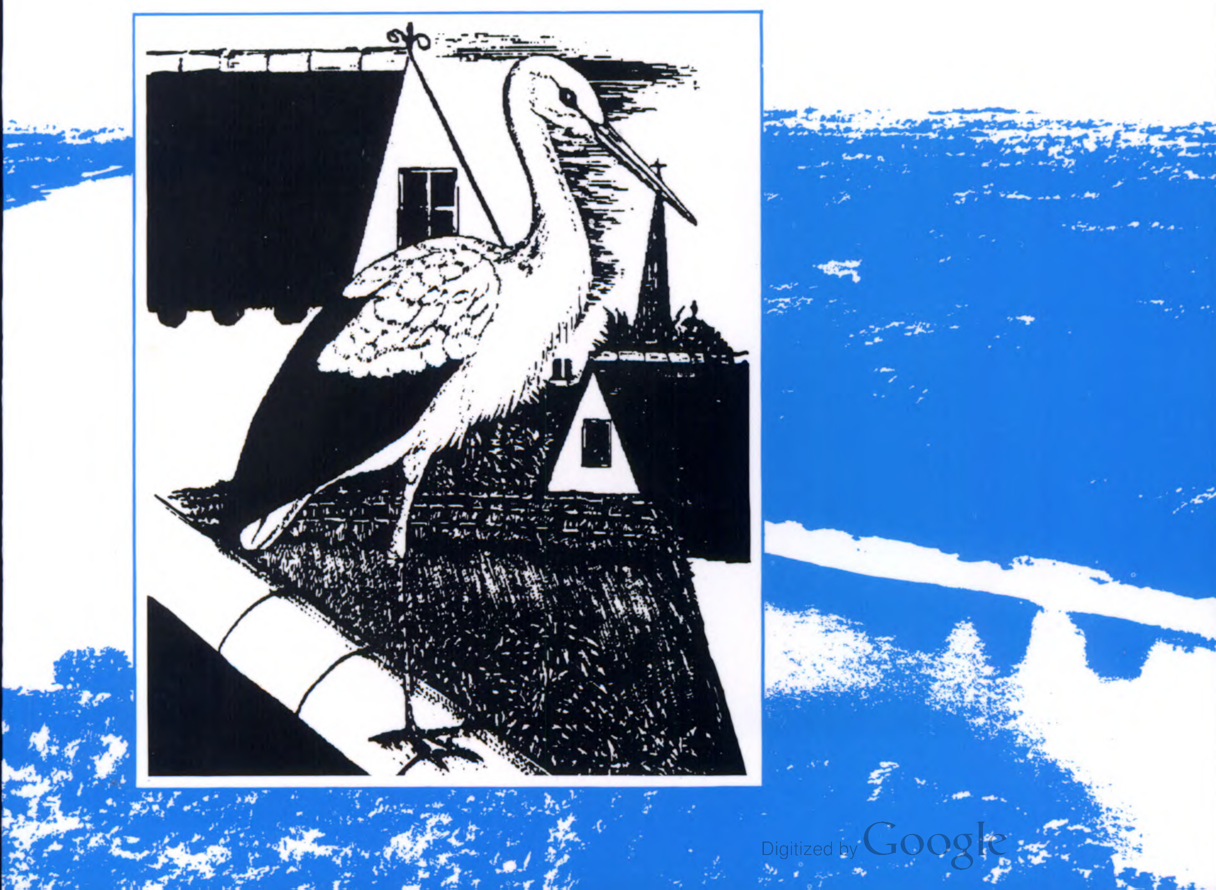
World Conservation Union

East European Programme

Environmental Status Reports

Volume Four:

Conservation Status of the Danube Delta



IUCN EAST EUROPEAN PROGRAMME

Environmental Status Reports

Volume Four

Conservation Status of the Danube Delta

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FOREWORD AND ACKNOWLEDGEMENTS

After many years of isolation, three representatives of the new Romanian government attended the IUCN East European Programme Advisory Group meeting for the first time in February 1990 in Moscow. They invited IUCN to help coordinate plans for nature conservation in Romania, particularly of the Danube Delta.

The IUCN East European and Wetlands Programmes convened a meeting in April 1990 of international organisations interested in working with the Romanian government for conservation of the Danube Delta. Dr Vadineanu, Dr Gomoiu and Dr Toniuc attended from Romania. Organisations present at the meeting were: ICBP, IWRB, Ramsar, Unesco and WWF. In addition, three experts from the Netherlands, UK and USA attended.

Representatives of those organisations were designated as the Steering Committee for International Assistance for Conservation of the Danube Delta at a second meeting in Montreux, Switzerland in July 1990. The Steering Committee has since met in July 1991 and April 1992.

This status report has been compiled by the offices of IUCN's East European Programme. It is a revised, updated and restructured compilation of the draft chapters by individual experts prepared following recent missions to the Delta and including research material as it first appeared in the Draft Report: Conservation Status of the Danube Delta, IUCN Mission September 17-27 1990. (May 1991).

Our grateful thanks go to Dr Angheluta Vadineanu, Secretary of State for the Environment, whose untiring efforts in pursuing protection of one of the most important natural sites in Europe, have gained the admiration of the international conservation community. Also to Dr Gomoiu, Governor of the Danube Delta Biosphere Reserve, Dr Baboianu and his staff at the Danube Delta Research and Design Institute in Tulcea and many others.

We owe special thanks to all who freely provided us with data that they had collected over many years under very difficult conditions and were never able to publish.

Dr Patrick Dugan together with Liz Hopkins provided extensive editing and new material to the May 1991 text. Individual authors provided additional comments to Carol Inskipp who standardised, revised and edited the complete May 1991 report.

Specialised editing was carried out by Kate Ward on Chapter 1 and Chapter 5, by John Norton on Chapter 8 and by Liz Hopkins on Chapter 10.

Mari and George Gömöri translated J. B. Kiss's article from Hungarian, which formed the basis to a draft of Chapter 10 prepared by Barbara Karpowicz.

Elizabeth L. Falconer translated from the Romanian the Organisational Structure Chart for Chapter 9 and Margreith Kemp translated Chapter 8 from the German.

Overall coordination was by Dr Z. J. Karpowicz.

INTRODUCTION

The Danube Delta is the largest in Europe, covering a total area of some 550,000ha, over 400,000ha being in Romania, the rest in Ukraine.

The Delta was declared a Biosphere Reserve in September 1990, a Ramsar site in May 1991, and over fifty per cent of its area was placed on the world Heritage List in December 1991. Overall, protection has been extended to 679,000ha of the Delta, parts of its floodplain and marine area.

Within the protected area is possibly one of the largest expanses of reedbeds in the world and at certain times of the year the majority of the world population of the red-breasted goose *Branta ruficollis* pygmy cormorant *Phalacrocorax pygmeus* are found. Both these species are threatened on world scale. Five per cent of the world breeding population of the Dalmatian pelican *Pelecanus crispus* can be seen in the Delta.

Little is known about the mammal populations. It is possible that the Delta is one of the last European refuges of the European mink *Mustela lutreola* and there are populations of other important mammals such as the wild cat *Felis sylvestris* and otter *Lutra lutra*.

The fish fauna is rich with 75 species belonging to 22 families. The majority of these (44) are freshwater species, the others being suryhaline migratory species that occur in the Black Sea and visit the Delta mainly during the breeding season.

Apart from the extensive beds of *Phragmites australis*, characteristic vegetation includes water lilies and on higher ground willow, poplar and oak. Forest vegetation is particularly interesting in the sandy former beach-barriers of Letea and Caraorman where climbing plants (including lianas) are a feature.

The health of a delta is a barometer of the health of the rivers that flow into it. Chapter 5 examines water quality in the Danube Delta and notes in particular high nutrient loads in the Danube river and changes in the hydrological regime of the river over the last few decades as possible causes of deterioration.

The northern Dobrudja is celebrated for the numbers of ethnic groups which have settled there over the centuries. In the Delta, Turks, Tartars, Macedo-Romanians and Slavs are amongst those which are still distinguishable. The best-known of the several Slav groups are the Lipovans, descended from refugees from Tsarist persecution in the late 18th century. The Lipovans steadfastly maintain their language (Ukrainian) and many of their customs, including observance of the Julian rather than the Gregorian calendar. The Slav groups, being skilled fishermen, are the closest to the heart of the Delta ecosystems and their villages are scattered throughout the Biosphere Reserve.

The challenge to governments, NGOs and financing organisations is to assist the Romanian government and the Biosphere Reserve Authorities to preserve the rich natural heritage of the Delta while ensuring the material well-being and dignity of its inhabitants.

CHAPTER 1: MORPHOLOGY, CLIMATE, GEOLOGY AND SOILS

L. J. Pons

1.1 Introduction

The Danube is one of the four largest rivers of Europe (Figure 1.1). It has a length of 2,860km, a catchment area of 805,300km^2, and runs through eight countries. Analysis of river flows indicates a mean discharge of 6300m^3/sec, with 1% of flows less than 1800m^3/sec and 95% of flows less than 17,000m^3/sec. At Tulcea, situated almost at the head of the Delta, river water levels vary between approximately 0.75m and 4.5m above mean sea level. High levels normally occur in March, April and May as a result of rain combined with melted snow from the mountains of the catchment (the Alps, the Carpathians and the Balkan massifs). The climate in most of the catchment area is continental with very low rainfall in summer and autumn, resulting in lowest water levels in August, September and October. However, maximum and minimum discharges, as well as the times of the year in which they occur, are variable (see Figure 1.2).

The Danube Delta (Figure 1.8) shows the classic form of a delta, being a very flat triangle with its apex at the point of division of the branches of the river. East of this point the valley widens giving way to the Delta proper which extends for about 100km in both length and width before discharging into the Black Sea. The total area of the Danube Delta, including the Ukrainian part, is about 564,000ha, of which 442,300ha lie in Romania.

The river branches into three main courses; from north to south these are the Bratul Chilia, Bratul Sulina and Bratul Sfîntu Gheorghe (Bratul Sf. Gheorghe). At low river discharges, they transport 60%, 21% and 19% respectively of the Danube water and at high discharges 72%, 11% and 17%. The three Delta watercourses have insufficient capacity to transport the total flow of the Danube at high water periods and the entire Delta then acts as one large water-transport system. In several places downstream, and especially near the sea, the water from the backswamps (areas extending away from the main channels) and the lakes collects again and returns to the rivers. Also, creeks which originate in the backswamps and the lakes, flow directly or via small lagoons into the Black Sea.

Old maps indicate that in the Delta's original, natural state, a small number of narrow and shallow overflow creeks connected the main river courses with the backswamps in the Delta. Some of the lakes were interconnected by small winding creeks in the backswamps. It is probable that, at periods of the lowest river water levels, the backswamps and lakes were fed by small amounts of water from the river, since the river's minimum water levels

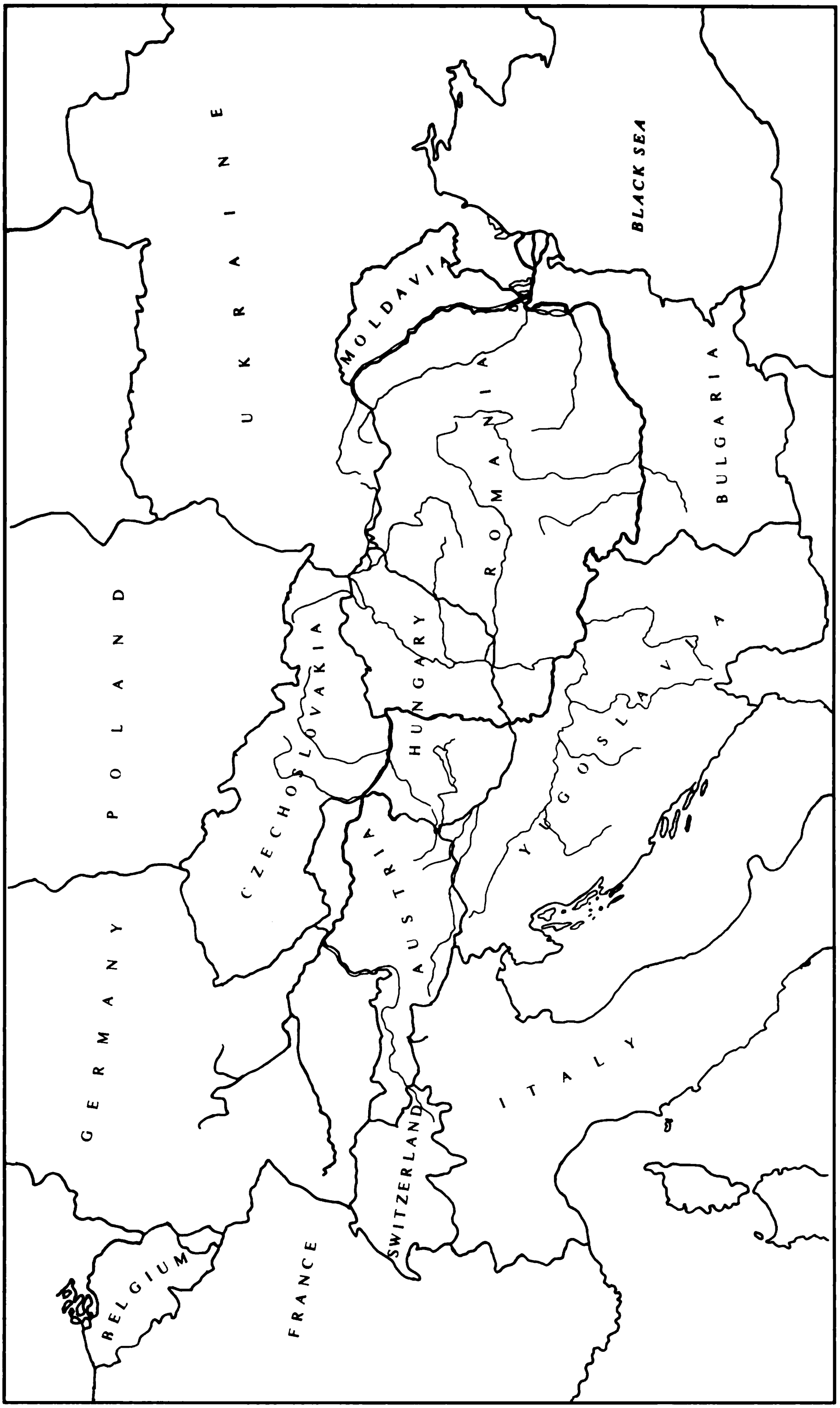


Figure 1.1. Course of the River Danube and its tributaries, showing their relative importance to the whole of Europe

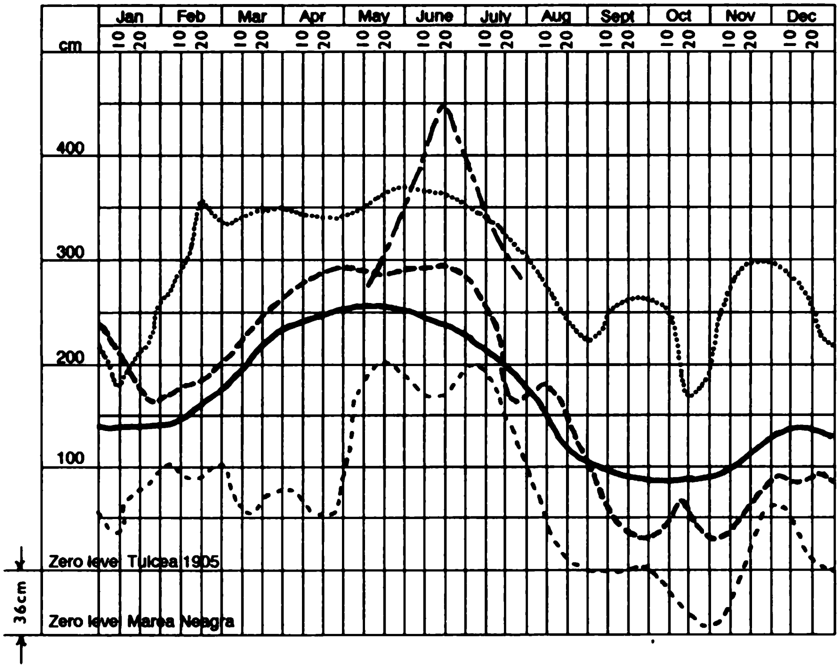


Figure 1.2.a Variations of water levels at Tulcea in some typical years

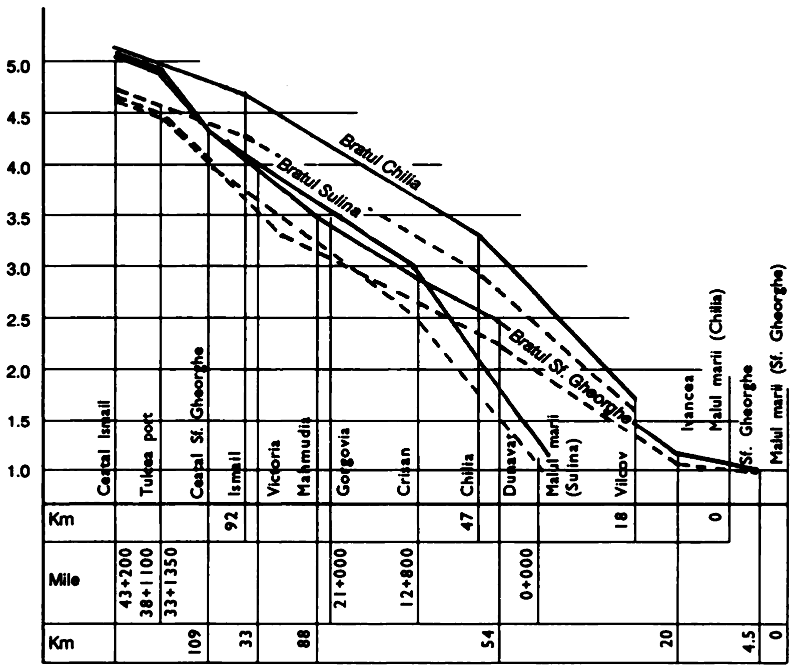


Figure 1.2.b. Maximum water levels in the danube branches with 1% and 5% limits

were probably not as low as at present. When the yearly flood rose, only small amounts of water entered into the backswamps and lakes via the overflow creeks: the bulk of the water has always entered the interior of the Delta by overflowing the river banks.

After flooding the levees (raised embankments) and entering the internal parts of the Delta, the bulk of the water is transported through the river-levee forests and the backswamp reedbeds and marshes.

The highest altitude of the Delta is at its head and is about 5m above mean sea level (measured on the natural levee). At Tulcea the natural levee is a little lower. The highest and lowest water levels of the river at Tulcea are equal to, and about 4m below, the natural levee level respectively.

Downstream from the Delta apex, the heights of the levees and of the backswamps drop gradually to near sea level. The bank profiles of the Sulina branch are shown in Figure 1.3. The bank heights are compared using hydrogrades, e.g. HG4-9, indicating river levels at 40-90% of the difference between the lowest and the highest water level respectively. It is clear that at high water, the banks are completely submerged.

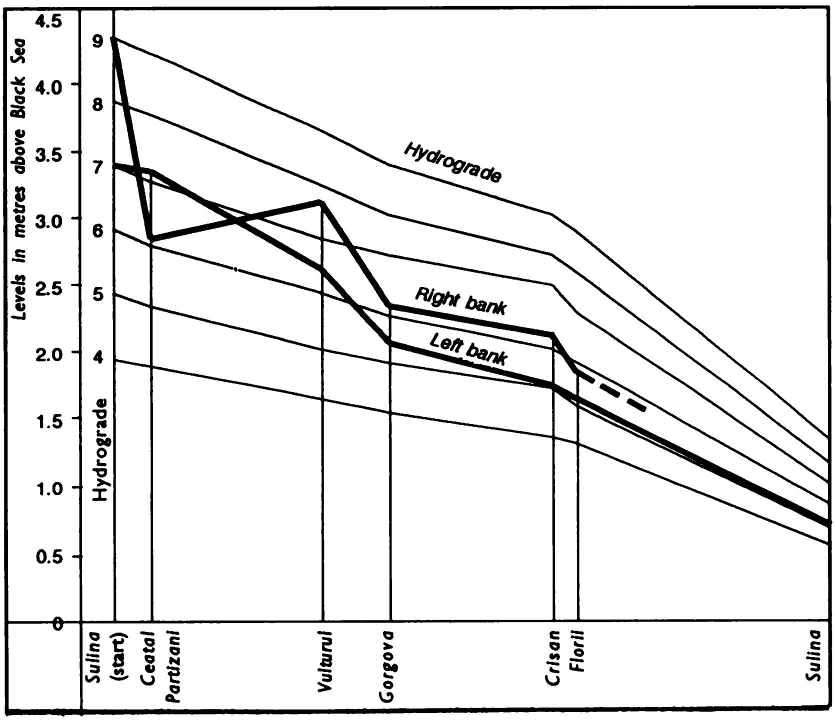


Figure 1.3. Profiles of the banks of the Sulina branch (in m above Mean Sea Level)

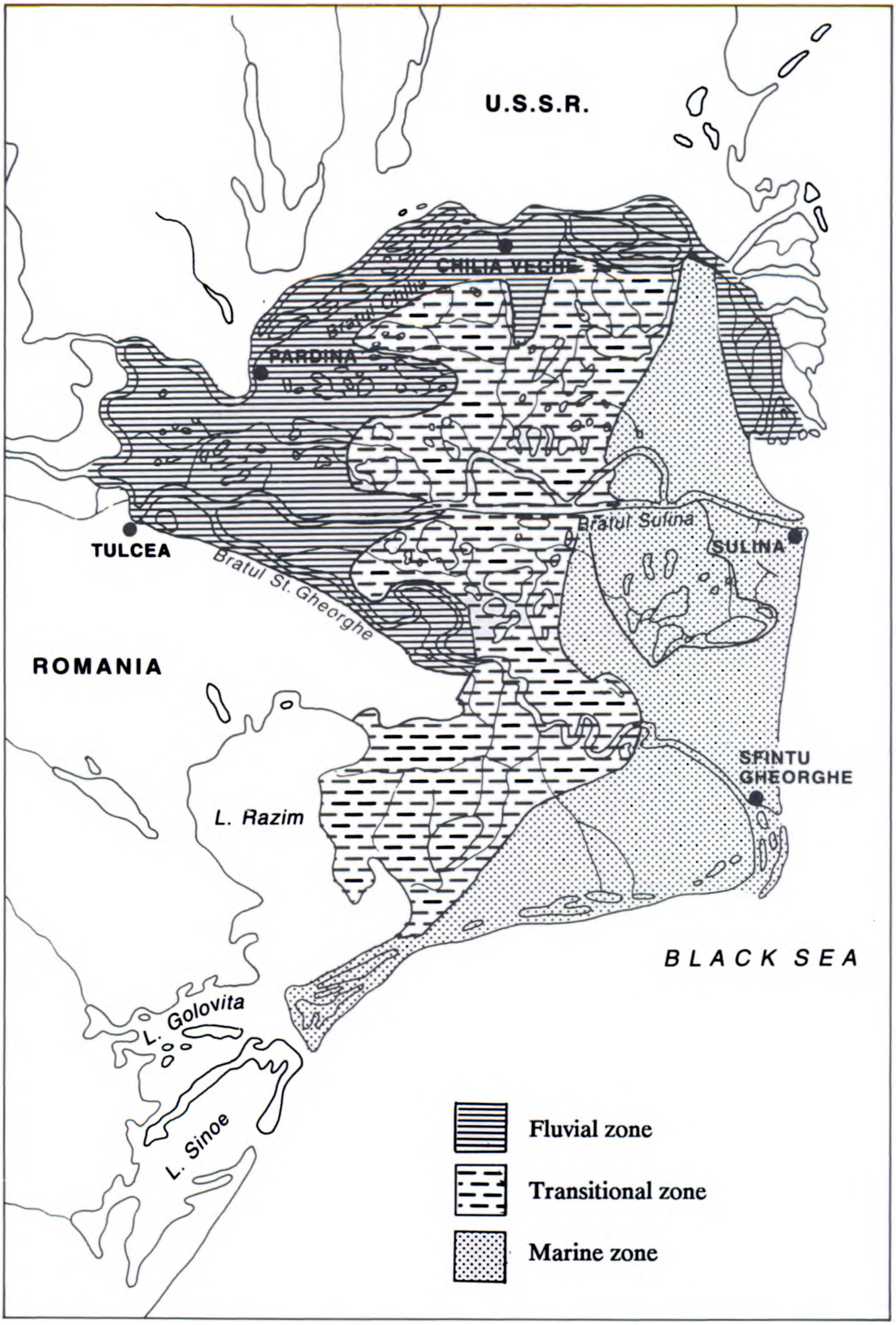


Figure 1.4. The physiographical, pedological and ecological zones

1.2 Delta zones

Three different zones may be distinguished in the Delta (Pons, 1988; Figure 1.4), based on new information on the genesis of the Delta (Panin *et al.*, 1983), the pedological data (Munteanu *et al.*, 1989) and a physical viewpoint. Each of these zones has specific physical characteristics, hydrological regimes and vegetation. The zones and their characteristics are as follows.

1.2.1 Zone 1 - The fluvial zone natural levees (Figure 1.4)

The river-levee forest is rather open with a dense to open herbaceous layer (see Chapter 8). The shrub vegetation dies during the winter and is not fully developed by the time of the spring floods, so the water speed is barely reduced and only the coarser parts of the suspended load are deposited. As a result, sandy to loamy, calcareous soils (the sandy alluvosols) are formed on the intermediate levees and loamy coarse sands on the highest ones. High biological activity within the soils destroys the primary stratification.

Backswamps and small lakes

Behind the levees, the water enters the dense vegetation of the backswamps. The vegetation consists mainly of reedswamp (see Chapters 3 and 8 for more details). Water speed is considerably reduced by the vegetation and finer particles (fine silt, clay and organic matter) are deposited. Under natural conditions, brown river water passes over the levees and into the vegetation, but the water reaching the lakes is clear.

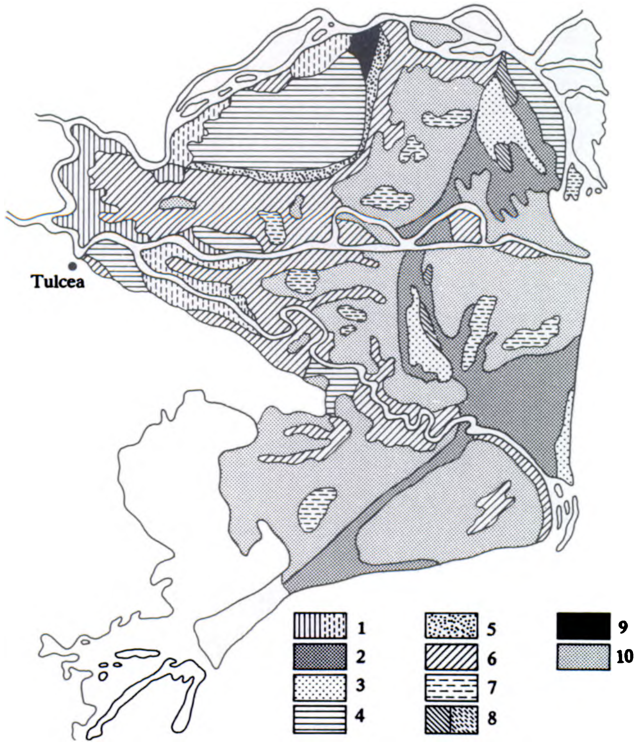
After the sandy sediments of the floodwater have been deposited over the levees, few sediments are available for accumulation in the backswamps, hence the numerous water bodies and extensive fen peats found there.

The sediments are trapped in the developing reed and mixed fen vegetation. They form black, peaty-clay to clayey-peat layers of less than 50cm thick (the gleysols), and are in the first stage of fen development. The finer part of the suspended river load (fine silt, clay and organic material) is nutrient-rich and, together with the nutrients dissolved in the river water, provides a natural fertiliser for the reeds and other plants. A very luxuriant vegetation develops with reed up to 5m high.

1.2.2 Zone 2 - The transitional zone

Lakes

In this zone deposition is less than in the fluvial zone resulting in more numerous and larger lakes. The water in the lakes is clear and poorer in nutrients, because of the more complete filtering out of sediments and the removal of nutrients. On the mostly sandy and silty lake bottoms, lacustrine 'gyttjas' (clayey organic mud) and sometimes marls are deposited (Munteanu *et al.*, 1989) (Figure 1.5).



		ha 10^3	%
1.	Sandy loamy-to-clayey loamy Alluvosols (Alluvial soils)	28.9	8.4
	a) periodically flooded	(25.5)	(7.4)
	b) unflooded (within dammed-in areas)	(3.4)	(1.0)
2.	Typical, salinized, gleyic and histic psammosols (on marine sands)	36.7	10.7
3.	Marine sands and typical psammosols (on mobile and anchored dunes, respectively)	18.7	5.5
4.	Loamy to sandy-loamy artificially drained gleyosols and alluvosols (alluvial soils) (within dammed-in areas)	31.1	9.1
5.	Loamy to sandy-loamy solonchaks and boggy gleyiosols (salinized gleyosols included)	1.4	0.4
6.	Loamy to clayey-loamy submerged gleyosols and histic gleyiosols	64.1	18.6
7.	Loamy limnosols (Gyttja) and limno-histosols (sedimenary peat)	31.3	9.1
8.	Solonchaks	5.7	1.8
	a) on loess	(1.7)	(0.5)
	b) on marine sands	(4.0)	(1.3)
9.	Loamy salinized kastanozems	0.8	0.2
10.	Typical and floating sulfidic cuhistosols	124.3	36.2
Total		343.0	100.0

Correlation with the FAO-Unesco legend: 1, a, b, Calcaric Fluvisols; 2, Calcaric, Sali-Gleyic and Gleyi-Histic Arenosols; 3, Calcaric Arenosols and Marine Sands; 4, Gleyi-Calcaric Fluvisols and Calcaric Fluvisols; 5, Salic Fluvisols and Inundi-Calcic Gleyiosols; 6, Inundi-Gleyi-Calcaric Fluvisols and Inundi-Gleyi-Mollic Fluvosols; 7, No correlation; 8 a, Solonchaks; 8 b, Sali-Gleyic Arenosols; 9, Sali-Calcic Kastanozems; 10, Sulfi-Thionic Histosols and Terric Histosols.

Figure 1.5. Soil map of the Danube Delta [after Munteanu *et al.*, 1989]

Backswamps and extended lakes

The backswamps of the Delta's transitional zone are formed in what was originally a large complex of rather deep lagoons, the former Danube and Razim Bays (Figure 1.8), as described in 1.2.1. The backswamps now form an extensive fen area with reedbeds, marshes and lakes. The water has already passed through long stretches of reedbed and contains few nutrients. Nutrient-rich water is only present immediately behind the lower river levees and along small creeks, leading directly from the river to the backswamps. Inundations in this part of the Delta are much shallower than upstream. The reed and herbaceous vegetation not only receives fewer nutrients but also grows on a peaty substratum and so is less luxuriantly developed.

Under these conditions 'plaurs' are formed. These are reed mats of several square metres, floating on the water (see also Chapter 8). The formation of these is described in Annex A.

The formation of fen peats

In the transitional zone the fen peat layers have accumulated to a thickness of 1-5m and more. Originally this transitional zone was a brackish lagoon. The continental climate with a high moisture deficit has resulted in the reduction of sulphates from the brackish water to sulphides which have accumulated in the peat.

Lagunal deposits

Most of the transitional zone deposits are situated on top of the lagunal deposits, originating in the Danube and Razim Bays respectively. These are sands and silts which, when not covered by younger sediments and deposits, form the present bottom of the lakes. In Lake Razim these deposits are 1.5-3m deep, and are mainly composed of sand and shells. In the northern part of the Delta, and especially in the transitional zone, the upper, lagunal deposits are very fine-sand silts with a fine stratification.

The physical conditions of the soils formed from the sediment after drainage are extremely unfavourable for vegetation growth. They are densely packed so that no roots can penetrate; their water retaining capacity is extremely low due to a lack of clay and organic matter; they have an extremely high capillarity and hence danger of salinization, and they are infertile due to the absence of nutrient-holding substances.

Lacustrine organic muds (gyttjas)

The erosion of sand peats and lake shores by waves and currents releases organic materials. These organic materials are mixed with available clay and calcium carbonate and deposited on the lake bottoms in thin to thick layers, and also under and between the younger plaurs. The peat profiles always show alternate layers of fen peat and gyttjas or organic-mud. The lagunal deposits generally closely underlie the gyttjas. Sometimes, much thicker layers are present on top of these lagunal silts.

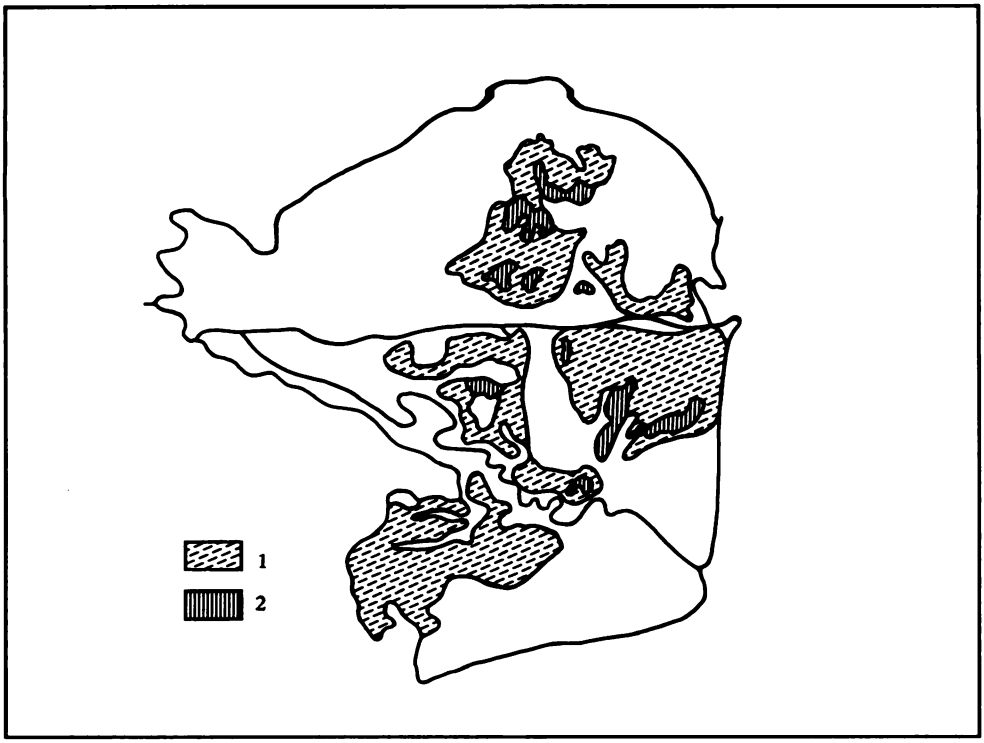


Figure 1.6. Location of sulfidic histosols and calcaric limnosols (Calcaric Gyttja) in the Danube Delta, 1, Sulfidic Euhistosols; 2, Calcaric limnosols

Lacustrine marls

In a number of lakes in the transitional zone as well as in the marine zone, extended deposits of marls occur. *Chara* are usually responsible for these, but in the case of the Danube Delta lakes this has not been confirmed. The distribution of the most important marl deposits is shown in Figure 1.6.

