.

If effectively regulated, there can be a sustainable yield of waterfowl taken by hunters from wetland areas. It is therefore clearly in the interests of both hunters and conservationists to maintain healthy and well-managed wetlands.

Hunting can provide valuable economic returns to regional economies when correctly managed. The average spending per hunter per year has been estimated at US$1,080 in France and US$830 in both Italy and Spain. The Camargue wetland complex supports approximately 5,000 hunters which generates close to US$5 million each year from hunting and provides 74 permanent jobs. A good hunting marsh in the Camargue can be rented for up to US$30,000 a year; without this income many such marshes would be drained or converted to rice fields.

In France, as in most countries, every registered hunter pays an annual fee for a hunting permit. More of this money could usefully be spent in promoting the conservation of wetlands on which waterfowl populations depend.

Duck hunting can be a sustainable economic activity if wetlands are maintained and hunting pressure correctly managed.

A. Beignet/ BIOS

Fisheries

The coastal population living along the Mediterranean puts high demands on marine products; 4 million tonnes are consumed each year. The Mediterranean alone is clearly unable to meet these demands. Between 1938 and 1955 the Mediterranean's annual catch was around 500,000 tonnes which gradually increased to 1,047,000 tonnes in 1985. The catch has increased by 48 per cent since 1973 but still only meets a quarter of the demand.

Although fisheries in the Mediterranean have declined in recent years through overfishing and reduced water quality, they can still be sustainable if properly managed.

Angling is one of the most popular "sports" in the developed world. It provides not only the enjoyment and relaxation of a leisure activity, but also generates financial spin-offs from the sale of fishing licenses and tackle as well as income from associated resorts and tourism. A fish caught by an angler costs five times more in investment of time and money than one caught by a professional fisherman. Although sportfishing is becoming a source of considerable foreign currency in many developing countries, it is still not very popular in the Mediterranean region.

Many wetland fish species, once widespread, are becoming endangered by the transformation of coastal wetlands and by overfishing. Such is the case of the eel *(Anguilla anguilla)*.
So great is the trade and so fast is their habitat declining that there is a real fear that this once common species could soon be threatened. There is potentially a thriving trade in young eels being taken from protected wetlands, such as Ichkeul in Tunisia and El Kala in Algeria, and exported live to markets in Italy and frozen to the Netherlands.
Tunisia's eel exports to Italy from Ichkeul brought the country over US$800,000 in precious foreign currency in 1988. This was up by 55 per cent from the previous year, and further increased in 1989. Unfortunately more recent declines in water quality at Ichkeul have reduced this valuable income.

While wetlands in industrialized nations produce large quantities of commercially valuable products, small developing countries depend on their wetlands for food and economic benefits for local communities. Fish and shellfish are an important source of protein for many people living along the north African coast.
In some parts of the Mediterranean, subsistence fishing for home consumption and for sale at local markets and restaurants is still a common practice.

Rivers and floodplains produce about half of the world's inland fish catch of 10 million tonnes.

One of the most numerous and productive types of wetland in the Mediterranean basin is the coastal lagoon. Covering some 600,000 to 700,000 hectares in total, they are unevenly distributed around the shores of the Mediterranean.
The absence of tides makes these coastal lagoons unique ecosystems and they have been exploited traditionally for thousands of years. The median yield of fish from Mediterranean lagoons is 56 kilogrammes/hectare per year.

The high price of bad planning: Lake Karla, Greece

Lake Karla was the largest freshwater lake in Greece (16,000 hectares), bordered in the north by the Olympus massif and in the east and south by the Ossa, Mavrovouni and Pilion mountains.

The fish from the lake was much sought after for its fine taste and provided 1,000 fishermen with a decent living. Tens of thousands of animals grazed in the lake vicinity and in the early 1960s more than 430,000 waterbirds were counted on its waters. This was the largest concentration ever recorded in Greece.

Plans for draining the lake began in 1910, but the drainage finally took place in 1962 when the lake water was emptied through a 10-kilometre tunnel into the sea. The operation was planned to extend irrigated agriculture to the Karla plain and lake bed.

The draining of Lake Karla has resulted in large quantities of water discharging into the sea every year. Loss of surface-water has meant that groundwater has to be used for irrigation purposes, affecting groundwater supplies. Drainage from the former lake basin, which also collects water from polluted sources upstream, contributes significant pollution to the sea. Many of the drained areas have proved inappropriate for agriculture due to alkalinity or salinity problems.

Today the waterbirds are gone, and cotton, sugar beets and alfalfa grow on the bed of the former Lake Karla. There is no more fishing and the fishermen have changed profession or emigrated from the area. Lake Karla is a sad tale of how inadequate planning and a careless approach to the use of available water resources, has resulted in heavy losses for the community. Plans are now being made to rehabilitate the wetland ecosystem of Lake Karla, but this will be costly. There is a growing awareness of the damage caused by wetland drainage and of the environmental problems caused by pollution.

For a realistic and sustainable future, the whole Karla ecosystem and watershed must be considered as one complete unit, with social and land-use issues as an integral part of the problem...and the solution.

Wetland resources and their uses


M. Gunther/ BIOS

Traditional fishing in the Menderes delta on Turkey's west coast.

136 species of fish have been recorded in French Mediterranean lagoons; this compares to 179 species in the adjacent coastal waters and demonstrates the importance of lagoon systems. Fishing activities in Mediterranean lagoons particularly target eels, mullet *(Mugil spp)* and sea bream *(Sparus auratus)*. Crabs and shrimps are also exploited commercially in some lagoons. Aquaculture primarily involves shellfish culture, including mussels, oysters and clams.

