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Harald Meixner, Ingo Schnauder, Jens Bölscher, Virgil Iordache
(Editors)

Hydraulic, Sedimentological and Ecological Problems of Multifunctional Riparian Forest Management - RIPFOR -

Guidelines for End-Users

2006

Im Selbstverlag des Instituts für Geographische Wissenschaften der Freien Universität Berlin

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Hydraulic,Sedimentological and Ecological Problems of Multifunctional Riparian Forest Management

Freie Universität Berlin

University of Natural Resources and Applied Life Sciences - Vienna

Universität Karlsruhe

Universita degli Studi di Trento

University of Bucharest

Federal Ministry of Agriculture and Forestry - Austria

Agenzia Provinciale per Protezione dell´Ambiente - Trento

Fifth framework programme of the European Community for research, technological development and demonstration activities (1998 – 2002)

Quality of Life and Management
of Living Resources Programme

Key Action N° 5:
Sustainable Agriculture, Fisheries and Forestry, and Integrated Development of Rural Areas, Including Mountain Areas

Period 01/03/2000 - 28/02/2003 - Contract number QLRT-1999-1229

Freie Universität Berlin   Prof. Dr. Peter Ergenzinger (Co-ordinator)

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PREFACE

The problem of prevention with regard to floodplains is related to two extremes: Prevention of floods and prevention of droughts, both urgent socioeconomic issues during the last years.

„Retard the flow of water in the stream corridor“ is the message to cope with both kind of problems. An amphibian landscape will help to maintain water supply during periods of droughs and by its retention area to reduce peaks of high floods.

Flood retention areas will function sustainably only if there is an intact ecological system and equilibrium between erosion and accumulation of sediments which in turn both depend from the evolution of the hydraulic conditions and from the succession of the riparian forest.

The RipFor – project laid emphasis on the hydraulic processes and their erosion / accumulation effects in retention areas with the aim to get insight into the interaction between riparian vegetation, sediment transport, hydraulics and ecology. Interdisciplinary and intereuropean work was carried out in the field, the laboratory and by modelling.

Results of the RipFor – project as presented in the scientific report and the attached „guidelines for End-Users “ in this way are a contribution to the international discussion on river restoration and to the implementation of the European Water Framework Directives.

The scientific report was compiled by Ingo Schnauder and Jens Bölscher (Karlsruhe and Berlin) from contributions of all partners, whereas the bulk of work on the „Guidelines“ was done by Ingo Schnauder (Karlsruhe), Jens Bölscher (Berlin) and Harald Meixner (Vienna), who also cared for the layout. Reporting of the Romanian NAS partner was directed by Virgil Iordache.

Assistance of subcontractors and endusers is highly appreciated, especially by Othmar Huppmann (Regierungspräsidium Freiburg / former Gewässerdirektion Oberrhein).

Funding within „Quality of Live and Management of Living Resources“ in the RP5 framework of the European Union was essential for this project and is highly acknowledged.

Prof. Dr. Peter-Jürgen Ergenzinger

THE FIFTH FRAMEWORK PROGRAMME OF THE EUROPEAN COMMUNITY FOR RESEARCH, TECHNOLOGICAL DEVELOPMENT AND DEMONSTRATION ACTIVITIES (1998-2002)

The Fifth Framework Programme (FP5) sets out the priorities for the European Union's research, technological development and demonstration (RTD) activities for the period 1998-2002. These priorities have been selected on the basis of a set of common criteria reflecting the major concerns of increasing industrial competitiveness and the quality of life for European citizens. The Fifth Framework Programme has two distinct parts: the European Community (EC) framework programme covering research, technological development and demonstration activities; and the Euratom framework programme covering research and training activities in the nuclear sector. FP5 differs considerably from its predecessors. It has been conceived to help solve problems and to respond to the major socio-economic challenges facing Europe. To maximise its impact, it focuses on a limited number of research areas combining technological, industrial, economic, social and cultural aspects. Management procedures have also been streamlined with an emphasis on simplifying procedures and systematically involving key players in research. A major innovation of the Fifth Framework Programme is the concept of "Key actions". Implemented within the specific programmes, these flexible instruments are targeted at achieving solutions to topics of great concern in Europe. "Key actions" will mobilise the wide range of scientific and technological disciplines - both fundamental and applied - required to address a specific problem so as to overcome the barriers that exist, not only between disciplines but also between the programmes and the organisations concerned. The aim of the Key Action N°5 (Sustainable Agriculture, Fisheries and Forestry, and Integrated Development of Rural Areas including Mountain Areas) is to develop the knowledge and technologies needed for the production and exploitation of living resources, including forests, covering the whole production chain, adapted to recent adjustments in the common agricultural and fisheries policies, while also providing the scientific basis for Community regulations and standards. Similarly, the aim is to promote the multipurpose role of forests and the sustainable management and utilisation of forest resources as an integral factor of rural development. Priority areas include:

- new and sustainable systems of production, including breeding methods, and exploitation in agriculture, forestry, fishing and aquaculture, taking into account profitability, the sustainable management of resources, product quality and employment as well as animal health and welfare,
- the integrated production and exploitation of biological materials (non-food uses),
- sustainable and multipurpose utilisation of forest resources; the integrated forestry-wood chain,
- development of methods of control, surveillance and protection, including protection of land and prevention of soil erosion,
- prelegislative research designed to provide a scientific basis for Community legislation,
- the production of new tools and models for the integrated and sustainable development of rural and other relevant areas based on optimisation of the specific potential of each area, including at regional level, diversification of activities and land use, and involvement of the people concerned.

The Editors

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Riparian Forest Management

Guidelines for End-Users

RipFor-Team

Guidelines for End-Users & Appendix I

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(elaborated by the RipFor NAS partner University of Bucharest)

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1. General information

„Hydraulic, Sedimentological and Ecological Problems of Multifunctional ***Rip****arian* ***For****est Management -* ***RipFor****"*

The RipFor - project is concerned with the optimisation of Riparian Forest Management, with special respect to hydraulic, sedimentary and ecological processes occurring in floodplains.

The project was financed by the European Community within the framework of the specific research and technological development program ***„Quality of Life and Management of Living Resources"***.

Principal contractors:

- Freie Universität Berlin, Department of Earth Sciences, Institute of Geographical Sciences, Germany
- University of Karlsruhe, Institute of Water Resources Management, Hydraulic and Rural Engineering, Germany
- University of Trento, Department of Environmental and Civil Engineering, Italy
- Agenzia Provinciale per la Protezione Dell'Ambiente, Italy
- University of Agricultural Sciences Vienna, Department of Soil Bioengineering and Landscape Construction, Austria

Assistant contractors:

- Federal Ministry of Agriculture and Forestry, Austria

2. INTRODUCTION

River control by regulation and straightening was common practice all over Europe. These severe interferences lead to a significant diminution of natural flood retention areas, increased and accelerated flood peak flows and the destruction of unique natural and cultural treasures.

Increased flood risks, pollution, loss of ecological diversity forced new priorities: The restoration and sustainable management of rivers and the installation of new flood retention areas. A substantial scientific background of information related to hydrology, hydraulic, morphology, vegetation, ecology and socio-economic interaction.

The RipFor Project focuses on these specific problems in the multifunctional management of riparian forests. Aiming to develop strategies for the improvement of management practices for riparian forests with environmental sound methods. Not for the sake of timber production but directed towards an improved floodplain protection with the goal of sustainability of natural resources.

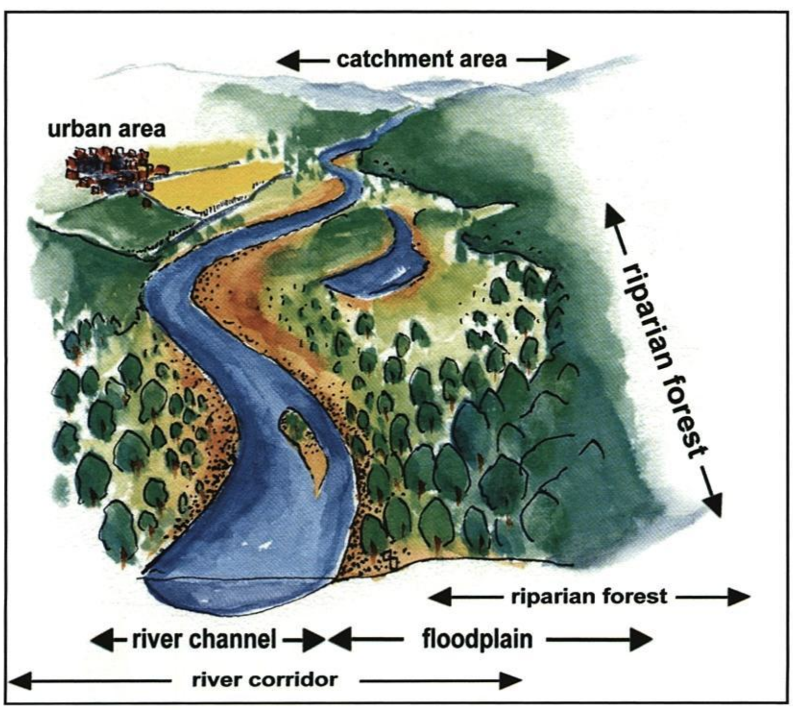


Fig. 1: Definition: River corridor, river channel, floodplain, riparian forest

2.1 Tasks and objectives

2.1.1 WHAT is a riparian forest?

Riparian forest forms an essential part of each riparian area, which is a 3-dimensional zone of interaction that includes the terrestrial and aquatic ecosystem. It extends from the vegetation's canopy down into groundwater, outwards across the floodplain, up the near slopes that drain to the water, laterally into the terrestrial ecosystem, and along the watercourse at a variable width.

Riparian forests are defined as those areas that are inundated or saturated by surface or groundwater driven by river dynamics (e.g. frequency and duration of flood events). Riparian forest areas support a prevalence of vegetation adapted to life in this typical aquatic-terrestrial transition zone.

The mosaic of grass, shrubs and trees within riparian forests protects areas against flood hazards by damping peaks and speed of progressing flood waves, regulates erosion and sedimentation, improves water quality and forms habitats for animals and plants. Furthermore, it contributes to an efficient biochemical degradation of pollutants and promotes the health of river systems and consequently socio-economic benefits.

In this way it acts as a self-regenerating natural resource. Recreation still relies on these non market values and their aesthetics as parameters of the quality of life.

Within the guidelines, special attention is given to the river corridor, which can be defined as the river channel together with its associated floodplains and the adjacent riparian ecosystem. Strong interactions between morphology, ecology and hydraulic processes occur in this area and determine the function of the entire riparian system.

2.1.2 WHAT are riparian forest management guidelines?

The guidelines are a menu of decision-support tools for the management of riparian areas depending on their function. The support is directed to potential end-users such as, landowners, resource managers, foresters, engineers, agencies, organisations and public officials. The guidelines balance social, economic and environmental objectives for riparian forest resources.

They give support in defining project-specific problems and present practicable methods for evaluation of the actual situation as well as future scenarios or objectives. The focus of the guidelines lies on selected components of a healthy riparian forest ecosystem (Figure 2).

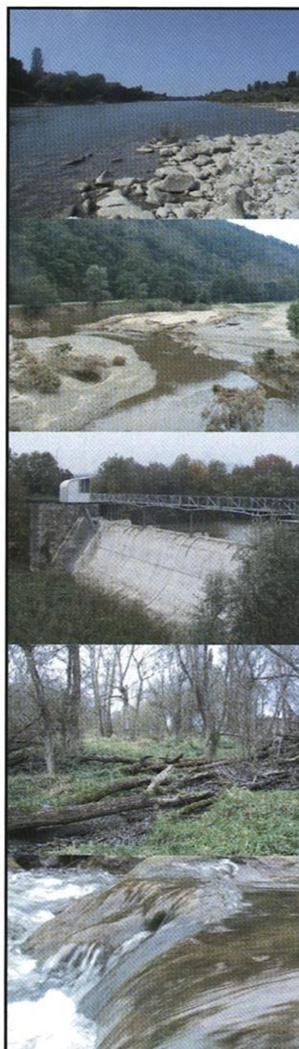
2.1.3 WHY have the guidelines been developed?

Within the European Water Framework Directive, these guidelines have been designed as a step towards more flood protection and safety as well as an enhancement of the ecological status of European rivers and riparian corridors. They are in line with concern about river corridors, their continuity and the need for river restoration.

In addition the guidelines supply basic information to raise more public awareness to the importance of sustainable riparian forest management.

2.1.4 WHO developed the guidelines?

The RipFor group is an interdisciplinary team of European scientists within the FP5 (EU frame programme 5) framework. The most riparian forest relevant fields of hydraulic, morphology, vegetation science and ecology were covered in an integrated way. The group consists of four universities (Berlin, Karlsruhe, Trento and Vienna), one environmental agency (APPA), one assistant contractor (Federal Ministry of Agriculture and Forestry, Austria) and



- River bed and floodplain geomorphology
- Flood dynamics, erosion and sedimentation
- Integrated water work constructions
- Succession of vegetation and soils
- Water quality
- Wildlife habitat
- Cultural resources
- Revaluation of landscape-scenery

Fig. 2: Objectives of the guidelines

are additionally supported by subcontractors from a local water authority (GWD Breisach) and a riparian forest environmental agency (WWF Aueninstitut).

For specific research, four field sites and two laboratory facilities were chosen to improve knowledge about hydraulic, sedimentary and ecological problems within riparian forests. In such way, different scales and regions in various climatic and ecological zones and with different aspects of function are considered. Drafting the proposed guidelines was carried out during the semiannual project meetings and by meetings of subgroups of project participants. End-users were involved during the development of the guidelines. The resulting draft was discussed and approved during the final RipFor congress in February 2003.

2.1.5 WHAT is specific with these guidelines?

These guidelines focus on hydraulic, sedimentary and ecological problems of multifunctional riparian forest management. They are not related to timber production in the first place but to a management serving flood protection, sedimentary and erosion prevention and the buffer function of riparian areas. The management comprises ecological self-regulation as far as possible. Socio-economic improvements, such as flood damage prevention or origination of recreational areas within the catchment basin are intended by their implementation.

The guidelines were edited with maximum respect to a universal applicability to different scenarios and types of riparian areas. Nevertheless, it has to be kept in mind, that natural processes and dynamics in this ecozone underlie long-term temporal and spatial changes and therefore require long-term monitoring and practical experience.

Furthermore, the RipFor research had to focus on some of the relevant processes within riparian forests and could not cover all of them. Groundwater dynamics for example were only considered marginally, whereas best attention was given to surface and open channel flows.

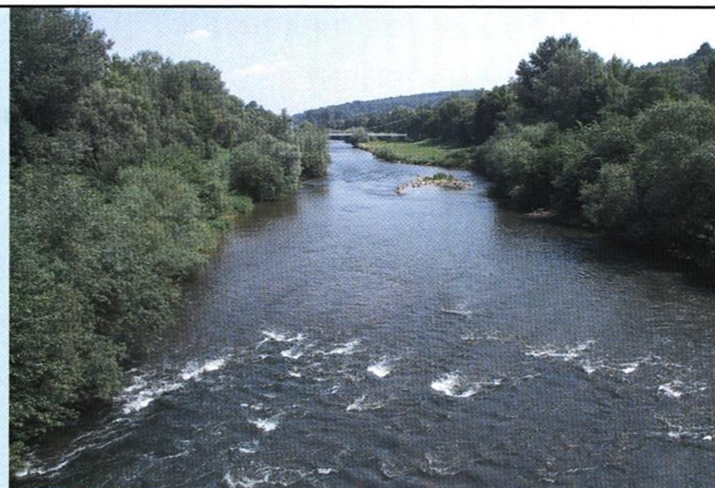
These aspects, formulae, methods and research studies have to be considered with regard to their boundary conditions and limitations.

2.1.6 WHY do we show case studies?

Case studies help to explain the theoretical Riparian Management Concept and make it much more comprehensible for end-users. The examples are taken from the four test sites of the project, located at different rivers in Europe and demonstrate how variable management objectives and strategic planning and measures are. Thus, some of the guideline chapters are accompanied by more than one case study to account for the diversity of riparian forest management practice.

Fig. 3: Test site Enz (Germany)

Location: Southwest Germany, city of Pforzheim
Scenario: Floodplain and morphological restoration in urban area (completed)
RipFor relation: Data analysis of hydraulic, sediment and vegetation interactions, experiences and recommendations for realisation



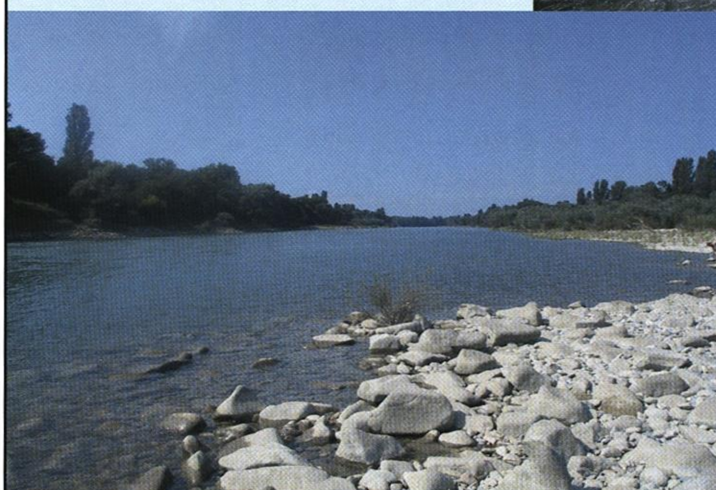


Fig. 4: Test site Upper Rhein (Germany)

Location: Southwest Germany, near Freiburg
Scenario: Riparian forest restoration (planned)
RipFor relation: Hydraulic, sedimentary and ecological field measurements and data analysis

Fig. 5: Test Site Wien river - test flume (Austria)

Location: City of Vienna
Scenario: Test flume for soil bioengineering river revaluation in urban area (planned)
RipFor relation: Hydraulic impact of the vegetation in different stages of succession by measuring the flow velocities, data analysis

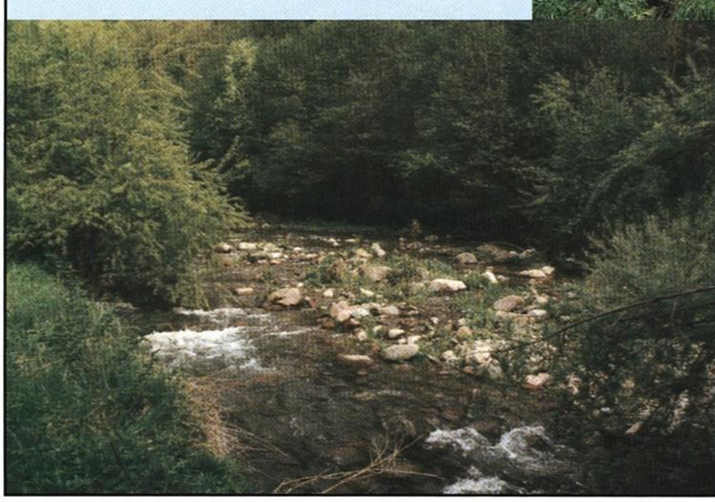


Fig. 6: Test site Fersina (Italy)

Location: Northern Italy, near Trento
Scenario: Ecological monitoring
RipFor relation: Ecological field measurements and data analysis

3. Methodology of riparian forest management

A forested buffer zone is one of the most desirable management alternatives for riparian areas where trees historically occurred. Buffer zones provide important self-purification potential for river systems. Trees help to stabilize banks and provide shade and woody debris for the stream and prime habitat for many species of wildlife. Beyond timber or other forest products could be an economic incentive.

Figure 7 shows the process of riparian forest management. The different sections (project definition, actual situation, objectives, analysis of deficiency, strategies, measures, analysis of impact, realisation, monitoring and evaluation) are not isolated, they complete one another. Therefore, the following subchapters describe in detail each of the necessary steps to apply the methodology of riparian forest management with suitable management techniques.