1.2.3 Zone 3 - The marine zone

Beach-barriers

'Beach-barriers' are formed by sand which has been transported from north to south along the coast and deposited through wave-action and the effects of currents. In combination with the building of the sub-deltas of the Danube branches, these barriers may grow into very broad 'beach-barrier' complexes, such as those of Letea, Caraorman and Saraturile. The beach-barrier complexes show a classic ribbon-like structure and are composed of more or less parallel, narrow, sand ridges and inter-barrier depressions which may weakly curve. The sand ridges are very dry and the soils are excessively rich in chemicals supporting a sparse vegetation.

In the older beach-barrier depressions, humus-rich sand-gleysols are present which support luxuriant forests. The well-developed vegetation is fed by water from the fresh groundwater body. The water tables in these gley soils fluctuate between about soil surface level to 1.5m below the surface. The oldest complexes, those of Letea and Caraorman, have the highest barriers, probably because at their formation, the sea level was somewhat higher than at present. They are also formed from rather coarse sand, originating from the north. The smaller barriers and the Saraturile complex are built from somewhat finer sand originating from the Danube branches.

Central beach-barrier depressions

The central parts of both the Letea and the Caraorman complexes have a so-called fresh groundwater 'lens' or 'body'.

The formation of a groundwater body with fresh rainwater in the subsoil of the complex is probably due to a rain-receiving surface (the whole central part of the coarse sandy beach-barrier complex) which is two to three times larger then the surface of the water-consuming forest. The rain, falling on the crest of the barriers, enters the subsoil immediately to feed the freshwater reserve and only a small quantity is used by the very open and sparse sand-dune vegetation (Figure 1.7). In this way, despite the continental climate with a mean water deficit of more than 600mm, the Delta supports a fresh groundwater body and luxuriant forest vegetation.

Shifting dunes

The high sand barriers which are about 1-2m higher than the inter-barrier depressions, form very dry soils with a steppe-like vegetation. There is a xerothermic grassland community on the more or less stabilised sands of the crests of the beach-barriers. Many of these areas have been overgrazed, leading to the formation of mobile dunes.

Sometimes, the high dunes have formed sand plateaux with shifting sand. Their vegetation is characterised by *Euphorbia seguierana*.

The central parts of these two beach-barrier complexes are surrounded by a broad zone of low-lying, saline, 'beach' sand soils. Although visible, the differences between the barriers and the depressions are much less obvious in this zone. Moreover the sand is finer and the capillary rise, even in the barriers, may reach the surface. This prevents desalination and the formation of a fresh groundwater body. The same soils occur widely on the Saraturului barrier complex and on many other smaller beach-barriers. Characteristic plants are *Tamarix ramosissima*, *Salicornea herbacea* and *Sueada maritima*.

Reedswamp

Extended reedbeds occur in the maritime zone in the beach-barrier depressions, which sometimes have the character of lagoons. Plants tolerant of brackish water, such as rushes *Juncus* spp. are mixed with the low-growing reed, especially towards the sea shore.

Lakes

Lakes are present in some deeper-lying beach-barrier depressions. These are shallower than the lakes of the transitional zone. Marl sediments are deposited in some of them.

1.3 Geology

Some 20,000 years ago, during the Würm Glaciation (early Pleistocene), the Black Sea flowed into the Mediterranean, where the water level was more than 100m lower than at present. The Bosphorus was the threshold of a lake (the present Black Sea) and formed a giant waterfall. Large rivers entered the 'sea', and, as no saline water could penetrate, its water was fresh. According to Neveskaya (1965), this was a lacustrine phase (after an earlier marine phase).

During the Upper Würm (end of the Pleistocene) and the beginning of the Holocene, the water level of the Mediterranean rose and in the Boreal, about 8000 BP (6000 BC), the threshold flooded and seawater again penetrated the Black Sea (Neveskaya, 1965). During the mid-Atlanticum, the saline bottom current through the Bosphorus was strong enough to turn the lake into a brackish sea.

The lower Danube valley formed a deep and broad erosion valley, in which, on a much lower level, an older Delta must have been present. The present lower Danube floodplain with the broad tributary valleys of the Prut, Siret, Buzau and Ialomita also flooded and formed levees and large lakes alongside the rivers (Figure 1.8). The Danube valley and its tributary valleys up to Galat, and from Galat to Isaccea were for the greater part filled with sediments.

Later, the rapidly broadening west-east part of the valley started to fill especially east of a line drawn between Orlovka and Isaccea. As the continued supply of sediments from the Danube by far exceeded those of the tributaries along this part of the valley, the central part of the Danube valley proper was filled whereas water remained in the tributary valleys. The widening of the valley allowed the formation of a real Delta with natural levees along the branches, and backswamps inbetween. This now forms the fluvial zone (Figure 1.4).

The pro-Delta sediments penetrated the Black Sea and rapidly came more and more under the influence of its waves and currents. At about 5500 BP (3500 BC), the Danube underwater delta had already progressed east of a line joining Letea, Caraorman, Perisor and Lupilor, especially its southern part. At that time, which must be dated at about 5500 BP and not earlier as is suggested by Panin *et al.* (1983), when the sea level reached its maximum, the 'initial beach-barrier Letea-Caraorman' of Panin was formed (Panin *et al.*, 1983) (Figure 1.8). In Figure 1.9 the successive stages of the development of the Danube sub-deltas are shown, according to Panin (1974).

Morphologically, the Sf. Gheorghe-I Delta belongs to this system and must be the same age (estimated at 5500 to 4000 BP on the basis of international standards and the youngest age determinations of Panin *et al.* (1983). It formed the main Danube branch.

The north-south sea drift, together with Black Sea wave action, reworked the sediments of the underwater delta, and formed a broad beach-barrier complex. Together with now partly disappeared beach-barriers to the north and to the south (Figure 1.8), it closed the Danube *liman* (bay or lagoon), in the north and the Razim bay in the south from the direct influence of the Black Sea. An extensive complex of large and small lagoons with variable depths up to 5m or more was formed. It stretched between the Bessarabian uplands, the Chilia promontory, the fluvial part of the Delta proper and the Dobruja hills on one side, and the initial beach-barrier complex on the other. The *ozeros* (lakes) Kotlabu, Kitai and Sasyk in the north, and some smaller drowned river valleys in the south were also included in this lagoon complex.

The sea level rise caused water stagnation in the Sf. Gheorghe branch, upstream of the river mouth. As a result, the branch started to lose water to different new watercourses flowing into the lagoons. One of them flowed north to Izmail and then turned eastward, forming the Stipoc branch (Figure 1.8), running from the present village of Pardina to the southern end of the Chilia Veche peninsula. This branch built a broad and high levee and probably flowed east of the Chilia Veche peninsula towards the north-east, forming a sub-delta in the lagoons around the present Lacul Merhei. This Stipoc branch was active until about 2750 BP but its upstream section is now reworked and covered by sediments from upstream of the Chilia branch.

To the south-west, watercourses developed and supplied Lacul Razim with large quantities of river water, which sought an outlet via the Cosna and Sinoe deltas (Figure 1.8). The younger Chituc and Portitei barriers were formed out of these sand deltas.

In the brackish lagoons outside these original levees, subaquatic lagunal deposits were laid down and dense reed fens accumulated *Phragmites* peats, partly mixed with clay. Many lakes formed and remained because of the lack of sediments, one of them being Lake Razim. This complex of lakes, peats and small river levees now form the so-called transitional zone (Figure 1.4) of the Delta.

Between *c.* 4000 and 2500 BP, the sea level dropped a little and the Stipoc branch was abandoned. An alternative branch of the Danube, the Sulina branch, developed and penetrated the initial beach-barrier north of Crisan (Figure 1.9). This branch developed a very large sub-delta projecting into the Black Sea to the east (i.e. outside the initial beach-barrier). Seaward of the 'IBB' sand was deposited in narrow beach-barriers and inter-barrier depressions. The formation of this sub-delta probably ended about 2500 BP.

After about 2900 BP the lower Chilia branch, downstream from Pardina village, took over from the Stipoc branch, developed into the main Danube branch and formed the present sub-Recent and Recent deltas in the north (Figure 1.9). From about 2500 BP, the Sf. Gheorghe branch was again activated and since that time has formed the recent Sf. Gheorghe sub-delta (Figure 1.8). The area of the sandy sub-deltas, east of a line connecting Letea, Caraorman and Lupilor forms the marine zone of the Delta (Figure 1.4).

On the basis of the morphology of these beach-barriers, Panin (1974) constructed a map showing the phases of development of the Delta (Figure 1.9). The author of the present paper has amended this and proposes instead the following sequence of events.

1. The Sf. Gheorghe-I Delta (until about 4000 BP), the initial Letea - Caraorman - Lupilor beach-barrier (from 5500 BP onward) and the lagoon complex of the Danube Bay;
2. The upper Chilia and the Stipoc branches (up to about 2750 BP);
3. The Cosna and Sinoe sub-deltas (up to 2600 BP and rather recent respectively);
4. The Sulina sub-delta (up to 2500 BP);
5. The lower Chilia sub-deltas (from 2900 BP to sub-recent and present);
6. The Sf. Gheorghe-II Delta (2800 BP- present);
7. The artificially reactivated Sulina Delta (AD 1850).

1.4 Climate

The climate of the Delta may be described as temperate to continental with a Pontic influence (Gastescu and Driga, 1985) and important topographical effects. The climate is influenced locally by extensive water surfaces and marsh vegetation, large areas of bare sand with open vegetation and the proximity of the Black Sea; a flat landscape giving free entry to the dominant, strong north-easterly winds.

The principle climatic parameters are shown in Figure 1.10. The data, derived from the three meteorological stations in the Delta from west to east (fluvial, transitional and marine), are at Tulcea, Gorgova and Sulina.

The mean annual temperature is 11.0-11.4°C, with mean January temperatures of minus 1.5°C in the fluvial zone of the Delta and a little over minus 1.0°C in the marine zone. The mean July temperatures are 22°C in the western part of the Delta and 21°C in the eastern part which results in mean annual temperatures of 23.5°C and 22°C respectively.

The mean annual rainfall varies between 400-450mm in the west and 300-350mm in the east. An absolute annual minimum precipitation of 132.7mm was registered in Sulina in 1920 and a maximum daily rainfall of 530.6mm in Rosetti (Letea island) on 29 August 1924. Long periods without any precipitation are characteristic, at which times water deficits may reach very high values.

The prevailing wind direction (Figure 1.11) is north, especially along the coast (Sulina), but winds from the south are also important especially in the interior (Tulcea). In Sulina, the winds from the north-west, north and north-east are by far the strongest. In Tulcea, southerly winds are the strongest and Gorgova takes an intermediate position. Long periods of strong winds may occur, especially in spring and autumn. Strong winds

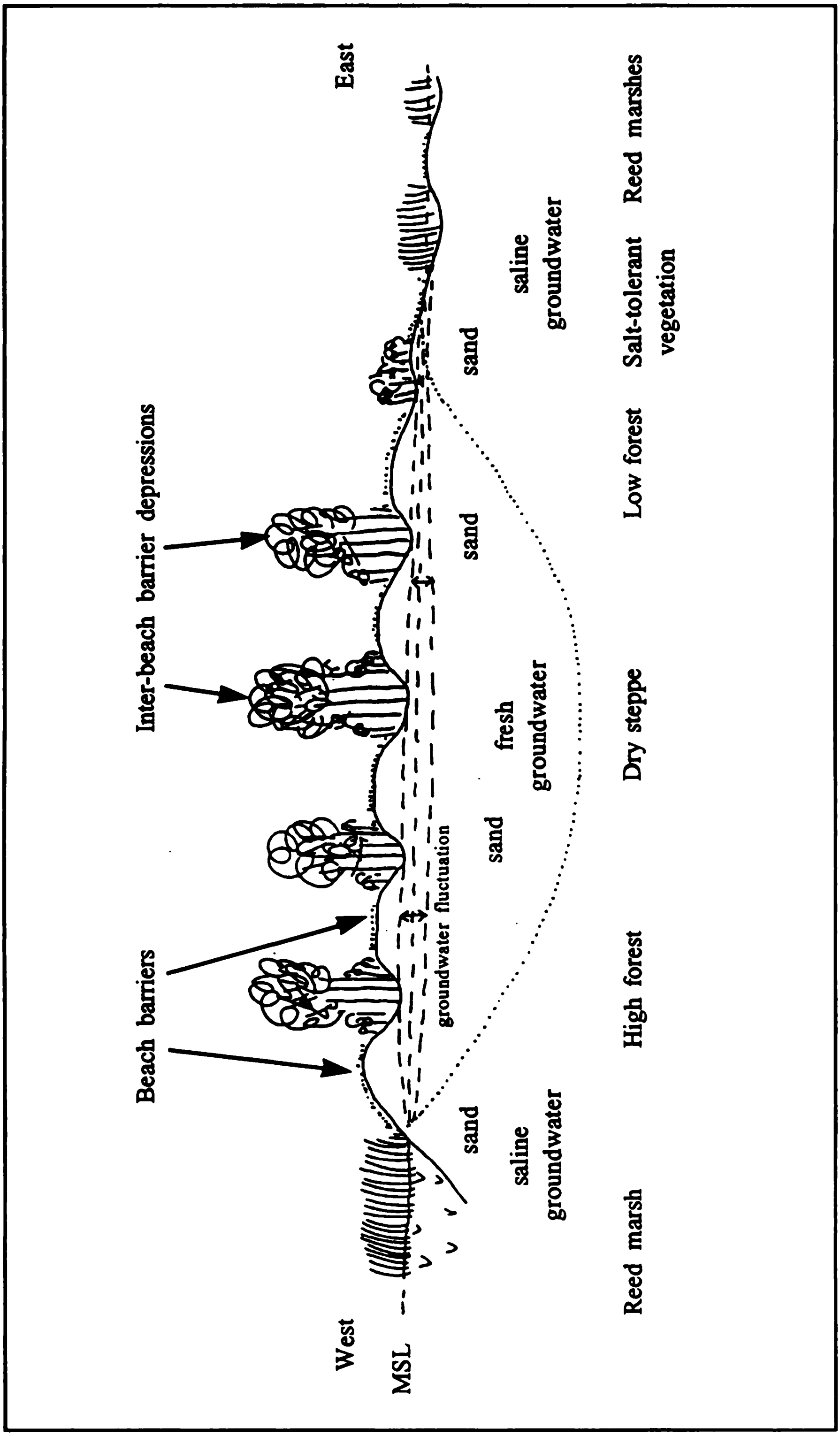


Figure 1.7. Cross-section through a beach-barrier complex with a fresh water body resting on saline groundwater depicting vegetation types

from the north-east contribute to the north-south sea current and may cause important abrasion along the Delta coast.

The continental character of the Delta's climate is illustrated by the very high potential evapotranspiration of 950-1000mm per year, especially in the transitional and marine zones, where the process is accelerated by frequent and strong winds. For this reason the danger of salinization is very high, mainly in the transitional and marine zones of the Delta.

1.5 Soils

Complete information on the Delta soils been collected only during the last 15-20 years (Munteanu *et al.*, 1989). Prior to 1965, only data on the Delta's terrestrial soils were obtained because the semi-terrestrial and subaquatic areas were not only difficult to access, but an adequate classification was lacking. In 1984, Munteanu introduced the term 'limnosols' for lacustrine deposits which are composed of mineral subaquatic sediments sometimes mixed with organic materials originating from the semi-terrestrial and subaquatic flora and fauna. New terminology for the sub-types of organic soils and of gley soils was also introduced, resulting from new diagnostic characteristics related to processes such as physical ripening, sulphide accumulation and sulphate acidity development.

In this report, the information given by Munteanu *et al.* (1989) in Figure 1.5 is correlated with the Delta's physical elements. Some soil conditions are described in more detail, namely those which are of special interest for forms of sustainable, ecologically-adapted agriculture and fishery, and for other ecologically appropriate developments in the Delta.

1a and 1b. Alluvosols; 4 and 6. Gleysols. The alluvosols (loamy sand, sand-loam to clay-loam, 5%-30% clay) include the "soils of the natural levees" along the Danube branches, sub-divided into natural and embanked alluvosols. The non-embanked alluvosols have weakly developed A-horizons (0.8-5.0% orgnic matter), are calcareous (8%-15%) and alkaline (pH 7.5-8.3). They are concentrated in the Delta's fluvial zone, are on relatively high sites (1.5-4m above sea level) and have active sediment deposition, but are only inundated for a relatively short period of time. Some are salinised especially in the eastern part of the Delta. They are distinguished into gleyic and salic alluvosols. The majority of the soils are physically ripened.

The gleysols (clay-loam to clay, 40%-60% clay) are the soils of the backswamp areas of the Delta's fluvial part, which are low-lying (-0.5m to +1.0m) and inundated for more than eight months of the year. The non-embanked soils (no. 6) are covered by a dense reed vegetation and receive only small quantities of sediment. These soils have dark coloured 'mollic' topsoils rich in organic matter (more than 10 to 12%), are often peaty ('histic') and have unripened, reduced subsoils. The mollic soils range from calcareous to shallow non-calcareous; the histic soils have non-calcareous topsoils. Those occurring on the lowest sites also have unripened topsoils. The embanked soils are ripened (period of ripening: 5-

10 years) and have already lost a part of their organic matter. Some have lost their peaty top-layers through burning of the peat, and some are salinised. The gleysols are subdivided into mollic, histic and salic gleysols.

2. *Gleyic psammosols.* These sand soils (calcareous sands) occur on the beaches, beach-barriers and the inter-beach depressions of the marine zone of the Delta. Those in low-lying areas have peaty topsoils (histic) and are saline in most cases. The gleyic psammosols, situated at an intermediate level and related to saline groundwater, are salinised (containing 0.2-0.5% soluble salts) and strongly alkaline (pH 9-10), because of their capillarity. The intermediate soils related to fresh groundwater have mollic topsoils and form very fertile sites. The gleyic psammosols are subdivided into histic, mollic and salic types.

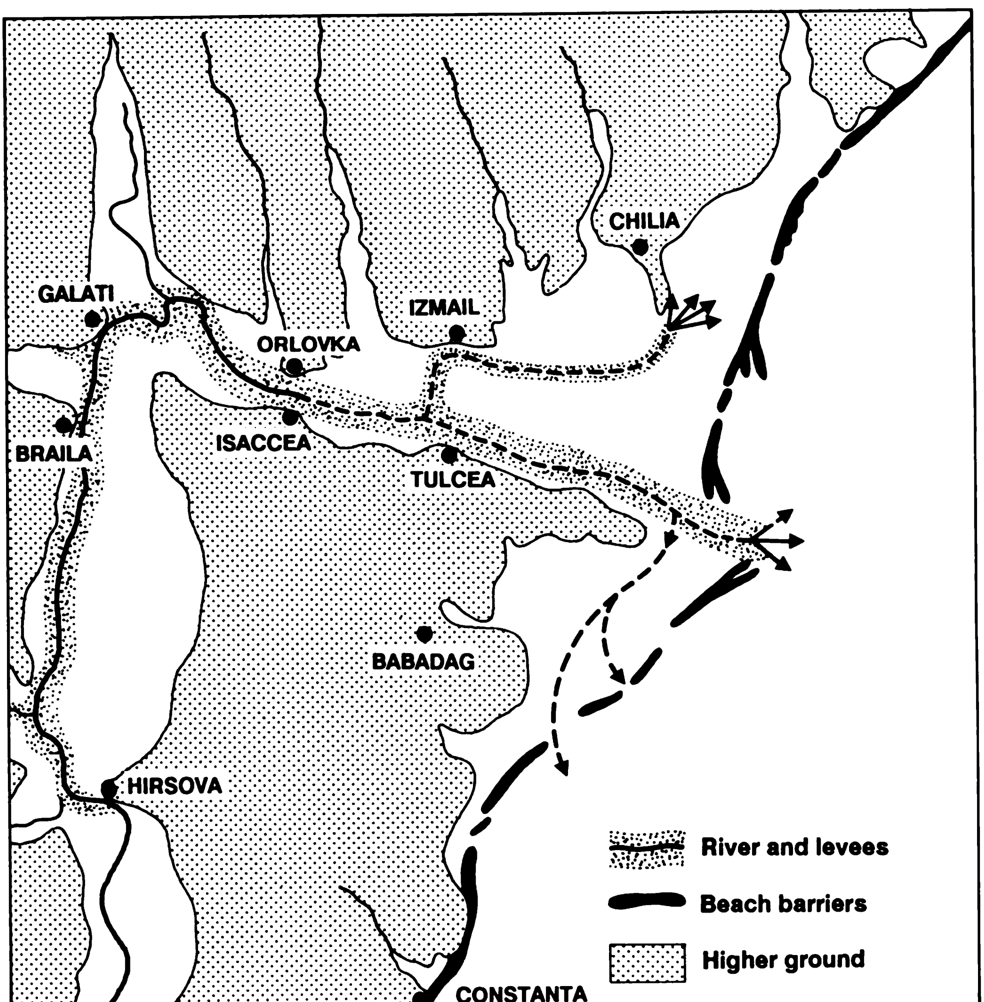


Figure 1.8. The Danube river and delta, *c.* 5,500 BC

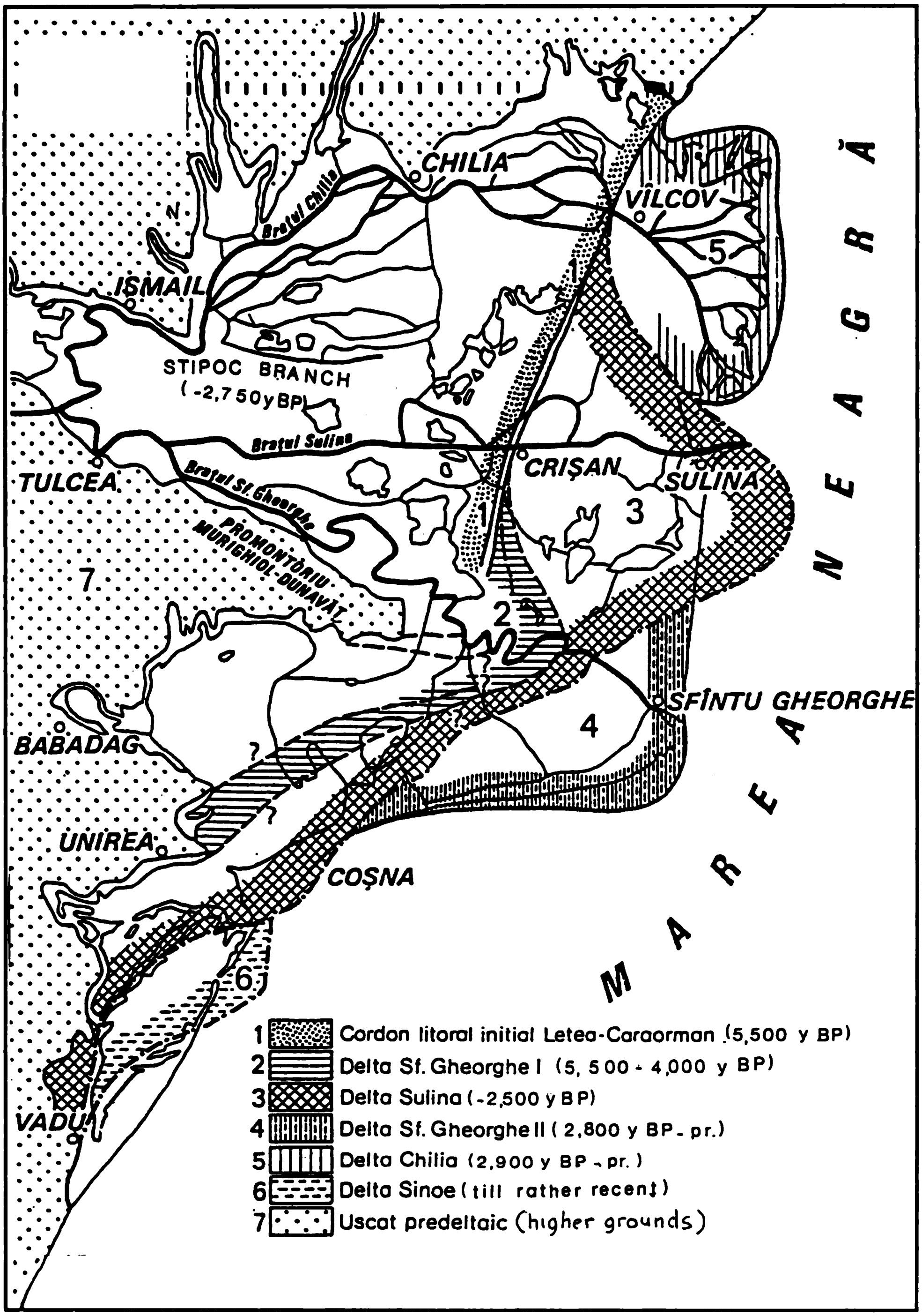
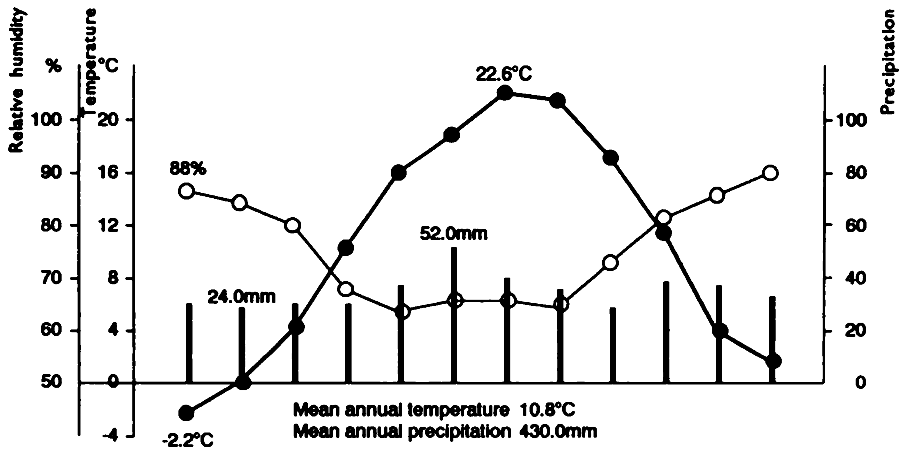
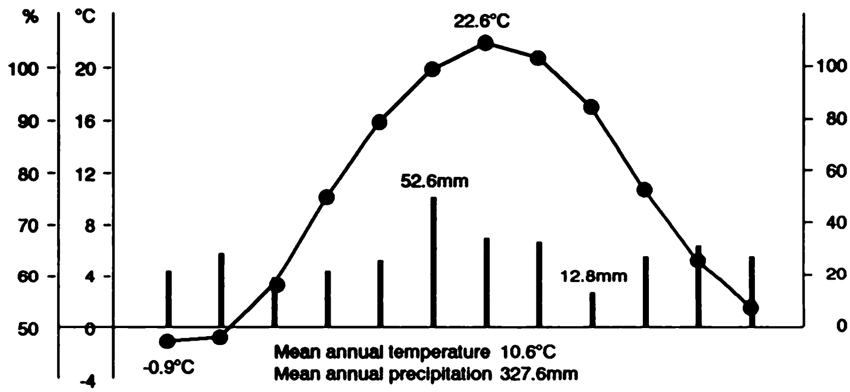


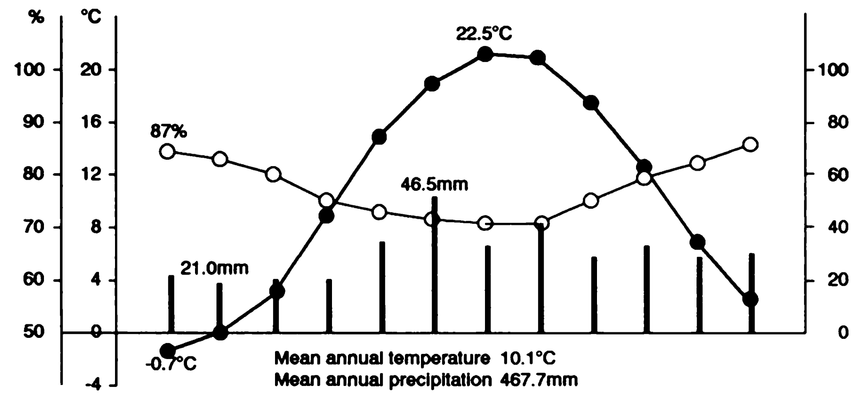
Figure 1.9. Palaeogeographical reconstruction of the Danube Delta area [after Panin, 1974]



Tulcea (35 years)



Gorgova (8 years)



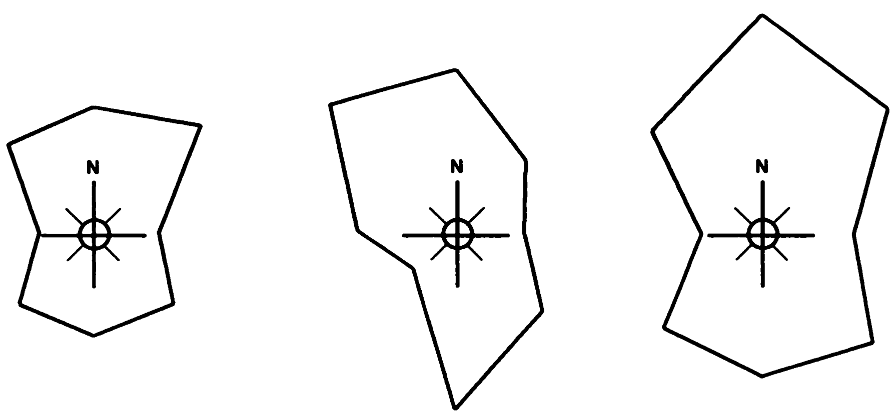
Sulina (80 years)

Figure 1.10. Mean monthly temperatures, air humidity and precipitation in Tulcea, Gorgova and Sulina

3. Well-drained psammosols. The soils of the shifting and stabilised sand-dunes, more than 2m above sea level, are well drained and poor in organic matter. They have a very low water-holding capacity and form very poor sites for plant growth (but have a high plant diversity).

5. and 8. Solonchaks, respectively on loess (a) of Chilia Island and (b) on marine loamy sands. The loess materials as well as the fine and loamy sands have a strong capillarity. Much water evaporates from these soils and their groundwater is very saline (10-60g/*l*). The vegetation is halophytic. These soils are widely spread on the Saraturului barrier complex and on many other smaller beach-barriers.

7. Limnosols. The sediments in the Delta lakes, called Limnosols, are all physically unripened gyttjas. They show silt-loam textures and differ strongly in organic matter as well as lime content. Those formed in the deeper lakes (1.8-3.0m) without vegetation, have relatively low organic matter contents of 4-16% (silty limnosols). In the isolated and shallower lakes (1.8-1.2m) with sub-aquatic vegetation, the mineral sedimentation was minimal and sedimentary peat layers (histic limnosols) as well as calcareous marls (limnic limnosols) may have formed (Figure 1.6). In the fluvial zone and elsewhere, after the



	Tulcea			Gorgova			Sulina	
	%	m/s		%	m/s		%	m/s
N	10.9	3.3	N	14.3	4.1	N	17.9	3.3
NE	13.0	3.3	NE	8.2	3.2	NE	14.0	3.3
E	4.0	2.3	E	6.2	2.3	E	7.2	2.3
SE	8.7	8.2	SE	9.9	2.5	SE	12.9	8.2
S	8.8	3.2	S	16.0	2.7	S	11.9	3.2
SW	6.3	3.0	SW	4.2	2.1	SW	10.9	3.0
W	4.4	2.5	W	8.1	2.3	W	4.7	2.5
NW	10.7	3.0	NW	15.0	3.8	NW	11.9	3.0

Figure 1.11. Wind directions at Tulcea, Gorgova and Sulina [after Rudescu *et al.*, 1965]

digging of the canals, river sediments have been able to enter the lakes directly and thin to rather thick layers of loamy sediments are deposited (loamy limnosols). Layers of loamy and other limnosols of different thicknesses may cover silty limnosols. Brackish lagunal deposits probably also form the bottom or near-bottom layers of the lakes elsewhere. These sediments are sharply stratified and are very adverse to plant growth.

9. Loamy salinised Kastanozems (steppe soils). These soils occur only on the loess island of Chilia Vecche. They are alkali-rich in the lower soil horizons and salinised to varying degrees.

10. Histosols. The Delta's transitional and marine zones are characterised by *Phragmites* fens, accumulating *Phragmites* peats over extensive areas and to considerable depths (0.5->5m) (Figure 1.6). The fen peats have relatively coarse organic materials (fibric to hemic), mixed with varying amounts of mineral materials (20-60%). Another sub-division is into non-floating and floating (plaur) peats, the latter having rather good weathered topsoils. Most of these peats contain sulphides, giving extremely acid soils with pH 2-4.5 upon oxidation when drained. In the marine zone, they also contain salts at concentrations of 1-5g/*l*.