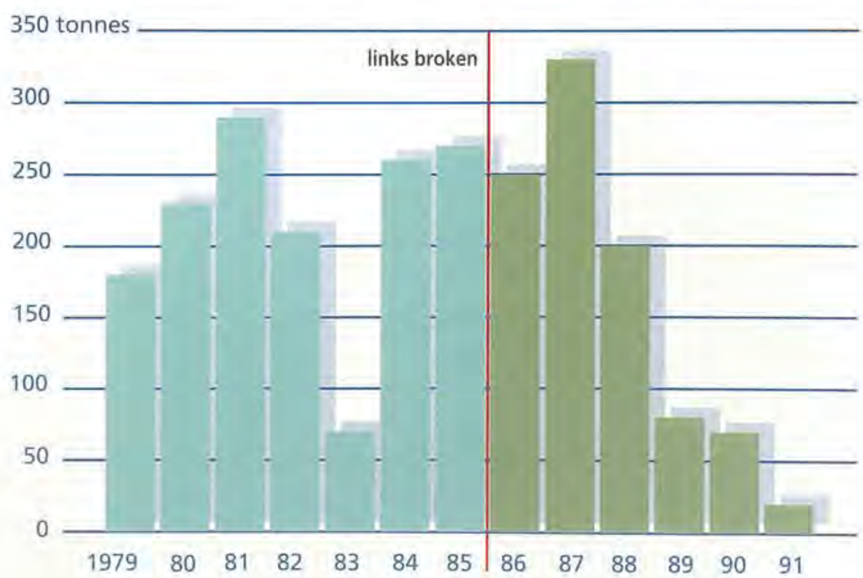
As evaporation in the Mediterranean always exceeds precipitation, their hydrological balance depends on inputs of freshwater from the catchment area, and inputs of saltwater from the sea.

The presence of animal and plant populations, and the potential for fisheries and aquaculture are determined by environmental factors such as the degree of water circulation, the natural primary production, depth of water, or the nature of the channels connecting the lagoons to the sea. Developments which profoundly modify the hydrological balance cause sudden changes to the lagoon ecosystems. For example, shellfish culture and cage fish-farming may have a significant local impact by enriching the sediments.

Many species migrate back and forth between the lagoon and the sea. Eels seem to be attracted by the outflowing fresher water while the migration of other species back to the sea may be controlled by temperature.

Nowadays, the main economic factors influencing the development and management of lagoon systems are agriculture and tourism, frequently harmful to the traditional fisheries and aquaculture. Fishing and fish-farming activities in lagoons can only survive if a certain biological quality is maintained in the ecosystem, and if solutions are sought for the problems of overfishing in the lagoon and coastal waters. Fishing, which was once the main economic activity of the Mediterranean lagoons, is now marginalized because of habitat degradation and socio-economic pressure from tourism and leisure activities.

At the Etang de Leucate, in the south of France, a tourist development on the sand bar required the enlargement of the openings to the sea for a marina. The lagoon was profoundly modified by the influx of seawater, increasing salinity from 30 to 38 grammes/litre. The number of fishermen slumped from 117 to 47 with a fall in yield from



DECLINE IN THE FISHERY AT LAKE BAFA (TURKEY) FOLLOWING DISRUPTION OF LINKS WITH THE SEA AND RIVER SYSTEM.

D. Simeonidis/ BIOS

4 million tons of fish are consumed locally every year, but the Mediterranean sea alone cannot meet this demand.

40 to 10 kilogrammes/hectare per year. In the Etang de Berre, also in southern France, a big drop in salinity followed the construction of a hydro-electric power station on the shore of the lagoon in 1966. Fed by water piped from the Durance river, the power station discharges a quantity of freshwater into the lagoon each year, equal to three to four times its volume. This has resulted in a major change in the species composition of the lagoon's fish populations.

Greece has around 43,500 hectares of lagoons. Total yield in 1981 was 2,000 tonnes. Yields were twice as high at the beginning of the century and nowadays it varies between 5 and 462 kilogrammes/hectare per year. Overfishing in the lagoons and in the coastal areas, organic pollution, tourism and urban development, and the degradation of the inlets are the main reasons for the decline of fish catches in the Greek lagoons.

In coastal lagoons, eutrophication results in high levels of organic matter being produced and retained. This results in massive die-offs of aquatic organisms during hot summers.

In the Languedoc lagoons in France these problems have occurred more regularly and over larger areas since 1975. The death of local oyster cultures in 1987 resulted in a loss of around US$6 million.

Coastal lagoon fisheries

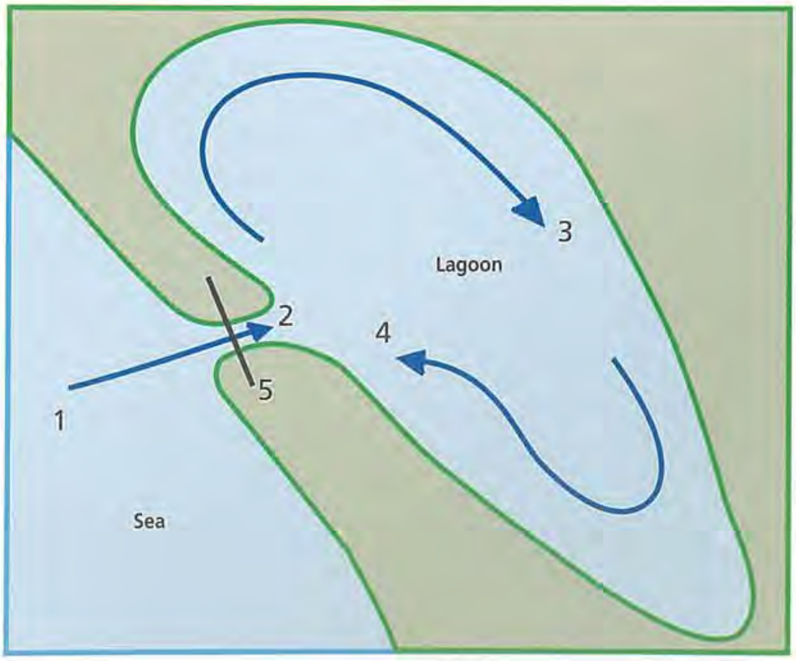
Coastal lagoons throughout the Mediterranean region have been fished for hundreds, if not thousands, of years. These fisheries are largely based on the species of migratory fish which breed in the sea but move into lagoons to grow and mature.