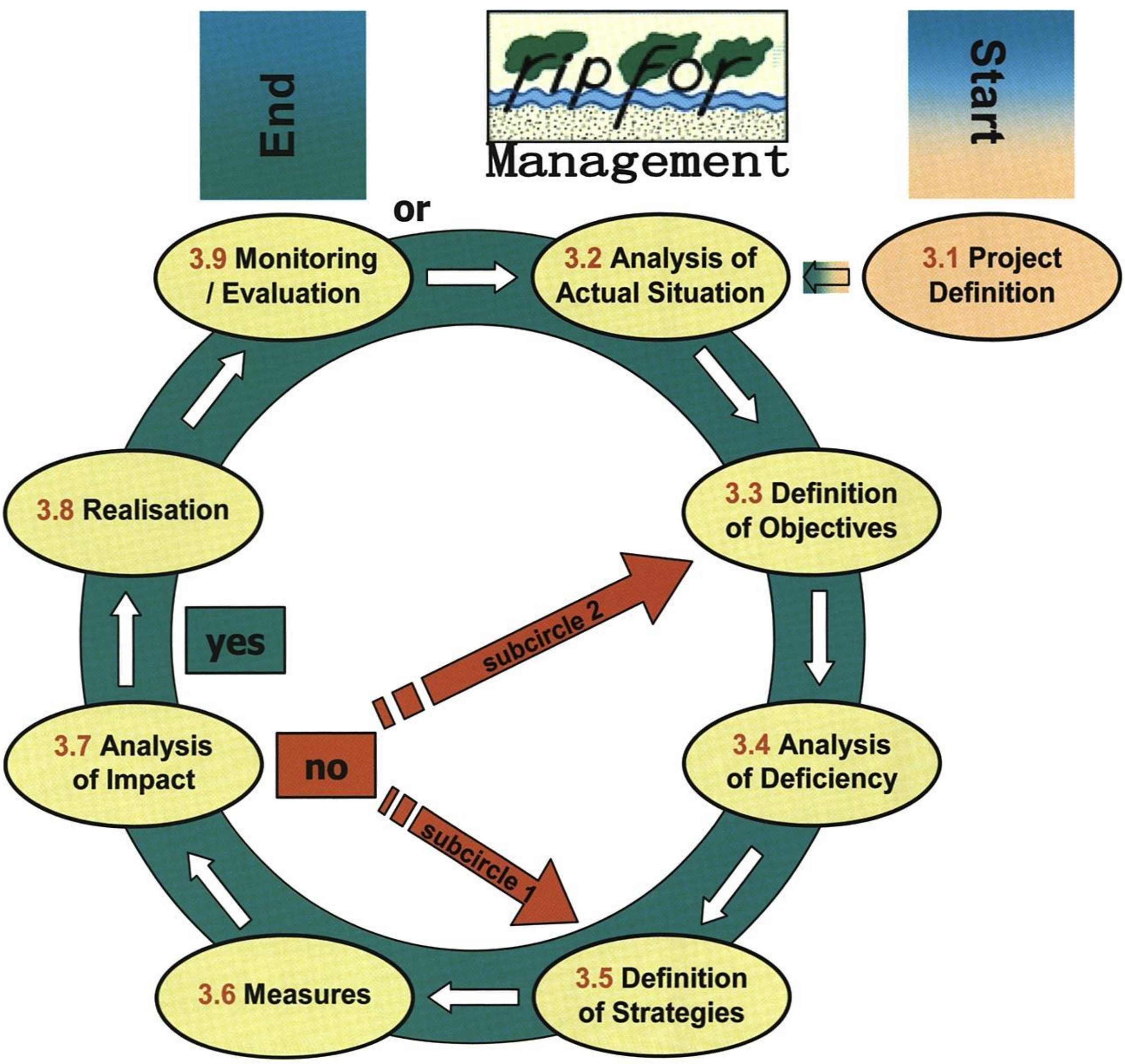


Fig. 7: Methodology of Riparian Forest Management

3.1 Project definition

The enhancement of the quality of life is the ultimate ambition of the proposed Riparian Forest Management. En route, a variety of demands asked by the human society as well as nature wildlife and environment have to be taken into account and balanced. Taking a closer look at these demands, the three basic aspects safety, ecology and use/function can be differentiated. The scientific disciplines involved in Riparian Forest Management include hydrology & hydraulics, morphodynamic, vegetation science, specific ecological science and socio-economy.

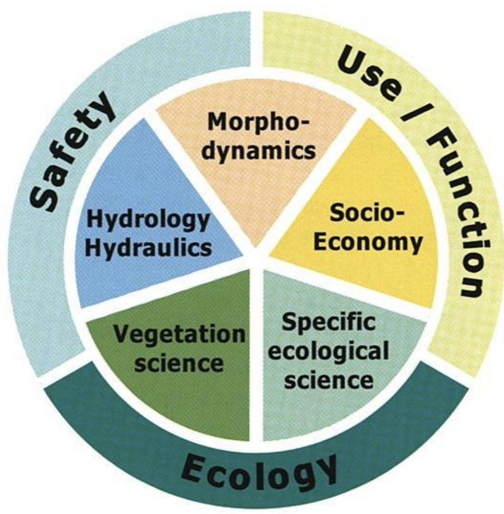


Fig. 8: Quality of Life

According to these central aspects, the end-user should be able to value his objectives and carry out feasibility studies before starting into a riparian management. This may help finding a structure of demands, from primary goals down to restrictive boundary conditions and simplify some steps of the following chapters to reach an efficient management concept.

Fig. 9: Safety - essentially flood protection

Fig. 10: Safety / Ecology - soil-bioengineering structure for bank protection and diversity of habitats

Fig. 11: Use / Function - management of floodplains

Figure 12 & 13 (next page)

Fig. 12: Enz - project definition

Fig. 13: Upper Rhine - project definition

Case Study

3.1 Project definition

Enz:

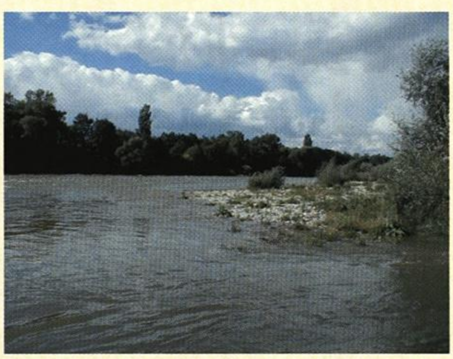
The river Enz was straightened and canalized into a double-trapezoidal cross section after a flood event in 1896. The channel was constructed on a grand scale to guarantee flood safety for the city of Pforzheim and a maximum discharge of 900 m³/s. The designed channel capacity proved to be higher than necessary: only the flood of 417 m³/s occurred since the establishment of a gauging station in 1933. This potential lead to the start of a restoration project of 1500 m length of both, river channel and river corridor within the urbanized area in 1990.

The primary objectives were increase of ecological quality as well as the use/function as a recreational area for the inhabitants of Pforzheim. On the other hand, restrictive safety aspects like flood protection against a 200 year event and maintenance of the existent levees had to be considered. Therefore, hydraulic engineers, geomorphologists, landscape architects and ecologists were involved in the planning of the restoration.

Upper Rhine - The Integrated Rhine Program (IRP):

About 150 years ago, the Upper Rhine still constituted a wild river. In its alluvial zone between Basle and Lautenburg, the river Rhine was running in numerous flat arms that were subject to constant changes, while embracing flood plains which extended over a width of 2-3 km.

The first correction of the Rhine has been carried out between 1817-1880 according to plans drawn up by Johann Gottfried Tulla. For this purpose, numerous branches were combined to form one main bed. The wide meanders were being interrupted and broken through. The length of the stretch of the Rhine between Basle and Worms was reduced from 354 km to 273 km and the floods were only able to spread across an area which was almost 1 km to 2 km wide. This also meant the loss of important habitats for fauna and flora. Max Honsell continued Tulla´s work by putting up groins, which narrowed the flow of the river along the banks of the Rhine. He diminished the cross-section of the Rhine, while concentrating the water in the river bed. The correction of the Upper Rhine resulted in a major loss of flood areas and the reduction in the frequency of the occurrence of floods impacting on the adjacent areas. After the First World War the systematic development of the Upper Rhine started. This was caused by the treaty of Versailles. In article 358 France was conferred the right to divert water from the Upper Rhine and to produce energy by making use of the hydroelectric power of the water. Between 1928-1977, the Rhine Side Channel and a total number of 10 barrages were constructed within the framework of three expansion stages.



Due to the systematic development of the Upper Rhine, a floodplain area of almost 130 km² and thus important habitats were lost. Another consequence was that the danger of floods downstream from Iffezheim had mounted considerably. Today floodwaves are distinctly higher than in the past. In addition to that the flood waves of the Rhine are meeting with those of its tributaries such as Neckar and the Main, since the river course of the Rhine has been straightened and shortened. The total damage resulting from a flood with a returning period of 200 years in the Upper Rhine Plain between Iffezheim and Bingen is estimated to an amount of more than 6 billion Euro. Moreover, risk for human life is to be expected, too.

The International Flood study Commission of the River Rhine (which was established in 1968) conducted a study on the impact of the systematic development of the Upper Rhine. The findings of the Commission emphasized the necessity for restoring the level of safety against floods that existed prior to the systematic development of the Upper Rhine. In 1996 this lead to the adaptation of the framework concept for the implementation of the Integrated Rhine Programme by the State Government of Baden-Württemberg. The reactivation of the former floodplains at the Upper Rhine for flood control purposes and the development of flood plains close to nature are the main goals of the Integrated Rhine Programme (IRP). The IRP proposes the creation of flood retention areas in the former flood plain in 13 locations on the Baden-Württemberg side of the Rhine. According to the present framework conception for the IRP, this would require a retention volume of about 170 Million m³ on the Baden-Württemberg side of the Rhine. The objectives should be reached by 4 different measures: the construction of polders, dike relocation, the use of weirs and the emergency operation of the power stations on the Rhine.

3.2 Analysis of actual situation

3.2.1 General characterisation

The first step has to be the definition and differentiation of the areal extensions of the project. The most important areal definitions that have to be consistent for the project are:

Catchment area is the area that supplies the project area with water (river, rainfall or groundwater), river sediments and provides ecological migration of flora and fauna from upstream of the project area.

The **Project area** is in the focus of the riparian forest management circle. Actual situation and future scenarios are referring to the project area. The areal extensions can vary significantly for different projects, from reach scale to catchment scale extensions.

Test sites are needed to characterise the project area by local measurements, field studies and exemplary calculations. Test sites should be chosen carefully to be representative for the project area, but have not necessarily be located inside the project area.

The case studies shows the differentiation between catchment, project area and test site. The general characterisation is based upon the European Water Framework Directive (EWFD).

ripFor Case Study

3.2.1 General characterisation - map:

Enz restoration:

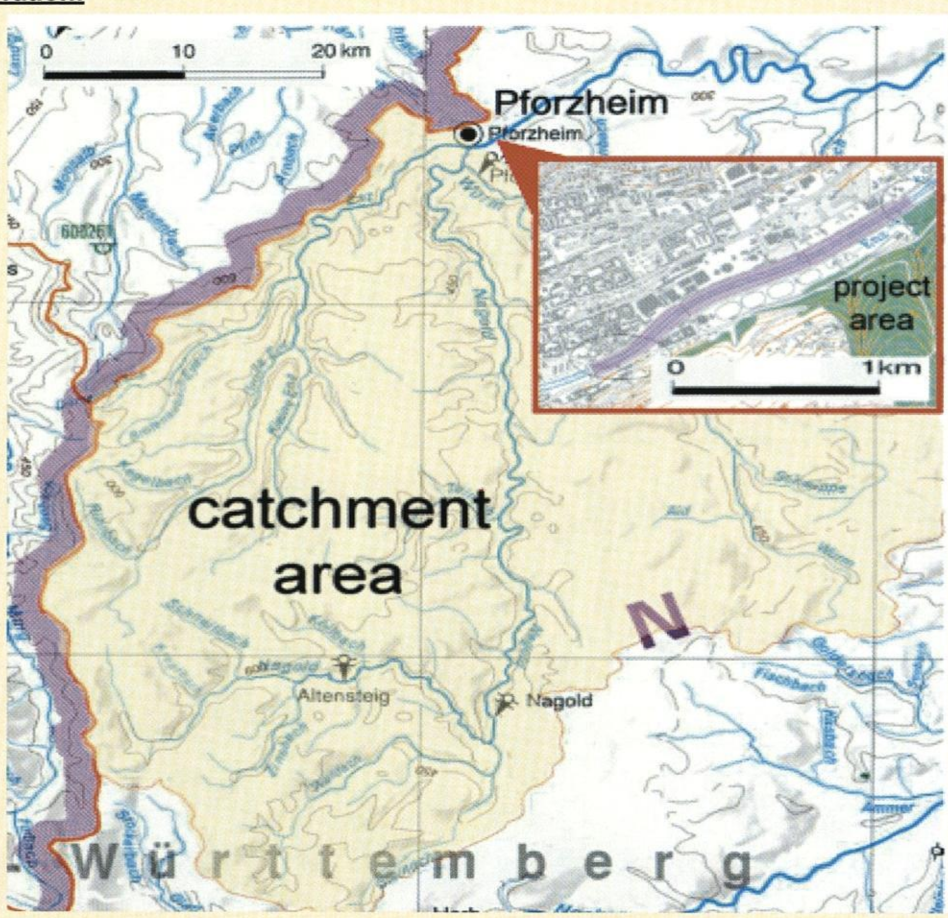


Fig. 14: Catchment area (yellow) and project area (in red frame = test site) of river Enz

Case Study

3.2.1 General characterisation - map:

Upper Rhine:

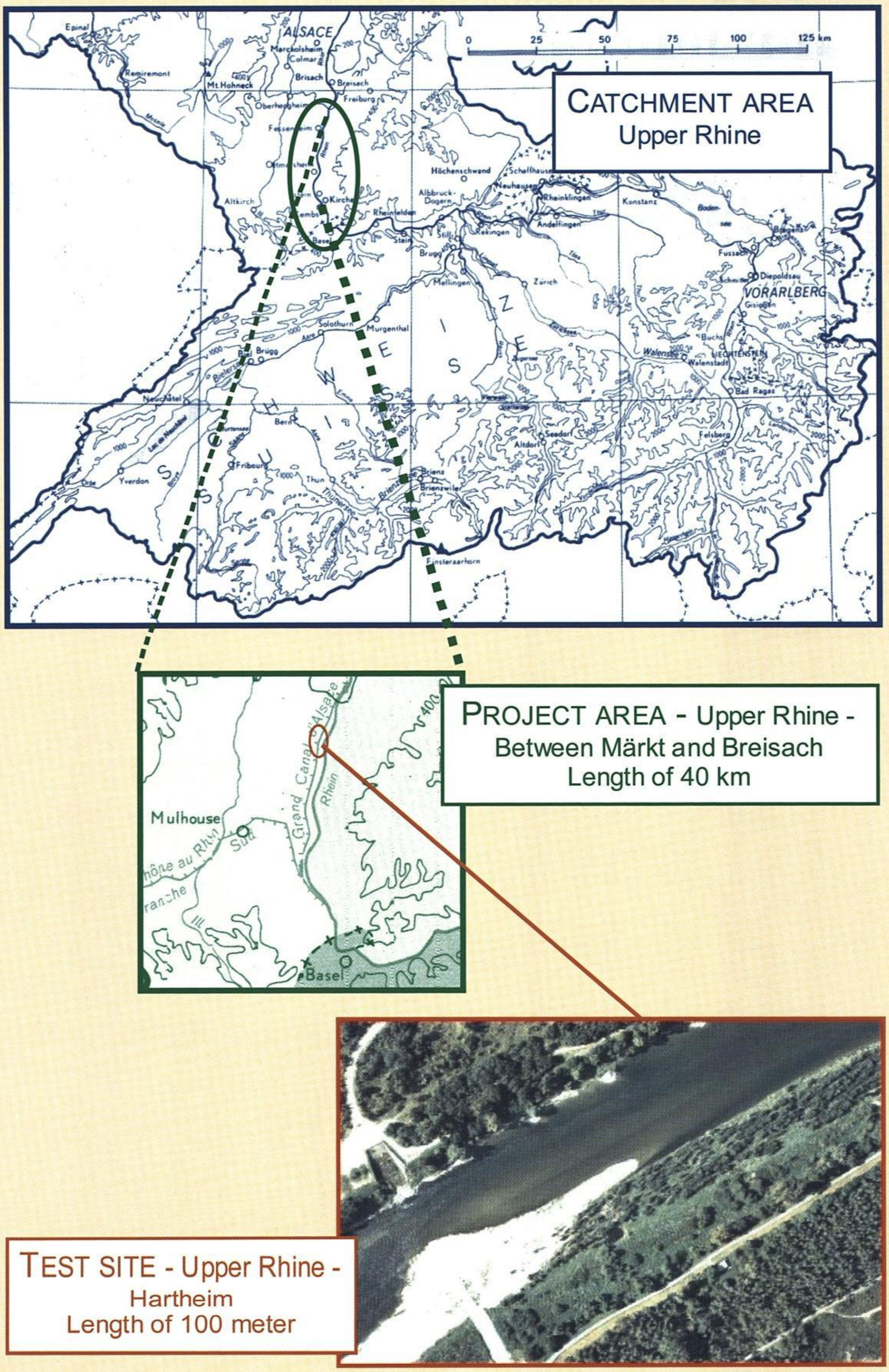
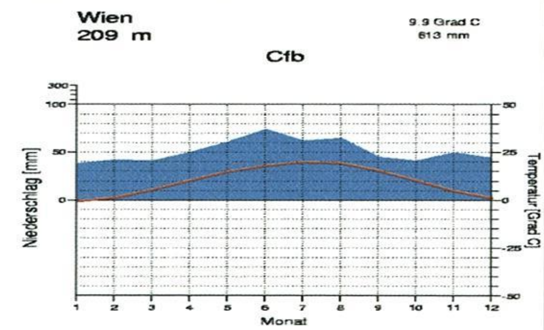


Fig. 15: Catchment area, project area and test site of Upper Rhine

3.2.1.1 Catchment area

Table 1: Description of catchment area (see Annex)

Description of catchment area		
River name		
Stream km		
Source level	Altidudinal typology	Lowland:<200 m
		Mid: 200-800 m
		High: >800 m
	Geographical region	
Catchment area	Small: 10 - 100 km^2	
	Medium: 100 - 1000 km^2	
	Large: 1000 - 10000 km^2	
	Very large: >10000 km^2	
River length	Upstream of project area	
Climate of catchment area		
		
Dominant geology of catchment area	Basement	
	Sedimentary	Siliceous
		Calcareous
		Organic

3.2.1.2 Project area

Table 2: Description of project area (see Annex)

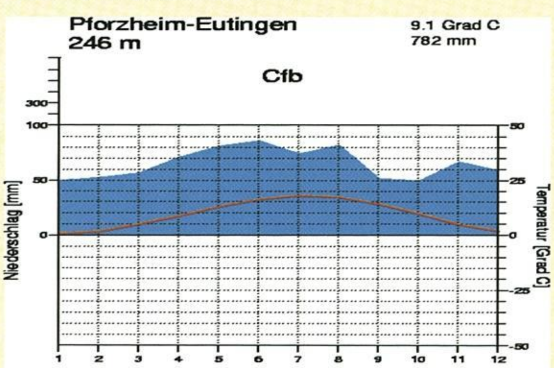
Description of project area		
1. General description		
Name		
Location	Country / Region / Community	
Project area	Extension stream km	
	Area	
	Length / Width	
	Elevation	
2. Hydrology / Geomorphology		
Hydrology	Discharge statistics	NNQ / MMQ
		MQ
		MHQ / HHQ
	Discharge regime	
Geo-morphology	Geology	
	Relief	
	River course / Valley contour	
3. Ecology		
Ecoregion	According to EWFD	
Biocenotical type / Fish zone		
Vegetation	Altitudinal characterisation	
Wildlife protection area		
Land use / Function (Valley floor)		
Water quality	Water quality map	
4. Historical development		
River channel	Description	
River corridor		
Floodplain		

Case Study

3.2.1.1 Catchment area

Enz:

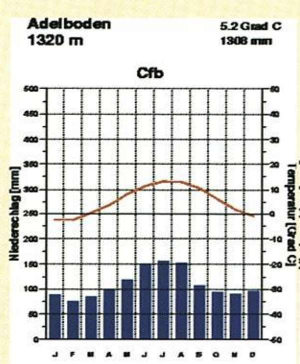
- River name: Enz
- Stream km: 56,55 km
- Source level: 820 m a.s.l
- Catchment area: 1.479 km^2
- River length: 108 km
- Climate of catchment area:

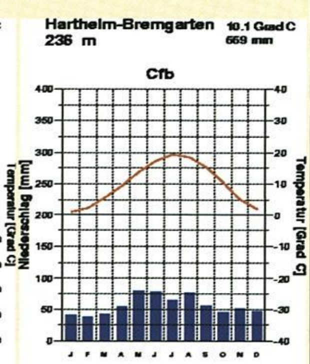


- Dominant geology:
  - Basement: Sandstone (Nordschwarzwald) / shell limestone (Kraichgau)
  - Sedimentary: Siliceous (bowlder)