1.6 Conclusions

The filtering system of floodwater through the vegetation must be increased and if possible restored to its original natural level. Free entry of unfiltered water to the Delta's interior and especially to the lakes through the canals must be avoided. The opening of some polders would assist in achieving this objective (see Chapter 2 for descriptions of the status of polders and proposals for restoration).

Polders must be fully or partly opened to floodwater in order to increase the area of natural vegetation. In these re-opened polders, the restoration of the natural vegetation and the formation of lakes must be allowed and promoted.

The natural vegetation of the river levees should be restored as far as possible and obstacles to the flow of river water over banks should be removed. *Populus* plantations in particular should be gradually replaced by more natural tree species, in order to restore a denser ground vegetation. The vegetation on parts of the dykes of abandoned polders should be given the opportunity to develop naturally.

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ANNEX A

Formation of plaurs (see also Chapter 8)

The genesis of plaurs has been studied by a number of Romanian biologists (see Rudescu *et al.*, 1965). They are thought to be formed from normal reedswamp communities where the roots are anchored in a peaty subsoil (Figure 1.13).

During the spring floods, when the water temperature rises, gases may be formed (hydrogen sulphide, methane and carbon dioxide) and accumulate in the layer of rhizomes. When the roots have lost too much contact with the firmer mineral subsoil and are no longer well anchored (i.e. when the peat layer is thicker than about 50cm), the mat of reed rhizomes, peaty soil particles and the standing vegetation begins to float (Figure 1.13). Waves and currents may tear parts of the mat loose and these may be transported over quite long distances.

The eutrophic plaur vegetation includes *Phragmites australis*, *Rumex palustris*, *Carex pseudocyperus*, *Thelypteris palustris*, *Cicuta virosa*, *Lythrum salicaria*, *Cladium mariscus*, *Eupatorium cannabinum*, *Mentha aquatica*, and sometimes also *Salix cinerea*. The thickness of the plaurs may reach several metres.

The floating plaurs are concentrated along creek borders and lake corners, and form floating reed islands, which quake from wave-action and when setting foot upon them. As the floating mat rises and falls with the flood water, they are never inundated and no nutrients can reach the reed plants by surface flooding. As they grow thicker, the rhizomes do not receive nutrients from below either. After some time, rhizomes are weakened, reed-stalk production nearly stops and herbaceous vegetation starts to replace the reed. This gradually weakens the reeds, and eventually leads to a succession by the other species present in the plaurs.

With the increase in thickness of the floating mat to 1-2m, the trapped water volume below the floating mass decreases considerably. The upper horizons of the floating plaurs are in fact relatively 'well-drained' and therefore provide ideal habitats and breeding grounds for birds and other animals. They are decomposed by a rich soil fauna to a friable organic soil, which is denser and heavier than the original coarse, partly decomposed, organic materials. After some time, as development progresses, the plaurs become attached to the subsoil and no longer float. Water richer in nutrients may flood the mats and inundate the marsh surface.

As the ecological conditions for reed growth (periodical inundation and sufficient nutrients) are satisfied, dormant nodes of the reed rhizomes are reactivated and new reed develops. The vegetation is now composed of stands of low reed (with fine stems) mixed with a number of other mesotrophic marsh plants, and shallow pools containing mesotrophic aquatic vegetation. This environment is impoverished because the water entering the reed stands is lacking in sediment and thus relatively poor in nutrients. The vegetation sometimes has a very heterogeneous aspect. At this stage, the process of plaur formation may start again and it is suggested that a complete cycle may last about 100 years.

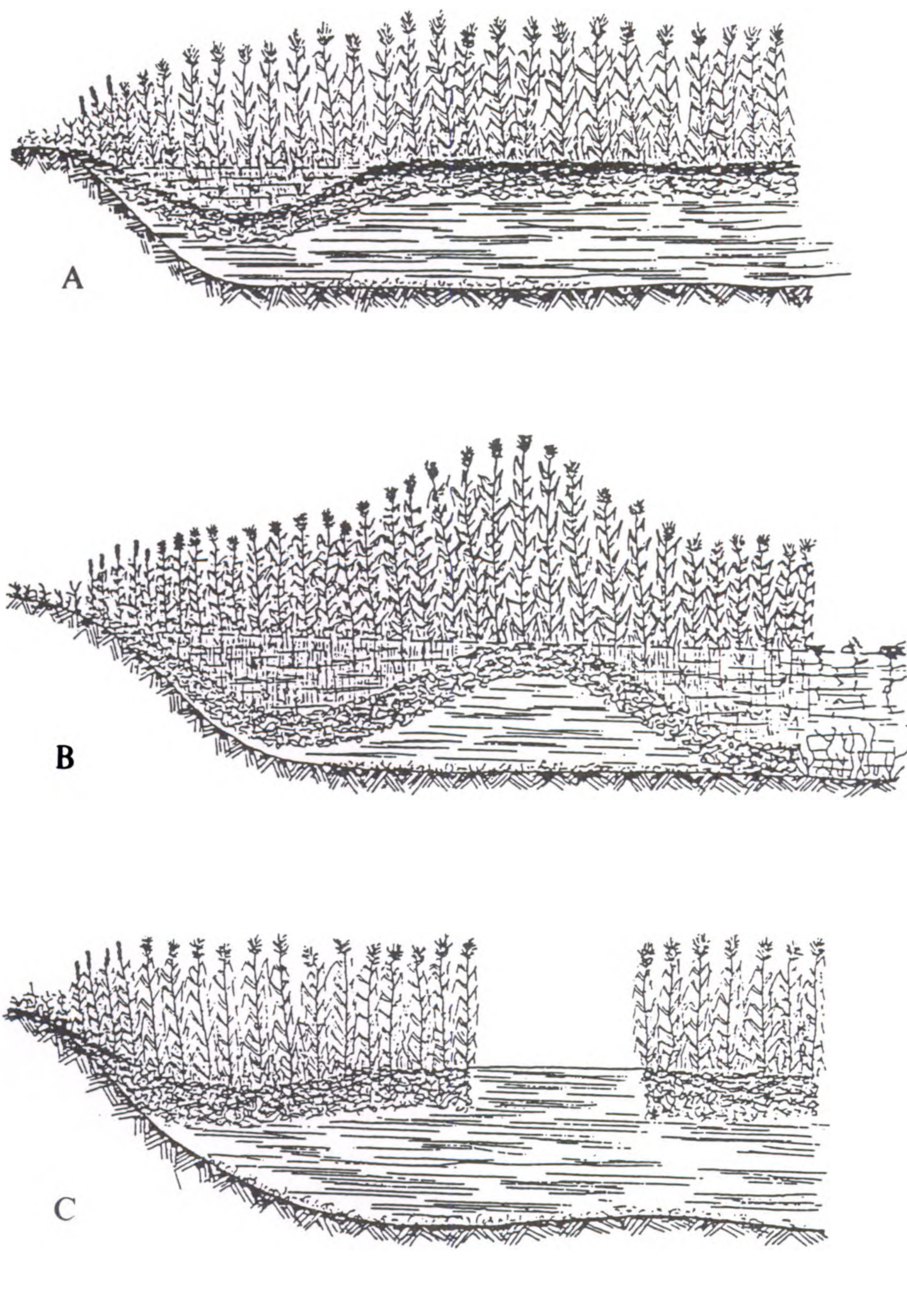

Figure 1.13. Sketch to illustrate the formation of plaurs (floating reed mats) in the Danube Delta [after Rudescu *et al.*, 1965]

A: Formation of gas in the rhizomes; B: the reed mat begins to float;
C: formation of plaur by tearing and floating away.

CHAPTER 2: NATURAL RESOURCES

L. J. Pons

2.1 Introduction

Traditional land use in the Delta included fishing, hunting, extensive cattle and pig breeding, cultivation of some agricultural and horticultural crops, honey production, hay cutting, and collection of materials, such as reed, for house building (see also Chapter 8).

River regulation and the excavation of a number of canals had a very important impact on the hydrology and the ecology of the Delta before 1975. Engineering schemes to control water flow in the Delta date from the second half of the 19th century with river regulation in the Ukrainian (Bratul Chilia, mid-19th century; Oceakovskoe Girl, 1926) and in the Romanian sections (Bratul Sulina, 1880-1902) (Figure 2.1).

2.2 Land use and associated engineering works up to 1975

2.2.1 Fisheries

Measures to improve the fisheries were introduced in the periods (I) 1903-1916, (II) 1930-1949, (III) 1950-1965 and (IV) 1965- present. The main works in the first period were the excavation and deepening of two small river courses in 1903 and 1912, in order to bring Danube water to Lake Razim (Figure 2.1). In 1976 the lake was cut off from the sea.

In the second period (1930-1949), a limited number of canals were constructed to connect the Danube with the interior parts of the Delta and to provide some of the larger lakes with Danube water (Figure 2.2). Some of the canals improved communication between the interior villages and the outside world.

In the third period (1950-1965) (Figure 2.3) a great number of canals were excavated and watercourses were broadened and deepened, both to connect the Danube with the smaller lakes and to connect the lakes with each other. These works were carried out to improve water circulation and with that the water oxygen content, the ultimate aim being to increase the amount of food available for the fish and so raise natural fisheries production.

The first fish polders were constructed in the 1950s. Figure 2.4 shows their maximum extent (see also Chapter 7). Later, the fish polders were also used for combined fishery and reed collection, because water level regulation facilitated the reed harvest in winter.

Apart from the canals indicated in Figure 2.3 a great number of smaller canals were constructed which are of minor interest and are not indicated on the map. Between 1956 and 1965 alone about 700km of canals were constructed.

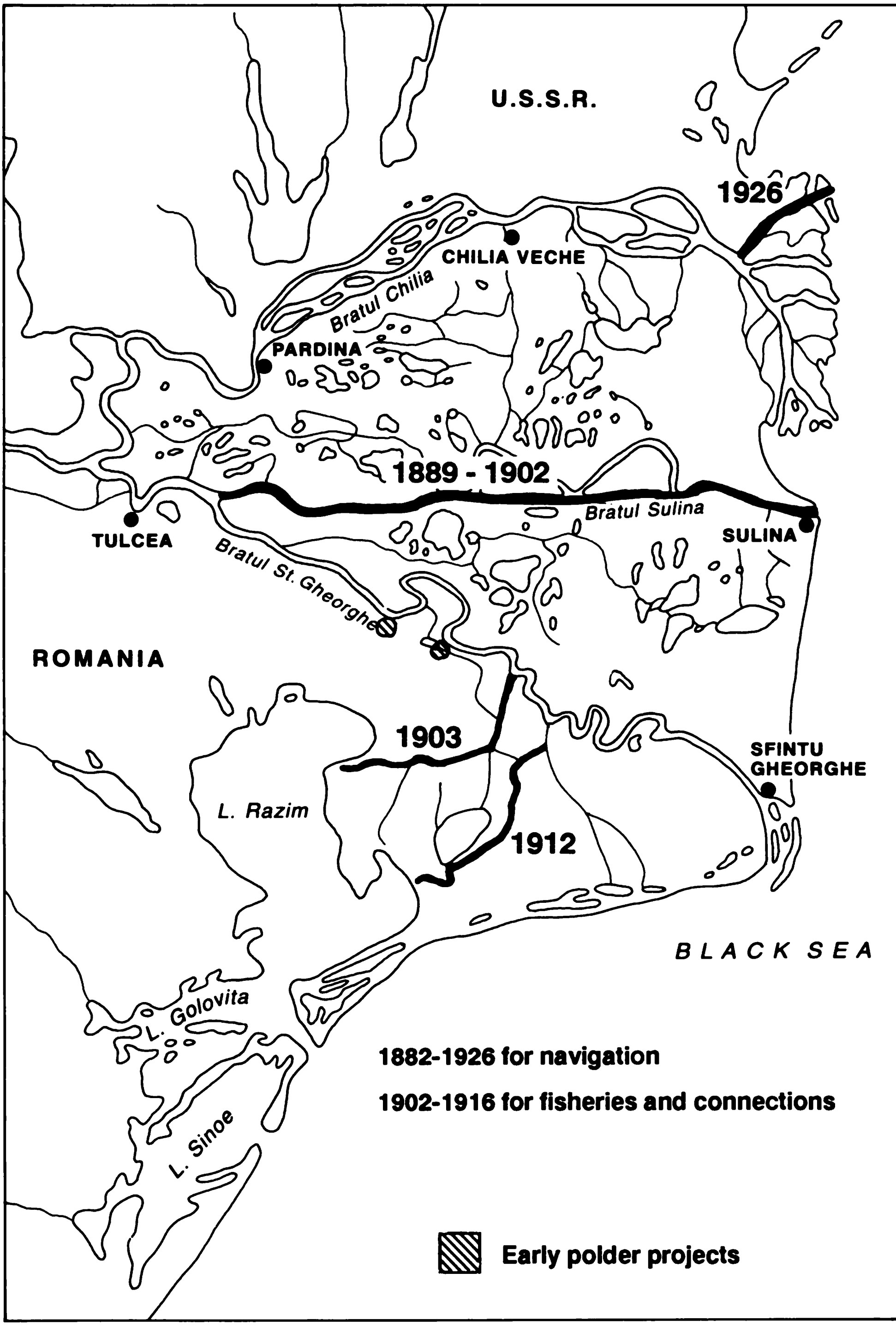

Figure 2.1. The first canalisation phase 1880-1926

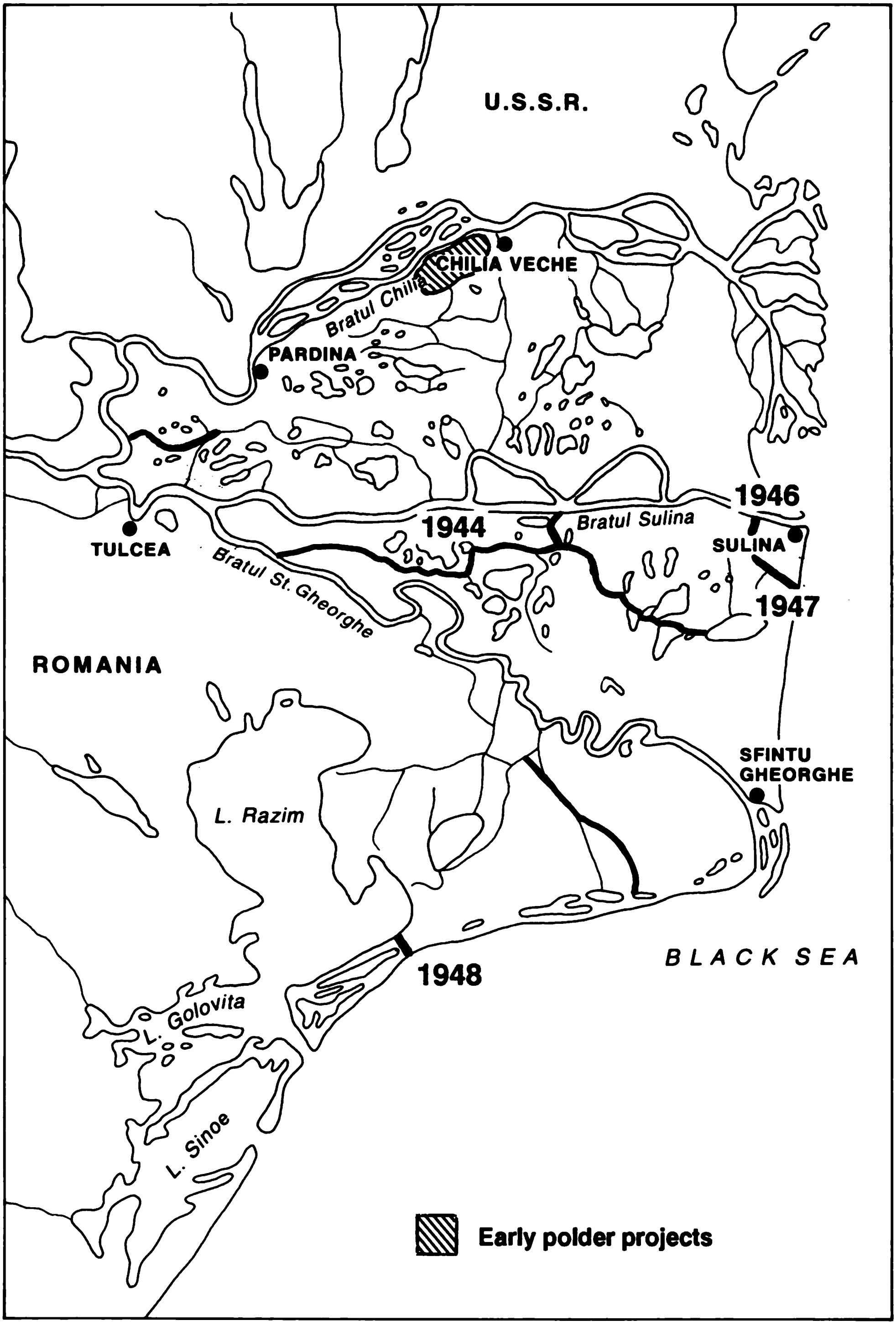

Figure 2.2. The second canalisation phase 1930-1940/1947

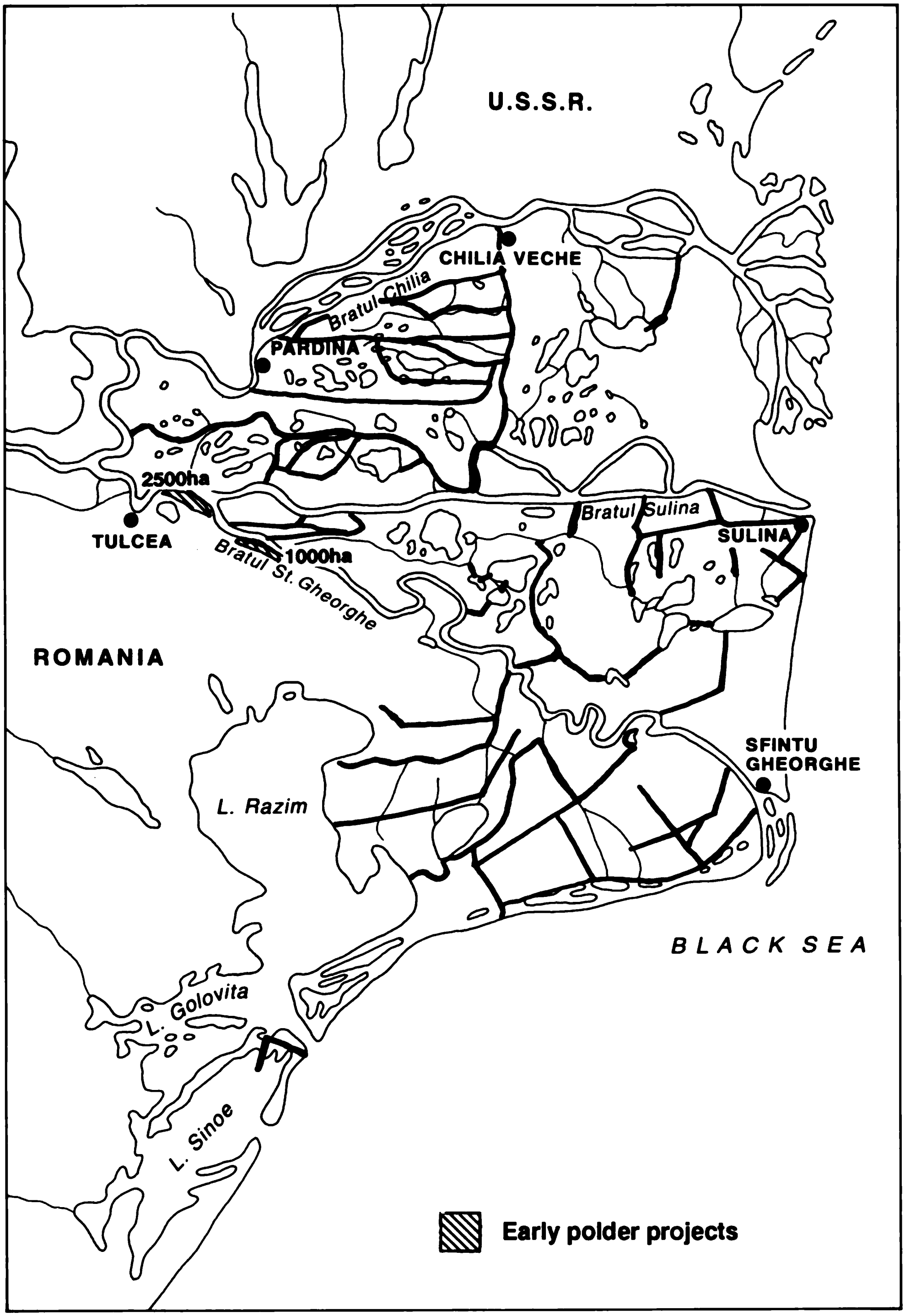

Figure 2.3. Third canalisation phase 1950-1963

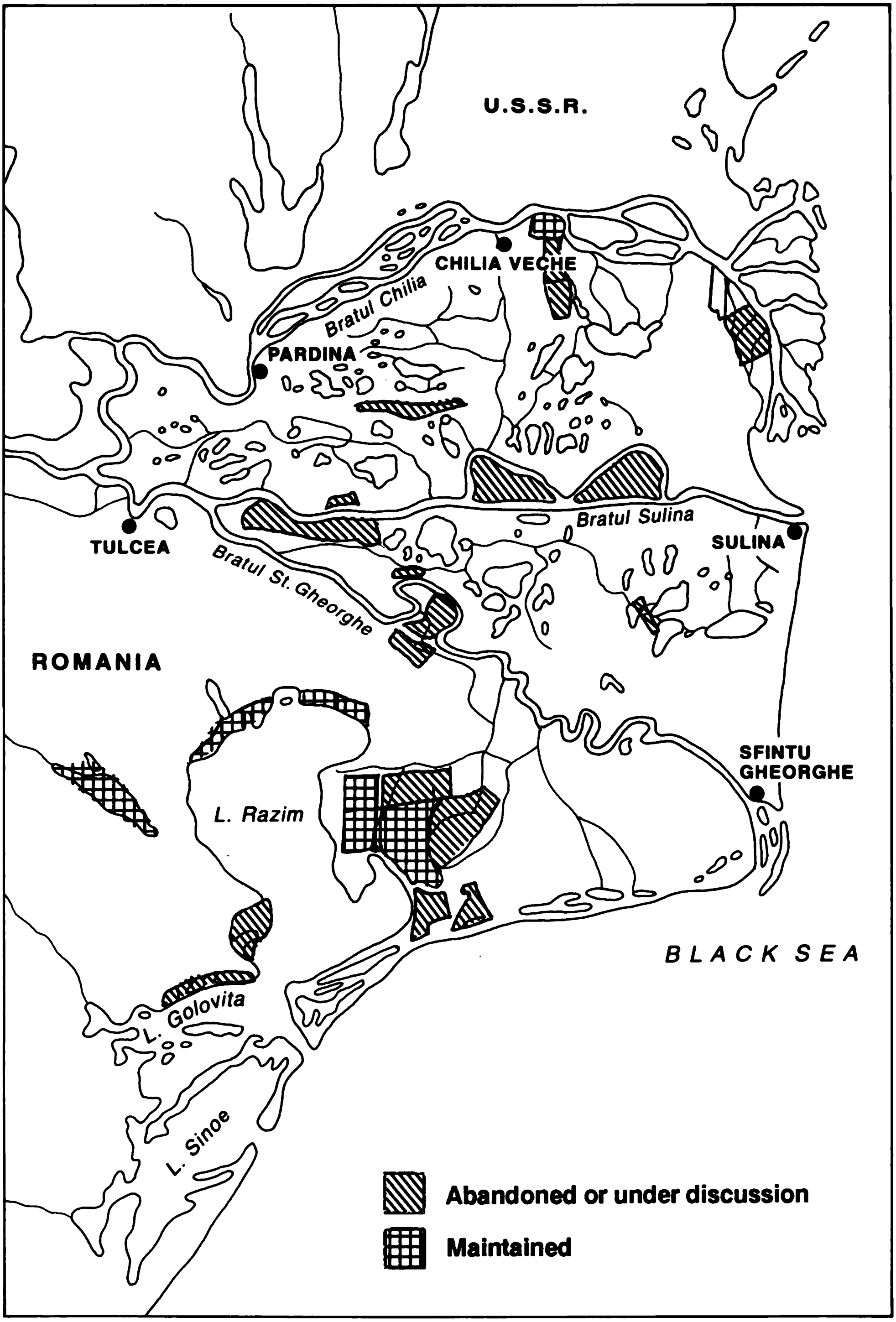

Figure 2.4. Fisheries

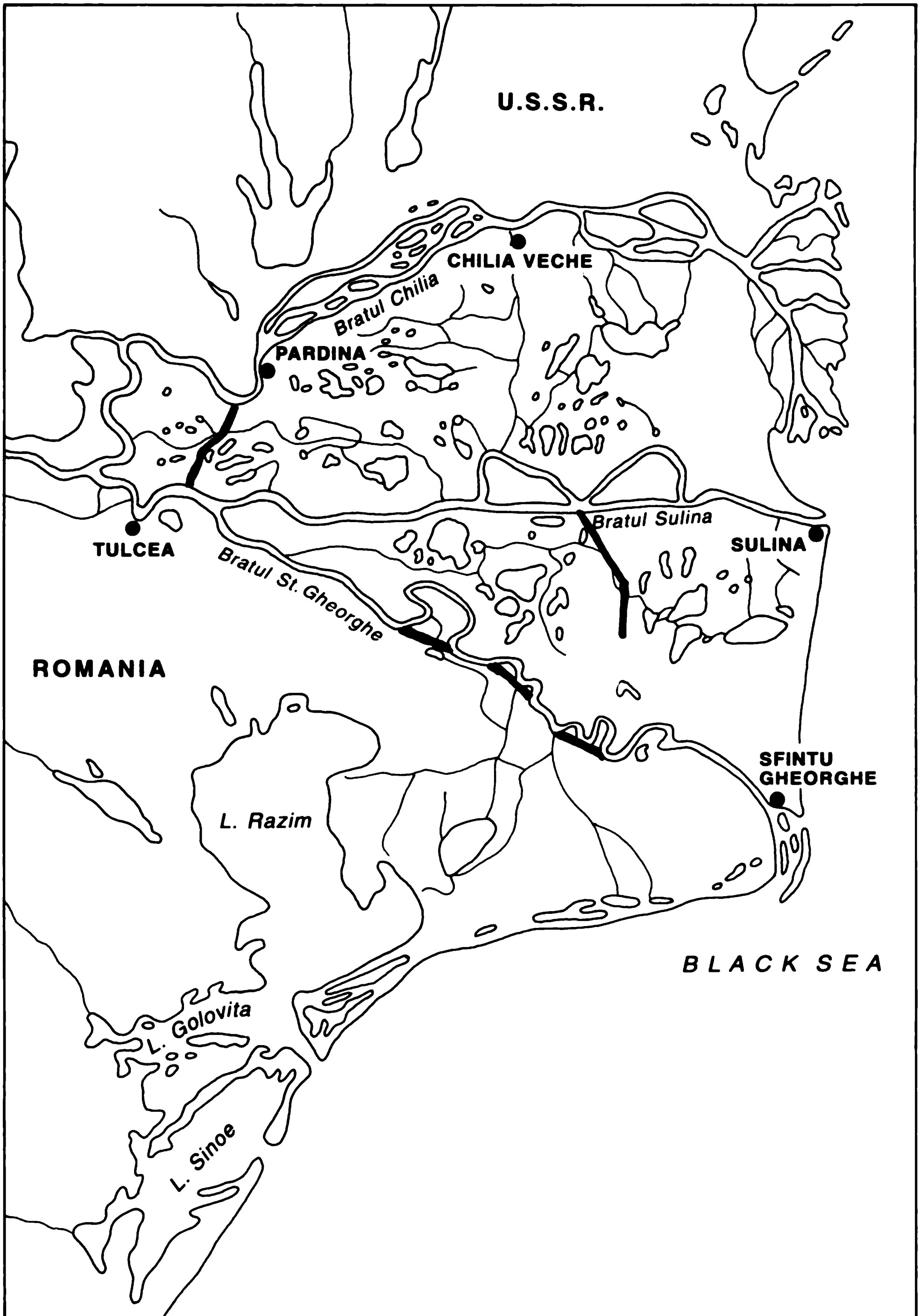

Figure 2.5. Fourth canalisation phase 1965-present

In the fourth period (1965- present) (Figure 2.5), the majority of the existing canals have been broadened and deepened. Few new canals were constructed: the very large Crisan - Caraorman (excavated for sand transport, but never used for that purpose), the Tudor Vladimarescu - Pardina canal and the six meander cuts of the Bratul Sf. Gheorghe.

2.2.2 *Agriculture and horticulture*

Agriculture has always been practised in the Delta, albeit on a very small scale, and probably on a sustainable basis. It was concentrated on the Letea and Caraorman beach-barrier complexes, on sandy soils with a shallow, fresh groundwater table and on some very high levees falling dry early. Grains and animal food crops were produced.

The European Commission for the Danube which was founded in 1856 to regulate navigation, introduced the idea of transforming the extensive reed areas into polders. It was predicted that the Delta would become the granary of Europe comparable with Lombardy. These ideas resulted in a French-Dutch consortium which proposed the embankment of some pilot polders. These were constructed at the end of the 19th century in the neighbourhood of Mahmudia and Murighiol (Figure 2.1), but turned out to be failures. Some agriculture was possible on the higher river levees, and these patches later became known as the 'French and Dutch gardens'.

Between 1938 and 1940 the Ostruvul Tataru Polder (3500ha), north of Pardina polder, was embanked, and in the period 1955-1965, the Tulcea-Nufarol (*c.*2500ha), Victoria-Bestepe-Mahmudia (*c.*1000ha) and Popina-I (3500ha) polders (Figure 2.5) were embanked. The agricultural results were meagre as no artificial drainage was provided.

Before 1979 polder construction for agriculture was never a success, because not enough attention was paid to drainage. The period of high water, from March to June with a maximum water level at about thc end of May, is totally unsuitable for agriculture. This, combined with the lack of tidal movements in the Black Sea preventing low river levels, has resulted in crops receiving no natural drainage just when this is most needed.

2.2.3 *Cattle-breeding*

Cattle-breeding on a sustainable basis has always been an important activity in the Delta. The local inhabitants fished in the summer and reared cattle in the winter.

Each family owned a small number of cows, sheep, goats, pigs and chickens, for which they cultivated some fodder crops and harvested hay for the winter. In the grazing season the cattle used the partly saline and/or marshy pastures around the villages on the beach-barrier complexes (Letea, Caraorman, Sulina, Sf. Gheorghe), and the continental island (Chilea Vecche). Cattle were held temporarily on some river levees and higher backswamps during lower water levels.

With the construction of polders and related dykes (300km up to 1963) however, the grazing area was greatly increased and for the most part uncontrolled. Most of the fish and reed polders supported cattle or sheep on their dykes. Overgrazing was widespread.

Pigs were, and still are, raised on a large scale in the Delta. When the water level is falling, they move into the reed marshes, especially in the marine zone with its numerous low beach barriers, where they find more or less dry ground. At very low water levels they also forage on the low grassy banks along the rivers, creeks and lakes. They are mostly left to run wild and are rounded up in winter.

2.2.4 *Harvesting of reed*

The impact this activity has had on the ecology, hydrology and social organisation in the Delta warrants separate treatment. See Chapter 3.

2.2.5 *Nature reserves*

The area of strictly protected nature reserves, now 81,000ha, would not have been changed under the Plan.

2.3 The Complex Plan for the Economic Development of the Delta

2.3.1 *Introduction*

In 1979, implementation of the works under the Plan was started. They included the improvement and extension of agriculture, fisheries, reed harvesting and cattle breeding. In this section the technical works carried out in relation to the Plan are discussed.

2.3.2 *Types of land use*

Figure 2.6 gives a schematic view of the 1975 situation compared with the ultimate objectives of the Plan expected to be achieved by 1995 (in thousands of hectares and as percentages of the 442,300ha total area of the Romanian part of the Delta).

The figure shows the areas allocated to the main activities: (1) fisheries and reed production; (2) agriculture and (3) forestry. These three activities are each divided into 'natural' (or extensive) use and 'cultural' (intensive) use. In the right-hand column, the total area of the Delta is indicated in future intensive (cultural : 149,000ha) and extensive (natural : 293,000ha) use.

Further details of the Plan are given in Annex A to this paper. Results of parts of the Plan which have been implemented are described below. They offer a timely indication of the care with which economic exploitation of the Delta's natural resources must be carried out.