In the eastern and southern Mediterranean the most sought-after fish species are mullet; in other areas sea bream, sea bass *(Dicentrarchus labrax)* and eel are also caught. Mullet breed in the sea in October and November, leaving their pelagic eggs to float in the sea currents. The larvae enter the lagoons, attracted by outflows in the channels which connect them to the sea. Growing and maturing in the rich, productive lagoon systems, they feed mostly on organic detritus in the mud, and on algae and invertebrates.

Remaining in the lagoon for up to three years, they return to the sea in September and October as adults weighing around one kilogramme. It is at this stage that they are caught by fish traps made traditionally from reeds, but more recently from steel or aluminium, which completely block the channel to the sea and guide the fish into holding traps.

Eel fisheries have developed recently as countries, such as Italy and the Netherlands, which regard the species as a delicacy have begun to import eels from countries which do not normally consume them, e.g. Turkey, Egypt or Tunisia. Eels are caught in nets and traps in the lagoons and exported fresh or frozen. They enter the lagoons as elvers and may spend five years or more maturing before returning to the Sargasso Sea to breed.

1 : Adult fish spawn in the sea.
2 : Fry migrate into the lagoon.
3 : Growth of fish.
4 : Return to the sea as adults.
5 : Fish captured by traps in the channel.



Pasture-land and grazing

Large numbers of domestic livestock are grazed on marshes which provide high quality grazing, even during the driest summer months. Two of the most extensive wetlands in the Mediterranean, the Camargue (France) and the Doñana (Spain), have long been grazed. The Camargue delta supports approximately 8,000 horses and cattle which have considerable economic value.

The 1,300 hectares of marshes at Lake Ichkeul (Tunisia), now increasingly desiccated by the effects of water restrictions, constitute the vital spring and summer grazing lands for cattle. The marshes around the lake provide nutritious seasonal grazing for nearly 9,000 sheep, goats and cattle, although with the recent increase in the number of animals grazing in the area there is a danger that it could soon become overpopulated.
The productivity of the marshes is hard to determine as cattle only graze there for part of the year, but the value of total livestock production (meat, wool and milk) of the marshes of the Ichkeul National Park in 1988 was estimated at US$105,000, based on local market prices. The grazing of wetland vegetation by horses and cattle promotes the development of a habitat mosaic which provides a wide range of conditions for wetland plants and animals. The herds of horses and cattle that graze the wetlands

Wetlands provide valuable grazing for buffalo during the summer months.

M. Gunther/ BIOS

Many species, particularly wading birds, prefer the more open conditions created by grazing. Cattle egrets depend on insects disturbed by the grazing herbivores.

F. Marquez/ BIOS

in the Camargue are useful in managing the marshes for waterfowl, particularly in marshes where the water levels are controlled. Managers of wetlands in other countries have also imported the local race of Camargue horse for this purpose as they are well adapted to grazing in wet conditions. Not only does the wetland generate revenue from hunting, it also provides rich summer pastures.

The marshes are the only source of high quality grazing for the Camargue's horses and cattle during the long summer drought, when the winter rain-fed grasslands have turned to straw. The traditional cycle is for cattle to graze the higher land in the winter and the marshes in the summer, the sustainability of the system depending on both dry lands and wetlands. However, drainage of the higher land to grow rice and wheat has deprived many herds of their winter pasture.

Most cattle are now fed partly on hay during the winter, but the availability of high quality grazing in the marshes for five or six months of the year still makes extensive cattle-raising a profitable activity, and the maintenance of Camargue traditions a reality. But the bulls must leave the marshes by mid-August to allow the hunters safe access at the opening of the hunting season, well before the end of the summer grazing months.

Using the water resource: man-made wetlands

Man-made wetlands are usually designed to capture or divert the key resource of wetlands – their water. They include extraction pits, salines, rice fields, waste-water treatment areas and reservoirs holding water for irrigation, electricity production and human consumption. Natural wetlands are multi-purpose; artificial wetlands are often single sector and have been designed to perform one specific function, such as providing drinking-water. Any other function the artificial wetland performs, such as providing a habitat for waterbirds, or replenishing groundwater, is usually a beneficial side-effect.

Artificial wetlands are unable to provide all the ecological and hydrological functions of the natural wetlands that they are often replacing. Multi-value ecosystems are often replaced by managed systems for the benefit of a single sector.

However some man-made wetlands have become important wildlife habitats, with reservoirs supporting important populations of wintering wildfowl following the loss of natural wetlands. On the Cheffia Dam in Algeria (near the El Kala National Park) as many as 100,000 ducks have been recorded. However, hydro-electric reservoirs in steep valleys are usually of very limited ecological interest because the constant variation of the water level creates a dead zone around their shores: the fluctuations in water level being too extensive and rigid to allow the establishment of a fringe of wetland vegetation.

Many countries are undertaking the restoration or rehabilitation of wetlands previously drained or polluted. The Italian Government is funding a US$12 million restoration scheme for the polluted Bella Rosa marshes bordering the Molentargius lagoon in Sardinia.

As so many wetlands have already been destroyed, any body of water can be considered as having some conservation significance. Even lagoons associated with sewage plants are important to wildlife as they are less likely to freeze over in the winter months. For example, the sewage farm in Jerez de la Frontera (Spain) is a strategic site for migratory and breeding birds.

Flooded and abandoned gravel pits, clay extraction pits and salt-pans are becoming increasingly important habitats, not only for wildfowl but also for plant and animal species. The commercial use of canals is declining and they are now providing relatively undisturbed habitats for wetland species, and enjoyment for those who use them for leisure activities.

The taming of the Nile

Although man's tampering with a complex ecosystem can bring about considerable advantages for the country, it may also cause serious, sometimes irrevocable consequences.

In 1964 the Aswan High Dam began harnessing waters of the Nile. The flood cycle was broken, radically altering the rhythm of agriculture and generating enormous stores of hydro-electric power. The character of the Nile was to change forever.