Upper Rhine:

- River name: Alpine-High-Upper Rhine
- Stream km: 186,2 km at Rheinweiler
- Source level: 4.275 m a.s.l. Aare catchment
- Catchment area: 36.649 km^2 incl. Aare
- River length: 432 km
- Climate of catchment area:





- Dominant geology:
  - Basement: Granite, gneiss (vosges, black forest)
  - Sedimentary: "Flysch, Molasse", lime, schist, sandstone

RipFor Case Study

3.2.1.2 Project area

Enz - Project area:

1. General description
   - o River name: Enz
   - o Location: Germany / Baden-Wuerttemberg / Pforzheim
   - o Project area:
     - Extension stream km: 56,5 - 58,0 km
     - Area: ~ 75.000 m²
     - Length / Width: ~ 1.500 m / 50 m
     - Elevation: ~ 240 m a.s.l
2. Hydrology & Geomorphology
   - o Hydrology:
     - NNQ / MNQ: 2,33 / 5,41 m³/s
     - MQ: 17,4 m³/s
     - MHQ / HQ: 175 / 532 m³/s
   - o Geomorphology:
     - Geology: sandstone / limestone
     - Relief: cuestas
     - River course / Valley contour: Linear / Kastental
3. Ecology
   - o Ecoregion: Central Highlands
   - o Biocenotical type / Fishzone: Hyporithral / Grayling zone
   - o Vegetation: Collin
   - o Wildlife protection area: No
   - o Land use / Function: Recreational, urban area
   - o Water quality: (class II) moderately affected (LAWA Index) moderate (FFI Index)
4. Historical development:
   - o River channel: Canalised in 1902-1907, double trapezoidal cross section, armoured banks
   - o River corridor: River-parallel levees since 1902
   - o Floodplain: Retired, grass cover since 1902

Fig. 16: Enz - project area

Upper Rhine - Project area:

1. General description
   - o River name: Upper Rhine
   - o Location: Germany / Baden-Wuerttemberg / Märkt till Breisach
   - o Project area:
     - Extension stream km: 176,0 - 217,0 km
     - Area: ~ 4.000.000 m²
     - Length / Width: ~ 43 km / 70 to 400 m
     - Elevation: ~ 217 m a.s.l
2. Hydrology & Geomorphology
   - o Hydrology:
     Gauging station: Rheinweiler 186,178 km (parallel to the Grand Canal d'Alsac at the original course of the river Rhine)
     - NNQ / MNQ: data not available
     - MQ: 30 m³/s
     - MHQ / HQ: 1.150 / 2.600 m³/s

     Gauging station: Rheinfelden 148,300 km (upstream of the Grand Canal d'Alsac)
     - NNQ / MNQ: 315 / 472 m³/s
     - MQ: 1.030 m³/s
     - MHQ / HQ: 2.750 / 4.270 m³/s
   - o Geomorphology:
     - Geology: Granite, gneiss (vosges, black forest); „Flysch, Molasse", lime, schist, sandstone (Alps)
     - Relief: Plane (Upper Rhine Valley)
     - River course / Valley contour: A former braided river system; linear, trapezoidal cross section
3. Ecology
   - o Ecoregion: Alps / Central low mountain range
   - o Biocenotical type / Fishzone: data not available
   - o Vegetation: willows/ Floodplain forest
   - o Wildlife protection area: Partially protected
   - o Land use / Function: Recreational area, gravel industry
   - o Water quality: (class II) moderately affected (LAWA Index) moderate (FFI Index)
4. Historical development:
   - o River channel: Canalized, incised river bed
   - o River corridor: Weir, groynes
   - o Floodplain: Armoured banks, groynes substantial loss of floodplains, mixture of grass, herbs and floodplain forest

The general description of the test sites is given implicit with the project area. Thus, no extra tables for test sites are required here. Further studies or local measurements carried out at the test sites will be included in the following chapters.

3.2.2 Problem orientated characterisation of project area

The characterisation of typical hydraulic, sedimentological, ecological and socio-economical properties of the project area is the basis for further measures and strategies. Some of these properties can only be surveyed by direct field measurements at the test sites, while others can be estimated or calculated by applying theoretical considerations. This does not mean, that every determinable parameter has to be determined. Only the most significant ones for the end-user's specific situation as well as methods for their determination should be sorted out. Considerations of financial or technical limitations as well as the predefined problem orientation (see 3.1) have to be included.

3.2.2.1 Data recherche

It is obligatory to analyse the available information before putting any efforts on acquisition of new data. Generally a data recherche should provide information on historical and baseline conditions of stream corridor structure and functions, as well as the social, cultural, and economic conditions of the river corridor and the larger watershed. In many cases data is available and documented at local authorities, educational institutions and consultants.

ripFor Case Study

3.2.2 Problem orientated characterisation of project area

Upper Rhine:

The correction and regulation of the Upper Rhine has caused a dramatic intensification of flood risks for the area between Iffezheim and Worms due to shortening of the river course and the loss of floodplains. In order to guarantee the protection for a 200 year flood event (Q > 5000 m³/s) it is necessary to create new flood retention areas at the Upper Rhine. For this purpose a total retention volume of 167 Million m³ is required. Hence 25 Million m³ account for the project area between the communities of Märkt and Breisach, which is located upstream of Iffezheim and at the southwest of the city of Freiburg.

The measure encompasses the excavation of former floodplains which are spared by floods due to the incision of the Rhine by several meters after the beginning of the Tulla Rhine correction in 1828. At the same time ecological aspects have to be considered within the planned measures by recreating and developing riparian forests and typical flood plain habitats for fauna and flora at the excavated areas.

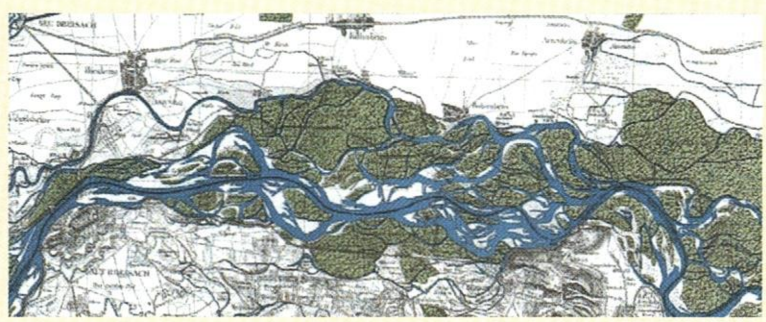


Fig. 17: Typographical map Upper Rhine, 1828: furcating Upper Rhine; situation before Tulla'sche correction

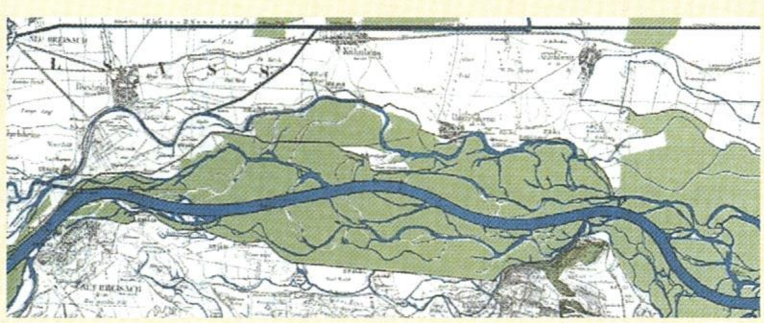


Fig. 18: Typographical map Upper Rhine, 1872: situation after Tulla'sche correction

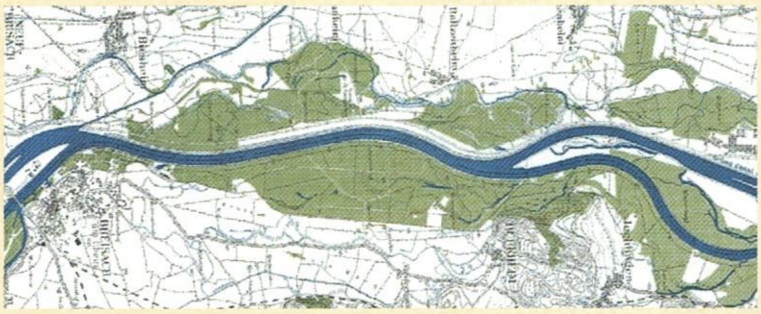


Fig. 19: Typographical map Upper Rhine, 1963: situation after regulation and canalisation

Hence the superior objective is the linkage between flood protection and the design and development of riparian forests at the future retention areas.

The implementation of those time and cost intensive measures demands a detailed investigation of the project area. Suitable and available areas have to be prospected.

As a basic principle it has to be examined under the use of models and field surveys if the planned excavation will effect the desired results. The analysis of the spatial and temporal dynamic and interaction of flood discharge, stream velocity, sediment transport, vegetation and morphology is an essential part of the investigation.

In this regard riparian forests and their different stages of succession play an important role by their impact on flood discharge and sediment transport. The vegetation is of special importance for the discharge of flood events since it forms an obstacle for the water body. This may result in a deceleration of the flood wave by decrease of stream velocity but as well in an increase of the local water level. With respect to hydraulics and sedimentation it is of particular interest what are the differences between young flexible and old rigid trees and in which way different stages of succession affect the flood wave.

Another scope of duties is the investigation of accumulation and erosion and the geomorphological stability of the floodplain. On the one hand it is primarily desired that fine material will be accumulated at the excavated areas but in the long-term perspective the siltation should be avoided. Thus the analysis of sedimentation and erosion and its dependency from flow velocity, distribution of vegetation and the magnitude and duration of flood events is necessary. The development and adaptation of a typical fauna and flora of riparian areas and the evolution of habitat structures has to be provided. If is mainly a result of the variation in frequency, duration and magnitude of flood events .

For the detailed investigation of the micro- and meso-scale interaction between flow velocity, vegetation, sediment transport and the development of riparian forests a monitoring system was implemented at the Upper Rhine by the Freie Universität Berlin. The continuous measurements of different parameters like flow velocity, sedimentation and erosion, the development of vegetation before, during and after flood events gives the opportunity to analyse the abiotic and biotic boundary conditions of riparian forests and allows the description and analysis of changes under consideration of riparian forest management.

Fig. 20: Upper Rhine: interaction between vegetation and sediment transport

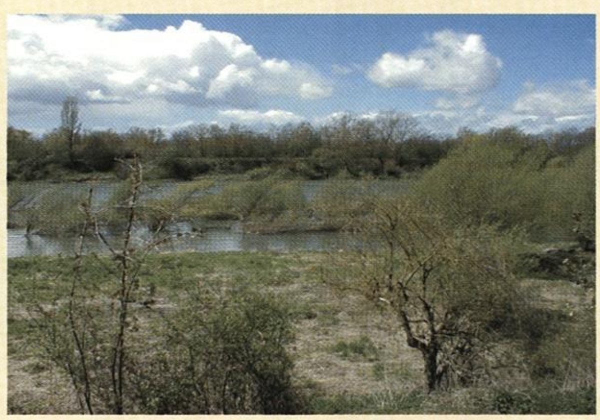


Fig. 21: Flood event at the Upper Rhine: interaction between water and vegetation

3.2.2.2 Methods

The methods are the core of the RipFor-Guidelines. They provide a state-of-the-art collection of practicable measurement techniques, tools and theoretical approaches that are necessary to evaluate both the actual situation of test sites as well as future scenarios or objectives.

To give a clear overview the methods are structured in tables (see below). Each method is characterised by:

- Goal (relevance of results)
- Application area (river and/or floodplain)
- Scale (test site, project area, catchment area)
- Connection (basic discipline)
- Application (stage of project)

This classification should enable end-users to filter the huge amount of parameters and sort out the ones, that are useful for their individual situation and with regard to the existing boundary conditions (e.g. financial budget or technical limitations).

How to use the following tables:

1. Output-parameters
2. Scale and area
3. Potential methods
4. Annex: exact description of each method
5. Selection of the method (time effort, available technical equipment, financial management)

The tables can contain only some basic information's (see above) simply because details and explanations would go beyond the scope of the Guidelines. Therefore, an Annex was attached to the Guidelines.

For most methods, the annex includes characterisation of the input-output parameters (e.g. method "GMS universal flow formula" needs geometry and hydraulic roughness to get discharge and flow velocities). Furthermore, a short description of the method and its limitations, expenses, practicability and further literature is given.

<u>Description - table of methods:</u>

Step 1: Goal (output-parameters of methods)

Step 2: Area and scale

Step 3: Potential methods

Step 4: Annex (description of each methods and further references)

Step 5: Selection of usable methods

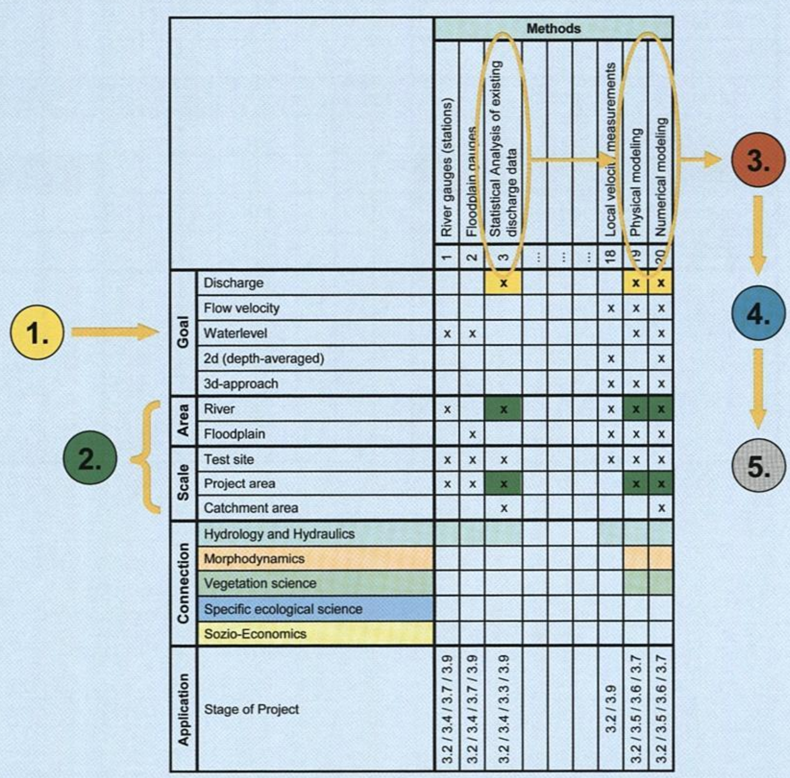


Fig. 22: Help for the selection of methods

Table 3: Table of Methods „Hydrology & Hydraulics“

	hydrological & hydraulic data	River gauges (stations)	Floodplain gauges	Statistical Analysis of existing discharge data	Basic hydraulic formula	GMS universal flow formula	Colebrook-White universal flow formula	Könemann compound channel formula	Einstein/Horton compound roughness formula	Lindner (DVWK) flow formula for rigid vegetation	Mertens (DVWK) vegetated trapezoidal channel formula	Pasche (DVWK) vegetated compound channel formula	Nuding vegetated compound channel formula	Roughness of aquatic vegetation	Formula for aquatic (submerged) vegetation	Bed roughness formula (logarithmic law)	Flow attack (momentum equation)	Woody debris mapping/levelling	Local velocity measurements	Physical modeling	Numerical modeling
	Methods	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Goal	Discharge	x	x	x	x															x	x
	Flow velocity				x	x	x	x	x	x	x	x	x	x	x	x			x	x	x
	Waterlevel	x	x		x													x		x	x
	Bed roughness															x				x	x
	Bed stability																x			x	x
	Roughness of macrostructures					(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)							x	x
	Roughness of vegetion									x	x	x	x	x	x					x	x
	1d (depth- and width-averaged)	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x		x
	2d (depth-averaged)				x						x	x	x						x		x
	3d-approach				x											x	x		x	x	x
Area	River	x		x	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x
	Floodplain		x		x	(x)	(x)	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scale	Test site	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Project area	x	x	x														x		x	x
	Catchment area			x																	x
Connection	Hydrology and Hydraulics																				
	Morphodynamics																				
	Vegetation science																				
	Specific ecological science																				
	Socio-Economics																				
Application	Stage of Project	3.2 / 3.4 / 3.7 / 3.9	3.2 / 3.4 / 3.7 / 3.9	3.2 / 3.4 / 3.3 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.9	3.2 / 3.9	3.2 / 3.5 / 3.6 / 3.7	3.2 / 3.5 / 3.6 / 3.7

Table 4: Table of Methods „Morphodynamics“

morpho-logical data

Methods (1–13)

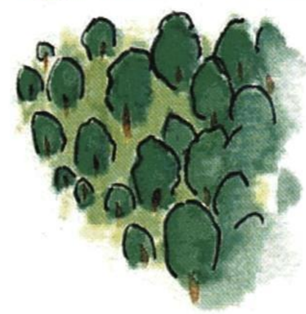
		1 Equivalent sand-roughness formulae	2 Bed resistance formulae (incipient motion)	3 MPM sediment transport formula	4 Suspended load formula	5 Local bedload sampling	6 Local bedload measurements	7 Local suspended load sampling	8 Local suspended load measurements	9 Sieve analysis (grain size distribution)	10 Multifrequent echo sounding	11 Side scanning radar	12 Geochronology	13 Soil survey by USDA, FAO, KA 4
Goal	Bed material					x	x		x	x	x		x	x
Goal	River geometry										x	x		
Goal	Floodplain geometry										(x)	(x)		
Goal	Area floodplain (active / former)												(x)	
Goal	Bed roughness	x				x	x	x	x	x	x	x		x
Goal	Roughness of macrostructures	(x)									x	x		x
Goal	Erosion and sedimentation	x	x	x	x	x	x	x	x	x	x	x	x	x
Goal	Sediment transport	x	x	x	x	x	x	x	x	x	x	x	x	x
Goal	Habitat structures					x				x	x			x
Goal	Historical conditions									x			x	(x)
Goal	Historical geometry												x	
Area	River	x	x	x	x	x	x	x	x	x	x	x	x	
Area	Floodplain	x	x	x	x	x	x	x	x	x	(x)	(x)	x	x
Scale	Test site	x	x	x	x	x	x	x	x	x	x	x	x	x
Scale	Project area	x	x	x	x					x	x	x	x	x
Scale	Catchment area										x		x	
Connection	Hydrology and Hydraulics													
Connection	Morphodynamics													
Connection	Vegetation science													
Connection	Specific ecological science													
Connection	Socio-Economics													
Application	Stage of Project	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.3 / 3.9	3.2 / 3.3 / 3.9

Methods (14–26)

		14 Sounding and Coring	15 Geological maps	16 Photo Electronic Erosion Pin	17 Erosion chains	18 Sediment traps	19 Echo sounding	20 Geodetic survey - actual and historical data	21 Video and photo monitoring / historical data	22 Remote sensing	23 Topographical maps (actual & historical)	24 Thematic maps	25 Geomorphological mapping	26 Geographical Information System GIS
Goal	Bed material	x	x						x	(x)			x	
Goal	River geometry		(x)				x	x		x	x		x	x
Goal	Floodplain geometry		(x)				x	x		x	x		x	x
Goal	Area floodplain (active / former)	(x)	(x)					x	(x)	x	x	x	x	x
Goal	Bed roughness	x	(x)			x	x	x	x	x			x	
Goal	Roughness of macrostructures						x	x	x	x	x		x	x
Goal	Erosion and sedimentation	x	x	x	x	x	x	x	x	x	x	(x)	x	x
Goal	Sediment transport	x	x	x	x	x				x		(x)	x	
Goal	Habitat structures	x	(x)		x	x	x	(x)	x	x	x	x	x	x
Goal	Historical conditions	x	x					(x)	x	x	x	x	x	(x)
Goal	Historical geometry	x	x					x	x	x	x	x	x	x
Area	River	x	x	x		x	x	x	x	x	(x)	x	x	x
Area	Floodplain	x	x	x	x	x	x	x	x	x	x	x	x	x
Scale	Test site	x		x	x	x	x	x	x		x	x	x	
Scale	Project area	x	x				x	x	x	x	x	x	x	x
Scale	Catchment area	x	x				x		x	x	x	x	x	x
Connection	Hydrology and Hydraulics													
Connection	Morphodynamics													
Connection	Vegetation science													
Connection	Specific ecological science													
Connection	Socio-Economics													
Application	Stage of Project	3.2 / 3.9	3.1 / 3.2 / 3.3 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.1 / 3.2 / 3.3 / 3.9	3.2 / 3.3 / 3.9	3.1 / 3.2 / 3.3 / 3.8 / 3.9	3.1 / 3.2 / 3.3 / 3.9	3.1 / 3.2 / 3.3 / 3.9	3.2 / 3.3 / 3.9	3.1 / 3.2 / 3.4 - 3.9