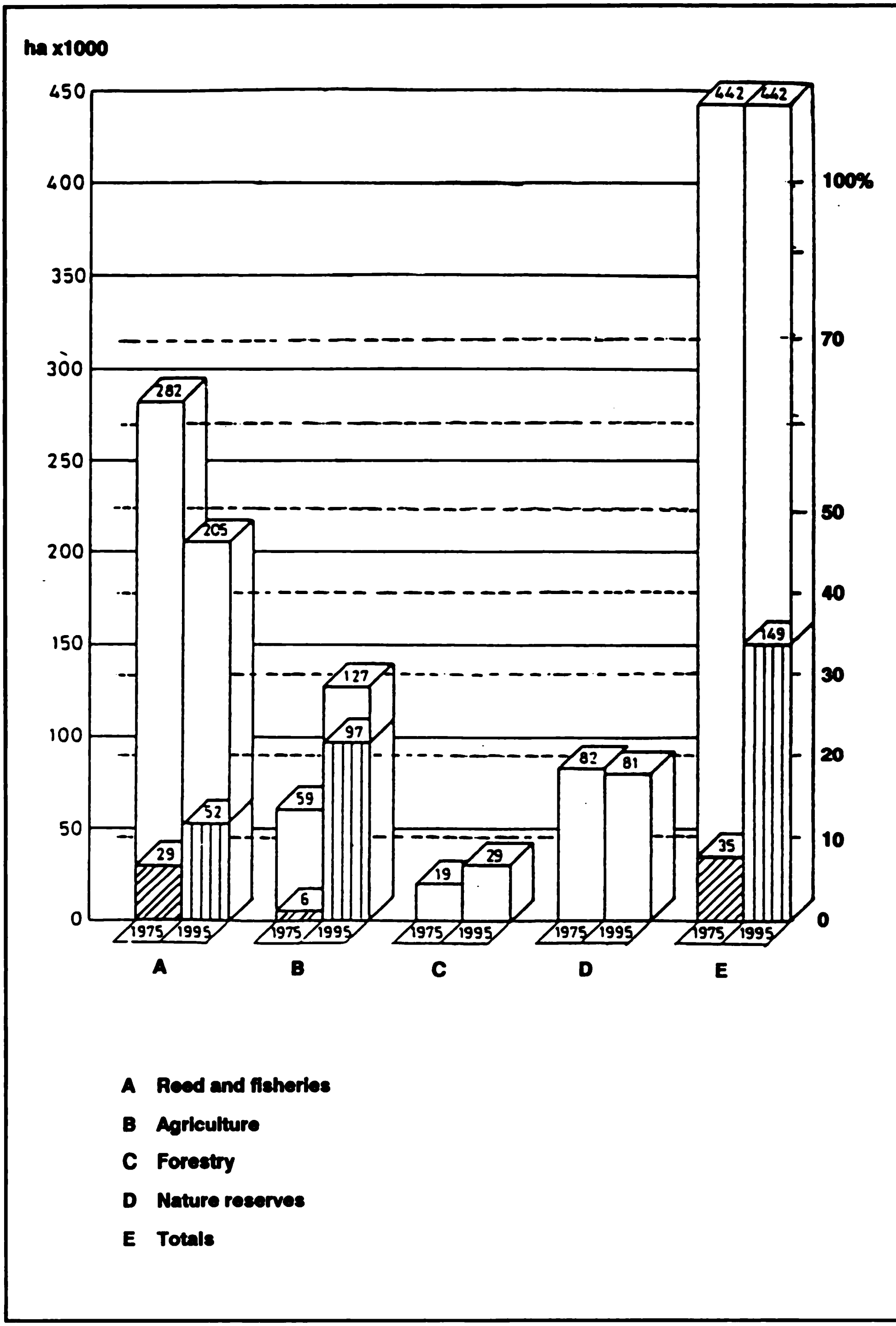

Figure 2.6. Development possibilities per land use type 1975-1995 (see text for explanation)

2.3.3 Status of the plan in 1989

By December 1989, the only significant progress was in the construction of polders for intensive agriculture.

Rudescu *et al.* (1965) indicate a potential mean yield of harvestable, natural reeds of 6 tonnes/ha. Assuming an area of 135,000ha, this would have produced a yearly yield of about 800,000 tonnes. From 1956 to 1965 the total yields increased from 6500 to 226,000 tonnes per year. Reed yields have however, considerably decreased since that time to 54,550 tonnes per year in 1980, and to as low as 47,000 tonnes per year in 1988 (Chapter 3).

Fish breeding in extensive fish polders has also drastically decreased and use of the greater part of them will now be discontinued. The intensive fishponds will generally be maintained (Figure 2.4).

Since 1975, few new forests have been planted and the planned extent of forestry plantations has not been achieved.

2.3.4 Status of polder development

The following polders were planned for intensive agriculture production and are at different stages of development.

1. Ostrovul Tataru (2500ha). This small polder, an island in the Chilia Branch, was already embanked, drained and irrigated in 1949. The soils are of good quality and yields are high (wheat: 4000-5000kg/ha; maize: 7000-10,000kg/ha).

2. Babina (2000ha) and 3. Cernovka (1500ha). These two polders are also small islands in the Chilia Branch. Dyke-building started in 1986. Given the soil characteristics (heavy textured clay in the backswamp covered by reed; saline soils on the river levees with *Salicornia* and *Hippophaë*; and sloef (silts poor in clay) in the subsoils. These polders were to be developed for rice cultivation, but little progress had been made by the time of the revolution in 1989.

4. Pardina polder (27,000ha). The polder was embanked for reed cultivation and fish breeding in 1964/1965. In 1982, after degradation of the reed vegetation, dykes were enlarged and an open drainage system was constructed. After clearing and grading, the first crops were planted. Regrowth of reed, burning of shallow peat layers and drought, however, were great setbacks. The irrigation system has not yet been installed.

Up to the present time, practically no community infrastructure has been developed and the social and living conditions are very poor. Permanent residences are almost absent and the people prefer to travel to the polder from the surrounding villages.

The soils are mainly sloef and ash soils with very low water-retaining capacities. A minor portion are river-levee soils of better quality. Yields depend heavily on rainfall which varies widely; 1985, 1987 and 1990 being dry years. Wheat yields without irrigation on the sloef soils varied from 2000-4500kg/ha. Yields are somewhat higher on the river-levee soils.

During the dry summer of 1990, the groundwater tables were very low. In some places depths of more than 5m were measured. Salinisation is a very great danger in the semi-arid climate and on soils with a very strong capillarity. It is hoped that this can be prevented with an adequate irrigation system.

5. Sonta (5000ha and 3000ha of Ostrovul Maliuc/Papada). This polder was planned north of the Sulina Branch stretching to the Sonta Canal. It was to include Ostrovul Maliuc/Papada, the former reed and fish polder. The soils are loam and clay-loam and good for intensive agriculture. Construction of this polder would have done great damage to the hydrology and functioning of the entire Delta ecosystem. Fortunately, this was prevented by the revolution.

6. Carasuhat (3300ha). This polder was embanked in 1961/1962 for reed production, but abandoned in 1971/1972. An area of 210ha is used for fisheries. The Plan provided for 2800ha of crop production and 490ha of forest. The centre of the polder has heavy textured river backswamp soils and a broad zone of river-levee soils, along the southern border, (from the Bratul Sf. Gheorghe). A narrow river levee is present along the northern border.

7. Murighiol - Dunavat (2680ha). The embankment of this polder started in 1979 and, the polder was reclaimed in 1986. Around half the soils are river-levee soils suitable for intensive crop production. The other half, however, are peat soils, some of which are very deep and will present great problems if used for crop production. If drained too deeply they will dry out irreversibly and may easily catch fire.

8. Sireasa (7500ha). The dykes around this polder have been built and the head-drainage canals excavated. The pumping stations are not ready yet and the backswamp of the polder has so far not been cleared.

The northern part of the polder provides river-levee soils which are 'technically' suitable for crop cultivation. The soils in the backswamps consist of sloef, covered by a clay layer greater than 30cm, and are suitable for intensive agriculture.

9. Uzlia-Gorgova (23,000ha). The soils of this polder are very poor. The polder contains a number of large and small lakes. It has a very heterogeneous surface with an extensive area of peat soils and very fragmented river-levee soils. The revolution prevented the reclamation of this polder, which is believed would have been an economic failure and done great harm to the ecosystems of the Delta.

10. Tulcea/Nufarol (2500ha), Victoria/Bestepe/Mahmudia (1000ha), Popina-I (3500ha). Some small polders have been constructed between the Sf. Gheorghe Branch and the higher grounds of the Dobruja between Tulcea and Murighiol, and are now in use by neighbouring inhabitants. The total area of these polders is about 7000ha.

In the Plan, a number of polders were included in the transitional zone (mostly peat) as well as in the marine zone (with only sterile, saline sand soils) south of the Sf. Gheorghe Branch. All of them would have been failures.

2.3.5 Conclusions

In the past, decisions relating to agriculture were based on evaluation which only took into account technological or economic criteria within the context of large state farms. Considerations of ecological issues and social welfare were totally neglected. These considerations together with current land privatisation (which has already been implemented in some parts of the Delta), will have a radical impact on land use planning.

All negative impacts on the surrounding ecosystems will have to be avoided in the Delta. A balanced use of fertilisers must be practised so that none leach into the subsoils and enter the ground or surface water. Water pumped out of the polders should be clean. The same criteria should also be applied to stable manure.

It is unlikely that intensive agriculture in the Delta polders will ever be economically and sociologically feasible. Soil conditions in different polders are very heterogeneous and only partly suitable for intensive large-scale agriculture. In addition, the likelihood of low yields (even with irrigation), salinisation, wind erosion, acidification, peat fires, irreversible drying-out of peat and luxuriant weed growth are serious threats.

It will be very difficult to find the necessary skilled labour under the present, very poor socio-economic conditions in the Delta. On the other hand, it will be undesirable to attract people from outside the Delta. This would risk destroying the current ecologically sound and sustainable economy practised by the present inhabitants.

The argument that much money has already been spent in the Delta and would be totally lost if intensive agriculture is not continued, is widely criticised. Although precise measurement is very difficult because of the shortage of data, it is very likely that "modern" agriculture in the Delta is already costing the government more than it earns. It would be much wiser to invest in agriculture elsewhere in the country, where it will be at least several times more profitable than in the Delta, according to some general estimates.

The application of insecticides and pesticides should not be permitted. Biological control methods should be used instead. Herbicides will have to be avoided and weed control should be by mechanical means. On poorer grade soils, the weed problem will probably be daunting, for example as shown by the development of reed and willows *Salix*, on the Pardina Polder.

When a detailed soil map of the Delta is published this will allow more detailed proposals on land use potential to be made. Priority should therefore be given to its publication with explanatory notes and ecological and hydrological data as well as to undertake a survey and study of the vegetation in relation to hydrology.

As practically no data are available on current agricultural practices and the combination of agriculture, cattle breeding, fishing, etc. in the Delta villages, this must be studied by interviewing the local population. Without these data, land-use evaluation cannot be carried out. A project for land and water evaluation of the Danube Delta for sustainable land use, linked to the soil and vegetation maps has been proposed, as well as determination of the cattle carrying-capacity of common grazing grounds.

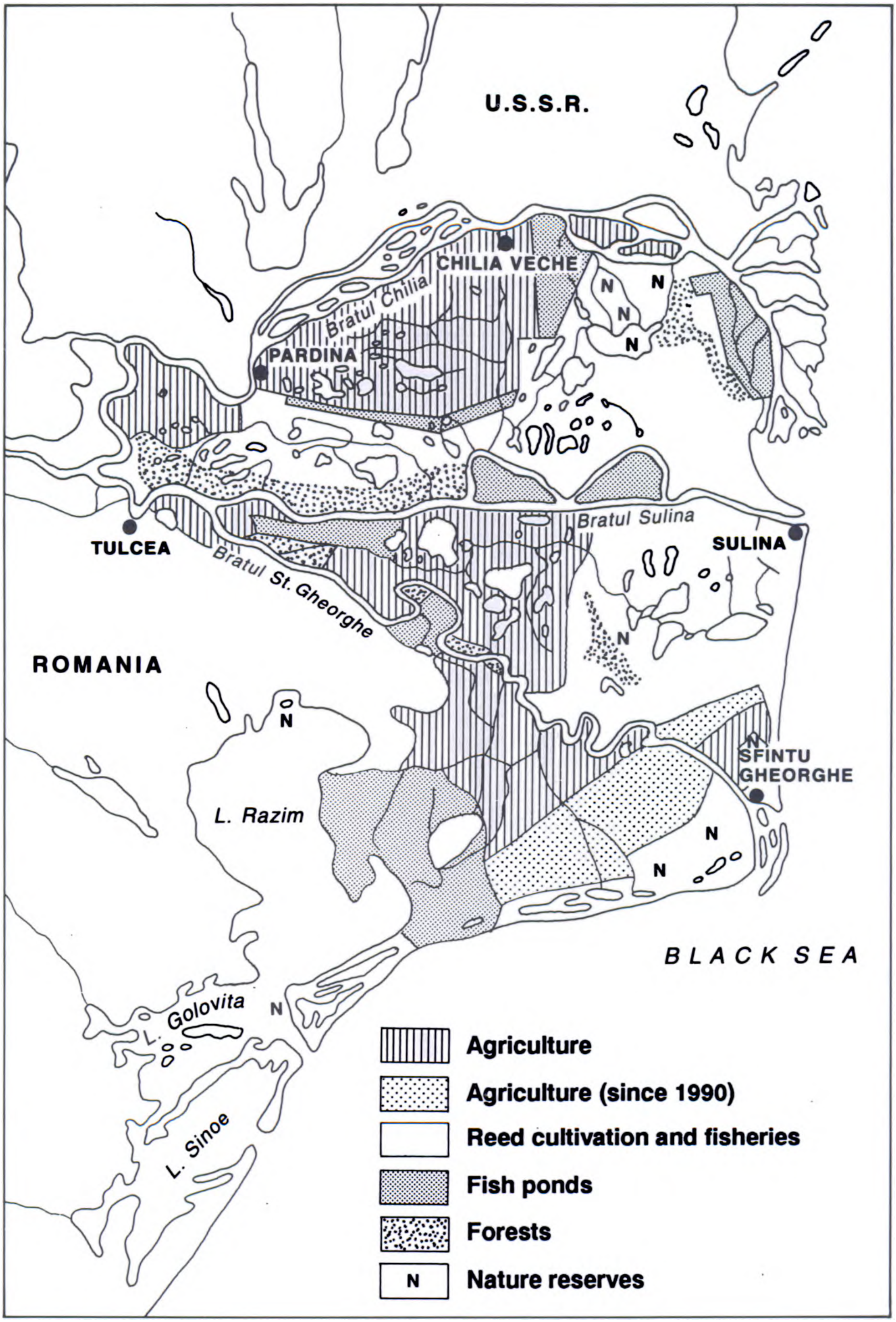

Figure 2.7. Future land use

sustainable land use, linked to the soil and vegetation maps has been proposed, as well as determination of the cattle carrying-capacity of common grazing grounds.

The local freshwater reserves of the forested areas of the beach-barrier complexes should be treated with great care. The slightest increase in exploitation of these freshwater bodies (subsoil reservoirs), for example for tourist development in the villages, will have catastrophic consequences for the Letea and Caraorman forests.

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ANNEX A

The Complex Plan for the Economic Exploitation of the Delta (1975)

Additional details

Fishery and reed production

The area used for fish production in intensive fish ponds and extensive fish polders was to be increased from 29,000ha to 52,000ha (to about 11% of the Delta area). Reed would also be harvested in some of the extensive fish polders. The area covered by reed would have decreased from 253,000ha to 153,000ha under the Plan.

Agriculture

The area used for intensive agriculture was to increase from 6,000ha to 97,000ha, or nearly 20% of the Delta area. The crops envisaged were maize (50%), cereals (25%), potatoes and sugar beet. Only 30,000ha were to be used for extensive agriculture (rough pasture).

Forestry

Forestry plans foresaw an increase in forested area of 19,000ha to 29,000ha (about 7% of the Delta area), with rapidly growing pioneer species such as willows and poplars *Populus*, which would have been used for cellulose and paper production.

CHAPTER 3: REED EXPLOITATION

L. J. Pons

3.1 Introduction

The reedbeds of the Delta are the largest closed unit of reeds in Europe covering an area of 284,000ha. They have long been looked upon primarily as offering an economic opportunity and that aspect will be discussed in the present chapter. Chapter 8 and Annex A to Chapter 1 describe the botanical characteristics and formation of reedbeds.

3.2 History of exploitation

Towards the end of the 19th century, many authorities drew attention to the enormous reed reserves of the Delta and discussed possible economic exploitation.

Between 1896 and 1944, the Romanian biologist, Antipa, published many articles about the Delta and suggested using reed for the manufacture of cellulose. In 1906 he succeeded in interesting investors and obtained a concession for a factory, which was constructed in Braila in 1907-1908. The cellulose was of good quality and some was exported. Unfortunately, the factory was destroyed in 1916 during World War I and not rebuilt.

New research describing the excellent quality of the cellulose and of the various bi-products was carried out and published by Antipa up to 1944. The research was continued after 1944 and in 1948, a group in Tulcea suggested the manufacture of hardboard from reed. This was followed up with the construction of a pilot factory in Tulcea.

Sugar, another product extracted from the reed, was found to form an excellent basis for yeast production.

Since 1948, research was carried out into the cultivation, exploitation and mechanical harvesting of reed. Application of the research started in pilot areas in the Delta proper at Crisan. In 1950 Maliuc island was embanked as a pilot area for reed cultivation. Matita-I followed in 1955 and Rusca in 1957. In 1953, all research was concentrated at the Research Station for Reed Culture in Maliuc.

A new cellulose factory in Braila was ready for production by 1958. In order to meet the heavier demand for reed, a number of reed polders were constructed. The majority (80%) of the reed polders were constructed in the fluvial zone of the Delta and a number of secondary canals were excavated for reed transport (Figure 2.3). The mean yield on the polders is about 15(5-25)t/ha (cut at 20cm from the soil surface and with 15% humidity).

During the period 1955-1963, it was realised that improved understanding of the biology of reed and harvesting techniques will enhance successful reed production. As a result the work in the Maliuc Research Station was intensified. Research subjects included the influence of heavy harvest machinery on reed regeneration; the advantages and disadvantages of reed burning; the hydrotechnical problems of reed cultivation; reed biology; the influence of dykes on the growth and on the harvest of reed, and new Italian reed varieties. At a symposium held in 1963, it was concluded that reed cultivation should be extended, supported by further research.

Shortly after, the maximum extent of reed cultivation and the highest yields were reached. Figure 3.1 shows the areas of reed-polder cultivation in 1965. These areas were surrounded by low dykes and a shallow inundation was maintained by pumps from March to October. The polders were then drained to allow for mechanical harvesting.

3.3 Current trends

After 1963, reed yields decreased sharply. The annual yield was 226,000 tonnes in 1965, 55,000 tonnes in 1975 and is currently 33,000 tonnes. This resulted in the Braila cellulose factory replacing reed with wood as the raw material.

One of the causes of the failures was the use of heavy machinery for harvesting which destroyed reed rhizomes. Recent research on reed has therefore concentrated on harvesting methods. This technical problem now seems to have been largely solved by the development of lighter machinery. However, reed has still not regenerated in the polders.

Reed burning may have been an important contribution to the maintenance of the reed marshes. Presently, only limited areas are burned because burning was forbidden by the former government in order to maintain more harvestable reed. The very limited extent of reed burning is revealed by the small numbers of recently-burned, old white willow *Salix alba* trees observed in the Delta. In contrast the absence or only scattered presence of *Salix* trees in the transitional and marine parts of the Delta is due to the practice of former large-scale reed burning.

When the failure of reed cultivation in the polders was fully realised, their conversion into polders for irrigated crop production resulted in the development of large-scale agriculture in the Delta as proposed in the Complex Plan for the Economic Development of the Delta. Now reed is only collected from natural sites outside the polders.

3.4 Causes of reed bed degradation

Lack of reed regeneration in the polders (even after improving mechanical harvesting methods which did not damage the rhizomes), was probably caused by the exclusion of sediments and nutrients supplied by floodwater. Reed marshes need free flow of river water over the surface, especially during the plants' development in spring and early

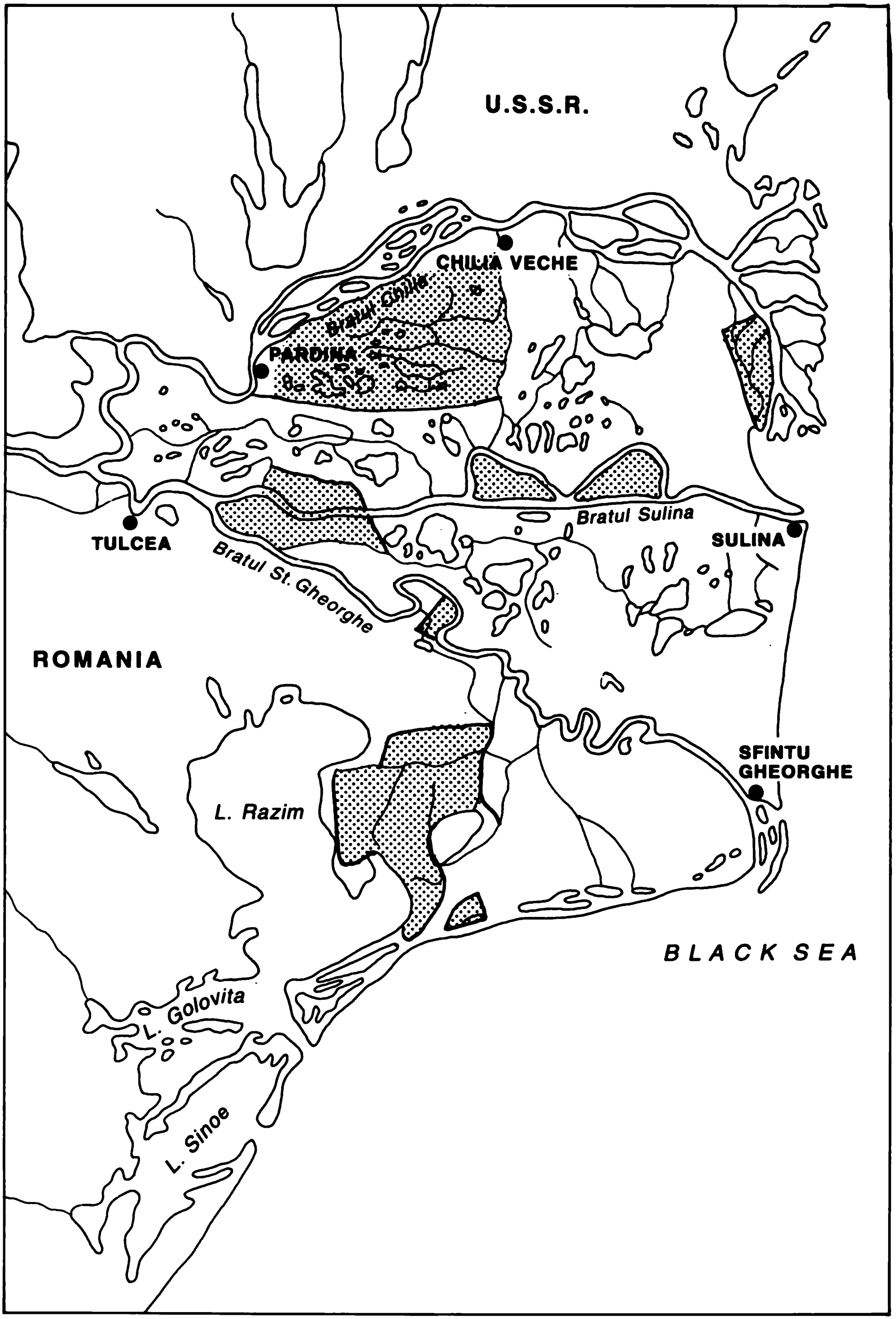

Figure 3.1. Maximum extension of reed polders (c.1965)

summer. Pumped water cannot provide enough nutrients for a good yield. Standing water is a disaster for the reed because it prevents the slight oxidation of the upper soil layer required by reed rhizomes. Other plants, such as *Typha*, took advantage of the poor nutritional status of the reeds and replaced them. The only way of restoring the reed marshes in the polders is to open the dykes and let floodwater penetrate.

3.5 Conclusion

Reed cultivation and harvesting of natural reed should be investigated, to try to find an ecologically safe method which can also increase the nutrient and sediment filtering capacity of the reedbeds.

In rapidly accreting deltas, more or less closed reedswamp (*Scirpeto-Phragmitetum* associations) normally form only during a rather short period. They occur between the initial *Scirpetum* association of the mudflats and the white willow *Salicutum albae* association of the river banks. In the freshwater Rhine estuary, they reach an estimated age of about 100 years (I. S. Zonneveld, pers. comm.).

In the Danube Delta, many sources have observed that reedbeds originally occupied the greater part of the backswamps, which would mean that their successional period is much longer. There are several possible explanations:

1. Probably the most important reason is a natural one. The sediment load of the Danube contains relatively small amounts of clay. The presence of numerous lakes in the Delta proves that the backswamps do not receive enough mineral sediment to fill them. The gradual growth in height of the natural levees allows a correspondingly gradual rise of the area of the backswamps covered by reeds, mostly by the accumulation of peaty clay and clayey peat. The hydrological situation is in equilibrium with shallow to deep inundations over short to long periods to which the rooted reedbeds (not the floating plaurs) are adapted. River flooding brings enough nutrients to maintain a luxurious reed vegetation. The prolonged successional stage of reedswamp communities in the Delta may only be interrupted by the advanced age of the individual reed clones (I. S. Zonneveld, pers. comm.)

2. In former times, the local inhabitants burned reed in the winter, apparently on a very large scale. The reed was burned in order to retrieve the semi-wild pigs and to hunt wild pig, and to capture European mink *Mustela lutreola* and other wild animals for fur. At the same time burning at the right period favoured purer reed vegetation, because other plants such as *Typha* were eliminated. The same holds true for reed cutting in the proper way and at the proper time (without damaging the stolons), as was practised, for example, in the Netherlands (Zonneveld, 1960). Both burning and appropriate harvesting may be considered as a kind of weed control. Reed cutting also favours the early growth of food for wild and semi-wild animals.

CHAPTER 4: COASTAL EROSION AND ASSOCIATED ENGINEERING PROJECTS

E. Stamhuis, M. Marchand and J. P. M. Dijkman

4.1 Introduction

The present and future condition of the Danube Delta is determined by a complex interaction between both natural and man-made developments. A brief glimpse at this interaction reveals a number of problems which are threatening the environmental well-being of the Delta. As an example of these, this chapter focuses on coastal erosion which is leading to proposals for major engineering works and has already resulted in the straightening of meanders in the Sf. Gheorghe river branch. Water flow and water quality are treated in Chapters 1 and 5 respectively.

Coastal erosion is, however, only one of a number of issues that must be considered in an integrated manner. In order to obtain an overall picture of the problems, a systems analysis approach is considered most effective. An overview of the systems approach is given in Annex A to this paper.

4.2 Coastal erosion and increase in the drainage capacity of the Delta

4.2.1 Present status

Along the Romanian coast, the main currents of the Black Sea run from north to south, chiefly because of the prevailing winds. The result is a southward shifting of the Danube Delta river mouths.

The mouth of the Sulina branch has been extended by means of breakwaters to provide and maintain a sufficient depth for sea-going vessels. Nearly 10 million tons of material has to be dredged each year to maintain this depth. This extension to the Sulina branch and the southern branches of the secondary Delta of the Chilia branch are now approaching each other.

Natural accretion on the Black Sea coast near the mouth of the Danube has ended. The coast is being eroded, along practically the whole length of the Delta shore and further southward to Constanza. The most seriously affected parts of the Delta are the sections between the Sulina and Sf. Gheorghe estuaries, between the Sf. Gheorghe and the Portita estuaries, and a large part of Lake Sinoe . In some places beach erosion is threatening infrastructure, for example a fish farm near Parisor and also beach protection structures at Constanza, which raises concern for the tourism industry.

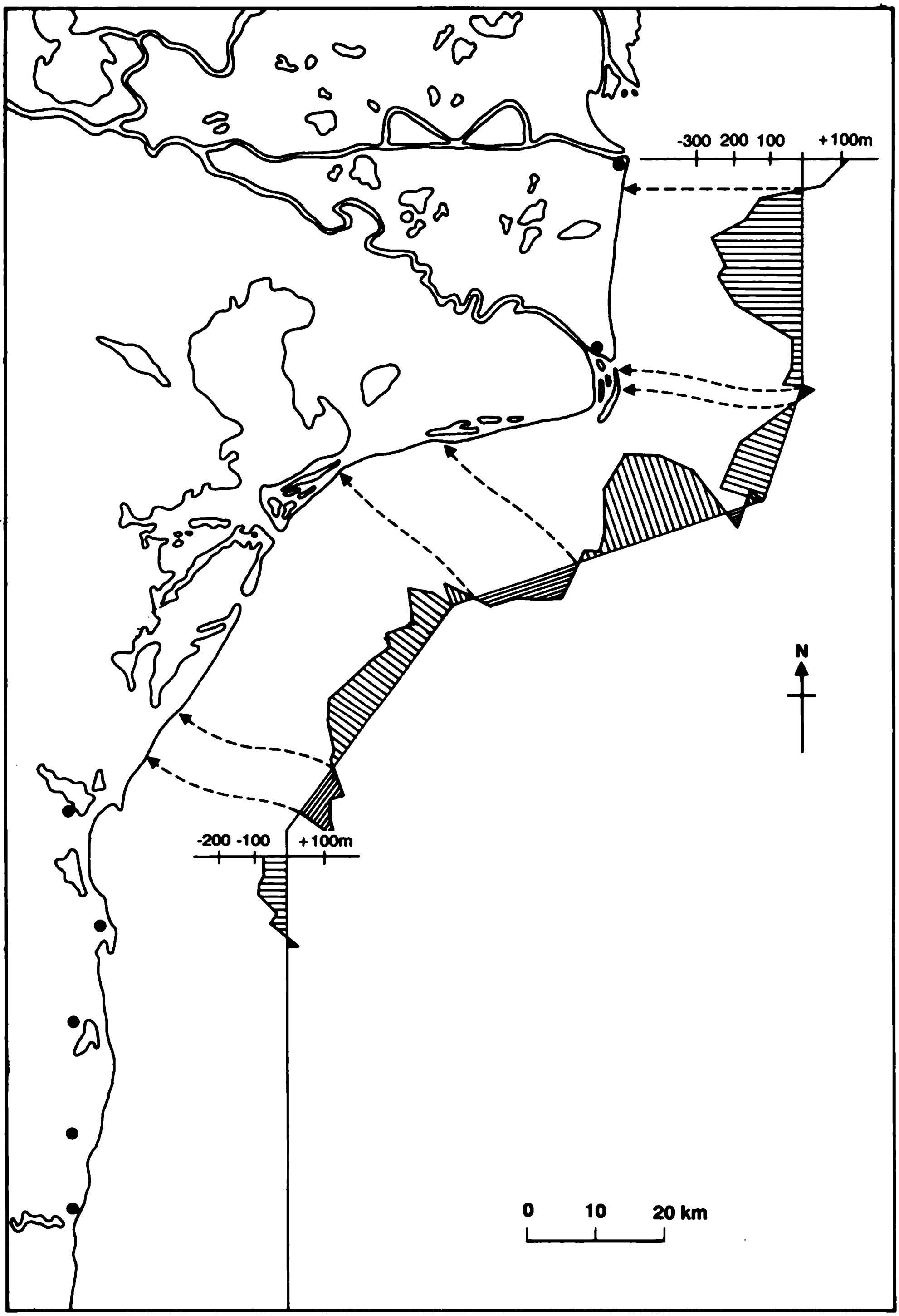

Figure 4.1. Erosion and accretion 1962-1989

The current situation is partly due to dam construction on the Danube which has reduced the transport of sediment. Figure 4.1 shows the results of 27 years of measurements of erosion and, in a few limited areas, accretion along the coast from Sulina to Constanza.

Dredging straight channels between some river bends on the Sulina Branch for improved navigation, has increased the discharge from 7% to 18%. However, similar measures carried out to direct a greater sediment load through the Sf. Gheorghe branch to the Black Sea, do not appear to have significantly altered the discharge rate.

4.2.2 Proposed solutions and possible impacts

One of the options for remedial action which is currently being considered is to increase the volume of sediment transported to the coast by increasing the Delta's drainage capacity. This has already led to the straightening of the widest meanders of the Sf. Gheorghe branch. An analysis of the possible impacts is presented in Figure 4.2. This scheme only indicates relations and possible changes in a qualitative way, and thus precludes a final assessment of the magnitude of the impacts. Nevertheless, it pinpoints interactions which should not be overlooked and identifies the kind of quantitative research needed.

The most obvious impact is that the increase in sediment load entering the Black Sea will result in an equal reduction of sediment deposition in the Delta itself. This will no doubt have consequences for the fertility of Delta soils and the maintenance of habitats. The actual extent over which the sediment reduction will take place, however, is more difficult to assess.

Another possible impact of increased drainage is reduction in inundation frequency. Again, the exact order of magnitude of this decline is difficult to assess, but the impact upon the vegetation will be easier to predict. There is a fairly well known and precise relationship between inundation frequencies and timing, and vegetation composition. In general it is likely that a significant reduction in flooding will result in a change in vegetation composition towards one which is less characteristic of the natural Delta ecosystem (see also Chapters 1 and 8).

A more radical option proposed by some engineers for direction of sediment to beaches threatened by erosion is to construct branches from the Sulina and Sf. Gheorghe river branches to more southerly mouths along the coast (Figure 4.3). Deviations of the bedload through these new branches would be achieved by making specially adapted bifurcation points.

It is clear that such measures would pose the threat of irreversible change in the natural values of the Delta. More research is necessary.

A third proposal is based on the belief that coastal erosion along the Delta coastline is caused by waves and can be stopped by digging a canal parallel and close to the beach (Figure 4.4) and dredging here is continuing.