It is true that the Aswan dam has preserved Egypt from the famine that periodically grips its neighbours in the south. The dam allows enough water to be stored in Lake Nasser to satisfy Egypt's needs for about three years. However, critics of the dam accuse it of blocking fertile silt, formerly distributed to farmlands by the annual floods; increasing the incidence of diseases caused by parasites, such as bilharzia which thrive in slow-running or stagnant water; and bringing about a rise in groundwater levels in the Nile Valley down to Cairo, due to year round irrigation of the floodplain. The Nile delta, made up of the 22,000 square kilometre triangle between Cairo and the Mediterranean coast, is Egypt's bread basket. Although the delta and the narrow Nile Valley to the south make up only 3 per cent of Egypt's land, they are home to 96 per cent of the population. Fifty-nine million people live in the Nile delta and the population is increasing by one million every nine months. In some places the population density in the delta is as high as 1,200 per square kilometre.

This delta, as well as a shelf extending far into the sea, was formed by sediments brought down by the Nile from north-eastern Africa and deposited at its mouth. The coastline is now retreating as sediments no longer replenish the delta and saline groundwater has penetrated up to 30 kilometres inside the delta. Homes have started to fall into the advancing sea. At the mouth of the Nile the flow is so diminished that the sea is actually filling in the river channel with its own sediments; sea-level rise compounds the problem. Thirty-five years ago the river had an average depth of 10 metres. Today it is dotted with islands. There are fears that the sea may break through Egypt's coastal barrier beaches, flooding precious agricultural land and starting to reclaim the delta.

Although managers are not yet sure whether the complex function of natural wetlands can be perfectly mimicked artificially, they are sure that in the long term, the natural wetland system can perform certain functions, such as improving water quality, at a lower cost than the technical engineering solutions.

Lake Kerkini: a man-made Ramsar site

In 1932, a small wetland on the floodplain at Kerkini in northern Greece, was transformed into a reservoir by the construction of a dam. Situated on the floodplain of the River Strymon, the reservoir was intended to provide irrigation water for crops such as maize and rice in the Serres plain, further downstream. It was also designed for flood control.

However, fifty years later the reservoir has lost nearly two-thirds of its storage capacity due to siltation of the lake caused by sediment, from soil erosion, being brought down by the River Strymon. Because of this siltation, a higher dam and new embankments were constructed in 1982. As a result there was flooding of previously dry areas which has led to major changes to the habitat and landscape of the area.

Greek lakes offer refuge to some of the remaining 3 500 pairs of Dalmatian pelicans.

M. Gunther/ BIOS

M. Gunther/ BIOS

Owing to the man-made modifications to the ecosystem, with the construction of a new dam, many changes in breeding and wintering birds have been observed at Lake Kerkini.

Because of the rise in water levels, the number of breeding aquatic birds typical of reedbed habitats declined, and fish-eating species preferring deeper open-water habitats increased. Between 1982 and 1991 studies carried out on the wintering birds at Kerkini showed that they are now different from those species found in the same wetlands before 1982. This is due to the major alterations to this particular wetland, rather than to an overall change of migration patterns in the region. As far as breeding birds using the habitat are concerned, the numbers of fish-eating birds, particularly diving birds such as cormorants *(Phalocrocorax carbo)*, rose substantially because of the increased fish in the lake. These species are also attracted to the flooded trees, which provide suitable night and day roosting sites. Owing to a decrease in the area of shallow marshes, wintering shorebirds such as black-tailed godwit *(Limosa limosa)*, dunlin *(Calidris alpina)* and avocet *(Recurvirostra avosetta)* have practically vanished from the lake.

In addition to wintering and breeding birds, there has been a great increase in the numbers of non-breeding fish-eating species such as Dalmatian pelicans and great white pelicans *(Pelecanus onocrotalus)* during the spring and summer. In the particularly wet spring months of 1986 and 1991, up to 600 pelicans were counted feeding on the spawning sites of fish in newly flooded areas.

A rich fish fauna of at least 25 species is found in Kerkini, although eels have decreased rapidly in recent years, probably because of the dam which prevents the young of this migratory species from entering the lake.

The overall changes that have taken place in the fish and bird populations of the Lake Kerkini ecosystem between 1982 and 1991 are positive, as compared with the diversity and the abundance of species present before 1982. However, scientists are voicing

J.P. Taris

The Doñana wetland is an area of great natural beauty and is also of cultural importance for traditional religious festivals.

doubts about the future of Kerkini's flood forest, which is considered to be a key factor in maintaining the lake's rich biological diversity.

The natural vegetation of the Lake Kerkini watershed is rich and diverse, providing local people with valuable grazing.

The 25,000 hectares area covered by natural vegetation is grazed by 14,500 cattle, 27,000 sheep and 5,000 goats belonging to the region's village communities. However, the forest is declining.

The lengthy flood period, cutting by local people and overgrazing is preventing the growth of new reedbeds and trees. While experts are calling for new management steps to be taken to reconcile economic interests with those of nature conservation, the government is going ahead with plans to raise the dikes around the reservoir, further aggravating the situation.

Lake Kerkini is an example of a man-made lake which possesses many of the functions of a natural wetland as well as providing valuable economic resources in the form of irrigation, fishing and grazing sites. The international importance of Lake Kerkini is such that it is classed as a Ramsar site.

The cultural importance of wetlands as heritage sites

For centuries, wetlands have played an important role in cultural activities.
In southern Spain an annual pilgrimage at Pentecost takes place across the marshes of Doñana to the village of El Rocio, a tradition which dates from the 15th century.
Half-a-million participants make their way to El Rocio on foot, on horseback or by oxcart to pay reverence to the statue of the Virgin. The marshes of the Doñana have always played an important role in the festivities.
Up until recently the only way for many "pilgrims" to reach El Rocio was by crossing this beautiful and isolated wetland. At night they would rest at the mystical palace, or "Palacio", in the heart of the Doñana. Gypsies, peasants and their companions lit their camp fires around the "Palacio" and turned their animals loose to graze the marshlands.
Today this trek to the shrine of El Rocio still takes place, although the "Palacio" has been turned into a biological research station. During the week of festivities,
the otherwise closed National Park of Doñana is thrown open so that the modern-day pilgrims may once again make their away across the marshes to pay homage to Nuestra Señora del Rocio.