Table 5: Table of Methods „Vegetation science"

vegetation data

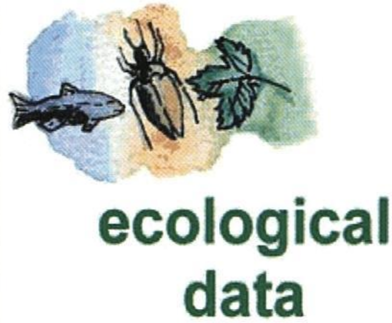


		Methods																	
		Ecological-Structural Methods												Yield Sampling Methods					
		Braun-Blanquet Method	Point-Quadrat-Method	Line-Intercept-Method	Point-Centered-Method	Leaf-Category after Vareschi	Photographic Method	Vegetation Density Profile	Structure Measuring Tube	Light Methods	Aerial View Analysis	Method after DVWK	Complete Vegetation Sampling	Complete Yield Sampling	Harvesting Method	Phytomass Rate Estimation	Point Sampling	Fixed Sample Plot Size	Sampling Plot System
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Goal	Abundance / Frequency / Density	x	x	x	x[4]			x[5]	x		x[7]	x	x	x	x		x	x	x
	Coverage	x	x[1]	x	x		x	x			x		x						
	Vatiety of species	x	x	x		x		x[6]	x		x[7]	x[6]	x	x	x	x	x	x	x
	Crown diameter				x						x[7]		x						
	Leaf-Area-Index - LAI							x[2]		x					x				
	Phytomass / Timber volume												x	x	x	x	x	x	x
	Diameter at breast height				x							x	x	x			x	x	x
	Plant height / Canopy height							x			x[8]	x	x	x	x		x	x	x
	Average plant distance		x[2]		x[2]						x[7]	x	x	x[2]			x[2]	x[2]	x[2]
	Pattern of vegetation	x	x[3]			x		x	x	x	x	x	x						
	Type of vegetation	x	x			x		x[6]	x		x[7]	x[6]	x	x	x	x	x	x	x
Area	River																		
	Floodplain	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scale	Test site	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x
	Project area	x		x	x		x				x	x		x			x	x	x
	Catchment area										x						x	x	x
Layer	Tree layer	x	x[1]	x	x	x				x	x	x	x	x			x	x	x
	Shrub layer	x	x[1]	x	x	x				x	x	x	x						
	Herb layer	x	x	x	x	x	x	x	x	x	x		x		x	x			
Connection	Hydrology and Hydraulics																		
	Morphodynamics																		
	Vegetation science																		
	Specific ecological science																		
	Socio-Economics																		
Application	Stage of Project	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9

Indices:

1 Point-Intercept-Method (see annex)
2 Additional calculation necessary
3 Multi-Cubus-Stratimeter (see annex)
4 Calculation of frequency possible
5 Structureanalysis after Barkman (see Annex)
6 Possible result
7 Applicable for tree layer
8 Stereo aerial photography

Table 6: Table of Methods „Specific ecological science“



		Methods			
		1 FFI (Fluvial Functioning Index)	2 Leaf packs methodology	3 Short term organic matter retention measurements	4 Benthos quantitative sampling
Goal	Quality of ecosystem	x		x	x
	Biodiversity		x		x
	Morphological diversity	x		x	
	Self-equration capacity	x	x	x	x
	Ecological network		x		
	Land planning criteria	x			
	River management	x			
Area	River	x	x	x	x
	Floodplain				
Scale	Test site		x	x	x
	Project area	x		x	
	Catchment area	x			
Connection	Hydrology and Hydraulics				
	Morphodynamics				
	Vegetation science				
	Specific ecological science				
	Socio-Economics				
Application	Stage of Project	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9

Table 7: Table of Methods „Socio-Economic“

	socio-economical data	Methods: 1 Examination, analysis and interpretation of topographical maps	2 Design, analysis and interpretation of thematic maps	3 Remote sensing	4 Geographical Information System	5 Investigation, analysis and interpretation of land use / land use mapping / design and use of land utilisation plans	6 Investigation of landscape framework / conservation plans	7 Investigation, analysis of regional planning targets, plans and current procedures	8 Investigation about legislation / entitlements and contracts / rights of use and enjoyment	9 Investigation/survey of economical and demographical data	10 Cost-benefit analysis local and regional	11 Public opinion poll / survey
Goal	Density of population	(x)	x	(x)	x	(x)		(x)		x		
	Existing and future infrastructure	x	x	x	x	x		x	x			
	Existing/planned technical construction	x	x	x	x	x		x	x			
	Intensity of land use	x	x	x	x	x	x	x	(x)	(x)		x
	Ownership and utilisation	(x)	x	(x)	x	x		x	x			
	Recreation and tourism	(x)	x		x	x		x		x		x
	Economical performance	(x)	x		x			x	(x)	x		(x)
	Economical value and function	x	x		x	x	(x)	x		x	x	(x)
	Nature protection areas	(x)	x	(x)	(x)	x	x	x	(x)			
	Jurisdiction and competence	(x)	x	(x)	x	x	x	x	x			
	Social, political and economical acceptance enforceability of obj.	(x)	(x)		(x)	x	x	x	x	x	x	x
	Identification of potential retention and flooding areas	x	x	x	x	x	x	(x)	(x)			(x)
	Risk / Prevention of flood induced human damages	x	x	x	x	x		x				
	Risks and costs of flood damages / Prevention	x	x	x	x	x		x			x	
	Costs and benefits of measures	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	(x)
Area	River	(x)	x	x	x	x	x	x	x	x	x	x
	Floodplain	x	x	x	x	x	x	x	x	x	x	x
Scale	Test site		x	x	x							x
	Project area	x	x	x	x	x	x	x	x	x	x	x
	Catchment area	x	x	x	x	x	x	x	x	x	x	x
Connection	Hydrology and Hydraulics					(x)		(x)	(x)		(x)	
	Morphodynamics											
	Vegetation science					(x)						
	Specific ecological science											
	Socio-Economics											
Application	Stage of Project	3.1 / 3.2 / 3.3 / 3.5	3.1 / 3.2 / 3.3 / 3.9	3.1 / 3.2 / 3.3 / 3.8 / 3.9	3.1 / 3.2 / 3.4 - 3.9	3.2 - 3.5 / 3.6 / 3.8 / 3.9	3.1 - 3.3 / 3.5 / 3.6 - 3.9	3.1 - 3.3 / 3.5 - 3.9	3.1 - 3.3 / 3.5 - 3.9	3.1 - 3.3 / 3.5 - 3.9	3.1 - 3.3 / 3.5 / 3.6 / 3.8	3.1 - 3.9

Case Study

3.2.2.2 Methods

Wien river - The Soil Bioengineering Test Flume:

Since the plans for revitalising the urban stretch are primarily based on the use of bioengineering methods, a soil bioengineering test flume was constructed to assess the stability of different structures under load and the hydraulic action of the vegetation. Artificial floodings allow to observe the distribution of the flow velocity. Velocity profiles show the difference between the open channel and the vegetated bank. Long-term monitoring of the development of local riparian vegetation allow an assessment of its influence on the discharge capacity .

Local situation:

The soil bioengineering test flume is located directly within the Wien River bed downstream of a sluice of one of the retention basins which were constructed for flood protection of the city of Vienna.

Method:

The investigations focus on the hydraulic impact of the vegetation in different stages of succession by measuring the flow velocities in different parts of the cross-section.

Preliminary work

- The ***construction*** of the test flume began in 1996 with the installation of a sheet pile wall that divides the test channel into two parts which can be flooded separately. It was completed in 1998 with three different soil bioengineering structures (brush mattress, branch layer, fascine layer).
- ***Physical modeling:*** A physical model of the weir was realized in the year 2000 to assess the exact discharge and the outlet coefficient. The discharge is a function of the water level in the retention basin and the opening height of the weir.

During artificial floodings:

- ***Local velocity measurements:*** The flow velocity measurements are done with Acoustic Doppler Velocimeters (ADV) and Acoustic Doppler Profiles (ADP) installed on a measuring bridge.
- ***Local bedload measurements*** (tracer - stones)
- ***River gauges:*** Observation of 15 water tables to get the exact water level along the test flume.

Seasonal work:

- ***Complete vegetation sampling:*** In order to describe the interaction between vegetation and hydraulic parameters it is necessary to characterise the vegetation, to measure relevant parameters and to observe its development over several years.

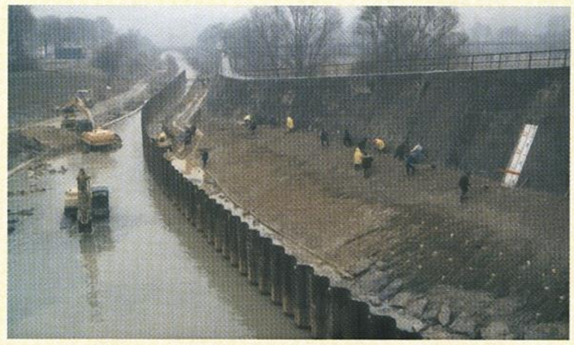


Fig. 23: Construction of the test flume

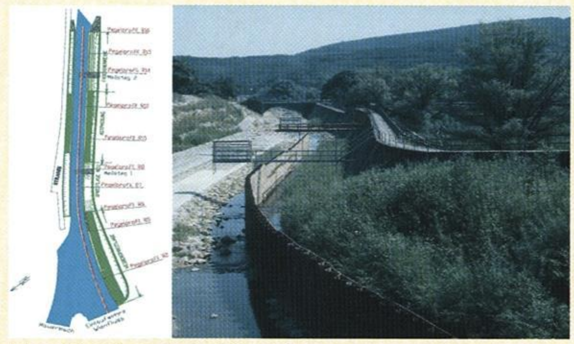


Fig. 24: Completed test flume

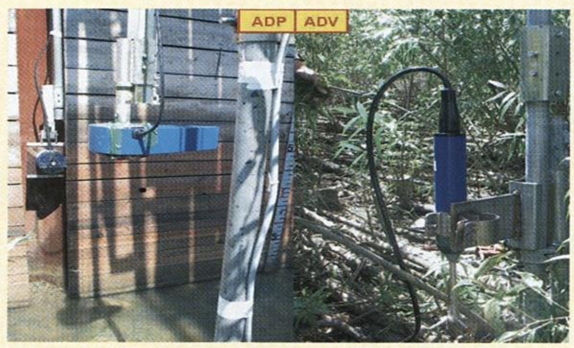


Fig. 25: Flow velocity measurement equipment

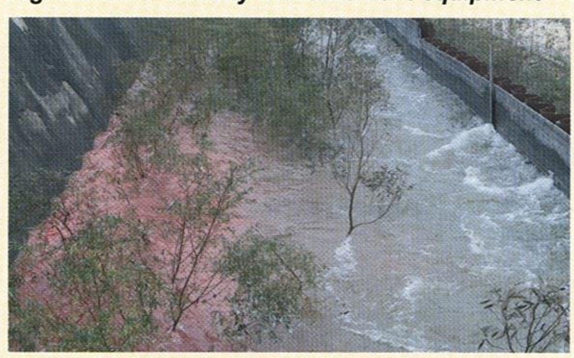


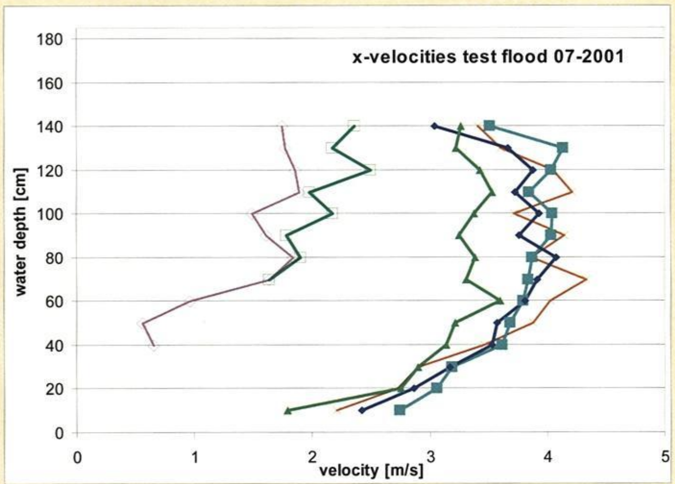
Fig. 26: Artificial flooding in the test flume

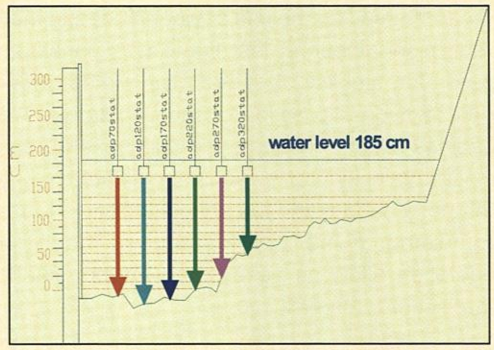
Fig. 27: Complete vegetation sampling

Case Study

Typical results - Wien river:

- *Local velocity measurements:*





Red, cyan, blue and green: mean flow velocities in the open channel (without vegetation)
Dark-green and mangenta: mean flow velocities in the vegetated bank

Fig. 28: Wien river results: flow velocities in different vertical profile of the cross section

- *River gauges:*

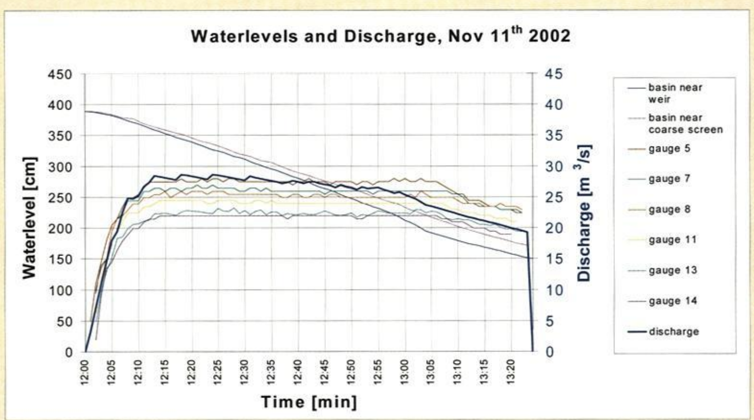


Fig. 29: Wien river results: graph of water levels and discharge during an artificial flooding

- *Complete vegetation sampling:*

Vegetation sampling **Page 1**

Test site: Wien river
Type: Fascine layer
Profile: 15
Date: 01.11.2000
Name: Mayer / Vollsinger

Location		Sprout			Species	Lateral branches / shape of crown
		diameter		length		
x	y	Base	H=100			
2	86	0,29		40,9	S.purpurea	1
9	86	0,613	0,59	120	S.purpurea	1
25	86	2,15	0,96	250	S.purpurea	3 (4)
6,5	94	0,79	0,48	137	S.purpurea	1
8	94	0,99	0,67	153	S.purpurea	2
9	94	1,73		36	S.purpurea	1_V2
34	94	1,79	0,645	131	S.purpurea	2 (2)_V2
19	97	2,1	0,54	140	S.purpurea	2 (2)_V2
90	42	1,55		99	S.purpurea	3_V1
5	152	0,88	0,4	144	S.purpurea	1
...	...	...	...	...	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...

Fig. 30: Wien river results: part of a vegetation sampling form

Case Study

Enz - River restoration:

A ***physical model*** of the river Enz restoration for prediction of flood risk as the primary aspect has been constructed (University of Karlsruhe). In the experiments, the influence of morphological and vegetative restoration on the hydraulics was investigated for different restoration alternatives. Special regard was given to the maintenance of the 200 year flood risk safety (design discharge: HQ =540 m^3/s).

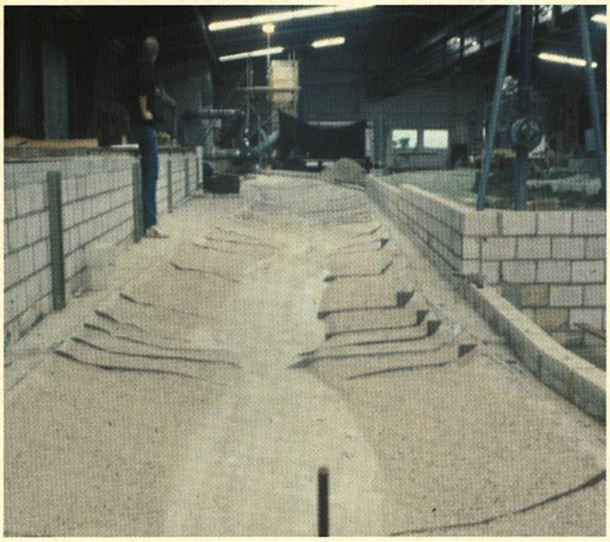


Fig. 31 (left): Physical model of river Enz restoration: phase of construction

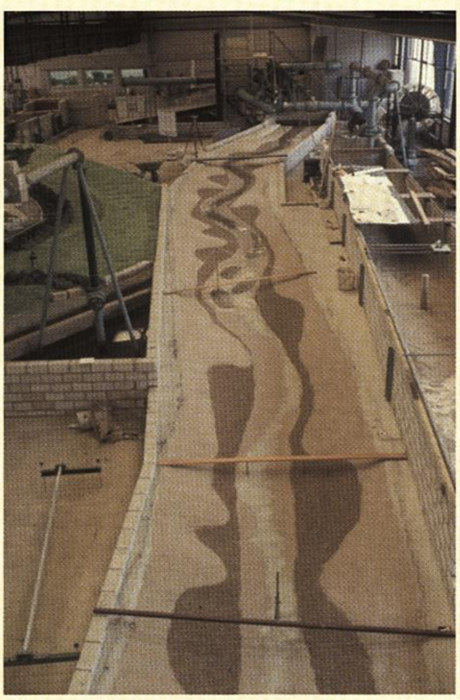
1:40 scale; Theodor-Rehbock-laboratory

Fig. 32 (below left): Physical model of river Enz restoration: before vegetation growth

State after the restoration of morphological structures within river channel and floodplains before the vegetation layer has developed

Fig. 33 (below right): Physical model of river Enz restoration: after full vegetation growth

Stage of the river Enz restoration (future scenario) with fully developed vegetation and morphological structures



Methods *used in the experiments:*

- Mapping of water level by pointer gauges to determine the influence of vegetation on the water level
- Local velocity measurements with propellermeters to determine areas with high/low hydrodynamic forces that cause erosion/sedimentation
- Local bedload and suspended load measurements by adding tracer sediments to the flow
- Visualisation techniques (dye tracer, video and photo) to analyse the influence of morphological structures and vegetation on the integral flow field and the sedimentation/erosion processes
- Topographical maps as input data for the cross sections and bed slope in the model
- Vegetation mapping of the plants in the model (spacing, density, structure, permeability)

ripFor
Case Study

Upper Rhine:

Field measurements Upper Rhine:

The estimation of changes in topography was carried out using ***geodetic surveys*** before and after subset flood periods. More detailed information about height and total amount of sedimentation and erosion could be obtained ***using local suspended load and bedload sampling*** (sediment traps and chains) which were placed at 30 locations inside the floodplain. The location were selected under consideration of both the morphological situation and the distribution and types of vegetation. Changes in vegetation and the actual situation of the test site during and after flood events were monitored by a constant recording remote ***video monitoring*** system and by ***complete vegetation sampling***. This allowed a permanent control of the situation in the field over the whole year and a better understanding of the dynamic of the boundary conditions.