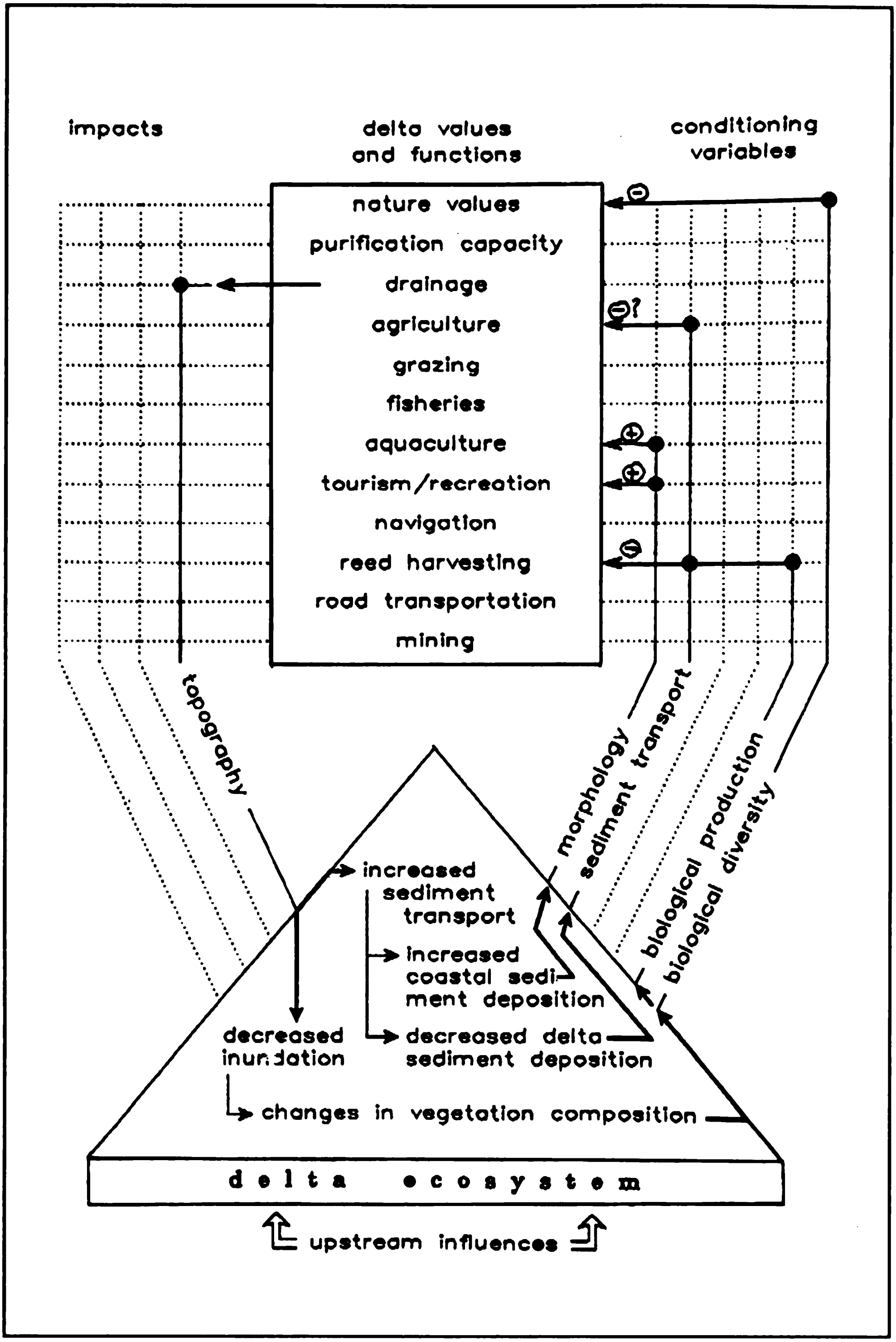

Figure 4.2. Danube Delta impact analysis flow chart

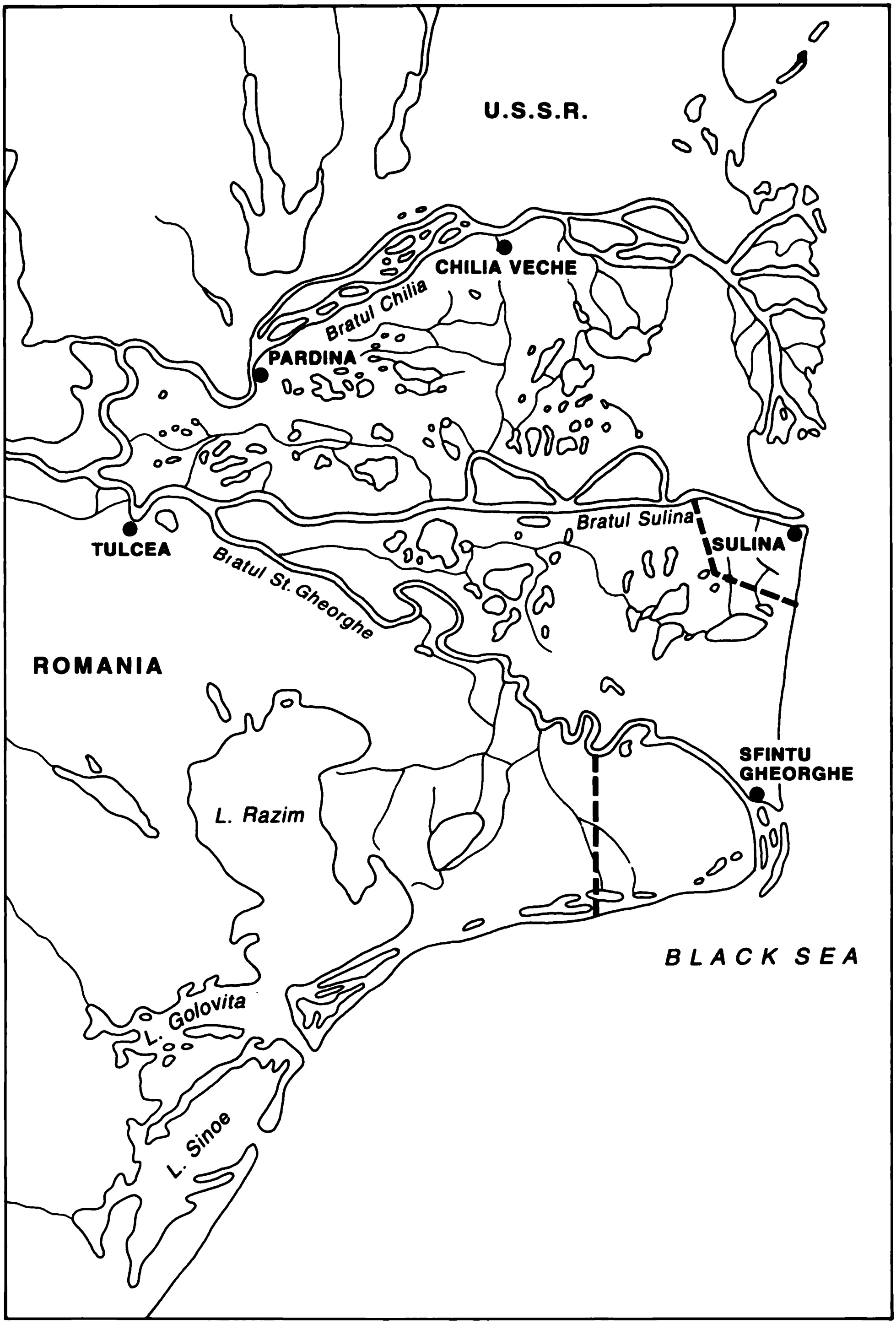

Figure 4.3. Proposed new canals

These projects, their potential impacts, and alternative approaches to the problem of coastal erosion therefore need to be studied in detail.

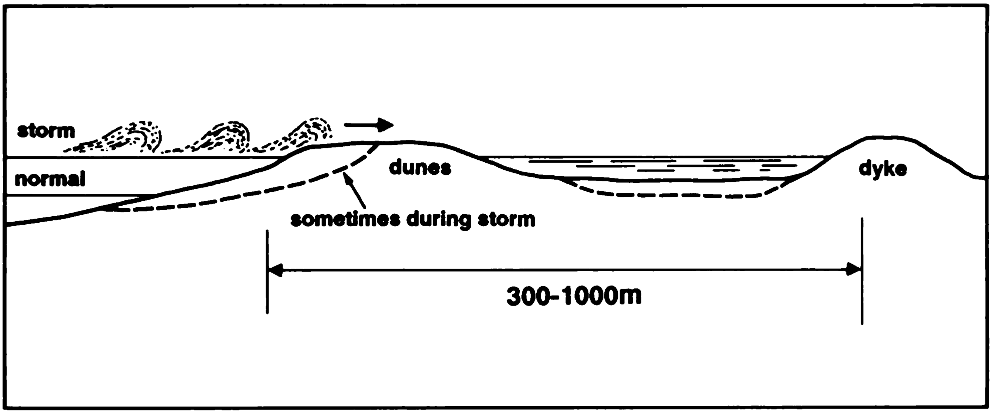

Figure 4.4. A scheme for coastal protection

4.3 Conclusions

Formal government support for recent conservation efforts in the Delta is provided by the Decree of 7 February 1990 that curtailed certain engineering work in the Delta, and Decree No. 983 of 27 August 1990 which created the Biosphere Reserve and provided for initial management structures (see Chapter 9). Nevertheless there is an impression that the momentum of the 'Complex Development Plan' of 1975 has not yet fully come to a stop.

Investigations into the ecological effects of current and planned engineering works that could influence the Delta's hydrology are urgently needed. These investigations should be carried out by Romanian Institutes and, where appropriate, in close cooperation with specialised foreign institutes.

ANNEX A

A framework for a systems analysis approach to management of the Danube Delta

The complex relations between the activities and the environment in and around the Delta call for a systems approach in which the system components and interactions are clearly identified. A schematic representation of this system is given in Figure 4.5. Natural values can be described in terms of important habitats, and the great biodiversity in terms of numbers of birds, plants etc. The main functional properties of the Delta accruing from natural resources which may not to be exploitable, but which provide spontaneous benefits for society are the purification capacity of the immense reed beds and the drainage capacity of the Delta itself.

Human uses of the Delta include agriculture, reed harvesting, forestry, fisheries, aquaculture, road transportation, navigation, tourism and recreation. However when poorly managed these human uses can lead to the degradation of Delta resources.

The Delta ecosystem is the product of physical, chemical and biological components and their interactions. Inputs include the influences of upstream conditions, notably changes in water discharge and pollution loads, and the impacts generated by the uses of the Delta. These impacts are:

- over-exploitation of natural resources
- environmental degradation and habitat destruction
- pollution
- changes in topography

The flow chart given in Figure 4.5 discerns six conditioning variables which determine the functions and values of the Delta. These variables are:

- morphology of the Delta and coastal zone
- water quantity
- water quality
- sediment transport
- biological diversity
- biological productivity

The arrows and dots provide a summary of the interrelationships between human activities and their impact upon the ecosystem, and indicate the impact, both upon human activities and the values and functional properties of the Delta. The flow chart enables priorities for the analysis to be set.

Thus, the analysis should concentrate upon three different questions:

(a) What are the minimum and optimum levels of the conditioning variables for each of the functions and values?

(b) What are the impacts of human activities upon the environment?

(c) How does the Delta ecosystem react to changes in the environment?

In order to assess the actual and potential exploitation levels of the Delta's resources both minimum and optimum levels of environmental conditions should be quantified as much as possible. This should include minimum water quality standards for fishing and agricultural practices, minimum water levels for navigation, and optimum inundation frequencies and duration for flood forests.

Accurate assessment of impacts requires a well-defined description of the activities and should pay special attention to cumulative and synergistic processes. It should define sources of contamination, the extent of habitat loss, changes in river courses, etc. These 'first order impacts' will in many cases induce higher order impacts through changes in the ecosystem.

Management of the Delta and its coast

Management of the Danube Delta and adjacent coastline is not an objective in itself, but a condition for the realization of other objectives, e.g. social, economic and ecological objectives. Delta and coastal management deals with complicated physical, chemical and ecological phenomena and with a number of different, and sometimes conflicting, interests. An integrated management plan of the Delta and coast is essential.

Therefore, the implementation of Delta and coastal management requires a well-structured management institution with a clear task, sufficient power and financial resources. Such an institution should at least cover the following four different aspects related in such management, and comprise specific departments to carry out these tasks:

- department for legal and administrative aspects;
- department responsible for monitoring and measurements;
- research department;
- construction and maintenance department.

It is considered outside the scope of the mission to further elaborate on this topic. It is suggested to the authorities involved, to devote ample attention to the institutional aspects of Delta and coastal management. The current situation certainly could be improved, for example by paying more attention and giving more facilities to the work of the "Institute of Meteorology and Hydrology", to the hydrological and hydrographic observations and measurements performed by this Institute with minimal means.

Suggested future activities

Possible objectives of follow-up activities are as follows.

(a) detailed problem analysis, using the framework of figure 4.5, with due attention to:

- the demand side: which are the minimal environmental conditions for function optimization?
- the on-going and planned developments in the region - the impacts of these developments.

(b) the identification of development alternatives

(c) analysis of the impacts of the various alternatives

(d) selection of the preferred alternative, using explicit criteria (e.g. sustainable development of the Delta and coastal ecosystem, optimal resource management, etc.), and drafting of a Danube Delta and Coastal Management Plan.

The suggested Danube Delta and Coastal Management Plan should consists of:

- A Delta and coastal protection and development strategy, which is a coherent set of measures, specified in time and place, regarding the protection and development of the Danube Delta and adjacent coastal strip.

Such measures include:

- technical measures: preventing or alleviating (the effects of) problems in the Delta and coastal zone by means of technical interventions, for example the construction (or removal) of dykes or breakwaters;
- administrative measures: preventing or alleviating problems by for example taxing pollutant discharges, restricting hunting, etc.;
- a monitoring control and inspection system.

This report does not aim to provide a firm suggestion of how to proceed with the preparation of a Delta and coastal management plan. Rather, it offers information on what simulation methods and techniques are currently available to support the preparation of a management plan.

Computational framework

A computational framework provides a consistent set of quantitative tools (including corresponding data bases), which assist the analyst in understanding the system under study and allow the evaluation of alternative strategies.

Central to the computational framework (Figure 4.5) is a hydrological simulation model to which other models are linked, describing:

- water quality distribution;
- ecological situation (eutrophication);
- sediment distribution;
- coastal morphology;
- functional uses including agriculture, aquaculture, fisheries, navigation, tourism and hunting.

For the description of the physical and chemical aspects of the whole system, quite powerful computer simulation models are available. The processes are generally well understood and can be quantified accordingly. These aspects include hydrology, river discharge dynamics (non-steady water motion), suspended sediment transport, bed load sediment transport, water quality processes (chemical, physical). Many examples of similar studies for other Delta and coastal areas illustrate the power of such a quantified approach. In this respect it should be noted that the coupling of models, whereby the output of for instance a hydro-dynamical model is used as input for a water quality model is increasingly being applied, which greatly enhances the integrating power of such an approach. On the other hand, however, quantitative simulation models to describe biological and ecological aspects are not yet so well developed, not in the least because the processes involved are very complex.

The following are brief descriptions of simulation models that could play a major role in modelling the various process in the Danube Delta and coastal zone.

WENDY

The WENDY program comprises a comprehensive set of software applications for river and estuary engineering and research. The core of the package is a one-dimensional dynamic flow-routing model (called WAFLOW). Additional modules are available to cater for various river and estuary problems such as:

1. Water flow including density effects, e.g. salt intrusion in an estuary (SAFLOW);
2. Sediment transport and bed level changes (SEFLOW);
3. Suspended sediment transport and bed level changes (SUSFLOW).

The various options of WENDY are typically used in studies assessing the effect of human interference in a natural water course. More specifically, the WENDY program can be applied in studies related to:

- river training;
- river canalization;
- dredging optimization;
- meander bend cut-offs;
- intake of water for industry, drinking water, cooling water, irrigation;
- effect of regime change caused by reservoir operation or climatological changes;
- flood level computations for risk analysis and design of embankments;
- low water computations for navigation and water intake structures.

Many, if not all, of these items are of relevance for the Danube Delta. The application of WENDY is therefore considered of great value in studies on the Danube Delta and coastal zone, not only to support studies on more or less isolated problems, but also to provide a general water, salinity and sediment model for the entire Delta area.

DELWAQ

The DELWAQ model is a water quality model. It calculates the behaviour and fate of water quality constituents, based on scenarios which have been formulated as inputs. The model is capable of describing any combination of constituents and is not limited with respect to the number and complexity of water quality processes. Information on the hydrodynamic situation is provided by other models, for example WENDY.

DELWAQ is capable of handling one-dimensional (river and Delta system), two-dimensional (non-stratified coastal waters) and three-dimensional (stratified coastal waters) representations of the study area. Dynamic simulations can be performed (time-dependent flows, reactions, wasteloads and concentrations) as well as steady-state simulations (concentrations as steady conditions).

In the modelling of water quality processes (kinetics) DELWAQ provides the option to use almost any specific set of equations, or to link DELWAQ to other models, for example the dynamic model for algae BLOOM-II. Hence, DELWAQ is not a "fixed" model, but rather a tool-kit for water quality modelling that allows the integration of various specific water quality routines in a flexible system scheme. Since in many cases a satisfactory description of the dynamic behavior of the system is the most complicated part of water quality modelling, this is considered a very powerful feature. In particular, this may be very useful in the water quality modelling of the Danube Delta and coastal zone, where serious problems related to eutrophication, oxygen depletion the deeper water layers, bacterial pollution and (locally) heavy metals are observed or expected.

HYMOS

HYMOS is a data base management and data processing software package for hydro-meteorological data. In the framework of the Danube Delta analysis, HYMOS can be applied to store hydro-meteorological data with respect to the hydrological input to the Delta system (time series of upstream Danube discharges and sediment loads), and the hydro-meteorological situation in the Delta itself (time series of rainfall on the Delta, climatological data, measured discharges and water levels in branches of the Delta, etc.).

Coastal Morphology Models

Coastal erosion and accretion can be understood and explained in terms of the sediment balance in both the Danube river and Delta and the coastal zone. It is clear that when for example, reservoir development upstream in the Danube alters sediment input, impacts can be expected on morphology in the Delta and along the coastline. An understanding of the sediment transport pattern is of basic importance in coastal erosion studies as required for the southern part of the Delta coastline.

Depending on the nature of the problem, the available information and the complexity of the physical processes, a modelling approach can be used to deal with the problem. The problem can be modelled by means of mathematical models, scale models or a combination of both.

Various mathematical models are available for simulating coastal evolution. One-dimensional coastline models (for example the KC/KL model) are applied to situations in which interest is focused on integrated coastal development without the need to reproduce the individual small-scale morphological processes. Two-dimensional coastal field models (like for example the COMOR model) are applied if a detailed insight is required into the interaction of all processes involved. At this stage it is difficult to suggest which approach is most appropriate to follow for the Danube Delta coastal morphology problem.

To model the flow pattern in the coastal zone, the program DELFLO can be used. DELFLO provides numerical modelling of two-dimensional depth-averaged unsteady flow, such as tide- and wind-generated water motions on continental shelves and in estuaries.

Figure 4.5 illustrates the main components of the computational framework to support the analysis for the Danube Delta and coastal zone. The blocks in this figure identify either simulation models describing certain aspects of the Delta and coastal zone, or identify impact assessment activities. The arrows between the blocks represent the flow of information between the blocks.

The hydrological analysis is carried out with the help of HYMOS, creating input information for the water dictribution model WAFLOW. In addition to the hydrological information, WAFLOW also requires information on the layout of the dalta system, cross-sections of the various channels and various hydraulic parameters.

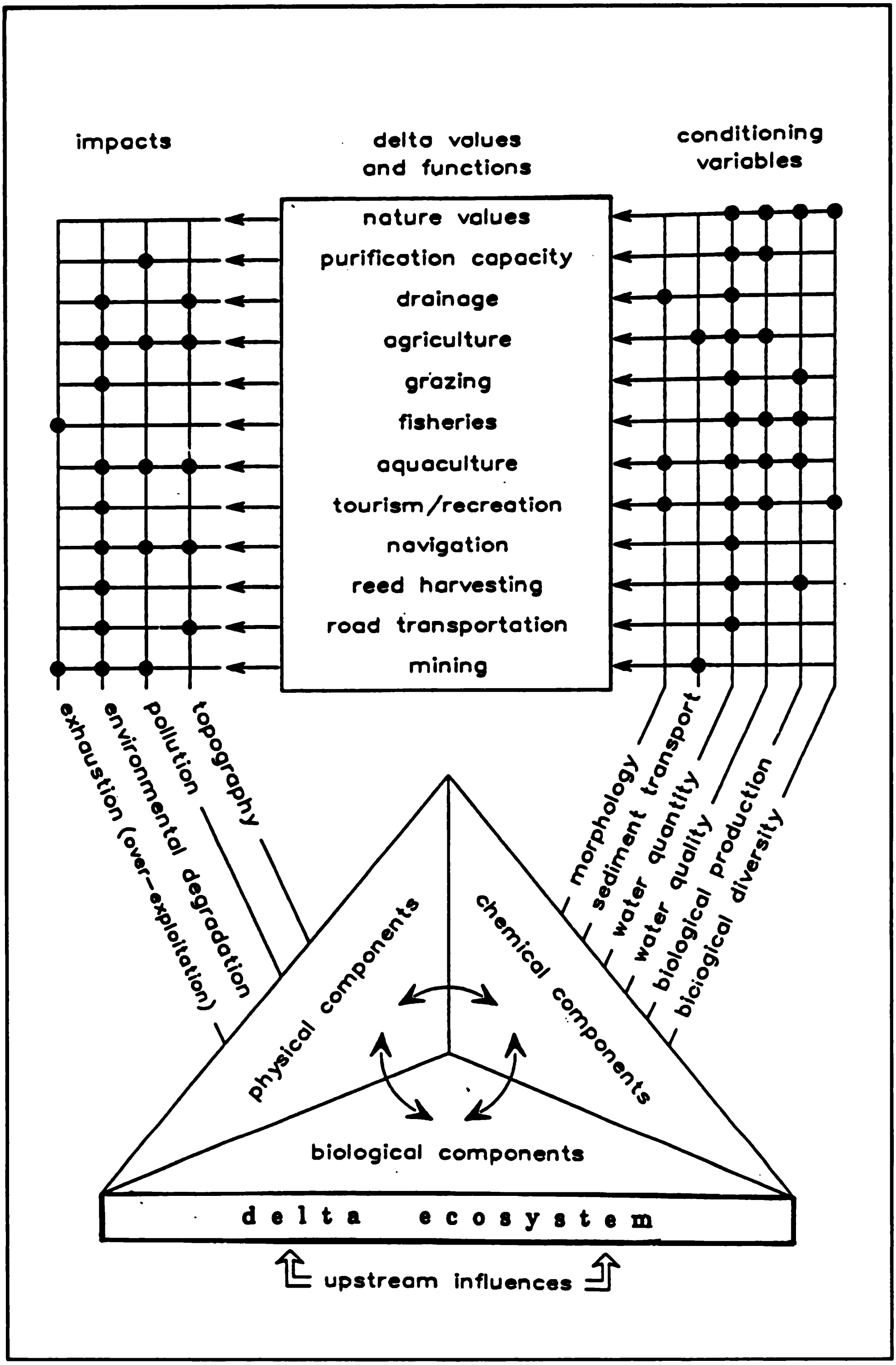

Figure 4.5. Components flow chart

The results of the water distribution simulations are used as partial inputs for the coastal morphology model, the sediment model for the Delta (both suspended sediment as modelled by SUSFLOW as well as bottom sediment modelled by SEFLOW), the salinity distribution modelled by SAFLOW and finally the water quality model for the Delta and coastal zone DELWAQ.

The results of all models provide input for the ecological impact assessment and the impact assessment on user functions of the area, including agriculture, aquaculture, fisheries, navigation, tourism and possibly other uses as well.

CHAPTER 5: TROPHIC STATUS OF THE DANUBE DELTA: A WATER QUALITY ASSESSMENT

G. Pinay

5.1. Introduction

The Danube Delta is intrinsically a system in dynamic equilibrium under the control of seasonal dynamics and geomorphic influences, where nutrients, water and sediments are either retained or their movement retarded. These buffering capacities confer on the Delta a key role in the functioning and the regulation of the lower Danube River System. Due to these characteristics the entire Delta should be considered as a functional entity when considering its restoration and sustainable management.

5.2 Status and trends

The biochemical status and trends of the Danube Delta are closely related to those of the Danube River itself, which provides the major input of water and energy, and largely dictates the natural geomorphic changes of the Delta.

For several years the Danube Delta Research and Design Institute and the Braila Research Station for Aquatic Ecosystems of the University of Bucharest have monitored the water quality of the Danube River as well as the numerous water bodies of the Delta. The results discussed here are derived from the work of these two research institutes.

5.2.1 The Danube River

Since 1980 nitrogen and phosphorus loads have increased in the Danube River downstream from the city of Tulcea, with values averaging 2.5mg/*l* of nitrate and 250µg/*l* of phosphate. Moreover the lower values in the range have been increasing. Chemical Oxygen Demand (COD) values, which increased up to 10mg of O_2/l in 1988, suggest an important load of dissolved organic and mineral matter in a reduced form. This increase in COD coincided with a sharp increase in hydrogen sulphide (H_2S) concentration, up to 0.3mg/*l* since 1985, which indicates the existence of anaerobic conditions in river sediment.

Heavy metals have followed two patterns of evolution: iron, lead and cadmium concentrations have increased in the Danube River downstream from Tulcea since 1980 to 3mg/*l* for iron, 50µg/*l* for lead and 13µg/*l* for cadmium, while manganese, zinc, copper and aluminium have decreased (Table 5.1). The sharp increase in zinc at the beginning of the 1980s was due to a malfunction at the Braila paper mill. Since then the fault has been repaired and the zinc concentrations have decreased. See Annex A for water quality standards in France, for comparison.

Concentrations of phenolic compounds ($C_6H_6O_5$) increased sharply in 1985, up to 7µg/*l*. Since then their concentrations have decreased below 1µg/*l*, while organochlorine pesticides have increased since 1982 to 5µg/*l* in the Danube River.

The water quality of the Sulina branch of the Danube has been monitored since 1982 downstream from Tulcea to Sulina. However levels of nutrients and heavy metals do not show any significant change. These results underline the fact that channels such as the Sulina branch, which has been canalised since 1902, do not offer any kind of filtering or retention capacity regarding nutrients or heavy metals. On the contrary, such man-made channels conduct the pollutants straight to the Black Sea.

Table 5.1. Trends in heavy metal loads in the Danube River downstream of Tulcea (µg/*l*)

	1980	1989
Iron	3	6
Lead	7	13
Cadmium	2	8
Manganese	100	60
Zinc	200	100
Copper	25	11
Aluminium	20	8

Source: Danube Delta Research and Design Institute, Tulcea, 1989. Unpublished.

5.2.2 Danube Delta water bodies

Water quality of the main aquatic ecosystems of the Danube Delta (i.e. lakes, channels) has been monitored since 1980. These lakes and channels represent a very important part of the Delta ecosystem, in view of the area they cover and their ecological and hydrological functions. Thus creeks and channels cover 3470km, which represents a drainage network of 1km/km^2. There are also 668 lakes which represent an area of 31,262ha (i.e. 9.28% of the Delta surface) including 50 lakes which cover 21,195ha (Gastescu and Driga, 1983).

Dissolved nitrogen and phosphorus content of lakes and secondary channels is lower than those measured in the Sulina branch of the Danube River, but has been increasing since 1980. Dissolved inorganic nitrogen concentrations range between 1 and 3mg/*l* while phosphate phosphorus content ranges between 80 and 280µg/*l*. These nutrient values are far above the limiting values for algae or macrophyte growth. Seasonal dynamics of nitrogen and phosphorus in the main Delta lakes present opposing patterns which can be explained by the internal functioning of the lake ecosystems. Release of phosphorus in summer could be due to sediment desorption under anaerobic conditions. The high oxygen demand (BOD, COD) recorded during the same period, as well as the continuous increase of hydrogen sulphide (H_2S) in water since 1982 (from 0.1 to 0.8mg/*l*), seem to confirm this hypothesis.

Heavy metal content in secondary channels of the Delta and its lakes depends on the load in the Danube itself as well as on the position of the channels in relation to the main Danube channels. These lakes, secondary channels and reedbeds act as filter systems not only for nutrients but also for heavy metals. A study undertaken by the Braila Research Station for Aquatic Ecosystems allows an evaluation of the retention capacity for heavy metals of the lake ecosystem between the Uzlina and Rosu lake complexes (Table 5.2).

Table 5.2. Percentage decrease in heavy metals in the different compartments of the lake ecosystem between the Uzlina and Rosu lake complexes

Element	Water	Sediment	Seston
Manganese	38	49	90
Copper	90	21	43
Lead	52	37	52
Iron	7	14	34
Zinc	5	11	11

Source: Danube Delta Research and Design Institute, Tulcea, 1989. Unpublished.

In spite of these retention capacities, all heavy metal concentrations except zinc have increased in all the secondary channels and lakes since 1982, due to constant input from the Danube River itself. These concentrations reach up to 9µg/*l* for cadmium, 1000µg/*l* for iron, 210µg/*l* for manganese and 130µg/*l* for lead.

Organochlorine pesticides and phenolic compounds are also of great concern in the Delta water bodies since they show an increasing trend since 1982. For instance their concentration in water in the Matita-Merhei lake complex reaches 9.5µg/*l* and 10.1µg/*l* respectively.

The status and trends of Danube Delta water quality based on the data provided by the research institutes cited here reveal that the Delta is subject to eutrophication. Most of the lakes have experienced a decrease in macrophytes and some, total disappearance (Cristofor, 1987). Algal blooms (mainly Cyanophycea) occur throughout the growing season in lakes and secondary channels (M. Oltean pers. comm.). Macro-invertebrate diversity has also drastically decreased in the last decade. For instance, more than ten species of Chironomidae were present in 1980 in Lake Rosu; now there is only one (N. Botnariuc pers. comm.). The same trend can be observed for fish and bird populations (see Chapters 6 and 7). This advanced stage of eutrophication could soon be irreversible if corrective measures are not taken immediately.

5.3 Causes of water quality deterioration

Several interrelated factors explain the evolution of damage to the functioning of the Danube Delta (Vadineanu and Cristofor, 1987). These can be summarised under four headings:

1. The high nutrient loads of the Danube River upstream of the Delta;
2. Engineering impoundments (e.g. dykes, cut-offs, canalisation);
3. Human activities (i.e. intensive agricultural practices and fish farming);
4. Changes in the hydraulic regime of the Danube River over the last few years.

5.3.1 Nutrient loads of the Danube River

The Danube river water is of vital importance for about 70 million people living in the river basin. Economic development in the riparian countries is liable to cause water quality problems affecting public health and economic activities, as well as the ecological functioning of the Danube River. The river channel has been extensively engineered over the last few decades (e.g. by dams, dykes and cut-offs). The result has been a break in the connection between the river and its floodplain. For instance, from 1963 to 1967, embankments on the Romanian stretch of the Danube River reduced the area of the floodplain by 290,000ha, which corresponds to a loss of 4.3km^3 of flood retention capacity (Gastescu and Driga, 1981). In turn the Danube River system has lost the nutrient and heavy metal filtering capacity once provided by the floodplain. The decrease of the river's self-cleaning capacity and the increase of polluted effluents have resulted in a continuous deterioration of river quality.

Recognising this deterioration, in 1985 the Danube riparian countries signed the Bucharest Declaration on cooperation for water management and especially water pollution control.

5.3.2 Engineering in the Danube Delta

Creation of polders in the Danube Delta has reduced the flooded area by 25% since 1960 (435,370ha in 1960; 337,521ha in 1989). Thus, the water retention capacities of the Delta have been reduced (from 5 to 3.3 billion m^3) and water and nutrients have flowed directly to the Black Sea. The decrease in filtering capacities of reedbeds and aquatic water bodies of the Delta associated with this reduction is detrimental to the Black Sea, which is already eutrophic (M.T. Gomoiu pers. comm.).

Under natural conditions the wetland ecosystems of the Delta are dynamic and can change rapidly in response to allogenic development processes (water dynamics, erosion, sedimentation) and autogenic developmental processes (population dynamics, eutrophication, sedimentation). Embankments and channels block these autogenic and allogenic processes and lead to irreversible changes. For instance, the creation of the

Caraorman canal has resulted in an increase in the eutrophication and sedimentation processes in the Lumina-Puiu-Rosu lakes complex in the last few years. In addition, rejuvenation of lake ecosystems during flooding is limited by impoundments.

5.3.3 Human activities in the Delta

Traditional economic activities in the Delta (i.e. fishing, reed harvest, extensive agriculture) were probably generally in balance with the natural dynamics of the Delta ecosystems. However, radical changes have occurred in the last decade as a result of the development of intensive agriculture and fish farming. Not only do these developments require impoundments of the Delta, but they both require nutrient inputs, and pesticides are required for agriculture. To give an example of the effects of these intensive practices, organochlorine pesticides including DDT have been tracked in different compartments of the Delta ecosystem by the Danube Delta Research and Design Institute of Tulcea (Table 5.3).

These figures suggest that the entire food web of the Delta ecosystem is affected by pesticides, which come from the River Danube and from the polder soils of the Delta devoted to intensive agriculture.

5.3.4 Changes in water discharge

In the last few years changes in water discharge have occurred in the Danube River. Flood peaks which flushed the water bodies of the Delta (i.e. lakes, channels) have been lower in the last few years. Low water periods are longer and more dramatic since the loss of the floodplain in the lower Danube has significantly reduced the water-holding capacity of the river system which formerly released water during low discharge. These two facts mean that water bodies in the Delta which were previously connected are cut off from each other and eutrophication is enhanced.

5.4 Conclusions

The advanced stage of eutrophication encountered in the Danube Delta needs curative as well as preventive measures. Difficulties in tackling the problem arise from the fact that some causes are external to the Delta ecosystem (i.e. water quality of the Danube River) and that the Delta is a functional entity so all autogenic and allogenic processes have to be considered together.

Restoration of the river's water quality requires efforts from all the Danube riparian countries. Thus while although the Bucharest Declaration in 1985 was a step in the right direction, urgent concrete measures (e.g. wastewater treatment plants for the main towns and factories along the Danube River and its tributaries; restoration of river floodplains) are needed.

The effects of water regulation in the Delta should be assessed, taking into account ecological impacts as well as the consequences on nutrient retention capacities, before any further impoundment is carried out.

Consideration should be given to how the drainage network should be designed in order to ensure the best nutrient retention in the Delta without increasing eutrophication. In support of this work, research programmes on the nutrient and heavy metal retention capacities of the Delta ecosystems should be continued and serve as the basis of management proposals.

It is very important to develop simultaneously monitoring procedures to evaluate status and changes in the ecological systems in the Delta. These procedures should include chemical and population parameters as well as hydrological and geographical surveys. Such monitoring will help in the development of ecological guidelines for a long term sustainable management programme for the Danube Delta.

Table 5.3. Organochlorine pesticides (HCH) and DDT concentrations in the Delta ecosystem

	HCH (mg/kg)	DDT (mg/kg)
Pardina soils		
10 years of cultivation	100	0.05
20 years	500	1.5
Fortuna Lake		
Sediment	0.0019	0.081
Plankton	20.66	13.76
Silurus glanis	0.19	0.27
Matita Lake		
Sediment	0.01	0.112
Plankton	5.46	29.65
Silurus glanis	0.22	0.38

Source: Danube Delta Research and Design Institute, Tulcea, 1989. Unpublished.