J.L. Gonzales G./ BIOS

El Palacio, in the heart of the Donana National Park.

S. Zalewski/ BIOS

The economics and pricing of wetland values

In spite of the importance of wetlands to the community, the range of products and services they provide has traditionally been taken for granted. As a result, the maintenance of natural wetlands has received low priority in most countries. But even as apathy and ignorance continue to permit the destruction of wetlands, loss of the benefits they once provided free of charge is being increasingly felt.

Most authorities operate on the unrealistic assumption that natural systems can cope with the impact of pollution, diversion, irrigation and drainage. It is only when these systems disappear, or massive algal blooms occur, or water quality declines, that the community realizes its dependence on the system's natural functions. There is a growing appreciation that replacing functions like flood control, water purification, or groundwater recharge once they have been lost is extremely expensive. It is often more rational, and cheaper, to plan to maintain them in the first place.

Environmental degradation is generally due to the economic forces which have long promoted, and continue to promote, economic growth at the expense of environmental quality. The current economic system measures only what is traded, and takes no

Psarades, Greece: tourists relaxing in the summer sun and enjoying fresh fish from the lake.

J.F. Noblet/ BIOS

The "polluter pays" principle is a fundamental concept which recognizes that the full costs of effluent treatment should be borne not by the river or lake into which it is dumped, or by its riverine residents, but by the polluter (e.g. farmers, factories). Its application has so far largely been directed at industry, while farmers have escaped for the time being.

account of the degradation, or loss, of the capital natural resource base. A tropical forest tree, for example, has no monetary value in the current system until it is cut and sold for timber.

Both conservationists and economists have promoted the argument that if the natural environment has a "value " for people, then, by definition, it ought to be possible to calculate its price in monetary terms. Since the early 1970s economic scientists have increasingly attempted to calculate the economic benefits of maintaining a healthy environment and to integrate these quantitative monetary prices, which are currently not adequately accounted for by the market system, into assessments of national wealth. While this concept is intellectually viable, developing formulae which put clear, precise monetary values on natural services has proved extremely complex and is still some way from being operational. Under classic economic theory, an object's value is determined by the market, and results purely from the relationship between supply and demand. But for products or services which are not thus traded, their value can only be established by rather circuitous means.

This chapter does not seek to present in detail the complex economics involved in determining the monetary values of different functions and benefits of wetlands, but simply to introduce the subject and to explore the most important trends of the various approaches. Much of the research on this subject has been carried out in the United States of America, and consequently

The benefits of maintaining a healthy, functioning wetland are not traded on the market, and therefore do not contribute a monetary value to assessments of national wealth. This is known as "market failure".

there are very few Mediterranean examples directly linked to wetland issues. As with all scientific disciplines there are various schools of thought employing different methods, although there is general agreement on the issues presented here.

The most important consequence of this work is that non-quantifiable values are increasingly being taken seriously in decision-making, rather than simply relying on the value of marketable products.
A broad distinction must be made at this point between public and privately-owned goods and resources. The natural environment is a public good as it is not owned as private property. It therefore belongs to humanity as a whole, and is not normally bought or sold. One might therefore argue that no-one has the right to make personal gain, or to cause damage, through pollution for example, at the expense of the community. However, the legal and fiscal system, which acts to regulate the market, makes things extremely complicated at the interface between public and private goods.

The loss of upstream wetland, canalisation and dyking of the floodplain all increase the risk of floods downstream. Arles was twice threatened by "one-hundred-year floods" of the river Rhône during the winter of 1994-1995.

One of the key reasons for market failure is the so-called "externality" or "side-effect". These occur as a result of the lack of appropriate legislation and work in a number of ways, which can be positive or negative. For example, when air pollution leads to acid rain and causes crop damage, the economic loss should be borne by the polluter. In fact it is shared by all those who suffer

B. Pambour/ BIOS

The fundamental basis of economic theory, established by Adam Smith in 1776, is that no altruism is required for a market system to work well. A market is always an exchange between individuals, and no-one need give unilaterally to others.

from the "fallout". This impact, and the resulting loss, is an externality of the industry causing the pollution.
A second example might be a Mediterranean river with major dams. The sediments previously carried to the delta are withheld and the coastline begins to erode. The erosion control measures and the strengthening of sea defences, which are consequently necessary, should be considered a component of the economic viability assessment of the dam. Such externalities remain unaccounted for by the market, and are usually paid for directly out of state funds. This is, in effect, a direct subsidy towards the true costs incurred by damming the river.

An example of a positive externality might be the attractiveness of salines for birds, although they are designed purely for the production of salt from seawater by evaporation; tourism may also benefit from this positive externality.
Wetlands are classic examples of multiple-value systems where prioritizing one use over others almost certainly causes losses elsewhere. For example, when 1,000 cubic metres of water are removed from a river, piped to a farm and delivered to an irrigated plot, the price of the water is largely determined by the investment and management costs of the necessary infrastructure. However, no allowance is made for the loss of other services which that volume of water may have provided to fisheries, purification processes, aquifer recharge or sediment transport downstream. This loss, which is known as the opportunity cost of using the water for irrigation (i.e. income foregone from potential other uses), is frequently ignored. The classic example is the collapse of the sardine fishery following the building of the Aswan dam on the Nile, and the cessation of nutrient outflow. The annual cost of this loss of production should, in principle, be set against the economic benefits (although it is unlikely that it was sufficiently high to have justified re-evaluating the project).

The economic value of wetlands is substantial. Although there are few data on the global worth of wetlands in the Mediterranean basin, the value of wetlands in the United States is well documented. In 1986 it was estimated that America's wetlands contribute to a commercial marine harvest valued at over US$10 billion, support a fur and hide harvest worth US$300 to US$400 million annually, and are the basis for over US$10 billion in annual expenditure on nature study, fishing, hunting and other outdoor recreation.