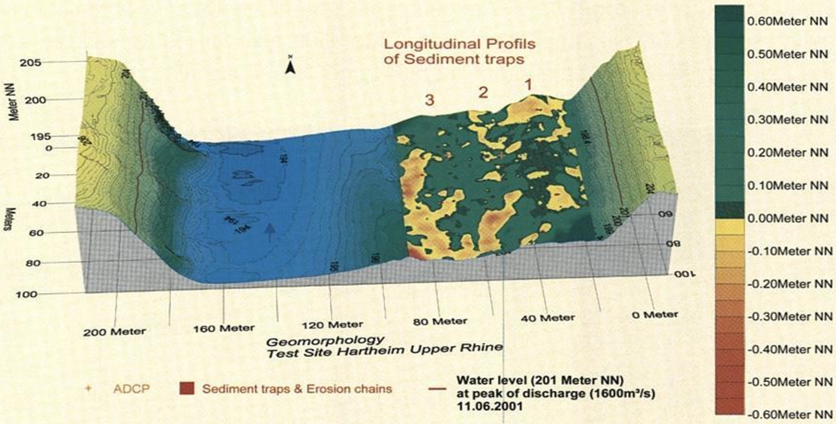
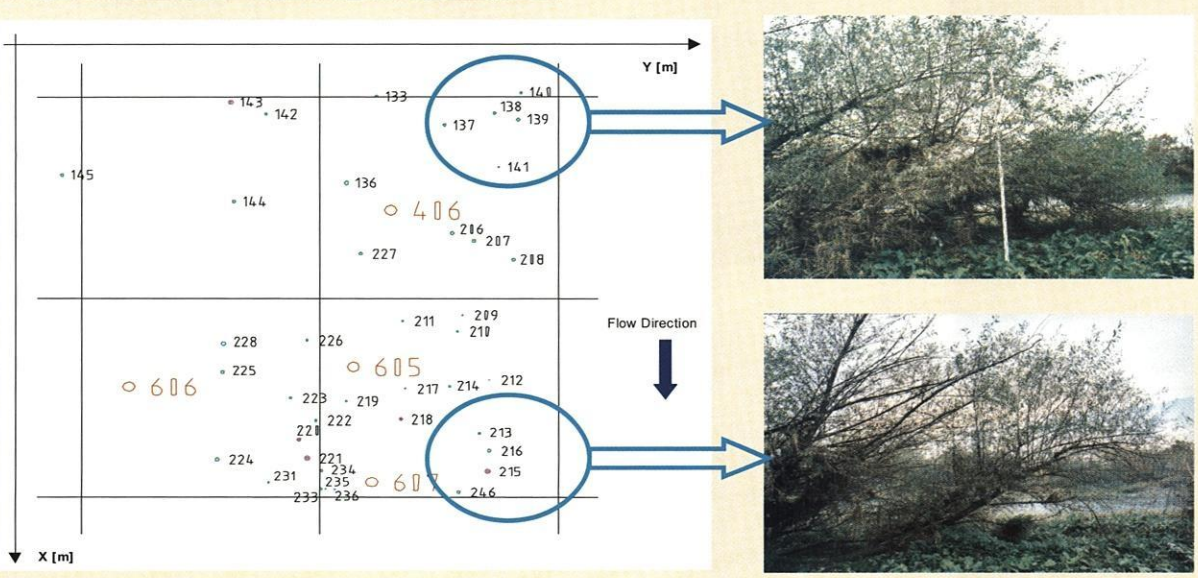


Fig. 34: Topographical / morphological changes after the flood period in 2001 at the test site Upper Rhine

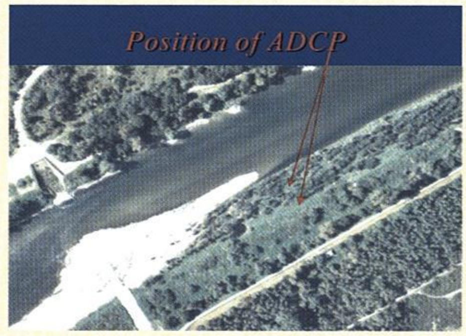
Fig. 35 (left): Video monitoring, observation of changes in vegetation during a flood event in 2001

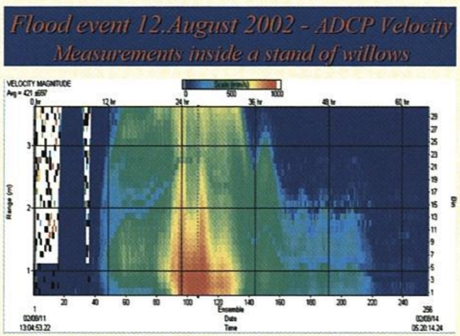
Fig. 36 (below): Complete vegetation sampling at test site Upper Rhine - partial result of the vegetation mapping



Case Study

The investigation of the impact of vegetation on the flow field was carried out as comparative study using ***local velocity measurements*** with Acoustic Doppler Current Profiler (ADCP). One ADCP was mounted inside a willow grove, the second one at a grass covered location. Both Profilers measured water velocity in three dimensions over a whole flood period. The permanent recording of flow data over the whole water profile and a longer period allowed the description and analysis of spatial-temporal changes in the flow field and the differences between a densely and non wooded area in terms of hydraulic roughness and its impact on discharge at floodplains.





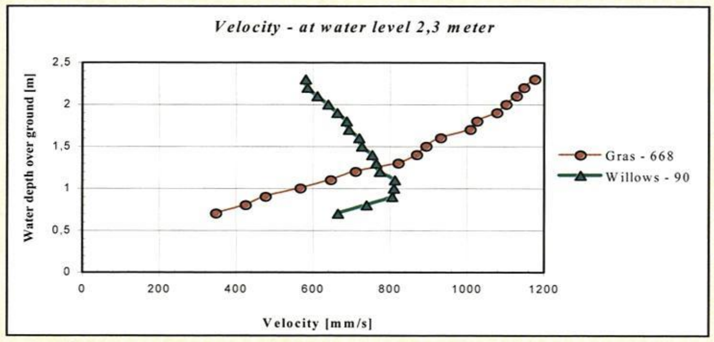


Fig. 37: ***(top right) Position of ADCP; (left) results of flow velocity measurements; (right) comparison of flow velocity for different types of vegetation under standardized conditions (water level and altitude)***

Physical modelling:

The aim of the physical model at the University of Karlsruhe was the determination of the influence of different types of riparian vegetation on the flow of the Upper Rhine and for varying types of vegetation and flow conditions complementary to the field measurements.

The cross section design and the investigated water levels were taken from field maps and transferred to the model. Due to the small model scale of 1:100, the experiments focused on an integral approach to the vegetation and their properties (flexibility and spacing). On the other hand, velocity data of the entire flow field were collected with high temporal and spatial resolution.

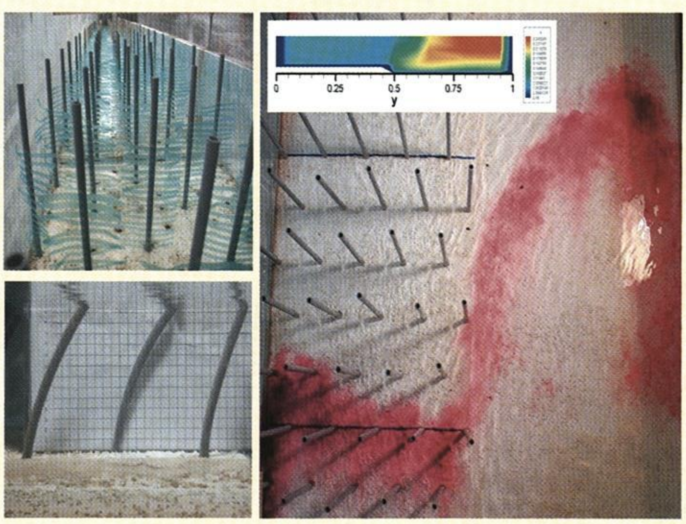


Fig. 38: Physical model of riparian forest vegetation

(top left) Rigid cylinders with foliage as a physical model of trees with leaves in an experiment with only-floodplain flow; (below left) Measurement of bending and oscillation of flexible cylinders; (right) dye visualisation of the flow field and measured mean velocity distribution (top left) for a floodplain situation with equally spaced rigid cylinders as a model of tree stems. The dye was added 2 seconds before the photo was taken as an immediate line source across the flume. The picture shows the horizontal velocity gradient between main channel (maximum mean flow velocity u = 0.27 m/s) and floodplain (u = 0.1 m/s). Furthermore, a isovelocity colour map of measured velocities is shown (blue: low velocity, red: high velocity).

Methods *used in the experiments:*

- Mapping of water level by pointer gauges to determine the influence of vegetation on the water level and calculate the overall resistance and drag forces
- Local velocity measurements with a 2D-LDV system to get spatial and temporal high resolution data of the flow field
- Visualisation techniques (dye tracer, video and photo) to analyse the influence of vegetation on the integral flow field and the sedimentation/erosion processes)

3.2.2.3 Results and interpretation of the actual situation

This chapter brings together the results obtained in the previous chapters to draw a detailed and widespread image of the actual situation. Hence, it is necessary to work in an interdisciplinary way to link together the information and results from each basic discipline. This step implies a broad understanding of the interdependency of riparian forest related processes. According to the expenses of the project and the accuracy of the results, the interpretation may be complex to a great extend and therefore demand professional guidance or consultancy.

Keep in mind for ACTUAL SITUATION!

- Differentiate periodical from singular changes
- Differentiate the stage of succession and see, that succession is a continuous process without a final stage
- Consider the relations between distance from water and diversity/succession/ buffer function
- Visit and focus existing problems and sensitive areas and evaluate location and degree of disturbances

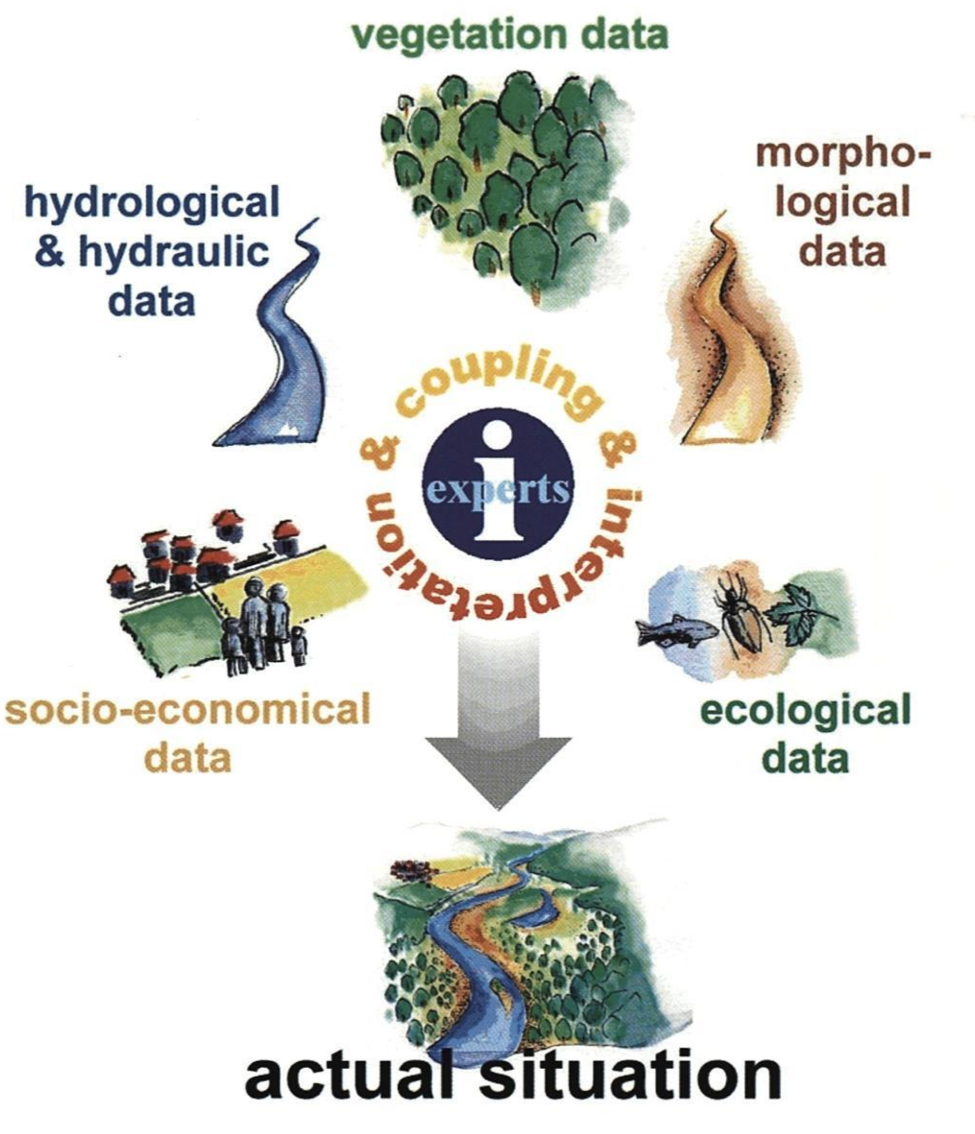


Fig. 39: Results and interpretation of the actual situation

3.3 Definition of objectives

After evaluation of the actual situation, the end-user has to define objectives or a future scenario within the RipFor-Management Guidelines. Once the objectives have been worked out clearly - in many cases quantified parameters will be obligatory - they can be compared against the actual situation to find out where deficits occur and what practicable measures and strategies can be applied to reach nominal conditions.

The responsibility for spotting objectives is a task of the end-user. The RipFor-Guidelines can only support this decision by supplying some typical objectives for riparian forest projects. According to the size of the project area and the present ecological/morphological situation, objectives have to be derived from the three basic aspects (see also Chapter 3.1 "Project definition"):

- Safety
- Ecology
- Use, function

By transforming these basic aspects into practical goals, different approaches can be specified:

(A) Restoration of floodplain areas and river corridors

(B) Management and maintenance of existent riparian forest

(C) Restoration of morphodynamics within channel and river corridor

(D) Restoration of river hydrograph (flood protection, water budget)

(E) Restoration of recreational areas for public use

(F) Site adapted forestry

(G) Restoration of water quality – buffer function of riparian forestry

Fig. 40: Definition of objectives

3.3 Definition of objectives

Enz:

The **basic objectives** for the restoration were:
(A) Restoration of floodplains
(B) Restoration of morphodynamics within channel and river corridor
(C) Restoration of recreational areas for public use

A close-to-nature river section upstream of the project area was chosen as a potential "Leitbild" for the restoration.

Fig. 41: Enz - diversity of flow velocities, water depth and bed structures

Specific objectives for the increase of **ecological quality** were:

- Winding river course
- Diversity of flow velocities, water depth and bed structures
- Biodiversity of aqua-terrestrial habitats
- Succession of vegetation

Specific **safety aspects** were:

- Maintenance of existent levees
- Flood protection against a 200 year event
- Protection of drinking-water sources from river infiltration
- Constant local flow velocities and shear stresses to prevent erosion

Specific aspects for **use/function** were:

- Integration in landscape
- Use of floodplains for recreational activities, acceptance of inhabitants

Upper Rhine - „Dike relocation between Märkt and Breisach":

The **basic objectives** for the restoration are:
(A) Flood control by restoring the level of safety against floods that existed prior to the systematic development of the Upper Rhine
(B) Preservation or restoration of the Upper Rhine floodplains

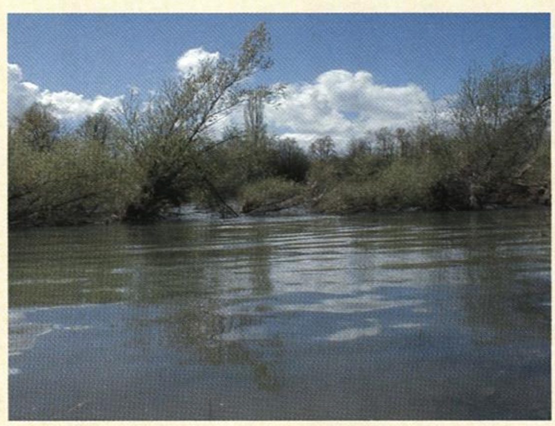


Fig. 42: Upper Rhine - floodplains

Specific objectives for the increase of **ecological quality** are:

- Restoration and preservation of floodplains
- Development of flood plains due to ecological floodings
- Typical fluctuation of groundwater level
- Shift of soils by floodings
- Diversity of species and structural diversity
- Preservation of genetic potential
- Protection of rare animals and plant species
- Succession of riparian forest

Specific **safety aspects** are:

- Flood protection against a 200 year event

Specific aspects for **use/function** are:

- Integration in landscape
- Use of floodplains for recreational activities, acceptance of inhabitants

Choosing one of these practical goals automatically sets restoration priorities. Based upon these priorities and the methods applied to the actual situation in Chapter 3.2.2.2, the end-user has to define a future scenario. Where quantifiable parameters are required, a certain bandwidth of tolerance should be set to avoid singularity.

3.4 Analysis of deficiency

After the preceding detailed survey of the actual situation and the definition of various objectives, the analysis of deficiency follows, to give a basis for the further planning of strategies and measures. It is necessary to visualise and assess the deficits for each involved scientific discipline. The matrix of deficiency is based upon the comparison of the actual situation with the nominal condition, which is a qualitative or quantitative definition of objectives.

Description - matrix of deficiency:

Step 1: Description and analysis of the actual situation for each involved scientific discipline (see chapter 3.2.2.2).

Step 2: Description of the objectives and the development of nominal conditions (see chapter 3.1 and 3.3).

Step 3: Comparison of actual situation with nominal condition result in a matrix of deficiency.

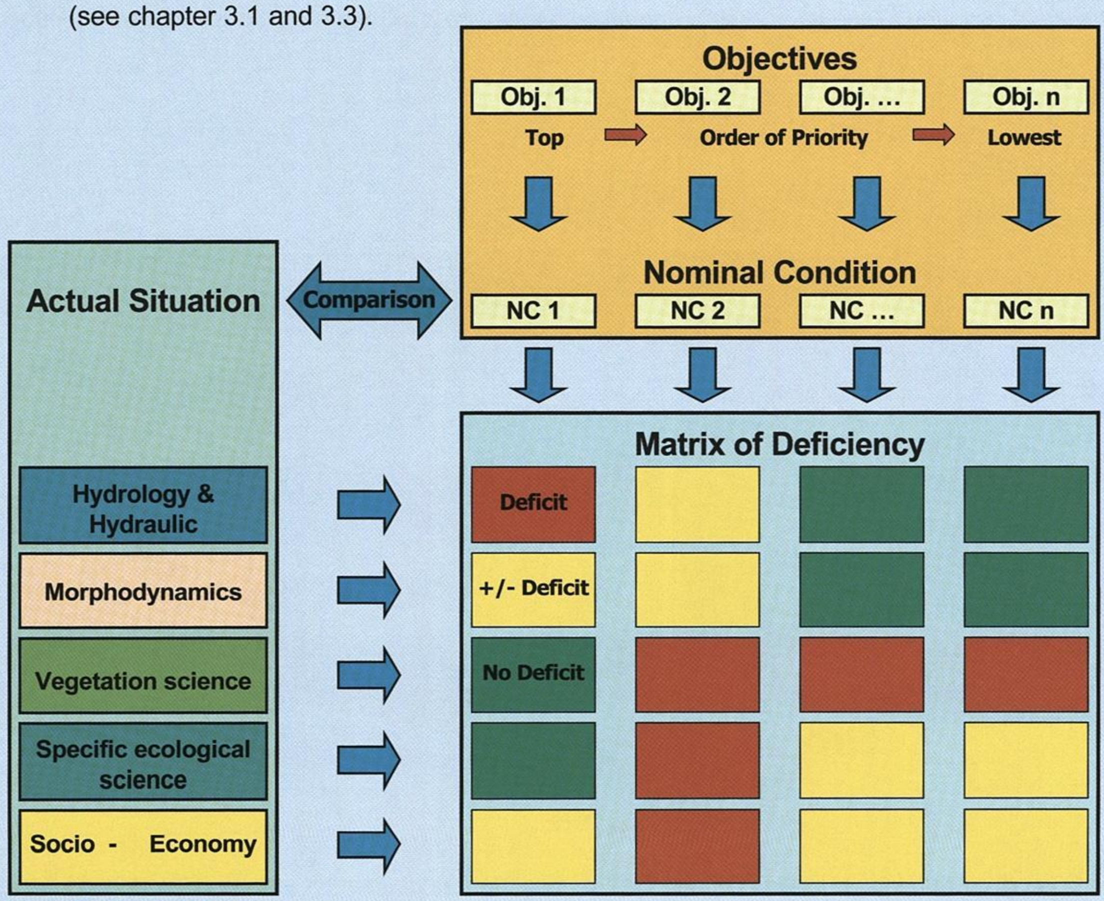


Fig. 43: Matrix of deficiency

Actual situation:

Fig. 44: Actual situation of the Wien river: concrete channel with a more or less constant cross section

Nominal condition:

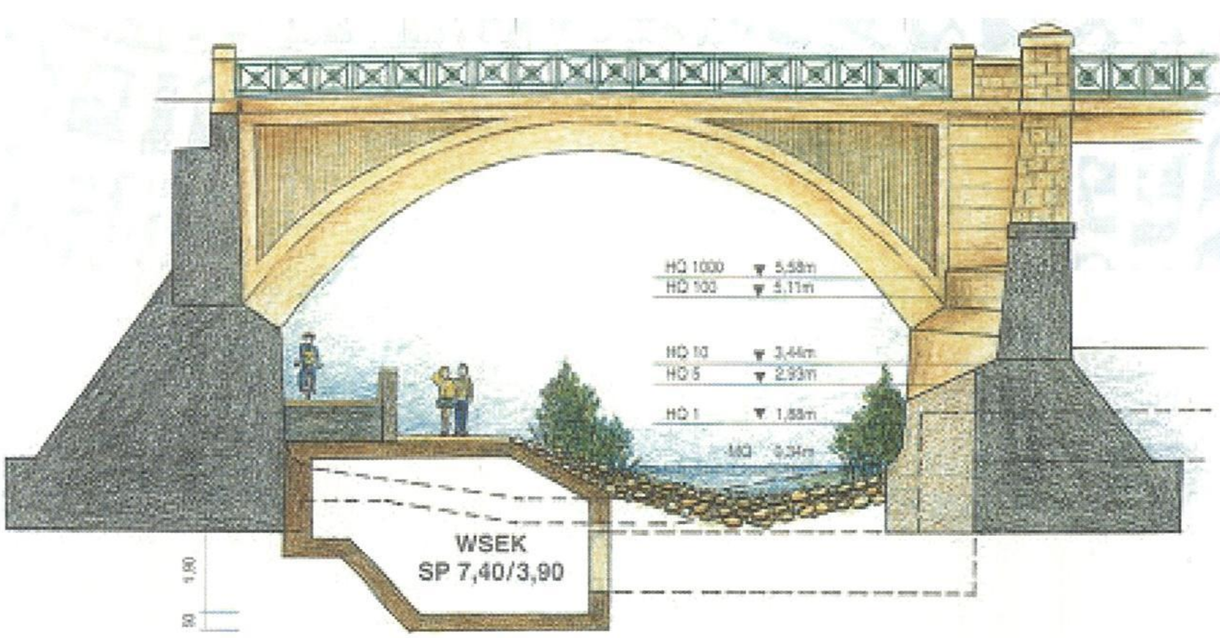


Fig. 45: Objective / nominal condition: projected cross section, revitalisation and waste-water channel

Case Study

3.4 Analysis of deficiency

Enz - River restoration:

In the case of River Enz, the three aspects maintenance of flood safety, ecological revaluation and recreational use/function had to be brought together. In the physical model (see Case Study 3.2.2.2 Methods „Enz - River restoration) different alternatives and their deficiencies for potential restoration were investigated. Hereby, the most important parameter was the hydraulic roughness and the resulting water level along the Enz.