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CHAPTER 6: THE ORNITHOLOGICAL IMPORTANCE OF THE DANUBE DELTA AND LAKES RAZIM-SINOE

R. Green

6.1 The principal bird habitats

The Danube Delta and associated wetlands provide areas of foraging and nesting habitat for birds which, although considerably reduced from their former extent, are still outstandingly large compared with most other wetlands in Europe.

The most extensive habitat is the large area of freshwater marsh, particularly *Phragmites* reedbeds, much of which grows on a floating mat of decomposing plant material. The reedbeds are the main habitat of the bittern *Botaurus stellaris*, little bittern *Ixobrychus minutus*, marsh harrier *Circus aeruginosus* and rails Rallidae. The nesting colonies of pelicans *Pelecanus*, great white egret *Egretta alba* and purple heron *Ardea purpurea* are also located in reedbeds.

There is a large number of shallow freshwater lakes and pools within the reedswamp which are used for foraging by wildfowl (Anseriformes), coot *Fulica atra*, large fish-eating birds such as cormorants *Phalacrocorax* and pelicans, as well as many other species including large numbers of breeding marsh terns *Chlidonias*. Most of the area of these water bodies has a mean depth of less than 2m. Some of the shallower lakes within the Delta support beds of submerged macrophytes which serve as a food source for herbivorous waterfowl. Shallow pools and the margins of channels through the reedbeds are used by herons (Ardeidae). The reed-fringed edges of pools and channels are used as nesting sites by wildfowl including the ferruginous duck *Aythya nyroca*. Domesticated livestock range freely in many parts of the Delta and create open areas in those reedswamps accessible from higher ground.

Areas of trees and scrub, especially willows *Salix*, on levees within the marshes act as nesting sites for many bird species including colonies of egrets and herons (Ardeidae) and glossy ibises *Plegadis falcinella* and solitary nests of raptors such as hobby *Falco subbuteo* and white-tailed eagle *Haliaeetus albicilla*.

The coastal fringe of the Delta is being eroded in places but in other areas there are sandy beaches along with the predominantly sand island of Sacalin. This island is used by nesting terns (Sternidae) and stone-curlew *Burhinus oedicnemus*. The coastal waters close to the Delta are used for feeding by terns and Dalmatian pelicans *Pelecanus crispus*.

The former coastal sand deposits now within the Delta support areas of dune vegetation, dry grassland and strips of mature *Quercus/Fraxinus/Populus* woodland within depressions between the old dunes at Letea and Caraorman. The dry grasslands have breeding populations of stone-curlew and roller *Coracias garrulus*. The woodlands have nesting pairs of raptors including white-tailed eagle and saker falcon *Falco cherrug*.

The lakes Razim, Golovita, Zmeica and Sinoe are large, brackish lakes protected from the sea by sand bars which formerly had gaps in them allowing the penetration of sea water. The islands of Popina and Lupilor provide breeding sites for ruddy shelduck *Tadorna ferruginea*. Sand dunes, sand islands and bars between the lakes and on the coast provided breeding areas for terns and gulls (Laridae), stone-curlew and collared pratincole *Glareola pratincola*. Pelicans use the lakes for feeding. In addition, large numbers of ducks and geese use the lakes for feeding and roosting in autumn and winter. They include many diving ducks *Aythya* feeding on benthic molluscs, and white-fronted goose *Anser albifrons* and red-breasted goose *Branta ruficollis* which feed on farmland and roost at the lake. In cold weather these large, brackish lakes tend to remain unfrozen for longer than the freshwater lakes of the Delta.

The freshwater lakes Istria, Nuntasi and the southern part of Lake Sinoe lie to the south of the Delta. They have reedbeds and marshes which hold bitterns, little bitterns and a little egret *Egretta garzetta* colony. Sandy deposits around the shore and dry grassland hold breeding collared pratincoles and stone-curlews.

6.2 Significant bird populations

Radu (1979) lists 176 bird species as breeding, at least occasionally, in the Danube Delta. Cramp and Ferguson-Lees (1963) point out that the Delta has a considerably greater number of breeding bird species than two other large southern European deltas, the Rhone and Guadalquivir. Published population estimates based on systematic censuses are not available for most breeding birds of the Delta, but estimates for selected species for 1986, mainly based on data from J. B. Kiss, D. Munteanu and N. Toniuc, are presented in Table 6.1. The numbers of wetland birds are large and for several species form a substantial proportion of the European, Palearctic or world populations. Of special note is the great importance of the Danube Delta for the pygmy cormorant *Phalacrocorax pygmeus*, the area holding a substantial part of the world population. This species is under review for listing in the IUCN Red List of Threatened Animals (WCMC, 1990). The Delta is of major importance for pelicans with half of the Palearctic breeding population of white pelican *Pelecanus onocrotalus* and 5% of the world population of Dalmatian pelican. The latter species is listed as Endangered in the IUCN Red List of Threatened Animals (WCMC, 1990). Single sites do not usually hold high proportions of solitary nesting species with large territories such as the white-tailed eagle. The concentration of eight pairs of this species, which is also listed as Vulnerable in the Red List should therefore be regarded as significant (Table 6.1).

Table 6.1. Population estimates (number of pairs) of selected species of breeding birds in the Danube Delta and the approximate proportion of the total populations of Europe, the Palearctic region or the world that they represent

	Danube Delta	Danube as % of European (E), or Palearctic (P) or world (W) population[4]
Colonial waterbirds		
Phalacrocorax carbo	4000	-
Phalacrocorax pygmaeus	12000[1]	61 (W)
Pelecanus onocrotalus	3500[2]	52 (P)
Pelecanus crispus	120[2]	5 (W)
Nycticorax nycticorax	3100	17 (E)
Ardeola ralloides	2150	26 (P)
Egretta garzetta	1400	11 (E)
Egretta alba	700	71 (E)
Ardea purpurea	1250	11 (E)
Plegadis falcinellus	1400	30 (E)
Platalea leucorodia	6[3]	<1 (E)
Raptors		
Halieetus albicilla	8[2]	<1 (W)
Circus aeruginosus	300+	4 (E)
Falco vespertinus	150	-
Marsh terns		
Chlidonias niger	10000-20000	-
Chlidonias hybridus	20000+	-

Notes: Estimates for the Danube Delta are approximate populations for 1986 supplied by J. B. Kiss, D. Munteanu and N. Toniuc and are mostly as published in Grimmett and Jones (1989) except where amended as indicated by superscripts. (1) total in Grimmett and Jones lower than estimated from Paspaleva *et al.* (1985); (2) updated figures for 1989-90, (J. B. Kiss, pers. comm.); (3) Colony moved outside Delta; (4) European and Palearctic populations are taken from Cramp and Simmons (1977, 1980) and include Turkey but exclude the Soviet Union. Totals for Ardeidae are supplemented with information from Fernandez Cruz (1975). World populations are from references cited by Collar and Andrew (1988). Population estimates for pelicans are from Crivelli *et al.* (in press).

The Danube Delta is also an important area for passage migrants and wintering birds. There have been records of slender-billed curlew *Numenius tenuirostris* on autumn migration, with a maximum of 28 birds recorded in 1971. The world population of this species is uncertain, but is probably less than 1000 individuals.

Large numbers of wildfowl occur in winter. Totals for teal *Anas crecca* and mallard *A. platyrhynchos* can exceed 100,000 and numbers of pochard *Aythya ferina* can approach 1,000,000. There are also important concentrations of pintail *Anas acuta* (14,000), shoveler *A. clypeata* (40,000), red-crested pochard *Netta rufina* (32,400), ferruginous duck (13,000) and smew *Mergus albellus* (1500). The numbers of wintering ducks vary considerably within the season and from year to year according to the weather. When lakes freeze over, wildfowl abandon the Delta.

The area around lakes Razim and Sinoe is of special value for wintering geese, especially red-breasted and white-fronted geese. Over 20,000 of the estimated world population of 275,000 red-breasted geese winter in the area, the main roost being at Lake Sinoe and the feeding grounds on arable farmland to the west. This is now the principal wintering site of the world population of this species. Formerly large flocks wintered near the Caspian Sea in the Soviet Union, but that area has now been abandoned. Apparently this was the result of a change in agriculture from arable crops to vineyards. Small numbers of another rare goose with a world population of about 3000 to 5000 pairs, the lesser white-fronted goose *Anser erythropus*, are also regularly recorded in the area.

In conclusion, the Danube Delta area is of great importance for bird conservation. It is important for several globally threatened species. It holds the majority of the world population of two of these at certain times of year, pygmy cormorant and red-breasted goose; has 5% of the world breeding population of a third species, Dalmatian pelican, and is a regular breeding area of a fourth species, white-tailed eagle. Two other globally threatened species, slender-billed curlew and lesser white-fronted goose make use of the area on migration or in winter. In addition there are significant populations of several species, which are not yet in danger of complete extinction, but whose populations have declined drastically, especially in Europe. Of special note here are the populations of colonial waterbirds, in particular White pelican for which the Delta is one of the main Palearctic breeding sites, and glossy ibis which has declined substantially in Europe. The Delta area is also a major wintering area for ducks and geese.

6.3 Trends in bird populations

Results from long series of counts of birds covering the whole Danube Delta and using uniform systematic methods have not so far been published. This is because the Delta is large and difficult of access and the resources available for bird surveying have been relatively small. However, there is information on the distribution and number of breeding colonies of waterbirds and the species represented in the 1930s, 1950s and from 1973 onwards. There is also information on the distribution of nesting colonies of some species such as pelicans from further back in time. Some of this information is difficult to interpret because it is not clear whether the more inaccessible parts of the Delta were surveyed for colonies or not. There is a tendency for recorded waterbird colonies to have been more concentrated towards the western side of the Delta in the 1930s and 1950s than at present (Catuneanu, 1985; Paspaleva et al., 1985). Colonies of ardeids (herons and egrets), glossy ibis, spoonbill *Platalea leucorodia* and pelicans were present in areas in which they no longer occur. pelican colonies were present in the Braila region of the lower Danube in the 19th century and the first decade of this century. This region also held larger colonies of other waterbirds than at present. Drainage of wetlands and disturbance and persecution from greater human activity are the probable causes of this change. Large colonies of great white egrets, spoonbills, Dalmatian pelicans, white pelicans, and mixed colonies of Pelecaniformes and Ciconiiformes were present in the Pardina part of the Delta which was drained in the 1980s and is now unsuitable for waterbirds.

This evidence of changes in the distribution of waterbirds does not allow the magnitude of changes in total population size to be assessed. There are no long series of counts that would permit this. However, there is evidence of major declines in some species. Reported numbers of both species of pelicans at the beginning of the 20th century appear to have been at least ten times higher than at present. Cramp and Ferguson-Lees (1963) estimated the total number of pelicans of both species combined in 1961 at 5000 birds composed of about 1000 Dalmatian pelicans and 4000 white pelicans. If these figures are correct then numbers of white pelicans are somewhat greater today, perhaps because of less persecution by fishermen. However, Dalmatian pelican numbers are now at a substantially lower level than in 1961 though the species is reported to have increased from the early 1980s. Cramp and Ferguson-Lees (1963) reported the following numbers of nests from one colony of waterbirds in 1961; 2500 night herons *Nycticorax nycticorax*, 2000 squacco herons *Ardeola ralloides*, 4000-5000 glossy ibis, 500-600 little egrets and 100 spoonbills. Comparison with Table 6.1 shows that these totals approach or exceed the estimated totals for the entire Delta in 1986. The work of d'Andone, reported by Paspaleva *et al.* (1985) indicates that there were 20 waterbird colonies in the Delta in 1961 so the total numbers then must have been much greater than now for all of these species. It is also clear from Cramp and Ferguson-Lees account that the numbers of glossy ibis relative to those of other Ciconiiformes were substantially greater in 1961 than now. They consider it to have been much more abundant than ardeids and estimated the total population of the Delta to be tens of thousands. Paspaleva *et al.* (1985) report that the species comprised about 47% of the total population of colonial waterbirds in their sample areas in 1974, but this proportion declined to 4% by 1983.

There is a series of annual indices (1973-1978) of abundance of colonial waterbirds based on numbers seen per day in the field in six sample areas based on work by Dragomir. Another series of population estimates for the same species in the same areas is available for 1979-1983 but based on counts of occupied nests rather than birds. Hence the two series are not strictly comparable and cannot be used to construct a longer series of absolute population indices for 1973-1983. However Paspaleva *et al.* (1985) were able to examine the data for trends in absolute abundance within each of the two series, and for trends in abundance of each species relative to the total number of colonial waterbirds counted over the whole period. The main conclusions were that the absolute indices of population showed evidence of declines within both time periods for glossy ibis and grey heron *Ardea cinerea* and increases in white pelican and purple heron. The more reliable data for 1979-1983 showed evidence for declines in populations of white pelican, Dalmatian pelican, purple heron, night heron, little egret, squacco heron and spoonbill. Numbers of great white egret, great cormorant *Phalacrocorax carbo* and pygmy cormorant increased. This analysis needs to be brought up to date.

There is no published evidence of trends in demographic parameters such as breeding success or survival though some data exist on colonial waterbirds and raptors which could be examined.

6.4 Causes of declines in bird populations and current threats to the existing ornithological value of the Danube Delta

In the absence of detailed studies conclusions on the reasons for bird population declines are necessarily speculative. Nonetheless some probable causes and threats can be identified.

The most obvious reason for a decline in waterbird populations is loss of wetland habitat through conversion to other uses such as agriculture and forestry. There has been substantial conversion of freshwater marshes to agricultural use and fish farming. Where extensive fish farming is practised the area will continue to be used as a feeding ground by birds, but in the case of agriculture or forestry the value of the area to waterbirds is entirely lost. Important colonies of waterbirds were situated in areas which have been drained for agricultural use so there has been direct loss of nesting sites. The loss of areas of freshwater marsh away from nesting colonies would also be expected to influence the number of waterbirds which could breed there. Hafner *et al.* (1987) found that the numbers of nesting pairs of ardeids in colonies were correlated with the extent of freshwater marshes in the vicinity of the colony. Studies of individual little egrets in the Camargue, France have shown that they may feed at a distance of more than 2km from the nest site whilst rearing nestlings (Hafner and Britton, 1983). It seems probable that they range more widely earlier in the breeding season, especially when accumulating reserves for egg production (H. Hafner, pers. comm.). Some waterbird species forage at great distances from the nesting site. Pyrovetsi (1989) reported that White pelicans breeding at Lake Mikri Prespa, Greece flew daily to feeding sites up to 177km from the nesting colony. In the Danube Delta Paspaleva *et al.* (1985) noted that white pelicans from the breeding colony at Rosca-Buhaiova were flying each day to feed in Lakes Razim and Sinoe up to 80km away. Hence losses of, or damage to, wetland habitat in one part of the Delta may affect the availability of food for birds nesting at a great distance from the affected area. In the case of the widest ranging species, such as pelicans, the entire Delta lies within the potential foraging range of any of the birds breeding in the area.

Another probable cause of reductions in waterbird numbers is deterioration in the quality of wetlands within the Delta. Engineering projects both within the Delta and upstream have caused changes in the magnitude and timing of flows of water within the marshes. These works have continued up to the present time with the project to straighten the Bratul Sf. Gheorghe. The water chemistry has been altered by upstream pollution of the Danube, particularly with nutrients such as nitrogen and phosphorus. These changes have been exacerbated by the drainage of floodplain wetlands on the Danube and the consequent reduction of their ability to remove nutrients from the river water. The effects of these changes on aquatic ecosystems will be dealt with elsewhere in the report. Among the effects of eutrophication have been a decline in the abundance of fish, impoverishment of invertebrate communities and losses of submerged macrophytes. This has been apparent in catches of commercially valuable fish which comprise part of the food of piscivorous birds in the Delta. However it is probable that fish of no commercial significance but of value to birds have also been affected. There is a clear spatial correlation within the Delta between the distribution of birds which feed on aquatic macrophytes, such as greylag goose *Anser anser* and coot, and that of their food supply. It is probable that losses of macrophytes from certain lakes caused by eutrophication has reduced the area of suitable habitat for these species. It is also possible that stagnation of water because of reduced flows has affected the incidence of epizootics such as that which reduced numbers of wildfowl in 1980 (Paspaleva *et al.*, 1984).

The effects of changes of flows and water chemistry on the food supplies of birds are not confined to the Delta itself. The input of nutrient-laden water to Lake Razim from the Danube, effluent from pig farms and arable land in the vicinity of the lake, and the sealing of the lake connection the sea in order to permit its use as an irrigation reservoir, are bringing about changes which are likely to affect the feeding grounds of piscivorous birds. In addition the reduced salinity and increased nutrient content of the lake is enhancing the growth of emergent vegetation along the margins. At Grindul Lupilor and other sites this appears to be reducing the extent of open sandy areas to the detriment of the collared pratincole and other species.

The more insidious impact of pollutants such as organochlorines and heavy metals in Danube water on the breeding success and survival of birds in the Delta is difficult to assess because of the scarcity of data on levels of contamination in the tissues of birds or in eggs. However the information available indicates a strong possibility that contamination has affected and may be continuing to affect, the performance of birds in the Delta. Measurements of some pollutants in fish are available and careful examination of these may permit some prediction of loads and effects in piscivorous birds. However, some elements such as mercury have not been estimated satisfactorily in the tissues of birds because of lack of equipment, though there are estimates for birds' eggs. Raptors and piscivorous birds are particularly susceptible to effects of heavy metals or pesticides on breeding success or survival because of their position near the top of the food chain. Some populations of brown pelicans *Pelecanus occidentalis* suffered severe declines because of reproductive impairment caused by contamination with residues of the pesticide DDT. Reduced thickness of the eggshell is caused by DDT contamination and the degree of shell thinning is correlated with the concentration of the metabolite DDE in the egg. High levels of DDE were found in eggs of white pelican, great cormorant and pygmy Cormorant collected in the Danube Delta in the early 1980s (Fossi *et al.*, 1984). The mean concentrations of DDE for these three species were 3.15, 4.17 and 8.95ppm wet weight respectively. In a sample egg study of brown pelicans, Blus (1982) found that no nest with recently laid eggs in which the DDE concentration in the sample egg exceeded 3.0ppm wet weight gave rise to fledged young. It is therefore likely that the reproductive success of white pelicans, and probably the cormorants, has been affected by DDE contamination. DDE concentrations in eggs of grey herons, glossy Ibis and night herons were considerably lower (Fossi *et al.*, 1984).

Measurements were made of the thickness of the shell of a single egg of Dalmatian pelican collected in 1982 in the Danube Delta. This egg appears not to have proceeded to a late stage of incubation so the thickness of its shell is probably not much reduced by calcium resorbtion by the developing embryo. Its mean thickness, 0.523mm, is 29% less than the mean thickness of eggs of this species collected prior to 1947 (Crivelli *et al.*, 1989). Given a mean thickness of 0.734mm and a standard deviation of 0.066mm for pre-1947 eggs, there is only a probability of 0.0007 of such a thin-shelled specimen being drawn from a population of eggs of pre-1947 thickness. This eggshell is also 1.4 standard deviations thinner than the mean for eggs from Dalmatian pelican nesting in Greece, which have shells with thickness reduced by an average of 17%. Hence it seems probable that the reproductive success of this species has also been affected by DDE.

Further direct studies of pollutants in the eggs and tissues of a number of species of piscivorous and raptorial birds themselves and their prey would be desirable and should include estimates of levels of HEOD which have not been published so far.

Grazing of cattle, horses, pigs and other domestic livestock is a traditional form of land use in the Delta. If the distribution and numbers of grazing animals are regulated this may not be harmful to birds and may even be beneficial in creating open habitats and diversity of structure within the marshes. Negative effects on birds of excessive densities of grazing animals would be expected if grazing was to eliminate the development of scrub, woodland or other vegetation valuable as nesting sites, or if trampling or eating of eggs and chicks by livestock were to take place on a large scale. Livestock densities appear to be at levels where such problems would be expected on Sacalin island where the nests of ground-nesting birds are frequently destroyed by livestock and the vegetation is overgrazed. On Popina Island, Lake Razim, the vegetation has been eliminated by excessive cattle grazing with possible damage to the breeding birds.

Damage to reedbeds by mechanical harvesting and burning of reeds to encourage growth are deleterious to birds if they permanently damage important bird habitats, or if burning or harvesting take place while young birds or nests are still present.

Fishing and fish culture have brought piscivorous birds into conflict with humans in the past and resulted in persecution of breeding colonies of waterbirds and shooting of birds. This probably had substantial effects on population size of some species. At present this is not reported to be a severe problem. Some birds are shot at fish farms but the numbers are said not to be large. Deliberate destruction of breeding colonies of piscivorous birds has taken place but is now believed to be uncommon. However, poor fishing brought about by eutrophication may lead to stronger conflicts in the future. Increased tourism in the Delta may also lead to the disturbance of waterbird colonies.

There are now many kilometres of electrical power lines within the Delta. In other places collisions of birds with cables has been shown to be an important cause of mortality. For example, Crivelli *et al.* (1988) reported substantial mortality of immature Dalmatian pelicans caused by collisions with a section of electric power line near a roosting site. Most of the deaths occurred in a short section of non-essential line that was subsequently removed. Populations of species with naturally low mortality rates such as pelicans and raptors might be severely affected if high rates of collision were to occur with power lines in the Delta.

At present levels of waterfowl hunting in the Delta seem low relative to that in other European wetlands. However future development of hunting by tourists from elsewhere in Romania or from other countries might lead to excessive disturbance. The unique wintering population of red-breasted goose might be adversely affected by the direct effects of unregulated hunting or by disturbance of roosts. This species would also be likely to be affected by changes in agricultural practice in the Razim-Sinoe region since much of its food is taken from farmland.

6.5 Conclusions

Maintenance and restoration of bird populations in the Delta will ultimately depend on the way in which human activities are organised. These must be planned taking into account impacts on bird habitat, feeding, behaviour etc.

Although much information has been collected, little has been published and the application of more recent analytical methods would help support management planning in the Delta.

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CHAPTER 7: FISH AND FISHERIES

A. J. Crivelli and R. Labat

7.1. Introduction

The fish fauna of the Delta is remarkably rich, with 75 species belonging to 22 families (Banarescu, 1964). The majority of these (44) are freshwater species, the others being euryhaline migratory species that occur in the Black Sea and mainly visit the Delta during the breeding season. About one third of the species are exploited by intensive commercial fisheries. Intensive and extensive pisciculture has developed greatly over the last twenty years.

As a result of the upheavals that have occurred in and around the Delta over the last fifty years, the fishery and the fish populations seem to be in a critical situation today. Catches have greatly declined and the number of full-time fishermen has diminished as it has become difficult to make a livelihood.

7.2 Status and trends

The fisheries in the branches of the Danube have always been closely related to the flood zones upstream. These fisheries concern only a few species: firstly, migratory species (sturgeon *Acipenser sturio*, shad *Alosa*) and secondly "semi-migratory" species (carp *Cyprinus carpio*, zander *Stizostedion lucioperca*, bream *Abramis brama*, wels *Siluris glanis*). All these were captured on their spring migration towards the Crapina, Brates, Borcea and Braila floodplains, the preferred spawning grounds. Today the spring catch of migratory fish may employ up to 500 fishermen between March and May.

In the past the fisheries in the river channels were very productive, but since the Romanian and Ukrainian floodplains in the Delta were cut off from the river by dykes, they have declined in importance and now capture mainly shad and a few sturgeon. At the beginning of the century, more than 1000 tonnes of sturgeon were caught each year in the Romanian part of the Delta, whereas only 20 tonnes were landed in 1989. Catches of shad have also declined, but to a lesser extent.

Changes to the fisheries on the floodplains and lakes of the Delta have also resulted in a decline in catches, especially of commercially valuable species.

Since the last century numerous hydraulic engineering schemes, especially the building of canals, have been undertaken in order to improve the fisheries. Canals were constructed to improve water circulation and fish movements. Dykes have also been built to retain floodwater for longer periods. In the medium term the effect of the works was an improvement in the catch from 5722 tonnes per year in 1903-1906 to 11,542 tonnes per year in the period 1953-1957. Over the longer term, however, the situation has deteriorated with the increasing construction of polders (6730ha in 1960; 104,779ha in 1989) and a decrease in the flooded area (350,000ha in 1960; 250,000ha in 1989), and the catch has fallen to only 7414 tonnes per year (1980-1989).

Together with these changes in the catch size, a change in species composition has also been recorded. Commercially valuable species such as carp, wels, pike *Esox lucius*, wild goldfish *Carassius carassius* and to a lesser extent perch *Perca fluviatilis* and zander have greatly declined. On the other hand, populations of species of lower commercial value (e.g. goldfish *Carassius auratus*, bream etc.) have increased enormously. As a general rule, there has been a decrease in predatory fish to the benefit of non-predators, and a replacement of carp by goldfish. Since 1981, several exotic fish species have been introduced into the delta and are fished commercially. Among the exotic species is *Carassius auratus*, whereas *C. carassius* is native.

The production of fish in intensive or extensive fish farms is very different from that of the traditional fisheries on the branches of the Danube or on the floodplain. Bream, roach *Rutilus rutilus* and goldfish *C. auratus* constitute the bulk of the catch. Although total production in the fish farms has effectively increased, commercially valuable species (carp, pike and zander) have greatly decreased over the long term and pisciculture has not been a great success. The closure of nearly all the extensive fish farms in the Delta confirms this state of affairs.

According to Bacalbaca-Dobrovici *et al.* (1990) there are 500 to 600 fishermen in the Delta. No fishing occurs during the winter. The fishing season starts between March and May, mainly in the canals and in the branches of the Danube; the fishermen then move to the flooded areas where they fish until September. The fish farms are fished in October (e.g. at Lake Razim).

Nowadays, annual productivity on the Romanian part of the Delta varies between 18 and 35kg/ha. Productivity in years with heavy floods is higher than those of light floods. In the Ukrainian part of the Delta, productivity varies from 27 to 45kg/ha per year. In the 32,685ha of extensive and intensive fish farms, production was 338kg/ha in 1986 (Bacalbaca-Dobrovici *et al.*, 1990).

7.3 Causes of the fishery decline

Reduction of species richness and decline in annual production can be attributed to habitat degradation in the Delta (polder construction, damming, reduction of floodplains etc.), eutrophication of the areas enclosed by dykes, disappearance of submerged aquatic vegetation, industrial and organic pollution transported by the river, a decrease in flood levels, and overfishing. According to the fishermen and certain Romanian scientists, the impact of piscivorous birds on the fish populations is also a factor.

With the construction of polders, canals, a network of dykes to prevent flooding, and extensive and intensive fish farms, the free circulation of fish through the ecosystem has been obstructed. Fish now have difficulty in finding their way to seasonally flooded areas, the most favourable spawning habitat. In addition, their offspring find increasing problems in escaping from the spawning areas towards deep water sites, suitable for passing the difficult months of winter.

As an example, a significant relationship has been demonstrated between the annual catch of carp and the area of land flooded each year ($n = 30$; $r = 0.63$; $P < 0.001$). There is however no significant relationship between the carp catch and the average water level at Tulcea between the months of May and September ($n = 30$; $r = 0.043$). These two results clearly show that since the construction of dykes, the important factor is not the water level but the area of flooded land available for the successful reproduction and healthy growth of the young fish. An additional factor is the increasing eutrophication of the Delta waters, due partly to increased quantities of nutrients from the river, and also to a decrease in water renewal since dyke construction. During the summer, this eutrophication can lead to massive fish mortalities caused by dissolved oxygen deficiency and the release of hydrogen sulphide. Another effect of eutrophication is the disappearance of submerged macrophytes which are indispensable for the breeding of certain fish species (e.g. pike).

Overfishing is also an important factor. Indeed its effects are all the more evident because of the stress on fish populations caused by the factors described above. Although few data are available on fishing techniques, the gear used and the structure of the catch, available evidence indicates that many species are caught when they are still immature so precluding correct regeneration of the populations. This is confirmed by Bacalbaca-Dobrovici *et al.* (1990) who state that the minimum takeable size of wels should be increased to 70cm in order to avoid the capture of immature specimens.

It is difficult to assess the impact of industrial and pesticide pollution in the Delta. Analyses made on fish caught in the Delta and of the eggs of piscivorous birds tend to show that this pollution is not negligible (Fossi *et al.*, 1984).

All these factors contribute, in varying degrees, to the deterioration of the fisheries in the Danube Delta.

7.4 Conclusions

It is essential that the degraded wetlands in the Delta be restored, taking into account the fish populations which are one of its riches. In addition, the various fisheries need to be controlled if this economic activity and the diversity of the fish populations are to be maintained in the long term. Measures aimed at the conservation of certain particularly endangered species will probably have to be taken.

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CHAPTER 8: VEGETATION

E. Schneider

8.1 Introduction

The Danube Delta is one of Europe's last and most extensive landscapes in a natural state. Its extensive reedbeds, maze of tributaries, canals and lakes with their great abundance of aquatic plants; its white willows *Salix alba*, poplars *Populus* and not least its dunes with their mosaic of forests and sandy grasslands, form one of Europe's unique habitat complexes.

In addition to the annual and monthly variation in water levels, the complexity of the Delta is further increased by its continental climate which results in great differences between seasons. Average annual precipitation is a mere 400-450mm.

Serious interference in the Delta in recent years has led to a drastic reduction or total loss of habitat for many species. The natural habitats in the Danube Delta consist of:

- water and permanently flooded areas - about 80%;
- occasionally flooded areas, i.e. dried-out ponds (*japsche*), low embankments (*grinde*) with willow bushes, forests and emergent grasses (Agropyro-Rumicion alliance), amounting to 74,000ha - 17%;
- non-flooded areas (upper embankments with villages, hamlets, fields, pastures, grasslands and dunes) encompassing a total of 14,000ha - 3% (Krausch, 1965).

Of the total area of the Danube Delta in Romania of 442,300ha, dams deprive 74,264ha (16.7%) from natural flooding, an area which is now exploited for various purposes. An area of 368,036ha is subject to natural flooding.

8.2 Open water and reedswamp

8.2.1 Aquatic vegetation

The aquatic vegetation is of many distinct types being influenced by a variety of different water types (Danube tributaries, canals, fresh and salt water lakes, ponds), with characteristically specific ecosystems (Rudescu and Godeanu, 1980). The main tributaries have no macrophytic vegetation, but aquatic plants grow in the creeks (*girla*) and in former tributaries. The Delta lakes (reaching depths of about 1-3m) have the bulk of aquatic vegetation, and support an abundance of macrophytes.

High summer temperatures encourage ample growth of thermophilic aquatic and marsh plants, i.e. *Trapa natans*, *Salvinia natans*, *Nymphoides peltata*, *Aldrovanda vesiculosa*, *Vallisneria spiralis* etc., which form different communities according to their location. *Myriophyllo-Nupharetea* are widespread in a characteristic thermophilic formation of water-lilies *Nuphar lutea, Nymphaea alba*, *Trapa natans* and *Salvinia natans*. *Myriophyllo-Nupharetum* form an uneven zone at the reed borders in former tributaries, and in canals and lakes. Towards the water's edge, *Myriophyllo-Nupharetum* are replaced by fen associations of *Sagittaria sagittifolia*, *Sparganium ramosum* and *Phragmites australis*.

Trapetum natantis is another characteristic association which covered large areas of the Delta until a few years ago, due to its excellent adaptability to water level fluctuations. It also grows in rather turbulent waters. *Salvinia natans* and *Ceratophyllum demersum* are constants in the association. In shallow waters, mostly where human influence has increased eutrophication, *Nymphoides peltata* grows, but recent observations have shown a continuing decrease in this species.

In many places the floating vegetation association of *Salvinia natans* and *Spirodela polyrhiza* form another characteristic community of the Delta. *Hydrocharis morsus-ranae* and *Stratiotes aloides* also occur in abundance, their biomass contributing significantly to the terrestrialisation process.

It is clear that there has been a marked decline of aquatic macrophyte vegetation in recent years, and this is evidently linked to excessive nutrients in the water. In many waters there are heavy algal blooms. The resulting high consumption of oxygen and decreased transparency of the water are the main causes of macrophyte decline (see also Chapter 5).

8.2.2 Reedswamp

Reedbeds are a characteristic feature of the Danube Delta landscape. Covering vast areas, totalling 284,000ha (Krausch, 1965), they represent the largest closed unit of reeds in Europe. Reeds grow densely, reaching heights of 3-4m or more. The *Scirpo-Phragmitetum* reeds association develops on a level just above the 'nadir' (taken from the level of the Black Sea), depending on total immersion of their roots in water. The high water level and constantly free circulation of water give these areas a constancy of water and soil nutrients within a highly stable system. Although they generally cover only small areas *Typha latifolia*, *T. angustifolia*, *T. minima*, *Schoenoplectus lacustris*, *Carex riparia*, *C. acutiformis* and terrestrial complexes of *C. elata* also belong to the distinctive elements of the Delta's flooded landscape. Reedbeds have been greatly damaged by mechanical exploitation and they are still seriously threatened because of regeneration difficulties. These reedbeds therefore need special protection (See Chapter 3).

8.2.3 Plaurs

A unique habitat is provided by the so-called 'plaur' formations - reed islands and floating vegetation in the deposition areas of the Delta lakes. Extending over an estimated 72,000ha, they consist of a mesh of reed rhizomes forming a cover of about 0.8-2m depth. Different species grow depending on whether the subsoil is humus silt or organic subsoil (reed peat). Characteristic species are *Thelypteris palustris*, *Cicuta virosa*, *Salix aurita*, *Carex pseudocyperus*, *Cladium mariscus*, *Eupatorium cannabinum*, *Lycopus exaltatus*, *Lythrum salicaria*, *L. virgatum*, *Typha latifolia*, *Rumex palustris*, *Ranunculus lingua*, *Mentha aquatica*, *Rorippa amphibia*, *Oenanthe aquatica*, *Senecio paludosus* and others. When water levels are unusually low, a part of the plaur dries out in the same way as other formations on the water body edges. They become more or less terrestrial in association with non-floating *Phragmites* (See Chapter 1, Annex A).

Plaur formations offer ideal habitat for a number of animal species. For example, European mink *Mustela vison* are found in the Delta only within plaur habitat. It is also the favoured habitat of wild boar *Sus scrofa* which are well protected on the floating islands. These floating islands are often ripped away from their sites, and driven by wind, frequently present obstacles to small boat navigation. For this reason, the local people burn the islands.