Many wetlands are therefore lost because their full value to society is not taken into account during the planning process.
The relatively new and rapidly developing science of environmental economics attempts to place a financial value on the many services and functions of wetlands in order to integrate this figure into the cost-benefit analyses of local development programmes. The economic evaluation, or assessment, of an ecosystem is difficult to calculate and is very much a new science, still in its infancy. What this calculation would achieve is the quantification and valuation of the resources, benefits and attributes of the system. These data could then be integrated into the cost-benefit analysis of any given project.
Wetlands have natural functions, such as water purification and flood control, and economic uses such as recreation and resource

The economics and pricing of wetland values

harvesting. Both their functions and uses have economic values. To make these values explicit, economists have broken down the monetary values of wetlands into three main components, two of which, direct use and indirect use values, are relatively easy to assimilate into current economic systems, although the third (non-use or existence values) draws more on ethical and philosophical positions concerning attitudes to nature.

Direct use values are all those benefits which accrue from direct sale of wetland products, such as fish or reeds and from tourism use. Indirect use values include all the services and functions of wetlands such as flood control, sediment transport and water quality maintenance which are not traded on the market.
The third category includes all the aesthetic and cultural values of wetlands which are as much the domain of philosophy and ethics as of economics.

Leisure activities, tourism and navigation are all examples of non-ecological services provided by wetlands.

P. Fagot/ BIOS

Striving in Turkey's Göksu delta for integrated management

Turkey is maybe one of the few Mediterranean countries that has not yet fully exploited its agricultural and touristic potential. Rapidly expanding, Turkey still offers a rare glimpse of traditional farming methods and a view of how northern European countries must have been 50 years ago. Bird species abound and wild flowers are not yet mercilessly bombarded with herbicides. But the landscape is changing under the heavy pressure of tourism and expanding agriculture.

The 15,000-hectare Göksu delta is rich in natural resources and is an internationally important area for waterbirds.
The environment of the delta has changed rapidly over the past 60 years and it is now used extensively for agriculture. There are plans to irrigate and drain a further 4,060 hectares and to build at least 2,500 more holiday homes along the coast. An airport is planned as well as a huge dam on the Göksu river, 10 kilometres upstream of Silifke.

The development of agricultural activities will bring adverse ecological changes, bringing the threat of pollution to the lagoons which will affect the valuable bird habitats and economically important fisheries. An increase in tourism will lead to a further loss of nesting beaches for marine turtles, and the dam construction will cause the loss of sediment inputs to the coast. The resulting coastal erosion, combined with the impact of sea-level rise, will increase the danger of sea incursions, threatening the loss of property, land and lives. Up until now, development policies have tended to be single-sector with each sector, whether agriculture, tourism, fishery or forestry, pursuing its own interests. There has been little understanding of how the different sectors of the system interact and overlap; no institutional structures have been able to undertake the global planning of the delta.

With so much at stake, wetland experts are pushing for a change of approach. If the sectoral development attitude to resource management persists, it will eventually result in the costly degradation of the delta's resources. Turkey's leading nature protection society (DHKD) is recommending that planning decisions be based on an understanding of the tight-knit relationships between the different wetland components, a desire to maintain the many values of the wetland and the need to avoid irreversible damage to both the delta's renewable resources, such as water, and non-renewable resources such as land.

An integrated planning approach would view the whole Göksu delta as a unique set of linked systems rather than as a range of unrelated resources that are individually exploited, with no regard for the impact on the neighbouring resources and their users.

Direct use values

In general, the direct use values gained from a wetland are obtained by harvesting and selling the wetland's resources – natural products which are traded on the market. Prices for these goods therefore fluctuate with supply and demand and are easily quantifiable. This includes income derived from the economic uses made of a wetland's resources and services, e.g. grazing and fishing, both of which are direct uses of the wetland ecosystem.

In the wetlands of the Petite Camargue, France, reed cutting in the Etang de Scamandre is a strong cultural tradition. The reeds are exported to northern Europe for use in thatching and their sale provides an annual income of around US$3,500 per hectare.
In the Camargue, hunters may pay up to US$30,000 for waterfowl hunting rights, making this one of the most lucrative activities for wetland owners.

Recreation, tourism and navigation are special cases of non-ecological services performed by wetland systems that also involve direct use value, but no decline of the resource ("non-consumptive use").

A valuation method known as the travel/cost approach can be used to calculate the value of recreation and tourist activities. The value of visiting a wetland area is expressed in terms of the cost of travel and of travel time via foregone wages. For water transport, the value can be expressed by the price of an alternative means of transport. Unfortunately this remains necessarily rather subjective as visitors rarely visit a wetland alone, but may include them in a more complex itinerary.

The biological diversity of the ecosystem as a whole might also have direct use value for scientific research, educational purposes and as a source of genetic material.

The financial analysis of Ichkeul National Park, Tunisia

There are few examples in the Mediterranean basin where an economic breakdown of resources and their worth has been carried out. The Ichkeul National Park in northern Tunisia has been the object of such a study, to establish the use and non-use values of the wetland.

Environmental economics have been used to justify the park's continuing existence, both as a wildlife haven and a natural resource vital to man. Garaet el Ichkeul is a 90-square kilometre lake with an additional 36 square kilometres of seasonally flooded marshes. The system's water is fresh in the winter, but highly saline in the summer. This wetland is an area of international importance for waterfowl and is both a National Park and a Ramsar site (since 1980).

However, a national water resources plan aims to dam and divert all six rivers feeding the Ichkeul wetlands by the year 2000. Two dams have already been completed and a third is under way. The water is to be used for drinking and irrigation in Cap Bon and Tunis, and for irrigating the floodplains bordering the lake.Hundreds of thousands of waterfowl winter on the freshwater lake and others pause there to feed after migrating over the Sahara. The dam scheme will greatly increase salinity in the lake and kill off the waterfowl's food plants, make grazing impossible on the marshes and seriously affecting the fishery associated with the lake.If efficiency is measured in terms of profit or revenue per unit of water, the benefits from releasing water from the dams to preserve the current ecological functions of Ichkeul are greater than those to be gained from alternative uses, and above all from agricultural irrigation.

Diverting water from Ichkeul does not have zero opportunity cost. The financial calculations on the viability of the Ichkeul dams should include losses from a US$600,000 annual fishery, grazing resources in the dry season for 9,000 animals, internationally important concentrations of waterfowl, a tourist attraction unique in the country, and the unquantified heritage value. These losses should be set against the economic benefits of the dam scheme on an annual basis.