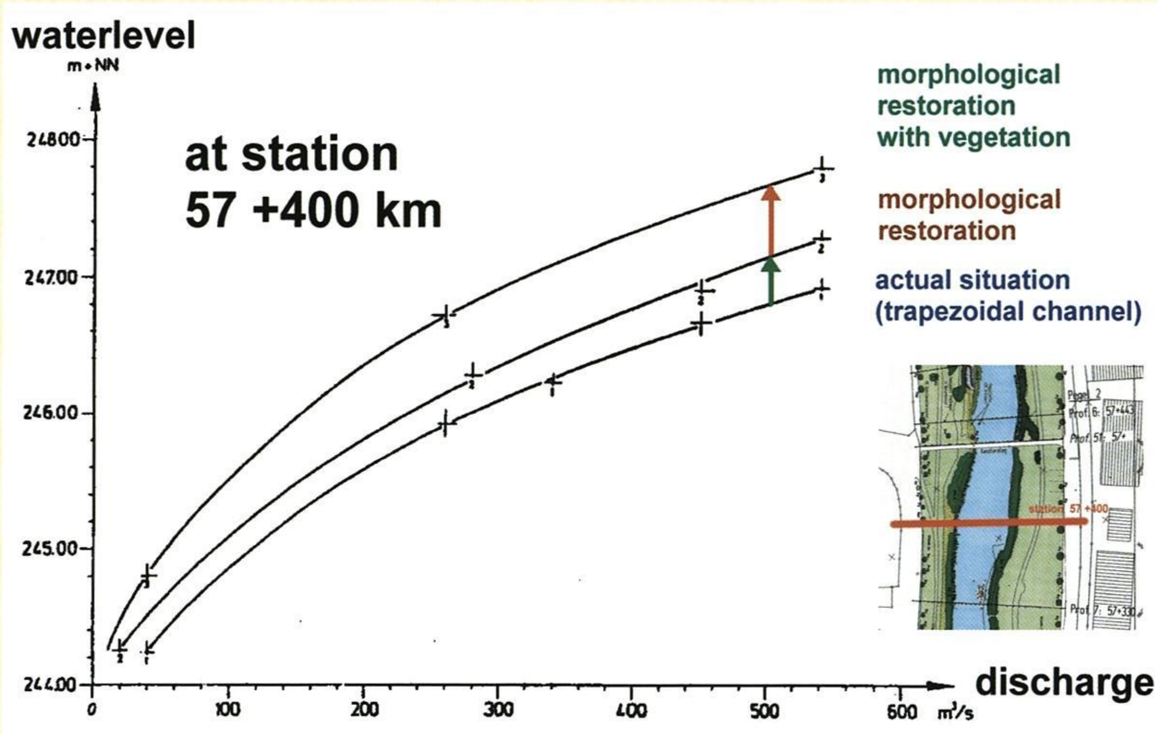


Fig. 46: Main result of the physical model of river Enz restoration

Rating curve (water level vs. discharge) for a critical cross section. The green arrow marks the increase of water level due to the restoration of river morphology, the red arrow due to the development of vegetation (maintained and managed).

Objective: Restoration of river and floodplain morphology and vegetation

Nominal Cond.: Flood safety, tolerable increase of water table due to restoration: **1.0 m** (for design discharge of 540 m³/s)

Deficits: Increase of water level for the critical cross section (station 57 +100 km):
~ **0.4** m due to morphological restoration (river channel and floodplains)

Alternative 1: **1.7 m** due to vegetation - natural succession of riparian forest (total channel capacity of 350 m³/s

Alternative 2: **0.6 m** due to vegetation - limited and managed (total channel capacity of 670 m³/s

Summarized, the increase of 1.7 + 0.4 = **2.1 m** of alternative 1 was to high to fulfil the nominal condition. Since the change of morphological structures was essential for the restoration, the only strategy to keep the safety was alternative 2: ***the limitation and maintenance of vegetation***.

Hence, the increase of water level could be kept below **0.6 m** and the nominal condition of an increase of **1.0 m** was successfully complied.

3.5 Strategies

A strategy can be understood as a planned procedure for the achievement of the predefined objectives. The goals have to be defined at the beginning of any project and for each project area by the end-user. Which strategy can be applied results from the interpretation of the matrix of deficiency and thus on the comparison between the actual and target state of the project.

The actual situation as it was shown in chapter 3.2 needs detailed information of the present boundary conditions of the project area. The end-user has to define a gainable target state of the project area on the basis of these information and with simultaneous consideration of the project objectives. With respect to different objectives and priorities belonging to each project area the interpretation of the matrix gives the opportunity to explore potentials of the resources and to spot out conflicts of utilisation.

Fig. 47: Revitalisation project - actual situation

Fig. 48: Revitalisation project - phase of construction

Development of strategies – some basic principles:

- Attention should be paid to transparency of strategies, public relations, risk assessment, sustainability, environmental compatibility, cost effectiveness and control of success
- Experts should always be involved
- Consideration of different sub-goals and their priorities
- Advertence of socio-economic components
- Consideration of non-local impacts
- Consideration of time scale
- A realisation demands public acceptance
- Preparation of several strategies to explore alternatives

The selection of a suitable strategy demands that the exigency of purpose has to be appointed and a weighting between different sub-goals has to be attempted. The objectives can be obtained in different ways employing individual strategies for every project. Hereby, experts should be consulted to find the best way.

Every change of the actual situation - even if only a single parameter gets modified - results in most cases in a change of the complete system. Consequently, new interpretations of decisive factors have to be considered (e.g. which way the project area should be modified, which parties are involved and have demands on projected area and last but not least in which way the project area should be managed in the future). Therefore

Fig. 49: Revitalisation project - six months after completion

Keep in mind for STRATEGIES!

- Consider long-term perspectives (up to climatic changes)
- Riparian forests have low sediment yields
- Retain stream shade to avoid warming up of the river
- Depth of groundwater table controls vegetation growth and maximum height
- Texture and organic matter content control the water availability in well-drained soils and thus the maximum vegetation height
- Interstitial and macro-pore structures are important for air and water supply to the roots
- Avoid the compaction of soils which will keep biomass productivity high
- Strong roots will preserve the river channel from bank erosion and widening
- Woody debris is more than a supply of organic matter and important for ecological quality and enhancement of habitats. It's a strong tool for morphological changes but can also contribute to bank protection. But floating and woody debris can significantly increase the hydraulic roughness of a river and the water table.
- Include old trees in planning as future woody debris supply or tree revetments for bank protection
- Favour native species for floodplain and riparian forest restoration
- Diversity of native species provide a natural supply of detritus for macroinvertebrates
- Dense grass and sedges contribute to floodplain erosion protection
- Vary width of river channels and riparian corridors
- Vary areas with softwood/hardwood
- Favour multiple canopy layers (grass, sedges, bushes, trees)
- Combine even aged, single canopied tree stands with uneven aged, multiple canopied ones at the water edge
- Consider the human factor (attitudes, beliefs, knowledge, expectation)
- Develop reasonable alternatives to spot out compromises
- Keep dialogue with the public and concerned citizens or citizen groups
- Riparian silviculture should aim at maintaining riparian functions not at producing wood and includes both wood and water

questions of the current and potential use of the project area take a centre stage for every strategy and every purpose.

It has to reviewed with every planning of a strategy if the goal can be achieved by measures on a local (project area) or a non-local regional (catchment area) level. Furthermore it has to be considered hat future developments, non-local interventions and modifications can have a significant impact on the evolution of a strategy. Thereby, the time scale of impacts of strategies has to be considered together with temporal achievement of the objectives. Every strategy should spot out measures of realisation and which methods are capable. A monitoring plan should be available to undertake a reliable measurement of results.

Other essential elements of a strategy should be factors like transparency of politics and planning, public relations and acceptance, risk assessment, sustainability, environmental compatibility, cost effectiveness and control of success. The consideration of these aspects does not guarantee the success of a project but without the acceptance in society, politics, science and industry a realisation is almost not possible.

Case Study

3.5 Strategies

Upper Rhine:

The problem:

Due to the regulation and correction of the Upper Rhine the congested areas of Karlsruhe, Mannheim and Worms have to reckon with the risk of substantial damages and the danger for human life due to flood threats. For these regions a 200 year flood event would cause total costs of more than 6 billion Euro. Furthermore the straightening of the river has caused the loss of 130 km² of floodplains and thus the loss of important habitats for species.

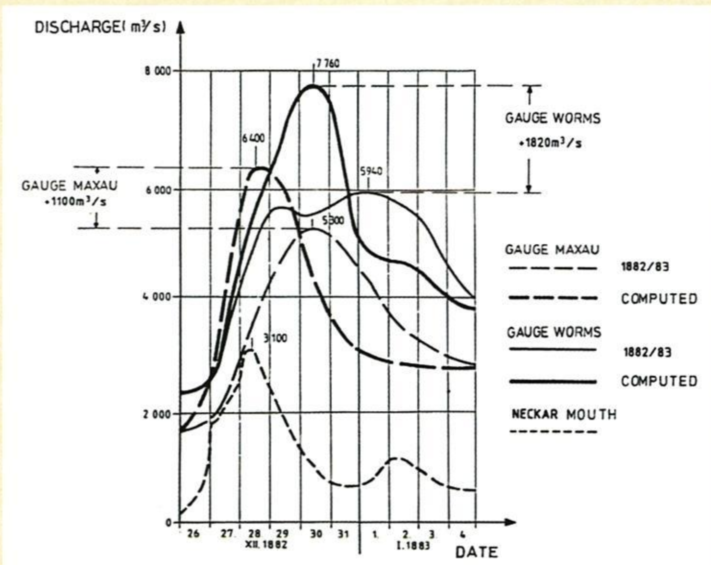


Fig. 50: Upper Rhine hydrograph of greatest occurred flood event 1882 / 83

The Problem: The figure shows the flood hydrograph at the end of the year 1882 / 83. It has been the greatest flood at the Upper Rhine Valley in the last 200 years. The computed hydrograph shows the situation, if under the same meteorological conditions this flood would come again today. At the gauging station Worms the peak value will be 7760 m³/s, that means an increase of 2 meter compared with the situation in 1882/83.

The objectives:

- Restoring the level of safety against floods that existed prior to the systematic development of the Upper Rhine which means a protection against 200 year flood events
- Increase of ecological quality

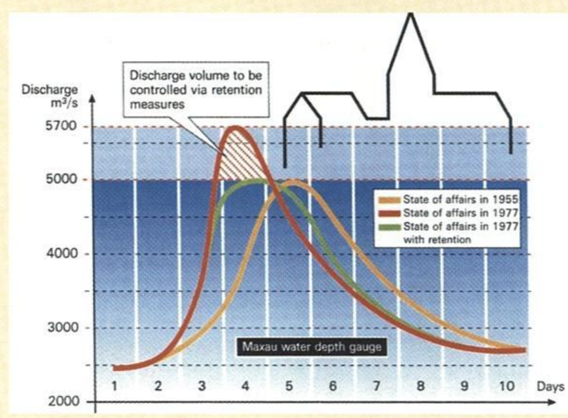


***Fig. 51:* The effect of retention measures at the Upper Rhine**

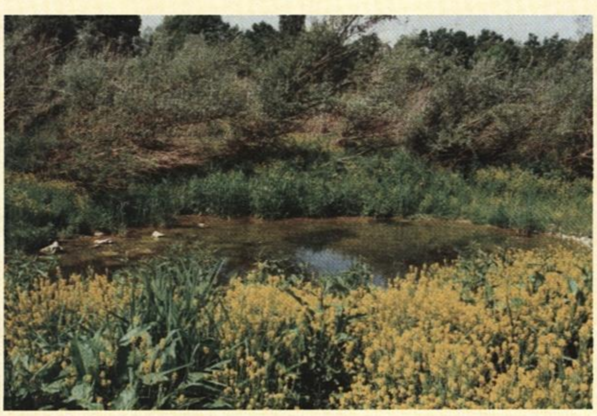


***Fig. 52:* Riparian Forest - different stages of succession**

Case Study

The solution:

- Attenuation of critical peaks of flood waves by creation of inundation areas and the use of natural floodplains
- Preservation or restoration of the Upper Rhine floodplains

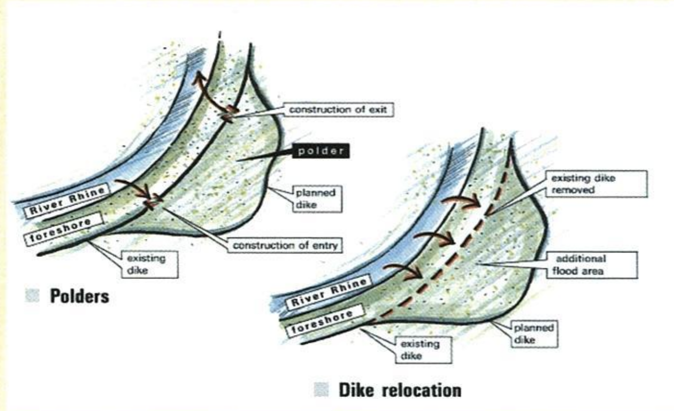


Fig. 53: Polders and dike relocation as new inundation areas

The way:

- A total retention volume of 167 million m³ is needed, 25 Million m³ of the total sum must be located along the Upper Rhine between Märkt and Breisach. At this area the erosion of the river bed has caused the loss of almost all natural inundation areas. In consequence of this impact it only exist a limited number of possible measures and areas to gain the objectives
- Therefore under consideration of scientific expertises and models different measures (the construction of weirs, polder, the excavation of former floodplain areas to the actual level of inundation and dike relocation) and its spatial temporal, technical, economical, ecological and political realisation were examined. Biota, hydrology, stream velocity, discharge, sedimentation and erosion and its interaction were of particular interest since these factors have great impact on the evolution of single flood events and the development of riparian forests
- The result of the investigation recommends the creation of new retention areas by dike relocation and excavation of floodplains since this measure considered both the flood protection and the preservation and restoration of riparian areas
- The creation of flood retention areas at the Upper Rhine therefore demands the development, monitoring and management of floodplains and riparian forests under special consideration of its hydraulic impact, the ecological function and land use

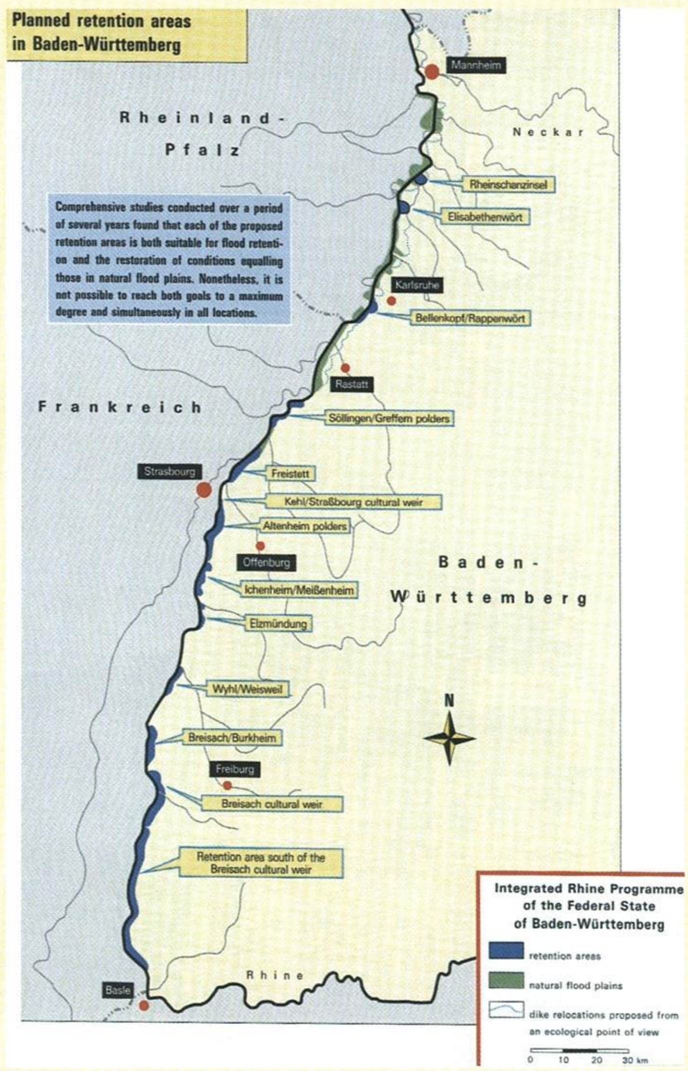


Fig. 54: **Planned retention areas in Baden-Württemberg**

3.6 Measures

Measures are the practical transformation of the strategies defined in chapter 3.5 based on the analysis of deficiency in chapter 3.4. There can be multiple alternative or combined measures to reach the predefined goals. In some cases it may even be necessary to study different variants and chose the one that leads to the optimal results in the easiest way and integrating diverse aspects (e.g. ecology, safety, social preferences).

Generally, measures have to be considered with regard to their temporal and spatial range.

Temporal range includes the acuteness (short-term impacts) and the lag of time until a realised measure responds and becomes effective (medium and long-term impacts). Furthermore, seasonal dependencies of measures and their practical transformation (e.g. access of riparian forest is easier in cold periods) have to be taken into account.

The *spatial range* classifies the regional extensions of measures and their impacts. This can reach from local punctiform (e.g. soil-bioengineering measures to protect river banks) and meso-scale interventions (e.g. restoration of river courses) to catchment scale measures of entire areas of nature or landscape (e.g. interventions in land use to manage sediment supply and discharge).