In order to assess the status of the plaurs it would be very useful to map their distribution with the aid of aerial and satellite photographs.

8.2.4 Effects of human intervention

Changes due to natural dynamics have always taken place. Sedimentation and terrestrialization are part of the natural evolution of a delta ecosystem. The natural processes have, however, been transformed or modified by human interference. All the more recently constructed connecting canals, particularly those running north south i.e. cutting across the west-east flow in the Delta, strongly influence the sedimentation process. The case of the Uzlina canal clearly shows this. A delta has formed at the entry of the canal into Lake Uzlina which is heavily sedimented and enriched. Increasing sedimentation has been recorded in the Puiu-Rosu lake system as a result of the construction of the Caraorman canal. The canal carries a high load of suspended matter and deposits it in Lake Rosu. A similar process has also been recorded in the Matita-Merhei lake system.

In general, artificial connections between water bodies and flooded areas increase the possibility of nutrients entering the nutrient-poor Delta lakes thereby leading to a change in those ecosystems.

8.3 Pioneer vegetation

Of the 368,036ha of the Delta normally subjected to natural flooding, recently, in September 1990, only 140,000ha were covered with water due to extremely low river levels. These low water levels enabled the growth of pioneer vegetation on the dried-out silt areas of the Danube tributaries and canals, ranging from a succession of short-lived 'pastures' of pioneer species on the recently dried river banks to successional stands of nitrophilous species.

Plants growing on these locations are very well adapted to these conditions and complete their development within a short period of time. Characteristic species include silt specialists such as *Dichostylis michelianus* and *Heleochloa alopecuroides* as well as *Cyperus fuscus*, *Gnaphalium uliginosum* and *Limosella aquatica*. These are followed, on slightly higher levels, by taller nitrophilous plants, including *Bidens tripartita*, *Aster tradescantii*, *Cyperus serotinus*, *Tanacetum vulgare*, *Echinocloa crus-galli* and *Polygonum hydropiper*. These species vary from year to year or do not grow at all depending on the water level fluctuations. They belong nevertheless to the complex of habitats dependent upon the river dynamics.

8.4 Forests

Forests occupy a relatively small proportion of the Delta, approximately 5% of its total surface (Stoiculescu *et al.*, 1987). These can be divided into two different types: forests in the fluvial zone and forests in the marine zone of the Delta (Figure 8.1).

8.4.1 The fluvial zone

This zone of the Delta encompasses the bulk of white willow forests which are found mainly along the embankments of the Delta tributaries and canals. These 'softwoods' consist principally of *Salix alba* and *S. fragilis*. On higher levels *Populus alba* and *P. canescens* also occur. Many of the trees on older embankments have been cut and only some isolated old willow or white willow fringes of different ages remain revealing the old water's edge.

The formation, development and maintenance of forests of white willow depend on water level dynamics. Flooding usually coincides with the maturing of the willow seeds. These are then carried away and washed ashore by the water. This concentration of seeds on the river banks results in a thick zone of willow regeneration. In periodic succession willow bushes of different ages develop and can be recognized by step-like formations along many embankments (Figure 8.2). Eventually they develop into mature woodland. In September 1990, such formations were observed along the Chilia tributary, at the Mila 35 canal near Sireasco as well as in other localities. The river also erodes embankments, undermining and felling trees. The Delta's softwood forests are therefore subject to constant dynamic processes which maintain their structure and diversity.

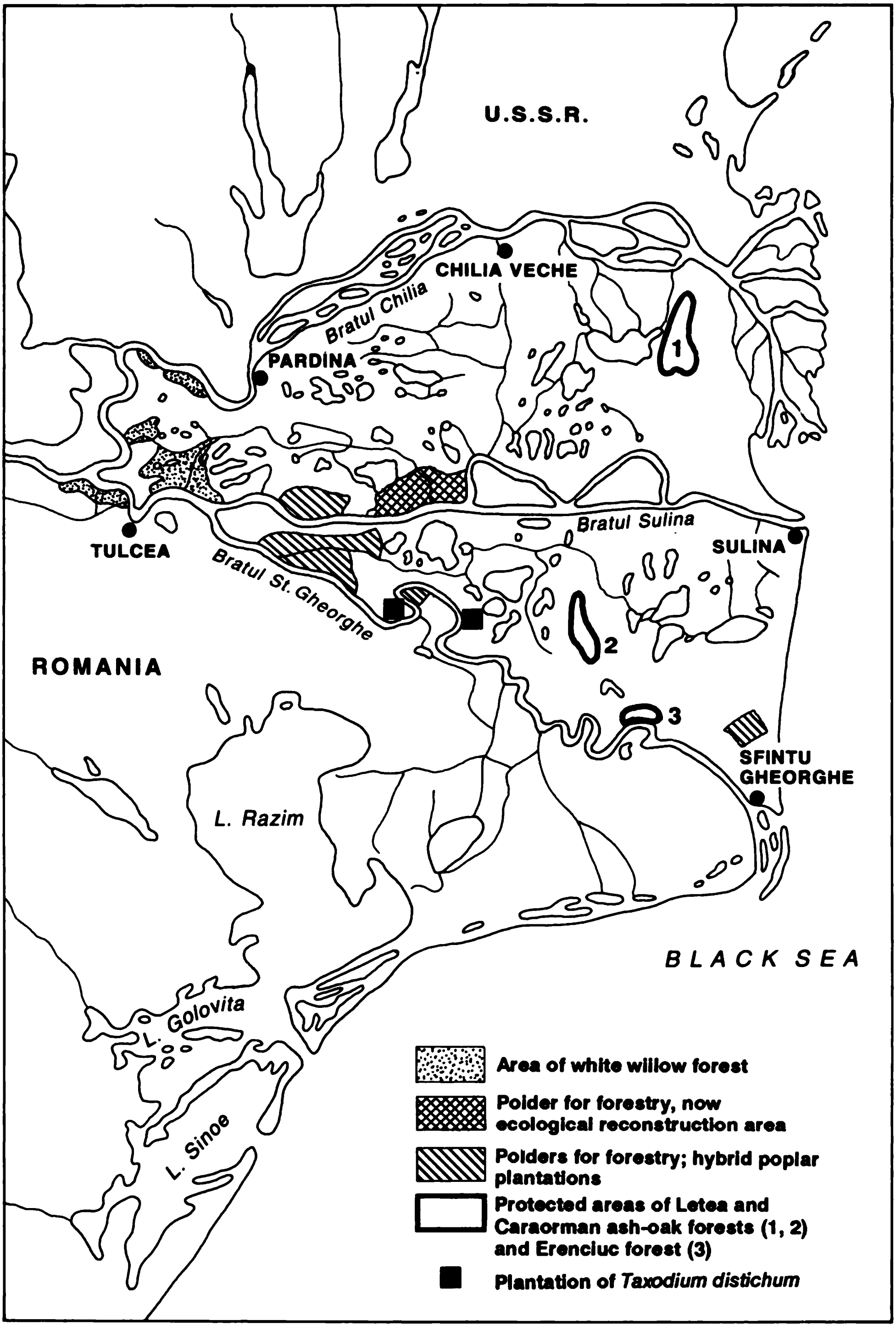

Figure 8.1. Forestry on the Danube Delta

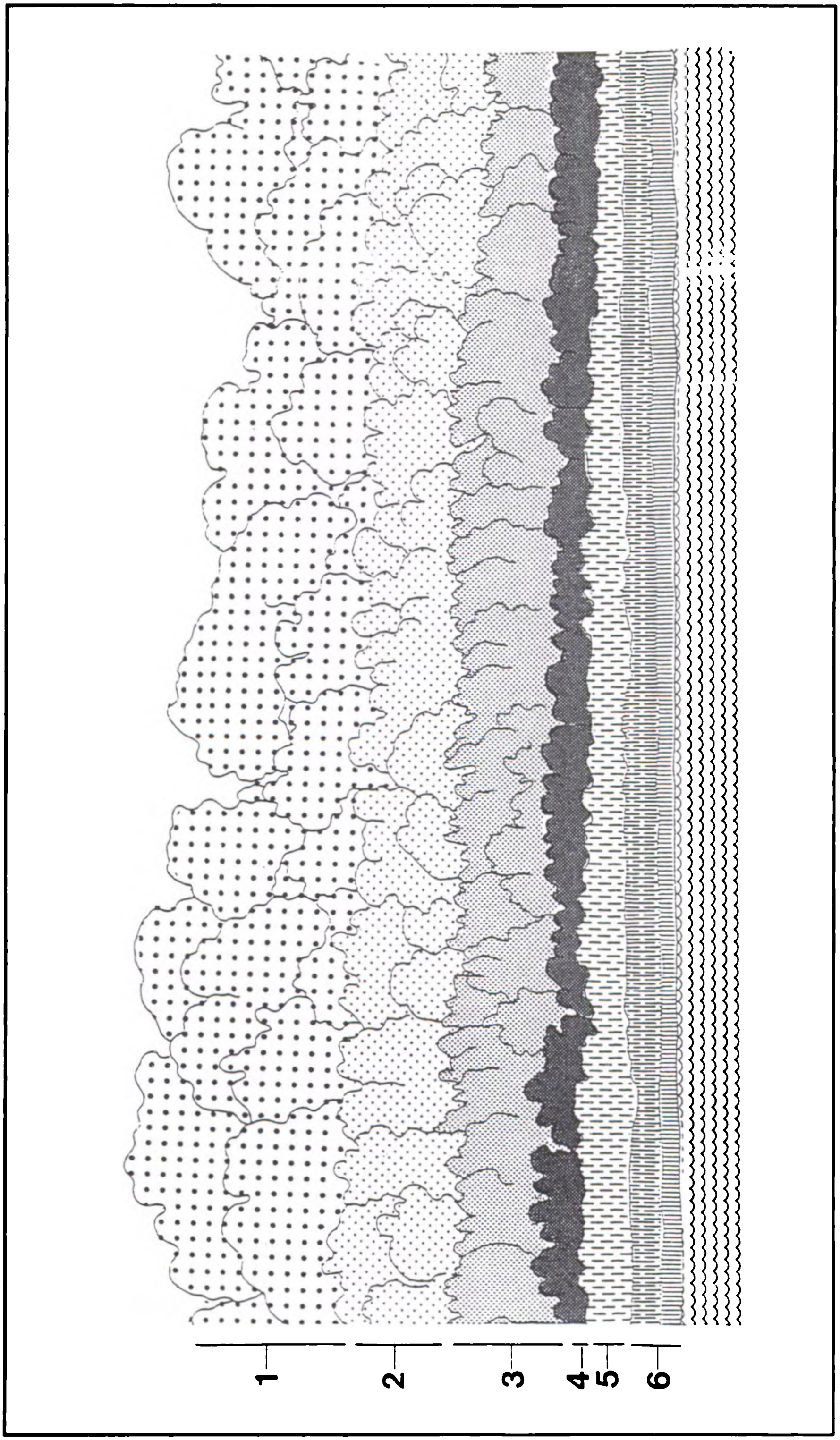

Figure 8.2. Regeneration of white willow border forest on the Chilia channel with three different stages of willow bushes (1, 2, 3); tall herbaceous vegetation (4); *Cyperus serotinus* association (5) and pioneer vegetation (Nanocyperion alliance) (6)

Depending on duration and height of flooding (measured by hydrogrades - see Chapter 1), it is possible to differentiate between two formations of white willow forests (Donita *et al.*, 1966). At low levels with a flooding duration of six or more months white willow forests (*Salicetum albae-fragilis*) of poor structure and type occur. They consist exclusively of white willows and very sparse ground vegetation of mainly *Amorpha fruticosa* (Donita *et al.*, 1966; Leandru, 1971; Schneider, 1990). The fragmentary ground vegetation is a consequence of high soil humidity and mainly consists of *Polygonum hydropiper*, *Myosoton aquaticum*, *Carex vulpina*, *Lysimachia nummularia*, *Symphytum officinale*, *Lycopus exaltatus*, *Iris pseudacorus*, *Galium aparine* and *Rorippa amphibia*.

The structure of the white willow forest changes at the upper levels of the embankments as well as in the highest and older part of the Delta (HG6-9) where flooding lasts no longer than four months each year. Softwood forests develop with *Populus alba* and *P. canescens* growing together with *Salix alba*, interspersed in many places by *Fraxinus angustifolia*. In addition, introduced trees grow, i.e. *Fraxinus pennsylvanica*, *Morus alba*, *Juglans regia* and *Acer negundo*. The latter species most closely resembles the willows in its tolerance to flooding. The same may be said of *Amorpha fruticosa*, growing along the canals of the Danube Delta and up to the coastal areas. These trees are partly overgrown with climbers such as *Humulus lupulus*, *Vitis sylvestris*, *Solanum dulcamara*. Quince trees *Cydonia oblonga* grow in many parts on the high embankments and islands. These originated in gardens, but now grow wild and are well adapted to the fluctuations of the Delta's water level. The ground vegetation in the white willow forest is dominated by *Rubus caesius* with associates including *Galium palustre*, *Stachys palustris*, *Lythrum salicaria*, *Euphorbia palustris*, *Bidens tripartita*, *Polygonum mite*, *Malachium aquaticum*, *Poa trivialis*, *Mentha aquatica*, *Urtica kioviensis*, *Glycyrrhiza echinata*, etc.

More or less intact softwood forests and softwood fringes with white willows, *Populus alba* and *P. canescens* occur in the border area of the Chilia tributary. These have been virtually untouched by forestry measures.

In some areas of the forests, there has been an increase in regeneration of ash trees, indicating long-lasting dryness. Normally the willows' habitat is flooded for two to six months annually, but for the last five years, no flooding has occurred. The consequences of low water levels and the resulting water table decrease were also noticeable on Ostrovu Tataru island where the willow canopies have died. Mixed softwood forests on higher locations (>HG7) have become rarer. There is also an increased frequency of *Populus alba* and *P. canscens* due to deforestation and agricultural exploitation. Normally, mixed forests would be followed at the highest locations in the Delta (>HG9) by more or less pure poplar forests, but remains of these can be seen in only very few places.

Tamarix ramosissima grows on the narrow natural or semi-natural embankments within the areas of white willow forests, expanding where these are being destroyed. This species also occurs as a pioneer on sandy deposits where salinity levels are high (Simon and Dihoru, 1963; Horvat *et al.*, 1974).

White willow and poplar forests have been replaced on many embankments by small areas of emergent grasses (Agropyro-Rumicion alliance) which are subjected to heavy pressure from grazing. The softwood forests are subjected to the same grazing pressure. The custom of reed-burning represents another threat.

8.4.2 The marine zone

Apart from softwood fringes and forests on the embankments, which resemble those further upstream, the ecological conditions of the marine part of the Delta allow development of different forest types. Alder *Alnus glutinosa* grow here where there is less fluctuation in the water level. In the area of the ancient tributary of Erenciuc (between Sf. Gheorge and the dunes of Caraorman) they form a continuous forest of approximate 49ha which is also stocked with crack willows and a few isolated grey willow *Salix cinerea* bushes. *Carex elata*, *Thelypteris palustris* occur in the herbaceous vegetation layer.

There are also forest areas with totally different, very specific characteristics. These are due to the structure of the dune area with its topography of dune ridges and depressions. Ground water close to the surface in the low-lying areas is the determining factor for growth of oak-ash hardwood forests. No direct flooding from the river occurs here, water levels changing only in response to ground water fluctuations. The dune slopes dry out towards the ridge and show partly desert-like conditions which in turn offer habitat for numerous xerothermic sand species. There are thus ribbon-like groups of forest areas on the low ground and open arid vegetation on the dune ridges.

The forest areas of the low-lying land between the dunes are locally called *hasmacuri*. The best known and largest of these is Hasmacul Mare in the Letea forest with a length of 7km and an area of 1200ha. The Letea forest encompasses a total area of 5212ha, whereas another in the dune area of Caraorman covers an area of 1265ha (Kiss, 1988). These are largely natural forests in their climax phase, comparable in structure to the forests of the Nestos Delta in Greece.

These forests exhibit mosaic patterns reflecting finely-tuned changes in ecological conditions dependent on ground height and its linked humidity. *Fraxinus pallisiae* and *F. angustifolia* thrive in the low parts of the *hasmacuri*. *Quercus robur* and *Q. pedunculiflora*, *Populus alba*, *P. canescens*, *P. tremula*, *Malus sylvestris*, *Pyrus pyraster* and sporadically *Tilia tomentosa* grow at the higher levels. Ulmus minor is less common in the *Letea* area but is of importance in the tree zone structure in the Caraorman dunes (Leandru, 1971). The abundance of climbers gives these forests a tropical appearance. The sub-Mediterranean Greek liana *Periploca graeca* deserves special mention as it reaches its most northerly boundary in the Delta. Added to this is the great abundance of *Vitis sylvestris*, the presence of *Clematis vitalba* and of *Humulus lupulus*. The well-developed shrub layer consists, according to humidity, of *Berberis vulgaris* growing in the driest locations, and of *Ligustrum vulgare*, *Prunus spinosa*, *Thelycrania sanguinea*, *Rhamnus catharticus*, *Rosa canina*, *Viburnum opulus*, and *Sambucus nigra*. *Rubus caesius* covers large areas.

Depending on humidity, the vegetation of the herbaceous strata consists of different species; those associated with wet habitats and old tributaries on lower places and species typical of medium and extreme dryness in the higher places. *Convallaria majalis*, *Galium rubioides*, *Vincetoxicum hirundinaria* and *Aristolochia clematitis* are typical species of the ground vegetation.

Xerothermic sandy grasslands have developed on the dune ridges between the lower-lying forest areas. Typical species adapting well to extreme dryness are *Euphorbia seguierana*, *Carex ligerica*, *Ephedra distachya*, and *Onosma arenaria*. Stoloniferous species such as *Polygonum arenarium*, *Cynodon dactylon* and *Tribulus terrestris* assist in stabilising the shifting sand dunes.

In more recently-formed dune areas there is little woodland vegetation. The pioneer woodland species in the sand dunes is above all *Populus alba*. In the primary phase of woodland evolution it is preceded in the low-lying lands between the dunes, by bushes of *Salix rosmarinifolia* and some *Hippophaë rhamnoides*. *Tamarix ramosissima* grows abundantly too, indicating salinity.

8.4.3 Status of the ash-oak forests

A major threat to the dune forests is afforestation with alien species, which eventually alter the original mosaic of the dune landscape and its complex ecosystems. Problems also arise through interference with natural regeneration, a fact which is particularly noticeable in the Letea forest. Despite its status as a nature reserve it is being exploited as woodland pasture. The high density of grazing cattle (*c.*1 cow/ha forest) has particularly negative effects for these areas, preventing oak and ash regeneration. Furthermore, the cattle are having a detrimental effect on the ground vegetation, and wildlife is being disturbed. The high density of pheasants which feed on acorns, is interfering further with the regeneration process. Attention must be drawn to the enforcement of protected status of the Letea and Caraorman forest areas.

The change in ground water conditions and water circulation as a result of the construction of dams and drainage canals is endangering the dune forests. Caraorman is particularly vulnerable as a result of the cutting off of the Sf. Gheorghe meanders. This has increased the gradient in the river arm and therefore the discharge velocity, and possibly lowered the ground water level in the Caraorman region (see also Chapter 4).

8.4.4 Forestry

Silviculture is carried out over 4652ha of the Delta. In addition to the natural forests and plantations subjected to the dynamics of the river and its free-flooding regime, plantations have been established in specially reclaimed land. In view of the past obligation to achieve high wood outputs, vast areas have been afforested with fast-growing hybrid black poplar, which has changed the appearance of the Delta landscape as it has also done in many river basins elsewhere in Europe. Only economic factors were considered in introducing this tree, and the loss of the natural, complex and varied ecosystems was disregarded.

The goal of high wood production using fast-growing species is visible in afforestation in the Delta. In addition to vast plantations between Girla Papadia and the Sulina arm, between Grindul Rusca, the Litcov canal and the Sf. Gheorghe arm and in the wide Murighiol meander, there are, along the river branches and canals, more or less broad strips of plantations, mainly of hybrid poplar (Figure 8.1). The softwood forests in the upper part of the Delta, near Sireasca and canal Mila 35, have also mostly been transformed into fast-growing hybrid poplar plantations. A typical example is the Sulina Canal. Beside the natural vegetation on the embankments, (typically white willow), there are continuous strips of hybrid poplar. The better adaptability of white willow to habitats with distinct water-level fluctuations is evident. While the roots of the poplars are totally exposed from the wash of boats and numerous trees have fallen, the white willows with their wide network of roots remain standing.

The beautiful lines of white willows along the waterway embankments have, in many places in the hinterland, been replaced by extensive plantations of hybrid poplar. A typical example is at Ostrovul Tatarului where old white willows remain only along the border of the water and extensive plantations of hybrid poplar stretch behind them.

Some other species have been planted, e.g. American introductions such as ash-leaved maple *Acer negundo* and red ash *Fraxinus pennsylvanica*. They have completely adapted and grow very well in the fluvial zone of the Delta. With their resistance to flooding they adapt almost as well as willows. Tests are being carried out with hybrid willows, which are preferred in many respects because of their resemblance to the white willows typical of this habitat. Such introductions should be treated with caution in view of the high ecological value of native white willows.

In parts of the Delta made up of marine deposits, afforestation has taken place next to natural forests, for example the Letea and Caraorman region. Alder *Alnus glutinosa* has been planted in the low-lying areas between the dunes, and mixed plantations of hybrid poplar and alder (Leandru, 1971) as well as hybrid poplar on the dry open spaces of the dunes. Under the extremely dry conditions of the open sand dunes they show inferior growth and their canopies are damaged. Plantations in the Letea and Caraorman areas show this clearly.

The afforestation in Letea dunes destroyed the natural vegetation on the open dunes and also the typical and unique mosaic of forest, shrub and xerothermic vegetation. Experiments were carried out on sandy grasslands with mixed species i.e. *Morus nigra*, *Pinus sylvestris* and *P. nigra* (only the latter grew), *Rhus typhina*, *Thelycrania sanguinea*, *Ligustrum vulgare*, *Cerasus mahaleb*, *Populus alba*, *P. nigra*, *P. canescens*, *P. canadensis*, *Elaeagnus angustifolia*, *Quercus robur*, *Quercus pedunculiflora*. *Phellodendron* and *Quercus suber* have been planted without success.

In the Caraorman dune area, apart from pine plantations, mixed forests have been planted consisting of ash, *Populus canescens*, and *Elaeagnus angustifolia*. This composition of typical native species is more successful than plantations of hybrid poplar.

In the dune area of Grindul Saraturile near Sf. Gheorge a 1600ha forest was established to anchor the sand (Figure 8.1). *Hippophaë rhamnoides*, *Populus*, pines, *Elaeagnus angustifolia* and various types of willows were planted.

It has generally been confirmed that plantations grow very badly on the dry, barren and partly saline habitats of the dunes. Salinity depends on soil humidity. It may endanger the natural forests if water circulation changes because of the construction of dams.

Following observations of vegetation occurring in other deltas, experiments involving plantation of exotic species have been carried out in the Danube Delta. There is, for instance, a forest in Uzlina consisting of *Taxodium distichum*, planted very densely (inter-canopy distance 0.8m) which shows no regeneration and no ground vegetation. Only at its extremities and where the inter-canopy distance is greater does *Fraxinus* regenerate and herbs such as *Solanum dulcamara*, *Scutellaria galericulata*, *Polygonum hydropiper* and *Mentha aquatica* occur. A similar forest is found in the wide Murighiol meander, corresponding as little to the natural habitat as the one in Uzlina.

8.5 Plants in the Delta economy

8.5.1 Reeds

Reeds have traditionally been harvested. Cut reed was used for roof thatching, construction of fences, fuel and for cattle litter. In the 1950s, the enormous areas of reed led to speculation about intensive exploitation for the cellulose industry. On its completion, the purpose-built reed factory in Braila was expected to consume one million tonnes of reed annually. Reed harvests in late autumn and winter necessitated the use of heavy machines which caused much damage. Originally, a heavy caterpillar-type vehicle was used which damaged the texture of growth at the top of the reed plant and, consequently, stopped regeneration. This led to a decrease of reed in the exploited areas. Consequently, *Typha latifolia* which was less susceptible to damage expanded at the expense of reeds. Therefore, a shift in the relative dominance of the two species has taken place. One of the largest reed exploitation areas was the reclaimed land at Pardina. The reed was harvested in a two yearly rotation cycle until 1984 when it failed to regenerate sufficiently. Soon reed was not only exploited on land reclaimed specifically for the purpose, or on areas used for pisciculture but also in natural areas.

After the experiences with the heavy caterpillar harvesters, smaller caterpillar vehicles were used with tracks made of rubber and sheet metal (tin). Nowadays a very light and wide-tracked machine is used (2145kg), which also works well on plaurs. A question which ought to be examined is how mechanical reed exploitation over large areas affects long-term regeneration.

The Danube Delta Institute in Tulcea has recorded the following figures concerning reed production (t/year):

1980	1985	1986	1987	1988	1989	1990
54,549	52,812	47,029	49,365	47,191	45,039	33,143

Considerable damage is caused by local inhabitants burning reeds in the autumn months. Fire spreads quickly in the dry reeds and many white willows fall victim to these fires and the habitat of many species is destroyed. Necessary precautions must be taken to prevent this.

8.5.2 Viticulture

Viticulture is a traditional occupation of Delta inhabitants and each household has a small vineyard to meet its own needs in the Caraorman and Letea dune region. The same applies to fruit-growing; quinces are preferred but apples, too, are cultivated for domestic use. Fruit plantations have been established in experimental areas at Uzlina and Pardina. Experiments have been made to cultivate figs which are grown for domestic use in the gardens of Sf. Gheorge.

8.5.3 Apiculture

Apiculture as an income-earning activity is also typical in the Delta and is entirely based on private initiative. Blossoms throughout the different seasons are exploited. Until the end of September the bee hives are kept outdoors, since even late-flowering plants such as *Mentha aquatica* can increase honey yields. This is a positive, ecologically healthy activity and should be encouraged.

8.5.4 Medicinal plants

Plants for medicinal purposes are collected on private initiative only. No measures need to be established to prevent damage if the activity remains at the current level. However, investigations of the income-generating potential for the local population from this and similar small-scale exploitation, should be carried out.

8.6 Pasture land and cattle-breeding

Livestock-breeding is a tradition in the Delta. Pastures are found in small areas that were formerly willow and poplar forests on the higher parts of the embankments. Cattle, sheep and sometimes goats and horses are subjecting this limited grazing land to heavy pressure (Antipa, 1911). This is clearly apparent in areas of intensive sheep grazing (e.g. Partizanu, Ostrovul Tatarului and opposite the dam of Pardina, along the Dranov canal and at Dunavat).

Pasture shortage and overgrazing are reflected in changes in the vegetation. Problems with overgrazing arise in three areas: Letea, Caraorman and Saraturile, but Letea has the gravest problem.

Pig-breeding is another traditional occupation of Delta inhabitants (e.g. in Uzlina). Pigs profit from the low water levels on the muddy, grassy river banks. Ducks, geese and other domesticated waterfowl may also profit from grazing the river banks at low water levels.

As long as the inhabitants only kept animals for domestic use, there was an appropriate balance with the environment. According to local people, environmental damage started with the intensification of cattle-breeding. In Letea this was pursued by cooperatives and cattle-breeding farms. The consequences of overgrazing are particularly damaging for ground vegetation regeneration in the Letea Forest nature reserves. Preventive measures ought to be taken to counteract this destruction. However, cattle breeding represents an alternative income to decreased yields from fishing.

8.7 Conclusions

This chapter has described some of the consequences to the flora of the Delta of engineering works that disturb water flow and ground water levels. With no further interference in the water regime and the restoration of flows that have been interrupted (opening polder dykes for example), it may be possible to restore some of the original vegetation.

Further research is needed to support conservation and restoration measures. This could be helped by organising exchanges of experts and ensuring that necessary scientific equipment is made available.

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CHAPTER 9: INSTITUTIONAL CONSIDERATIONS CONCERNING THE DANUBE DELTA

E. Maltby and A. Clark

9.1 Introduction

Concern over the environmental deterioration observed in the Danube Delta and the Black Sea coastal region has generated a growing awareness of its ecological importance and uniqueness, placing emphasis on the need for protective measures. The deterioration, which is undermining the contribution made by the Delta to the ecosystem in terms of acting as a filtering system and habitat for numerous plant and animal species, can be largely attributed to the following elements:

- hydrological works undertaken throughout the drainage basin regulating the flow regime and reducing sediment input;
- canalisation, dyking and polders preventing natural flooding;
- eutrophication and other aspects of pollution.

The combined negative effect of these developments upon the Delta has been a loss of biodiversity and habitat, and increased coastal erosion. Further development plans for the Delta have included additional agricultural and silvicultural reclamation, intensified livestock rearing, excavation of sands for glass manufacture, extensive reed harvesting for cellulose production, river straightening to improve sediment transport, airport construction and increased tourism activities. Whilst numerous opportunities exist for an ecologically sound economic exploitation of the Delta, without control and proper management, developments such as those described above run the risk of irreversibly harming the ecological balance of the Delta.

In recognition of this, the Delta has been declared a Biosphere Reserve and an application has been made for inclusion on the World Heritage List. In order for the Reserve concept to be effective, in preserving the Delta from further deterioration, in encouraging the regeneration of biodiversity and in recreating lost habitat, a comprehensive and coordinated management plan for the Delta must be developed and implemented. Indeed, in his 1991 'Status of the Danube Delta Biosphere Reserve Planning and Management Report', presented in September 1991, the Reserve's Governor, Dr Marian-Traian Gomoiu, states that the "only model we [the authority] are aware of and should like to adopt is the Broads Strategy and Management Plan (Broads Authority, 1987)".

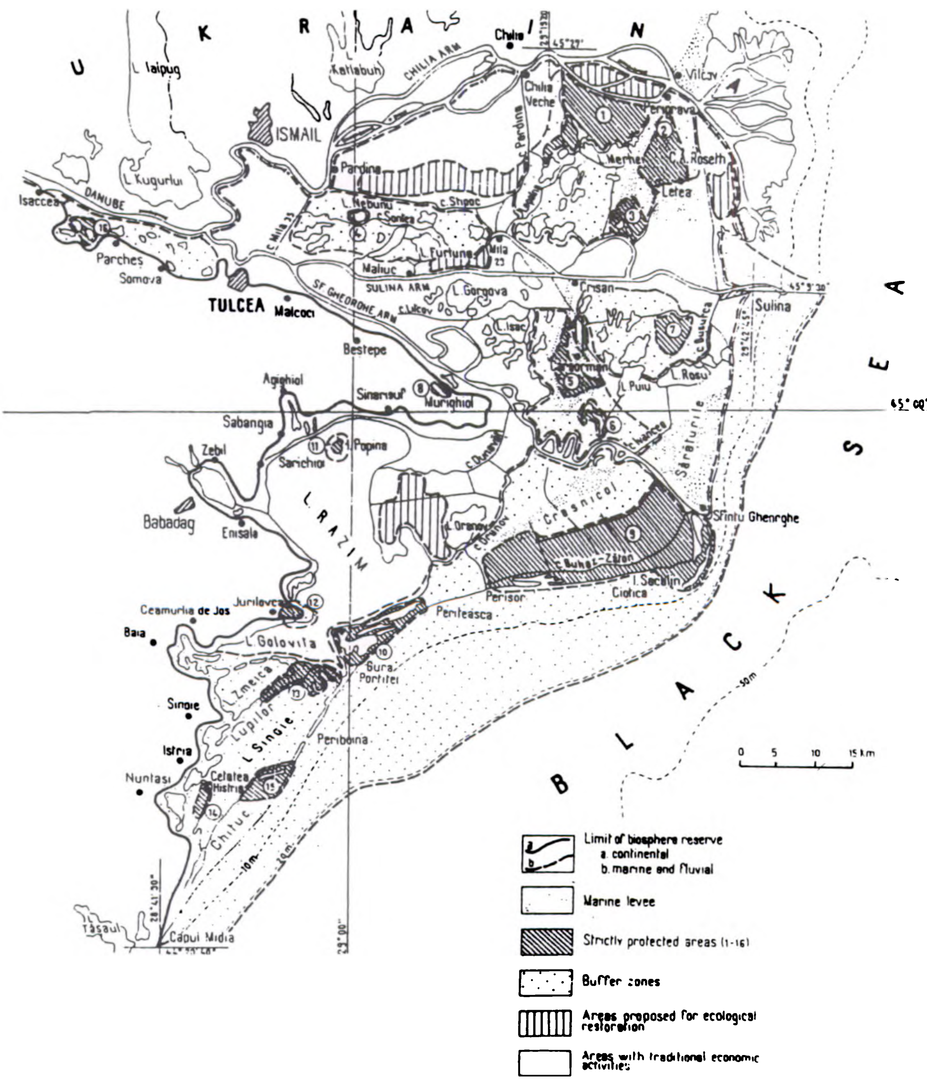

Figure 9.1. Danube Delta Biosphere Reserve

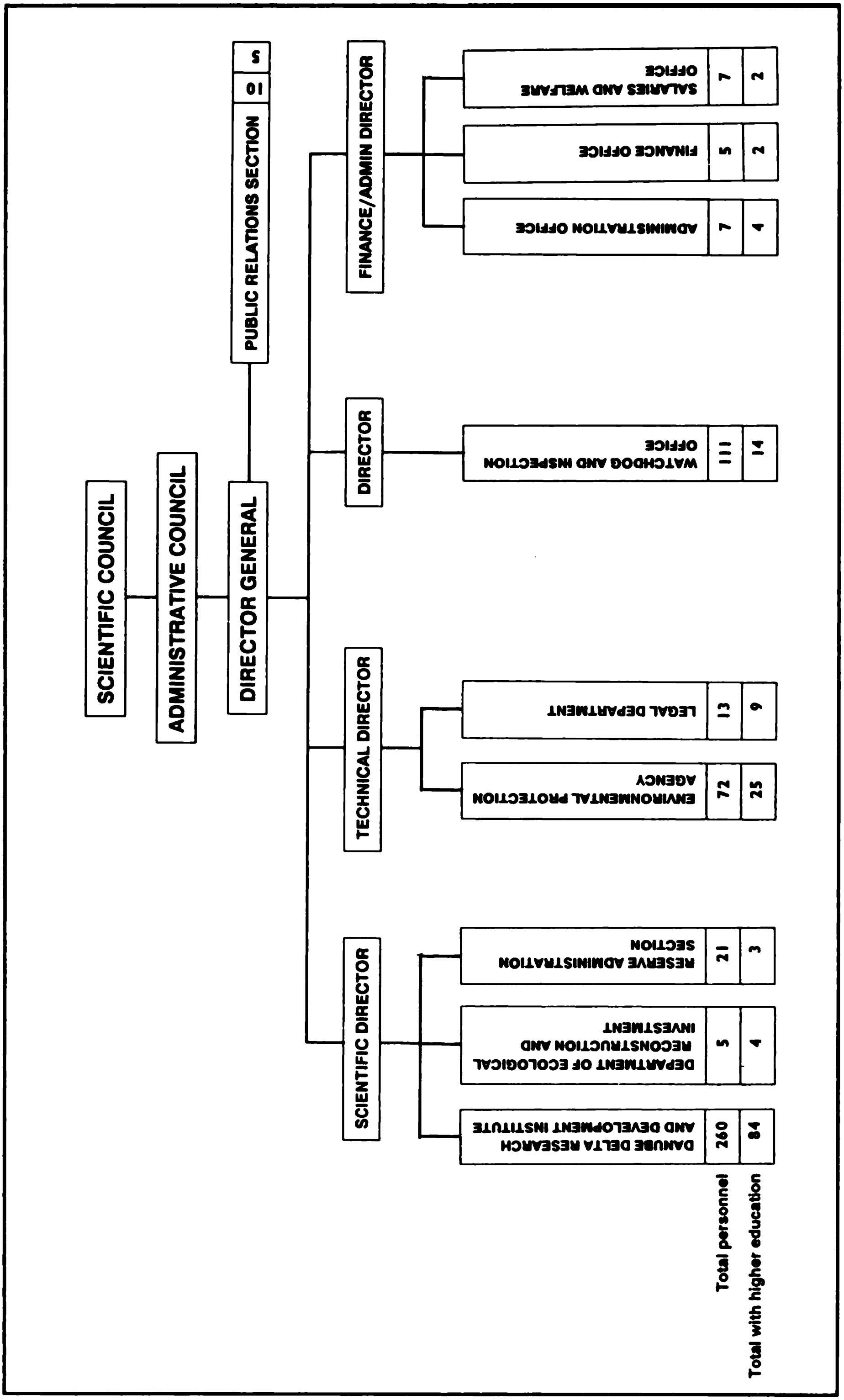

Figure 9.2. Organisational structure of the Biosphere Reserve Administration

The protective measures proposed by the Romanian Government must, moreover, be complemented by the enforcement of international agreements to clean up the whole Danube drainage basin. This paper explores the existing authority framework and discusses the structural and operational aspects of a concerted management plan for the Delta.