The economics and pricing of wetland values


J. Boutin/ BIOS

Reeds cut in the Petite Camargue are exported to northern Europe for roof thatching.

Indirect use values

This category covers all of the hidden, but useful, functions provided by wetlands to the water cycle, and to economic activity and property by the wetland's natural functions – "environmental services".

The lack of awareness on the part of the public and politicians about the true and multiple values of wetlands, and the consequent lack of public demand for their maintenance and conservation, have been a fundamental cause of wetland loss in the past.

All the hydrological functions of wetlands have indirect use values, their values coming from supporting economic activities that have measurable values. For example, flood control by wetland systems can protect agricultural production and property. Groundwater recharge replenishes aquifer supplies that are used for domestic, agricultural and industrial purposes. Sediment retention helps prevent siltation of irrigation networks downstream, while replenishing the fertility of agricultural floodplains within the wetland area.

These services pose a dilemma for the economist trying to assess the value of an untraded product. A partial solution is found by asking "what would be the cost of replacing this function if it no longer occurred naturally?". To take the example of the function of water purification, the cost of treatment of the equivalent volume by chemical means would give an approximation of the value of the natural function.

The disadvantage of the method is that functions virtually have to disappear and be artificially replaced before their true value can be ascertained. However, this recognition is one of the principal forces behind the growth in wetland restoration projects, which are increasingly seen as a means of replacing these lost values.

Difficult as indirect use values may be to calculate, they should not be underestimated as they may well prove to be far more valuable than direct use values in the long run.

Some replacement alternatives for values provided by wetlands

VALUES	REPLACEMENT ALTERNATIVES
Peat Accumulation	
● Accumulating and storing organic matter (peat)	● Artificial fertilizers
Hydrologic Function	
● Maintaining drinking water quality	● Pipeline to distant source
● Maintaining groundwater level	● Well-drilling
● Maintaining surface-water level	● Irrigation pipes and machines -
● Moderation of water flows	● Regulating gate
Biogeochemical Functions	
● Processing sewage, removing or transforming nutrients and contaminants	● Sewage treatment plant
● Maintaining drinking-water quality	● Water purification plant
● Filter to coastal waters	● Nitrogen reduction in sewage treatment plants
Food-chain Functions	
● Providing food for humans and domestic animals	● Agriculture production
● Providing cover	● Roofing and fencing materials
● Sustaining anadromous trout populations	● Releases of hatchery-raised trout
● Sustaining other fish species and wetland-dependent flora and fauna	● Work by non-profit organizations
● Species diversity; storehouse for genetic material	● Replacement not possible
● Birdwatching, sportfishing, hunting, and other recreational values	● Replacement not possible
● Aesthetic and spiritual values	● Replacement not possible

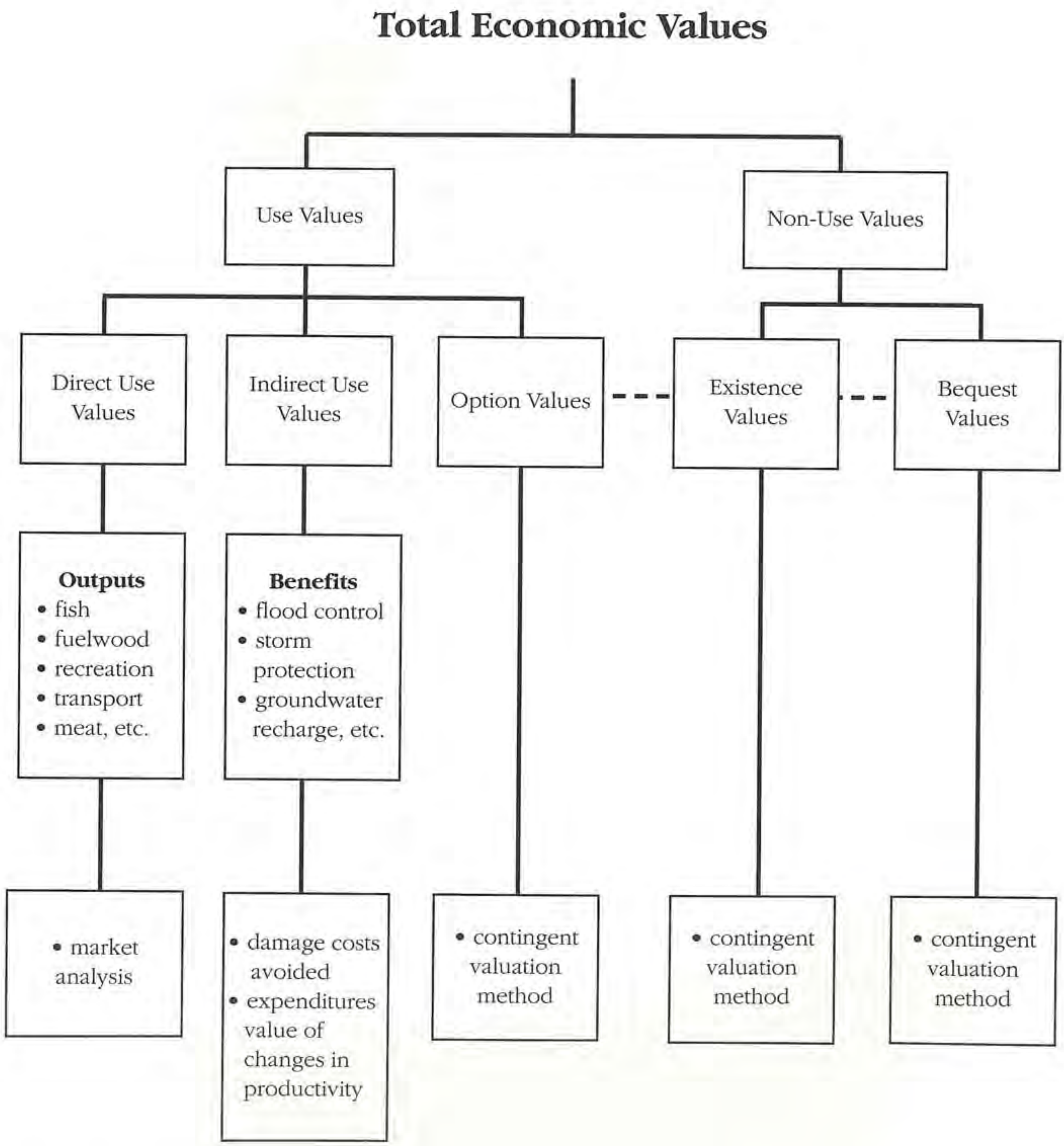
Source : Adapted from Folke and Kåberger, 1991