Besides the range, measures can be classified according to their maintaining, developing or reformative character:

- *Maintaining measures*
  Wherever natural riparian areas have remained, maintenance and protection measures are of prime importance. These areas are important reservoirs for aquatic and terrestrial plants and animals. They are a basis for migration and

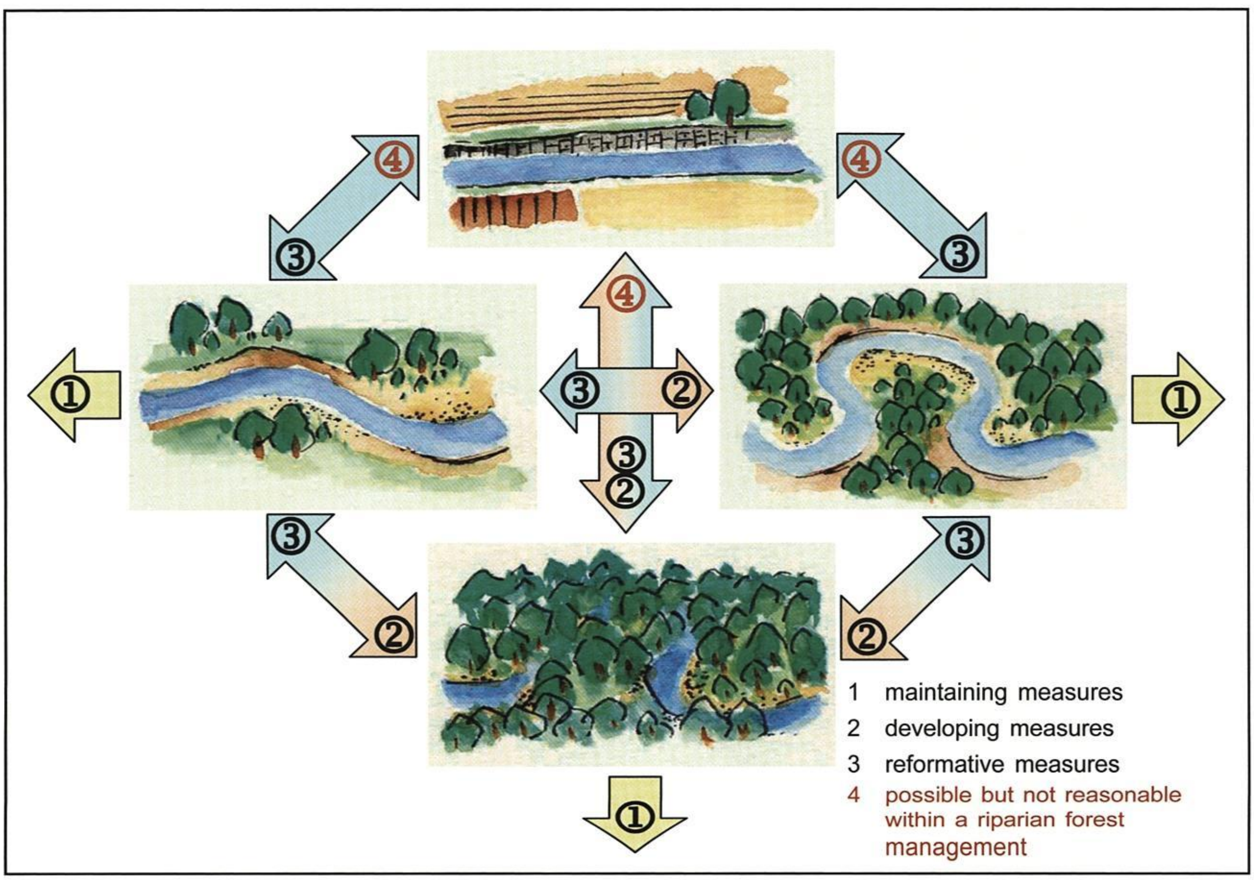


Fig. 55: Classification of measures for a typical riparian forest restoration

resettlement of former native species and can be considered as potential "Leitbild" for nearby restoration projects.

- Developing measures
  These measures have initialising character. In many cases, only the change of restrictive boundary conditions leads to a self-development of rivers and floodplain towards their natural stage. Examples are the elimination of "hard" bank protection measures to start the reformation of a natural river course and flow dynamics, the development of river broadening by providing retention areas or the tolerance of spontaneous vegetation growth or woody debris. In many cases just a change in maintenance strategies is needed to initialise riparian forest development and regeneration, whereas no further planning or interference is required and costs and expenses are small.
- Reformative measures
  Where no momentum for natural self-development in foreseeable future remained, reformative measures can be applied. They include the recovery of hydraulic permeability, the bed level adjustment and reconnection of tributary river courses, compensation of progressing bed erosion and elimination of "hard" bank and bed protection. For restoration projects, the objective should be the recovery of requirements for self-development and not the creation of a fixed pseudo-natural state.
  In matters of management strategies, reformative measures can also control or even reverse the natural self-momentum of a system (e.g. to keep a naturally meandering river winding).

Wherever it is possible, a separation of the project area into sections with homogenous properties such as restoration potential and protection necessities is recommended. The results can be visualised in a structural plan of measures or a river/riparian forest development plan, which is very helpful with regard to future realisation.

Keep in mind for MEASURES!

- Remove only the necessary amount of woody debris and sediment after flood events
- Integrate information exchange early in the planning phase
- Consider the spatial and temporal scale of measures that may influence larger areas than the project area and for long periods of time after the realisation
- Operate with less physical intrusion and more care in riparian areas
- Riparian areas should be planned as integrated areas and not isolated
- Maintain permeability of migration corridors for fishes and amphibians
- Timber harvesting may increase the number of stems on floodplains together with its hydraulic roughness and sedimentation
- Near-bank trees can be maintained as natural bank protection
- Harvesting increases direct sunlight to streams and therefore water temperature
- Harvesting close to the river channel reduces coarse woody debris supply and bed-form formations in sand and gravel channel (e.g. dunes)
- As a main principle, use the most natural and least intrusive methods and measures

Fig. 56: Blockstone embankment

„Hard“ protection of river banks is sometimes necessary. In the figure, the cut bank of a river curve had to be protected against erosion to stabilise the morphological changes and the growing of vegetation on the adjacent floodplain (in the background in Fig. 56). Blockstones often look unnatural, but in a careful positioning they still feature good habitat diversity and shelter for macroinvertebrates and fishes.

Fig. 57: Riparian wattle fence

Soil-bioengineering measures have relived a renaissance during the last decades. The experiences from over 100 years of mostly mountain river protection have been transferred to a variety of modern applications. Bank and bed protection of rivers and floodplains, initialising of vegetation growth and habitat recreation.

The advantages are the use of natural material that can be easily and harmoniously integrated in renaturalisation. Furthermore, the high resistance against mechanical stresses due to the flexible plant structures.

Fig. 58: Round timber under sinking fascine

Fig. 59: River channel restoration

The reformation of river channels within restoration projects often requires the use of heavy machines, such as excavators.

The elimination of existent reinforced concrete structures, bed or bank pavement is in many cases the essential step towards a self-development of natural riparian dynamics.

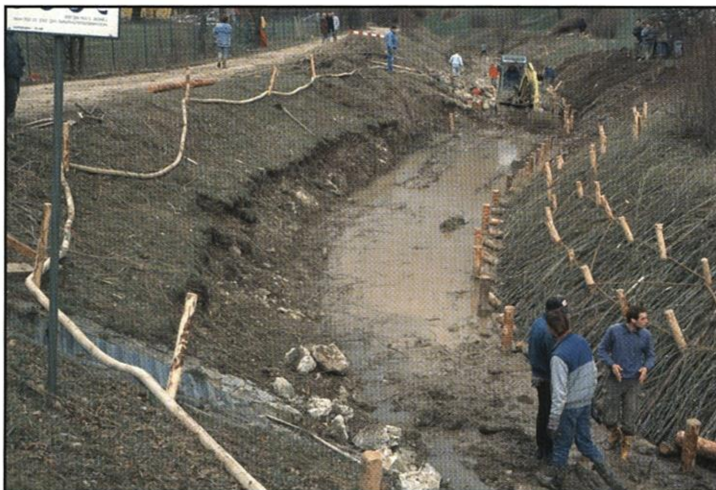


Fig. 60: Construction of brush mattress with willows

Realisation of soil-bioengineering measures requires less physical intrusion by heavy machines and more manual work. Therefore, it is a minor disturbance for the entire ecosystem conserving the surrounding resources (e.g. soil, vegetation, animals). Realisation makes the participation of public and citizens possible and leads to better awareness and understanding of restoration needs.

Fig. 61: Left side prune down

Maintenance of riparian vegetation is a common practice along rivers. The goals can reach from reduction of hydraulic roughness (in the figure the left bank was pruned to induce less flow resistance) to supply of habitat conditions to optimisation of forest growth with regard to timber production.

Fig. 62: Woody debris for morphological and hydraulic changes

Woody debris remaining in the river channel is a strong tool for morphological and hydraulic changes and amelioration of habitats.
Commonly used applications of woody debris are bank protection, initialising river winding or meandering and bed level increase.

Fig. 63: Use of woody debris

Even if woody debris is a natural tool, it can be managed and used to reach specified targets. In this case, a dead tree stem has been anchored to a living one to keep it in position and prevent it from being moved by hydrodynamic forces of the river.

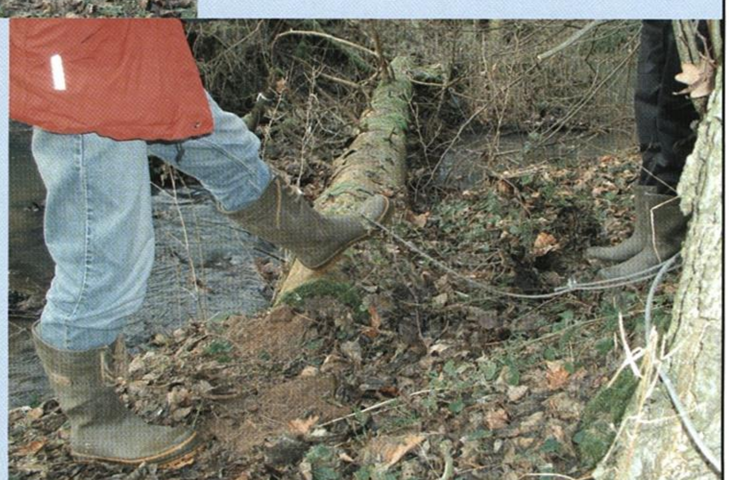


Fig. 64: Protection of a bridge

To protect a bridge from log jam, an overfall has been constructed. The bridge opening had too small capacity and was flooded and damaged by higher discharges. In this case, the river overflows the banks and passes the overfall which is armoured by blockstones and a grass layer against bed erosion.

Fig. 65: Inundation area for a river

One of the most important and effective measures for renaturalisation is to give inundation areas back to the river. Widening leads to aggregation of river sediments (e.g.. islands) and to diversified morphological and hydraulic structures.

Fig. 66: Simple pedestrian bridge

The pedestrian bridges in the figure have only been secured by steel cables against loss but can be moved by the flow when their blockage becomes too strong. In such a way, measures can be adapted to a highly dynamic scenario.

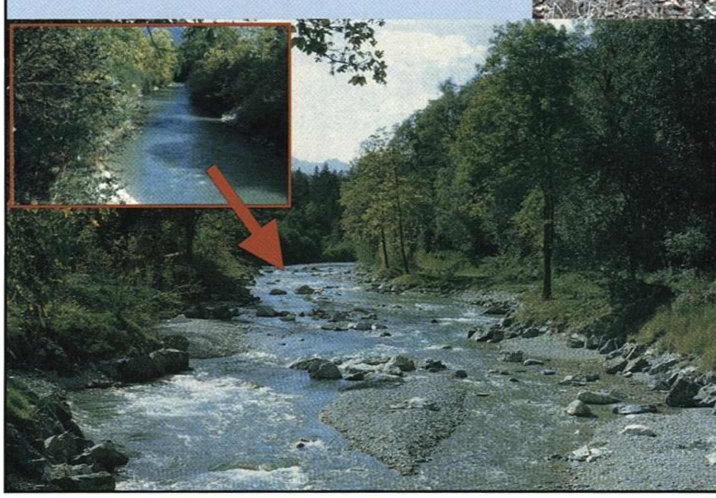


Fig. 67: Perturbing stones

Renaturalisation initialised by the insertion of flow perturbing stones in the river channel.
The banks have been protected by a loose embankment of large stones and filled with fine gravel. The material used was taken from the surrounding area.

3.5 / 3.6 Strategies & Measures

Case Study

Enz - River restoration:

Derived from the analysis of deficiency, the boundary condition for the River Enz restoration had to be management of the riparian vegetation. The succession had to be maintained and regulated when vegetation growth increased the hydraulic roughness to the point that safety against flood events would not be given anymore. The basic informations for maintenance strategies were transformed from the experience with the physical model and had to consider aspects of blockage of the cross section by the vegetation.
The ***concept of maintenance*** ("Unterhaltungsplan") for the River Enz restoration included:

- Allow vegetation growth and succession between predefined minima (aspects of landscape values, ecology) and maxima (aspects of flood safety)
- Define minima/maxima for individual situations such as different cross sections with variable morphological structures and use/function (e.g. islands, meanders, gravel banks, recreational areas, wildlife protection areas)
- Differentiate flexible (low resistance due to streamlining effects) from rigid vegetation (high resistance)
- Cut and thin out vegetation where the tolerable maximum is reached or overstepped
- Cut and thin out vegetation where flexible structures become rigid (e.g. willows after 2 periods of growth)
- Apply special cutting techniques (e.g. to coppice to reduce the roughness of trees by keeping their canopies above the flood water level because bare stems cause less blockage)
- Counterbalance vegetation on left and right floodplain (e.g. if strong growth occurs on the left floodplain, the right floodplain vegetation has to be thinned out)
- Use of on-site typical species of vegetation
- Where river banks had to be protected, soil bioengineering measures were applied (geotextiles, branch layer, brush mattress, fascine layer, cuttings)

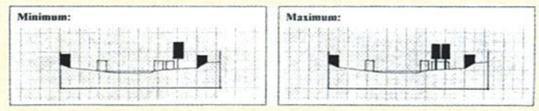


Fig. 68: Minimum/maximum vegetation growth definitions for cross sections of the Enz restoration

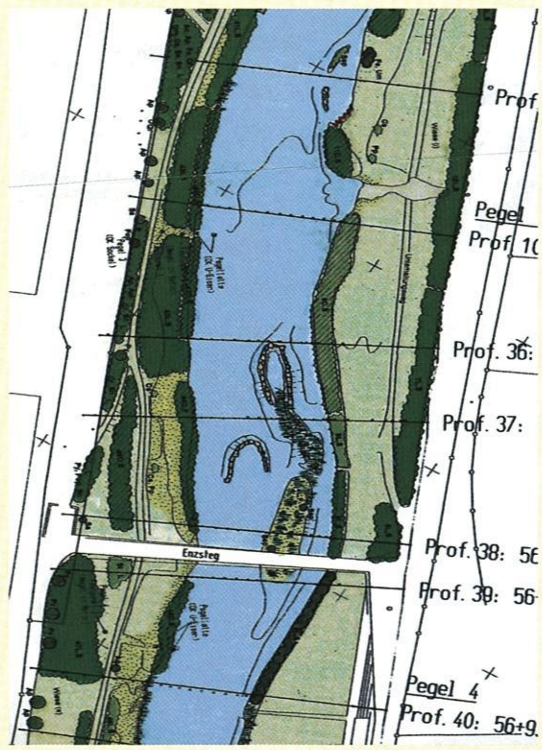


Fig. 69: Map of a section of the Enz river restoration as orientation for maintenance measures

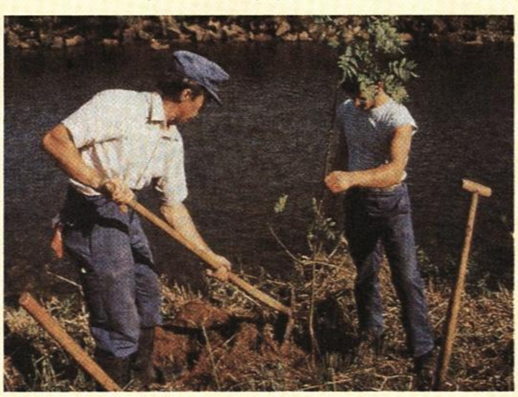


Fig. 70: Maintenance measures: planting of young trees close to the water's edge

Fig. 71: Maintenance measures: cutting of grass and sedges to boost young treegrowth on floodplains

3.7 Analysis of impact of measures

The impact of measures on the actual situation has to be spotted out and afterwards compared with the objectives defined in Chapter 3.3 before the realisation can start. Special regard has to be paid to impacts on the environment. They have to be considered carefully and are regulated by national laws within environmental impact assessment. A good example is the German "Umweltverträglichkeitsstudie (UVP)", the legal implementation of environmental policy for the analysis of impact of measures.

Primary goals of the UVP are:

- Prevention of environmental damages
- Holistic and precocious acquisition of impacts
- Increase of transparency within administrative decisions
- Protection of human health
- Amelioration of living quality
- Achievement of self-sustainability of ecosystems

The impact of measures has to be analysed with regard to:

- Human life,
- Animals, plants, soil, water, air,
- Landscape, cultural and real assets
- and their interactions

Returning to riparian forest management, the comparison between the impact of measures and the objectives leads to one of the following outcomes:

- Objectives achieved
  Start of Realisation (Chapter 3.8)
- Objectives <u>not</u> achieved
  Subcircle 1: Redefinition of Strategies or Measures (Chapter 3.5 and 3.6)
- Objectives <u>not</u> achieved
  Subcircle 2: Redefinition of Objectives after subcircle 1 (Chapter 3.3)

<u>Description of subcircles within the Riparian Management Circle</u>

Orange: Subcircle 1 (including steps 3.5, 3.6) Red: Subcircle 2 (including steps 3.3 - 3.6)

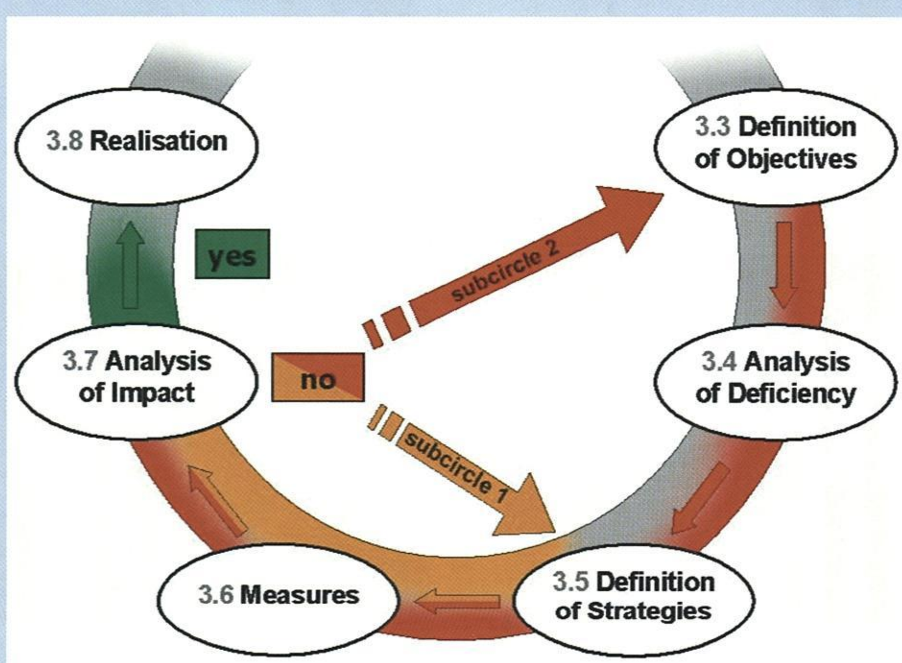


Fig. 72: Subcircles within the Riparian Management Circle

If the objectives are not reached within the first package of measures and strategies, subcircle 1 goes back to Chapters 3.5 and 3.6 where strategies and measures have to be redefined. Afterwards the analysis of impacts of the advanced measures and strategies has to be performed again.

If subcircle 1 is not successful, the advanced strategies and measures are not capable to reach the objectives. In this case, subcircle 2 may be necessary wherein a redefinition of objectives has to be performed pursuant to Chapter 3.3 and with regard to narrower boundary conditions.