9.2 The Danube Delta Biosphere Reserve

9.2.1. Background and legal framework

The Biosphere Reserve was created on 27 August 1990 by National Decree No. 983, (Articles 5 and 6). The Decree sets out the general legislative framework for the protection and management of the Danube Delta according to Biosphere Reserve sustainable management principles. The designated area comprises 442,300ha, which may be extended to over 500,000ha to ensure its integrity.

Decree 983 provides for a moratorium on any damaging exploitation of the Delta until the Delta Authority is in place, with a more detailed legal basis on which to draw up protective measures. The Decree specifically requires that: "... all agricultural units and other current economic activities in the Central Danube Delta Company pass from the Ministry of Agriculture and Food to the Tulcea Prefecture by 30 September 1990". The company referred to in the Decree was the agency through which large-scale activities and projects were carried out, financed by the State. This agency is to be restructured and its economic activities made subject to strict limitations set by the Danube Delta Governing Council. This new Danube Delta Economic Company is intended to reflect, in part, the general shift of emphasis from a planned economy to a market economy.

The Decree has set in train the preparation of a Biosphere Reserve Charter for the Danube Delta. At present, Parliament is preparing to pass a specific law concerning the management of the Delta as a Biosphere Reserve. A six-member Parliamentary group (two from Tulcea, two from Constanza and two from Galati) undertook a fact-finding mission to the Delta, where discussions were held with local communities and those with economic interests in the area. Apparently, this mission is not yet familiar with the Biosphere Reserve concept and the management principles required to achieve sustainable development. This mission is due shortly to present its findings to a Parliamentary committee comprising lawyers, scientists and economists, etc. Currently in Parliament there is all-party support for protection measures proposed for the Delta.

9.2.2 Scope of the Decree

The limits or precise area of the Danube Delta Biosphere Reserve have been defined. Including the lake complex, the reserve covers 442,300ha, spanning also an area of the Black Sea extending from the shore to 20m in depth (Figure 9.1).

The area of the Biosphere Reserve is ultimately likely to include approximately 80,000ha closer to Braila, thus extending its total area to more than 500,000ha.

Specific references made in the Decree to the Biosphere Reserve include:

- the ecological restoration of the Danube Delta;
- the conservation of biodiversity, including genofund and ecofund;
- setting the environmental production capacity of the Delta through an evaluation of the tolerable limits for exploitation of natural resources such as reed, fish and timber.

It is stressed in the Decree that the coordination of hydrological works intended to provide better water circulation in the canals and lakes system and to prevent further erosion of the coastline is necessary. This will be a particularly sensitive area of legislation given that the need to recover the natural filtering function of the Delta is likely to enter into conflict with certain proposed engineering solutions.

As well as providing for adequate research and scientific study of Delta phenomena, conditions and limits for fishing and hunting will need to be set along with appropriate areas designated for these activities. Furthermore, the pattern of circulation within and access to the Delta - ranging from the movement and navigation of maritime shipping to a restrictive access policy for visitors to sensitive conservation areas - must be established, giving due consideration to the whole hierarchy of movement on the land and rivers. This control should be extended to include scientific research teams. Lastly, criteria must be set for settlement and tourist development (see the principles for development of tourism in National Parks by the Countryside Commission, UK, and the Man and the Biosphere Programme (MAB) principles of Unesco).

A further section of the Decree charges the Delta Authority with responsibility for setting in place a regulatory system for the Delta where taxes will be levied and fines imposed upon companies and individuals breaching laws. By means of example, fish species, net size, size of fish and the number of fish which may be caught will be determined and controlled by an inspectorate. Likewise, where maritime vessels or oil tankers are concerned, controls and inspection will be carried out to ensure that tankers are properly washed for example.

An Inspectorate, newly organised and set up under Dr Kiss, with a planned staff of 100, will be responsible for the control of this maritime area of Delta operations as a part of its comprehensive regulatory and control function.

The Minister of State concerned with quality of life has approved the transfer to and use of the Institute's buildings in Tulcea by the Scientific Council and its Governor, who is head of the Danube Delta Biosphere Reserve Authority and represents the Romanian part of the Delta in its international context.

The Tulcea centre and its research staff were transferred from the Ministry of Agriculture to the Ministry of Environment, Forestry and Water Management on 30

September 1990. The resources of the new Danube Delta Biosphere Reserve Authority are composed of funds from the Delta Institute and its research projects in Tulcea, along with funds for environmental protection and surveying tasks, again carried out by the centre in Tulcea, added to which will be funds devoted to the formation of the Inspectorate, which is to be the third unit responsible to the Danube Delta Authority.

The Decree empowers the Governor and Scientific Council to determine which particular combined enterprise or public-funded operations may be carried out within the jurisdiction of the Reserve. Article 6 of the Decree deals entirely with the formation of the new Inspectorate and outlines its functions within the structure of the Danube Delta Biosphere Reserve Authority.

9.3 The Reserve Authority: structure, context and wider institutional framework

9.3.1 Introduction

This section of the paper describes the various institutes and organisations charged with managing the Delta Reserve. Their role is central in implementing a comprehensive and effective management plan for the Delta.

This plan was outlined by Act No. 264 of 12 April 1991 and is illustrated by Dr Gomoiu's organisational diagram of the new administration (Figure 9.2).

The top rung of this administrative ladder is occupied by the Scientific Council followed by the Administrative Council, comprising the directors of three subordinated institutes. The Governor himself, Dr Gomoiu, sits on the third rung of this hierarchy. He is in charge of a Public Relations Section with a staff of 10.

9.3.2 Administrative and Scientific Councils

The four following directors are subordinated to Dr Gomoiu:

1. Scientific Director, in charge of (a) the Danube Delta Research and Development Institute, staffed by 260 persons whose work focuses on the design and operation of various management projects, especially those associated with fisheries. It houses facilities for the technical and laboratory analysis of chemical, physical and biological materials, although it is unclear to what extent the analytical functions of the laboratories at the Agency for Environmental Protection and Control (supervised by the Technical Director) and this Institute are distinct; (b) the Ecological Reconstruction and Investment Office, which has a staff of five people; and (c) the Reserve's Administrative Section, staffed by 21.

2. The Technical Director, who administers (a) the Legal Department, which has a total staff of 13, and (b) the Agency for Environmental Protection and Control, which has a staff of 72 and was previously the Office of Water Management. It is one of the 41

regional agencies organised by the *Judet* [administrative department] throughout Romania. Its terms of reference cover four areas:

- regulation, legislation, standards and licences;
- inspection and control;
- laboratory analysis of water, air and radioactivity;
- the establishment and maintenance of monitoring networks.

Its underlying objective is to better understand how the Delta ecosystem works and develop management strategies according to the best available scientific base. Despite there being a strong technical labour force within the Agency, progress is hampered by many factors.

3. The Director of the newly established Watchdog and Inspection Office, which comprises a staff of 111 inspectors, wardens and general employees, all involved in the enforcement of environmental standards as part of the Reserve's management. It is hoped that this body will play a role not unlike that played by other environmental agencies such as the UK's National Rivers Authority.

4. The Financial and Administrative Director of the Heritage, who runs (a) the Administrative Office, manned by a staff of seven; (b) the Finance Office, with five employees, and (c) the Organisation and Methods, Salaries, Administration and Welfare Office, with a staff of seven.

In total, the Administration is run by a staff of 514 persons, 155 of whom are professionals. At the time of presenting his report to the Planning Seminar of 17-21 September 1991, Dr Gomoiu stated that the efficiency of this structure remained untested, some parts of it (for instance, the Research and Development Institute, the Environmental Protection and Control Agency, and the Watchdog and Inspection Office) still functioned independently, and 30 vacancies had been unfilled. In addition, it was Dr Gomoiu's concerted view that this legislature continues to contain many 'gaps' which require supplementation by the passing of a new bill.

9.3.4 The Scientific Council: its composition and functions

Largely as an outcome of the six-member Parliamentary Commission's visit to the Delta, the Scientific Council and Governor are likely to have a more detailed legislative framework in which to work, in the form of a legal charter with several articles, similar to the National Decree but articulating with greater detail and precision the duties and functions of the Danube Delta Biosphere Reserve Authority, as fulfilled by the Governor and the Scientific Council.

The fact-finding mission spent a day in the Tulcea *Judet* and a second day with members of the local population. A third day was spent hearing representatives from each of the Danube Delta localities. Discussions emerging from the mission have focused on local problems, notably comparing fishing as it was 20-30 years ago, when there was a surfeit at collecting points, with the current shortages. There is concern about the growing number of cormorants and pelicans and their impact on the fishing industry. Local people have explained that reed areas should be burned off and canals opened up to give better access and stimulate reed production.

A dimension missing from the discussions has been any reference to the Delta as a Biosphere Reserve and, seemingly, any understanding or explanation of the functioning and natural values of the ecosystem which will be the basis for future management of the area. It seems most important to us that public awareness and understanding of these fundamental principles be fostered and encouraged. Help in engaging the local population with the Danube Delta Economic Company is vital to ensure the compatibility of future economic development with the sustainable environmental capacity of the area. Under the previous centralised administration, local people found themselves working extremely hard, with little return. Predatory industries and inappropriate development projects failed. Polderisation projects were disastrous from an economic as well as an environmental point of view. A pattern of environmentally compatible and economically viable activities, geared to the traditional exploitation of the area, needs to be reintroduced with the support of the local population.

This poses quite a challenge. The huge shift from the centrally planned economy to a mixed enterprise network of locally based, low-intensity activities will be hard to achieve, given the very limited financial resources available for this transition. The authors believe that it will require commitment and financial support on an international scale to assist the Romanian Government and the inhabitants of the Delta in protecting the fragile wetland area and re-establishing sustainable patterns of use.

In this, the authors consider of vital importance the foundations of the Danube Delta Charter and its framing as a basic legal instrument. How the Charter provides for and specifies the strategy and management for the area over the next 5-10 years will be critical to its success, not forgetting, however, that without committed implementation of appropriate management tools and legal instruments, even the strongest charters are useless.

9.4 Management: Strategy and the Management Plan

Perhaps the most obvious difficulty in the Delta at present is the lack of comprehensive integrated management. There are many activities still taking place in a fragmented and uncoordinated fashion. The most disquieting of these is the large-scale programme of hydrotechnical works currently being prepared by the engineer, Mr Hîrjev, which will shortly be put to the Scientific Council for consideration. The programme requires careful assessment of the possible environmental impact it would have on the traditional character of the Delta. More importantly, hydrotechnical proposals in the future should form part of a comprehensive, environmentally sensitive strategy for the area and the principles of sustainable utilisation or wise use of the wetland complex would almost certainly preclude and invalidate proposals on the scale and of the type set out in the current programme.

The Charter should specify the preparation of a strategy and management plan for the Delta and require it to be formally adopted by Parliament through approval by the Ministry of Environment, Forestry and Water Management - a time-scale of up to two years could be set for such preparations. The Biosphere Reserve principles on which the plan will be based should be given sufficient reference and public consultation should also play an important part.

9.4.1 Method

In the view of the authors, the following broad guidelines for assembling the plan might prove helpful.

The Scientific Council is likely to comprise 35-37 members, including ten Tulcea *Judet* representatives, one from each of the local communities. The period of service - yet to be agreed - is likely to be three to five years. Included in the remaining membership will be a mix of the following interests: Romanian Academy specialists in biology, chemistry, ecology, and veterinary science, a hydrologist, agricultural scientist or expert, forester, fisheries expert, soil scientist, lawyer, housing expert, navigation officer, a local Member of Parliament and a journalist or press officer.

The first meeting of the Council was held in early 1991, amongst its first business being the preparation of a situation report on the Delta region. Mr Hîrjev presented his report on the hydrotechnical proposals at this meeting.

The authors recommend that a strategic working group be established, charged specifically with the coordination and preparation of a strategy and management plan for the Delta, according to appropriate management principles which optimise the natural ecosystem functions and values, as well as ensuring the compatibility of land uses through an integrated approach.

The Working Group might appoint a coordinator to carry out this task. It could be envisaged that the Group include the Governor and his departmental directors, together with a small representative body from the Scientific Council and local community members. Invitations could be offered to outside experts from time to time to provide specific inputs, where specific functions or topics are considered and short working papers assembled. By means of illustration, a working paper could be prepared on the water quality or fisheries problem, with precise proposals for (i) research needs, (ii) experimental management of a scientific nature, and (iii) practical projects involving, for example, the participation of the local community in a pilot project exploring the viability of a return to traditional practices, or alternatively the adoption of new ones. Such a group would benefit from the financial support of international agencies, and notably from their expertise. Furthermore, similar working groups could be set up to address other issues relevant to the Delta plan, such as conservation-sensitive tourism, forestry, agriculture, and the reed industry.

9.4.2 Proposed model for the development of a strategy and management plan for the Delta

Drawing on past experience, the authors believe that the consultation of local Delta communities throughout the preparation and implementation of the strategy is highly desirable. A forum intended for this purpose could be established.

The role of the Danube Delta Economic Company is most important. The Company, with a radically changed basis of operation, will be submitted to economic constraints set by the Delta Authority, and consequently, it is vital that both organs maintain regular and easy working contacts. It may be that intervention support - similar to that occurring in France and the UK - prove necessary, along the lines of the Environmentally Sensitive Area (ESA) designation which is shifting farmers from high production aspirations to low-intensity, conservation-led farming. This method is expanding in the UK, while in France it remains more limited in application. Although conservation-based, it is, however, a relatively expensive intervention measure. The economic appraisal of the Delta suggested earlier may find the current low economic base favourable for short-term support measures. It will in any case be necessary to engage the Delta Company fully in any economic study of the area; it would also be helpful to see the Company represented in the Strategic Working Group.

9.4.3 Functioning and integrated management

A recurring issue will be how to make the transition from unecological to low-intensity uses of the region. In this, economic studies will be an important element, alongside scientific and management studies, and should attract funding from international agencies.

Acquiring an understanding of the functioning of wetland ecosystems and identifying the resulting values is essential for sound management and wise use of the Delta. Appreciation of the variety of functions and products of such ecosystems is a potentially powerful tool for decision-making. Functional analysis should provide the scientific and socio-economic rationale for maintaining and/or enhancing certain wetland processes and their resulting environmental benefits. This can contribute to the restoration of rehabilitation of degraded areas as well as the management of continuously evolving and dynamic ecosystems. Such analysis must specifically evaluate the compatibility of different functions and match the natural benefits or values not normally costed (e.g. water quality) against economic values (e.g. fisheries).

The recent preparatory action of the EC DG XI on Integrated Management of Coastal Wetlands of Mediterranean type provides a range of useful conclusions.

- Wetlands should be self-regulating systems, characterised by primary biotic conditions.
- No wetland area remains which may be sacrificed for uses not directly compatible with wetland functions.
- An instrument for functional analysis based on natural, and as far as possible, socio-economic values is urgently required.
- Regularly updated, accessible wetland inventories are required, on a scale appropriate to management.
- Zoning of both the wetlands and the adjacent area is needed, for more effective environmental impact assessment and in order to avoid further degradation.
- An Integrated Management Plan is an essential instrument for ensuring satisfactory resource conservation.
- Competent executive management bodies must be established, as a particular service or institutionalised collaboration, to plan and enforce sustainable use, with the involvement of the local people and authorities.
- Together with the training of managers and concerned persons, awareness of the need for integrated management must be cultivated on a wider scale amongst the population.
- Specific guidelines for users must be developed for the wetland and its catchment areas, especially in regard to water and pollution management.
- Controlling and combating illegal use is considered a crucial yet highly sensitive aspect of wetland conservation and integrated management.

9.4.4 The local community

The large-scale damaging activities that have taken place over the last 20-30 years in the Danube Delta are likely to have generated a certain resistance to imposed change within local communities which may affect efforts in the future.

The lack of a unitary educational system has impaired the development of the 'ecosystem' view on environmental problems. Likewise, the tendency to train specialists purely in water/soil/chemistry/biology/hydrology, etc., has militated against an integrated approach to management of the Delta. The new Environmental and Engineering Research Institute has a brief to develop a more integrated approach to environmental problems but the staff are predominantly engineers (310), with chemists (60) and especially biologists (30) representing a small and relatively non-influential body. In consequence, understanding of wetland functioning and the many values of a wetland ecosystem is limited not only amongst the public, but also decision-makers.

So far, a methodology is lacking for resolving conflicting conservation and economically based objectives.

It will be critically important that local communities are in agreement with future policies for the Delta and that their support is given to any strategy and management plan adopted. The process outlined earlier is a general model allowing for the exchange of views between local people and the Delta Authority. As the area of the Delta is physically very large, explaining to local populations the motives and logic behind the strategy - and the constraimts and opportunities this represents - will be a major educational task. The difficulties of physical communication should not be underestimated, for there is, in effect, an 'unseen' dimension to the Delta in terms of people and places quite remote to the main centres. The limitations in basic educational opportunities are considerable, quite apart from the sheer logistics of reaching certain more isolated communities, some of which have sought this isolation historically for social and cultural reasons. The challenge of providing environmental education even of the most fundamental nature is enormous.

The benefits, however, are considerable. Gaining an insight and understanding of the cultural values and traditional modes of living within the Danube Delta is, perhaps, the key to a rationally based, dynamic strategy for the future which holds the confidence of the people who live and work there.

CHAPTER 10: ARCHAEOLOGICAL AND ETHNOGRAPHIC ASPECTS OF NORTHERN DOBRUDJA

Text based on a translation of an article entitled "A Short Archaeological Walk", by J. B. Kiss

10.1 Archaeology

From an archaeological point of view, the Danube Delta provides little evidence for the region's history or its anthropological genesis, due mainly to its incessantly changing physiographical conditions, (as the remains that have been exposed were covered by earth and have not been preserved intact).

The only finds worth mentioning are the few kenotafiums, or symbolic graves, containing large numbers of fragmented pots, including the broken neck of an amphora (an ancient two-handled Greek vase), dating from the 5th century BC.

However, the banks of the Danube, in common with all large rivers, have been densely populated from the Stone Age up to the present and it is here that the remnants of the past, of the chaotic intermingling of groups of people, have been well preserved.

Northern Dobrudja is littered with Dacian and Roman finds. In 1961, for example, the largest find of coins in south-eastern Europe, was made at Uzumbair. Over 23,500 pieces of Tartar silver from the late 13th century up to 1312 were discovered, and 195 Byzantine gold coins from the first half of the 13th century. It was assumed to be the hoard, hidden beneath a forest that has since made way to vineyards of an immensely rich merchant or dignitary, so providing clear proof of the widespread medieval trade connections of the Danube Delta.

Also worthy of note was the discovery, by a construction firm in 1969, of a 1,500 year-old giant sarcophagus at the village of Badila, between Niculitel and Isaccea within a group of tumuli in the valley of Capaclia. Excavations, ending in 1971, revealed the bodies of two high-ranking women dating from 140-143 AD and 156-157 AD, according to two coins found within the tomb.

Within the vicinity of the group of tumuli containing this huge sarcophagus, the ruins of a scattered Roman settlement were brought to light, typical of the villa rustica (or 'farm') category found in the Roman provinces. An inscription and some of the effects found within the tumulus lead us to believe that the owner of the nearby house came from the Near East, possibly Egypt, and was presumably an officer of the Lower Danube fleet stationed in Noviodunum (present-day Isaccea) and that he erected the sarcophagus for the funeral of his wife.

Other interesting discoveries include one of the most valuable Getian finds in the country which has put the name "Cotys", inscribed on a silver cup, on the map of archaeological history.

Niculitel, now well-known for its wine, is less well known for the excavations that took place simultaneously with those of the Badila sarcophagus to reveal an early Christian three-naved basilica from the second-half of the 4th century AD, built on the ruins of an even older church. Its significance hinges on the fact that it is not only the first known church of south-eastern Europe with an atrium (natrex), but that it is also the resting place of the country's first Christian martyrs, whose remains were re-buried with great pageantry at the Cocos monastery. Niculitel also revealed a collection of 6,000 coins from the late 14th century.

The museum of Tulcea now holds many of the treasures mentioned above, including finds from the early Bronze Age as well as from the area known as Isaccea in antiquity (Noviodunum in Roman times), which was a military base and trade centre, and the reason for the flourishing Roman homesteads in its vicinity.

Tulcea itself, originally named "Aegyssos" after its founder, goes back to the Iron Age and New Stone Age settlements that excavations have since revealed. Roman settlements were built on top of Hellenic remains in the Tulcea area.

The present-day name of the town is only 400 years old, and was first marked on a map of 1595; there is a theory that it was named after a Turkish dignitary.

The pleasant guide-book picture of windmills and two-storey houses described by Boucher de Perthes in 1853 has been supplanted by rows of ten-storey buildings and industrial chimneys spewing smoke over the once galleon-ridden waves of the old Ister in modern-day Tulcea, whose museum holds so many of the treasures of its rich past.

10.2 Ethnography

It is primarily northern Dobrudja's many co-existing nationalities that are responsible for its unusual popular customs. The existence of these nationalities is largely the product of Dobrudja's geographical situation since the northern part, together with the Delta area, was an important junction of trade routes, even in prehistoric times. Some groups were swallowed up in various wars, others drifted away, but those who remained welded into an united community with the others. But present-day inhabitants keep only an ever-receding memory of their links with the past. The Lipovans (descended from native Russians) are discarding their ethnic costume for modern-day jeans, and are training as teachers and skilled workers. More and more Macedo-Romanians, who formerly used to specialise in sheep-rearing are now in professional occupations, and the Tartars of Karaeba (present-day Colina) commute to the bauxite works of Tulcea. Interestingly enough, the most valuable members of the national kayak-canoe team of Romania are usually the descendants of the fishermen of the Delta.

Half a century ago 34.9% of the male and 59.8% of the female population of the area was unable to write (according to *Enciclopedia Romaniei*, 1936). Today illiteracy has practically disappeared along with many of the old customs.

According to census data provided by D. M. Ionescu, in his "Dobrudja on the Threshold of the 20th Century", the county of Tulcea was ethnically the most varied part of this region. A case in point is the town of Sulina (on the Black Sea coastline), where, apart from Romanian speakers, the following ethnic groups could be found: 2,056 Greeks, 594 Russians, 444 Armenians, 268 Turks, 221 Austro-Hungarians, 173 Jews, 111 Albanians, 49 Germans, 45 Italians, 35 Bulgarians, 24 Englishmen, 22 Tartars, 22 Montenegrans, 17 Poles, 11 Frenchmen, 7 Lipovans, 6 Danes, 5 Gagauzes and 4 Persians. This great variety of groups existed, nevertheless, within Sulina's relatively homogenous population that boasted a British, Swedish-Norwegian and Dutch consulate.

Of the minorities that had settled in multinational Dobrudja, the Circassians were scattered by wars to bequeath to history only the name of their mid-19th century settlement and a few family names ending in "villi". The Gagauzes were similarly absorbed, although there were still 2000 of them in the area at the beginning of the 20th century, to the extent that their origins are still a matter of dispute.

The larger groups of the Romanian population of contemporary northern Dobrudja consist of Moldavians and Wallachians, and of Macedo-Romanians, and shepherds from the southern Carpathian mountains. However, it is a great accomplishment for ethnographers to extrapolate who came to settle here and where they originated from. For instance, certain regional words and some elements of folk architecture or folklore preserve the characteristic features of their origin but for only one or two generations before they disappear.

The Turks, who first reached northern Dobrudja in the 13th century and were still dominant in the Delta area especially, are now to be found in insignificant numbers.

Ottoman rule, beginning in 1416 with the territorial expansion of Sultan Mohammed II, ended with the 1877-78 Russian-Romanian-Bulgarian-Turkish war. However, according to C. Bratescu, 62 per cent of the place names and localities registered in Dobrudja are of Turkish origin.

The Turk willingly allowed the infidel to look after the Delta; the political, economic-mercantile and intellectual centre of their rule was on the plateau of Dobrudja. However, after the 1848 war of independence, most of the Turkish population moved to Anatolia and only a small number has remained, up to the present, near Babadag and Isaccea, while in the mid-19th century there were already fewer Turks in Tulcea than elsewhere in the region. According to a contemporary local author, Sándor Veress, in 1856 the inhabitants of Tulcea were "a mixture of all kinds of Christians, and round Tulcea there are Germans and Lipovans...".

A large portion of the present-day Turkish population is employed in the service industry, particularly the men whose material expectations appear to be met in these occupations, which may explain why many more of the Turkish girls have secondary or higher education than the boys, especially as there has also been an emancipation of the women in the community.

Another ethnic group, whose language and customs are not unlike that of the Turks, is that of the Dobrudja Tartars. Only four of the villages within the Dobrudja area were inhabited by a sizeable Tartar community, which has become hard to trace due to the fact they have been assimilated even more with the Romanians and other nationalities than the Turks, although their characteristic features give away their origins even after considerable interbreeding. Most living outside towns work on the land - to the exclusion of fishing - and most are still Muslim.

The area's Muslim Gypsies, ethnically quite different from the two nationalities discussed above, do nevertheless resemble the Turks in their costume, particularly the women's half-skirts and half-trousers. This costume is as striking as the cross tattooed on the foreheads of older Macedo-Romanian women, or the beard of the Lipovans. Although most of the Muslim Gypsies live in towns, there has been little progress in encouraging their school attendance.

As for the Danube Delta's Slavic inhabitants, the issue is by no means a simple one, for while Lipovans are known to be Slavs, not all Slavs living here are necessarily Lipovans. Furthermore, not so long ago, the genuine Lipovans were still divided into different groups, although this situation no longer exists. They came to the Delta from Tsarist Russia in several waves seeking refuge from state and religious persecution.

The Lipovan sect originated near Pskov around 1419. Their traditionalist leanings did not fit in with plans for a centralised power of Peter the Great and Catherine II. They were daubed as 'raskolnikovs', or heretics, and it was to preserve the ancient ceremonies they had clung to that they fled from Tsarist persecution in 1772, first appearing in Bukovina, and then Dobrudja. It is for this adherence to their ancient customs and mother tongue that the Lipovans distinguish themselves from all the other nationalities of Dobrudja.

This observance of past rites has produced several notable discrepancies with the modern rule. The Lipovans have preserved the Julian calendar and lavish similar care on their beards, which still resemble those of the patriarchs of their icons. They have nevertheless carved out a reputation for themselves as good fishermen, sailors and construction workers.

Another ethnic group that settled in the Delta in the 18th century (1709) were the Cossacks of the Dniepr who also rebelled against curbs on their rights and liberties by the Tsarist power. They were contracted by the Turks to defend the borderlands, but in 1828 two Cossack regiments contravened the agreement not to fight against Christians when they joined forces with the Russians, a move which lost them their land and fishing rights. They subsequently became scattered all over northern Dobrudja.

The strange anomaly regarding the two last-mentioned groups is that despite sharing the same language (Ukrainian) and customs, the Cossacks did not mix with the Lipovans, although both are good fishermen and sailors.

Ukrainians proper, on the other hand, also have another name, they are called 'hahols', possibly, some authors think, due to their characteristic pronunciation of 'g' as 'h' (*hnezdo* [nest] for *gnezdo*, etc.). Meanwhile, the Lipovans probably got their name from the Russian *lipa* for lime tree due to the use of that wood in their icons and boots.

Another group of Slavic origin were the Molocans, called such from the derivation of the word *moloko* (milk), since they consumed milk and dairy products even at Lent. They have been completely absorbed and have disappeared as a sect and a national group, although Ionescu's monograph still mentions them in large numbers. The Molocans were a large, literate sect (even in the early 20th century) and refrained from taking community matters to court, reserving the right to reward and punish their members themselves.

Ionescu' monograph mentions another, now dying, sect, known as the castrated people (*Scopiti castrati*) who liked to be called 'white doves' and whose last eunuchs, now in their eighties, are living out their last days bee-keeping and gardening near Isaccea.

Other small communities have been dispersed by wars and economic or political crises. They included German settlers who moved here from Russia in several waves after 1841, the Bulgarians, the Circassians, who were Turkish subjects, the Greeks and the Jews, as well as several western Europeans who came to the area as merchants and, later, employees of the European Danube Committee. Some Hungarian veterans also probably remained here from John Hunyadi's campaign of 1422 and the names of their descendants live on in Turkish documents starting from 1505.

Customs

A custom that has continued to be popular among the northern Dobrudjan Romanians (as well as all other Greek Orthodox nationalities) is the so-called "Easter of the dead". It is a feast attended by the whole family at the cemetery and involves the sprinkling of wine on the graves, followed by its consumption by the family along with painted red eggs and cakes. Eggs seem to have played an essential role in funerary ceremonies as far back as the Middle Ages, since excavations at Isaccea of 12th and 13th century graves yielded painted Easter eggs.

The honouring of the ancestors is, indeed, a highly developed custom in the whole of northern Dobrudja, and that includes the villages of the Delta too. Vigils and wakes sometimes involve the exhumation and reburial of the bones of the deceased as long as seven years following their death. It is frequently hard to separate the remnants of pagan customs from the canonized rites of the orthodox church or from the customs of particular sects. The fact remains, that honouring the memory of the ancestors is an important factor in the preservation of national identity and survival.

The ornithological-ethnographic interest in the egg in the Delta region is further supplemented by the ceremonies connected with the vernal equinox. As this holiday was preceded by the Easter Lent it was closely associated with the health-related dietary switch from fatty winter foods and meat to a lower-calorie diet (a custom that lives on even in our days, though in a diminished form). Delta villagers stop consuming meat and dairy products as well as eggs two weeks before Easter and on the last day before Lent (our Shrove Tuesday), they have a 'farewell' feast of earthly products which will soon be forbidden.

The 'magical' egg appears once more in the customary rites of Maundy Thursday. On this occasion, eggs are painted and then appears on several occasions in the course of the next 10 days, always in a different context.

However, the Maundy Thursday ritual also involves the use of fire and water. The elements are employed again in customs on Good Friday when washing in the 'untouched' water of the nearest lake or river is undertaken, especially by the sick.

The Lenten fast ends with the Easter ceremony, and eggs (painted red) can be consumed, but not before they are doused in a bowl with water and some coins. Furthermore, washing one's face in the water splashed over the eggs will, it is believed, bring riches during that year.

The cleansing properties of fire and water are once more illustrated in the village of Murighiol where elderly couples jump over a fire to show their troubles are behind them when their last child has married. On similar occasions, in other villages, the parents of the bride and groom are taken in a cart to the Danube and dumped in the water to wash away their troubles.

A SUMMARY OF SOME SOCIO-ECONOMIC PROBLEMS OF THE DANUBE DELTA BIOSPHERE RESERVE

A. Volcov

In 1970 there were 21,657 inhabitants in the Danube Delta, in 1990 there were only 15,590. Today, five towns are virtually non-existent, because the number of inhabitants is less than 25. Of the 28 existing towns, only five possess their own water supply.

There are farms managed by individuals who have only finished one academic cycle (elementary school) and even in 1991 farms exist which are led by individuals with a poor professional qualification.

In several towns there are no more schools because the number of pupils has diminished, apart from Sulina, the other towns only have "general schools". In all towns the educational authorities are insufficient, the gap being filled by supply teachers. The reduced educational means for the children is one of the main reasons why the young do not continue with their education.

Providing medical assistance is a very difficult task because the average number of doctors and staff is very small. At Chilia Veche there is one doctor for every 3,095 inhabitants, and at C.A. Rosette there is one doctor for every 1,438 inhabitants. Medical dispensaries are only to be found in the parishes.