Non-use/existence values

Ask a resident of the city of Montpellier whether the thousands of flamingos on the nearby lagoons are worth conserving and the answer will certainly be "yes!". This is a subjective valuation based on the emotions of the individuals concerned who consider that the flamingos have a value and should be conserved. They would probably also go further and say that they would like their children and future generations to enjoy them as well.
This view would then embody the twin notions of "existence value" and "heritage value".

Philosophers argue that economics plays no role in determining the worth of individual species. If the loss of a particular habitat involves non-trivial and irreversible losses (species extinction, for example), the limits of economic analyses are crossed, and ethical reasoning is more appropriate. Many argue that all species should escape extinction unless the costs involved are unbearable by this generation.

Estimating non-use values or preservation values is even more controversial than estimating other values. The general approach is to find out from individuals how much they are willing to pay to preserve wetland attributes, or alternatively, how much they are willing to accept in compensation for their partial or complete loss. This gives rise to questions like "how much are you willing to pay to preserve a pelican?" The average of this figure, multiplied by the number of people who are prepared to pay, gives some notion of the intrinsic worth of pelicans to these people. However, economists point out that this value is unlikely ever to be realized, nor is it cumulative for all species – an individual may be willing to make a one-off payment of US$50 for a pelican, but not if he or she has also to pay an equivalent sum for an elephant, a flamingo, a tiger and all the other endangered species in the world. Those who contribute financially to environmental organizations are demonstrating their willingness to pay for nature conservation. Some people find value in wetlands without ever benefiting directly or indirectly from their services and components.
They derive satisfaction from simply knowing that a wetland exists – this is its existence value – and will be preserved. Similarly, some people may have no intention of using wetlands, but value the fact that future generations will have the opportunity to use them.
This is known as their heritage or bequest value.
Finally, economists identify what they call an option value.
This can be described as an extra insurance against the risk of losing wetland services and resources whose real values are as yet unknown. This is a hypothetical value and can play little part in decision-making. The importance of the idea lies in the realization that by not doing something, the potential for future economic gain is left open.



Source : E. Barbier (1989)

M. Gunther/ BIOS

Conclusion

Wetland management programmes can run into trouble through lack of an effective market or fiscal structure for services provided by private individuals for the public good. For example, a farmer sets aside a wetland area and does not farm it. If the area attracts tourists due to its landscape value, it will be restaurant or hotel owners who benefit financially and not the private farmer who has nevertheless foregone the potential economic benefits of wetland conversion.

Much of the work on wetland values is in its infancy and the approach remains rather theoretical. There is, as yet, no universally accepted method which can be applied to valuing wetland systems throughout the Mediterranean region. However, economic valuation provides a widely compatible and understandable quantitative measure of wetland utility, which allows objective and rational decisions to be made regarding wetland conservation and their role in integrated development.

Direct use of a wetland area by harvesting of resources may in the long term significantly affect fragile ecological and hydrological relationships. It is important to calculate the balance of trade-offs between direct uses and the long-term sustainability of important environmental functions, which may not be immediately apparent.

However the most important conclusion is not that a standardized evaluation method does not exist, but rather that there is a clear trend towards recognizing the intrinsic values and worth of the wetland environment and the processes therein.

This represents a willingness to integrate the wider concepts of wetland value into existing economic methodologies based on the market economy, and should contribute to improved appreciation of the need to conserve wetland systems for the future.

The marshes of the Coto Doñana National Park must share the available water supply with local farmers.

Glossary

Aerobic : an organism that lives only in the presence of oxygen.

Anaerobic : an organism or process that operates in the absence of oxygen.

Aquifer : porous rock containing water.

Bilharzia (schistosomiasis) : tropical flatworm parasitic in human circulation system.

Biomass : total weight of organisms in a given area.

Eutrophic : rich in nutrients and hence having excessive plant growth which kills animal life by deprivation of oxygen.

Externality : side effect of a given economic decision.

Floodplain : the floor of a valley over which a river may spread during short-lasting or seasonal floods.

Groundwater : the water stored within an aquifer.

Microorganism : organism not visible to naked eye (e.g. bacterium or virus).

Peat : black or dark brown mass of partially decomposed plant material formed under anaerobic conditions.

Pelagic : of, or performed on, the open sea.

Phytoplankton : plankton consisting of plants.

Silt : fine sediment deposited by water in channel, harbour, delta etc.

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The **Station Biologique de la Tour du Valat** was established in the Camargue (France) in 1954 by Dr. Luc Hoffmann as a private research institute, primarily for field ornithological studies.

In 1995 the estate consists of 2500 ha of land belonging to the Fondation Sansouire, created under French law in 1976. The estate is one of the few in the eastern Camargue on which extensive areas of near-natural landscapes have survived the post-war expansion of arable agriculture. Funding for the research and conservation programme of the major part of the core funding is provided by the Fondation Tour du Valat, a foundation under Swiss law.

The scientific programme of the station has evolved over the years, and has included programmes on the management of vegetation using domestic herbivores, fish ecology, optimal foraging strategies, behavioural studies, and migration and breeding success of colonial waterbirds. Most of these studies have been undertaken in the Camargue, but the Station has increasingly worked in collaboration with other scientists in the Mediterranean region.

This programme has provided the Station with a fundamental understanding of Mediterranean wetland ecology which can be applied to wetland management problems in the region.

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