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3.7 Analysis of impact of measures

Upper Rhine - Regional planning procedure - application and evaluation

Essential volumes of documents which are required for the application of the regional planning procedure

- Central documents concerning the regional planning procedure

  1. Description of the planned project
  2. Description of the selection process with respect to discussed alternatives / measures
  3. Geographical description and evaluation of the project area
  4. Environmental risk assessment study under consideration of the regional planning procedure
  5. General summary of all plans, measures and impacts

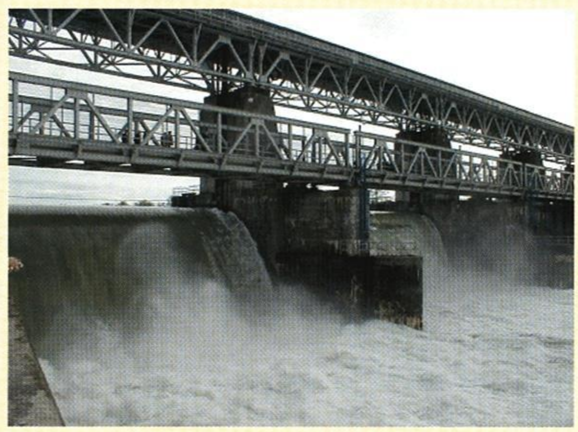

Fig. 73: Upper Rhine - flood control by a weir

- Extra Expert's reports concerning the environmental risk assessment study

  1. Survey about types of vegetation and habitats
  2. Survey about landscape typical species of plants and animals at the project area
  3. Survey about types of vegetation at the groyne fields at the Upper Rhine
  4. Impacts of the extreme flood in 1999 on the environment at the Upper Rhine
  5. Survey about moss and tresses
  6. Survey about the recreation value of the projected area
  7. Survey about the local climatic conditions and impacts of measures
  8. Soil survey (physics, chemistry, biology) and impacts of measures
  9. FFH- compatibility study / biota risk assessment study

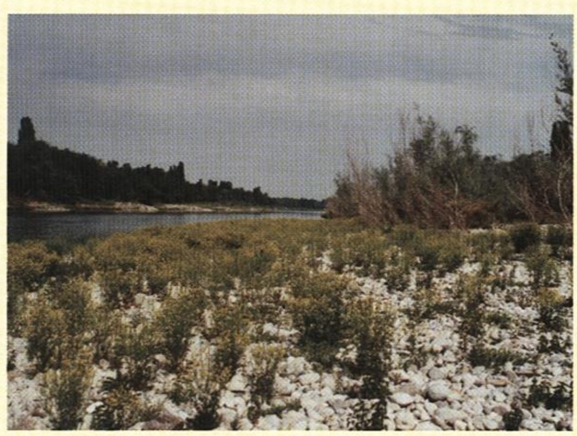

Fig. 74: Upper Rhine - actual situation of a floodplain; bar gravel areas covered by herbs and damaged willow

Case Study

- Special studies concerning water construction and hydraulics

  1. Survey about potential erosion on the floodplains between “Märkt and Karpfenhod”
  2. Modelling of the actual and future water levels and its evolution between “ Märkt and Breisach”
  3. Field measurements about stream velocity at vegetated groyne fields at the Upper Rhine near Bad Bellingen
  4. Validation of the impact of the extreme flood in 1999 on geomorphology and hydraulics

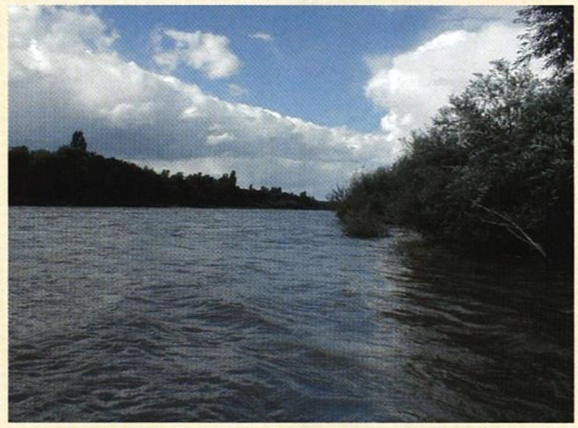

Fig. 75: Upper Rhine - the same location as figure 74 but during a smaller flood event

Based on the evaluation of the measure “excavation and relocation” within the regional planning procedure a variety of positive and negative impacts could be found:

- Positive impacts

  1. Improvement of flood protection
  2. Conservation and recreation of natural floodplain habitats and biota
  3. Development of attractive natural recreational areas
  4. Long term development of floodplains to a typical structure of the region and landscape
  5. Regeneration of a characteristic element of the Upper Rhine valley
  5. Improvement of function and performance of the local and regional ecosystems
  6. Increased exchange of water between the Rhine and other water courses, e.g. corridor function of the river
  7. Initiation of soil development at the new floodplains by the interaction between vegetation and sediment transport during flood events

- Negative impacts

  1. Impairment of local infrastructure and on local recreational areas and tourism due to construction works
  2. Change of the geographical situation in terms of a today’s characteristic and adapted landscape scenery
  3. Temporal impairment of protection and recreational function of forests
  4. Loss of farming land
  5. Irreversible change of soils at the affected area under special consideration of the exchange between surface and ground water
  6. Loss of pine forest monocultures and its typical biota
  7. Excavation of 50 Million tons of gravels over 15 years which can affect the local gravel and mining industry by deterioration of gravel prices

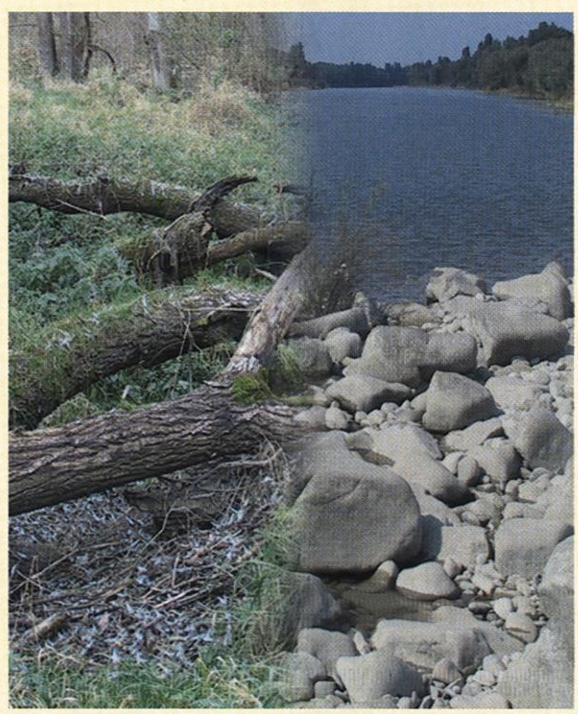

Fig. 76: Upper Rhine - diversity of habitat; riparian forest, gravel bar, stream

3.8 Realisation

The realisation can be defined as the implementation of planned strategies and policies to achieve the goals of a project. This implies the consideration and examination of following topics:

I. Planning

- A time schedule of realisation
- The definition of the central problem, the objectives and the measures
- Awareness of the three aspects: safety, ecology, use and function
- The required and available area
- The review of land use conflicts
- Examination and review of titles and legal questions
- The warranty of public acceptance, the political enforceability
- Warranty of short- and long-term financing
- The completion of scientific investigations of the actual and target state of the project area
- The completion of environmental risk assessment and regional planning procedure
- Tabulation of a landscape plan, coordination between landscape construction, hydraulics, ecology and geomorphology
- Special permission for encroachments in nature protection areas
- Monitoring plan

II. Construction

- Public invitation to tender – submission of measures under consideration of all objectives
- Allocation and conclusion of contracts
- Detailed construction and time plan for construction and workmanship under consideration of flood event periods, seasons, environmental protection
- Accomplishment of construction / landscape design

III. Completion

- Completion of construction
- Inspection of construction
- Control of success
- Monitoring

Fig. 77: Realisation of different constructions (brush mattress with willows, blockstone)

Keep in mind for REALISATION!

- Favour native species for floodplain and riparian forest restoration
- Avoid compaction of soils and ground disturbance by heavy machines by planning routes and selecting equipment carefully
- Realisation works best during dry periods and soils
- Use geotextiles and mats as traverses for machines
- Avoid putting sediments into river channels
- Avoid fueling, equipment servicing and pesticide applications within the riparian area

3.9 Monitoring / Evaluation

Standard definitions of monitoring and evaluation are given by Casley/Kumar (1987):

"Monitoring is a continuous assessment both of the functioning of the project activities in the context of implementation schedules and of the use of project inputs by targeted population in the context of design expectations. It is an internal project activity, an essential part of good management practice, and therefore an integral part of good day-to-day management."

"Evaluation is a periodic assessment of the relevance, performance, efficiency, and impact of the project in the context of its stated objectives. It usually involves comparisons requiring information from outside the project – in time, area, or population."

The development of objectives, strategies and measures does not mark the end of the project. Successful riparian forest management requires careful consideration of how the further development will be monitored and evaluated and how changing ecological, social and economic concerns will be met.

Fig. 78: Maintenance and rejuvenation by wildlife damage (beaver)

The fact working with living material and the complexities of the interactions between hydrology, hydraulic, morphodynamics and ecological aspects of riparian systems necessitate towards an iterative multi-disciplinary approach, where the goal will be achieved by successively approximations and controlled by monitoring and evaluation.

Monitoring and evaluation may be conducted for a number of different purposes and according to the basic aspects safety, ecology and use/function including:

- Performance evaluation of the project implementation and realisation of measures (e.g. were measures realised correctly?)
- Monitoring of ecological long-term changes (e.g. monitoring of water quality by periodical sampling)
- Assessment of potential safety risks (e.g. flood risk)
- Baseline monitoring

Important for monitoring:

- Sufficient amount of information needed
- Including physical, biological and chemical parameters
- Sampling, measurements at different spatial/temporal scales
- Use of methods, techniques and interpretation of results
- Basic questions:
  - o Implementation: were measures realised correctly ?
  - o Effectiveness: did measures achieve the project objectives ?
  - o Validation: is the technical and scientific background correct ?

Monitoring - Development of vegetation - Brush mattress

Fig. 79: Construction of brush mattress with willows

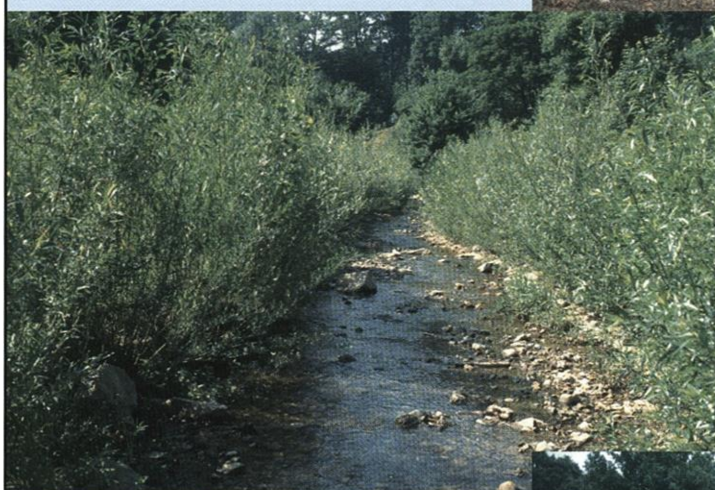

Fig. 80: Brush mattress with willows after one period of growth

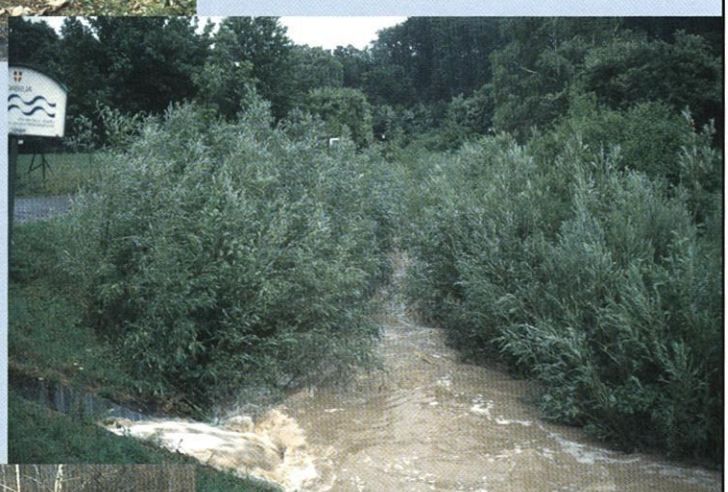

Fig. 81: Development of the brush mattress with willows after 2 years (summer)

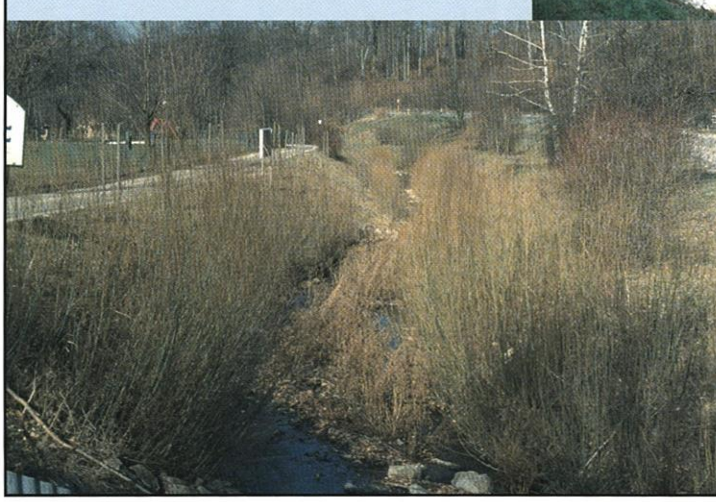

Fig. 82: Development of the brush mattress with willows after 2 years (winter)

Keep in mind for MONITORING / EVALUATION!

- Consider time and cost expenses and chose only the necessary commitments
- The questions of public and society should be considered in the monitoring objectives
- Monitoring is both, measuring changes and finding explanations for it
- Include natural changes in monitoring and consider global coherences
- Include long-term effects of historical development of the area
- Fix the locations for measurements, samples or photographs to keep comparability
- Consider macroinvertebrate numbers as a reliable short-term indicator for sedimentation
- Consider macroinvertebrate diversity and fish community as a reliable indicator for long-term changes

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3.9 Monitoring/Evaluation

Wien river - The Soil Bioengineering Test Flume:

By means of a monitoring study of the test flume at the Wien river and by observing the development of vegetation for several years, material properties of riparian wood (i.e. bending behaviour, flexibility, pulling-out resistance, capability to develop adventitious roots) has been surveyed, also taking into consideration its hydraulic influence.

Documentation of the development of vegetation by means of the following pictures:

Fig. 83: Test flume immediately after its completion (1998)

Fig. 84: Vegetation 4 months after the completion (1998)

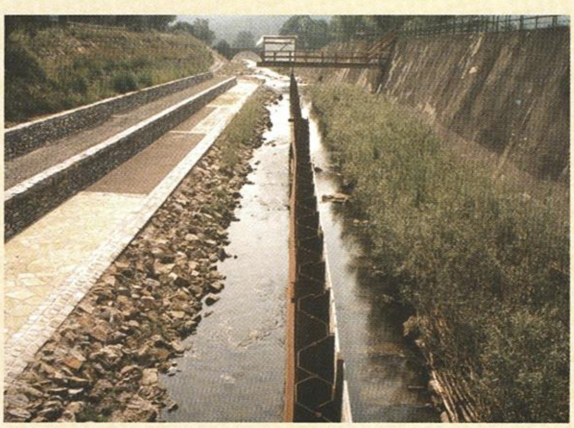

Fig. 85: Vegetation after one growth period (1999)

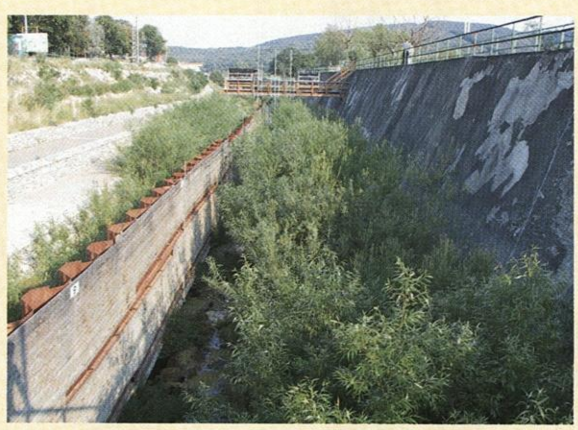

Fig. 86: Development of vegetation after 3 years (2001)

Case Study

In order to be able to describe the development of the vegetation, a complete vegetation sampling was carried out twice a year (see chapter 3.2.2.2, Case study methods Wien river).
Development can be described according to the statistic analysis and evaluation of the mapped parameters as well as by comparing data.

For investigating the influence bank vegetation has on discharge behaviour, artificial floodings are carried out at the test flume several times per year. Different hydraulic parameters (e.g. flow velocity, rating curve etc.) are observed and recorded.

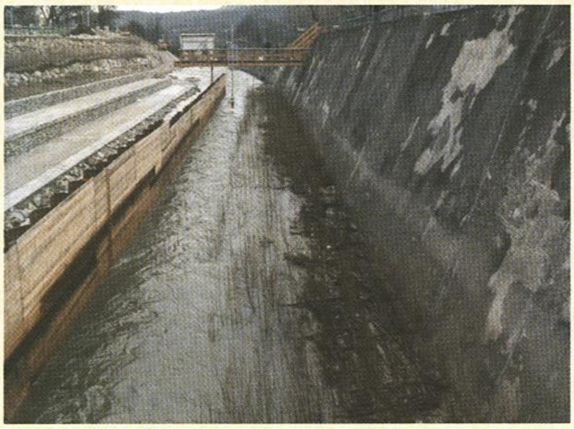

Fig. 87: Artificial flooding March 1999 (low discharge)

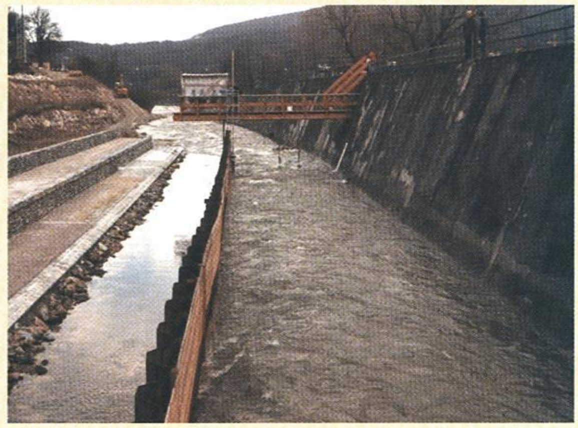

Fig. 88: Artificial flooding March 1999 (highest discharge)

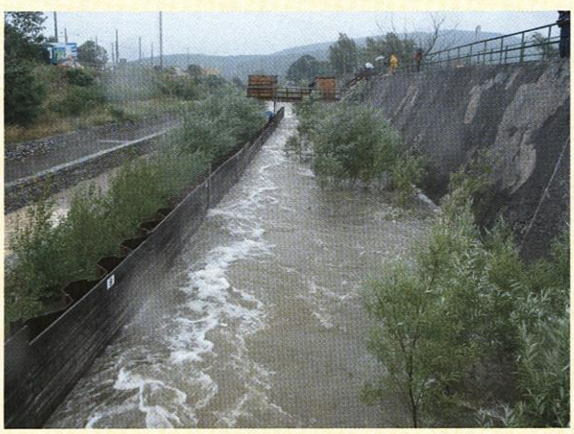

Fig. 89: Artificial flooding July 2002

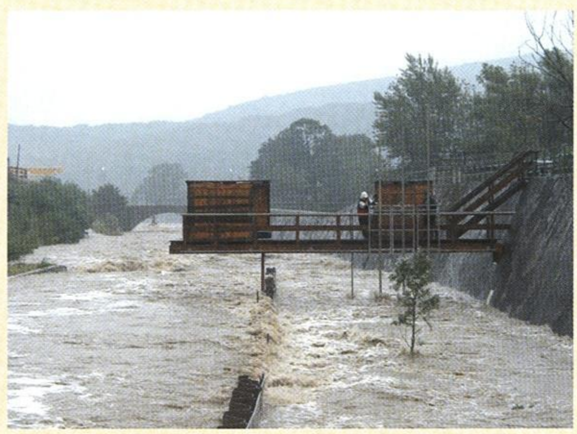

Fig. 90: Natural flood event August 2002

By comparing the data of vegetation development with the data of hydraulic measurements (also see chapter 3.2.2., Case study methods Wien river – velocity measurements, observation of water level), the influence bank vegetation has on the relation of discharge (distribution of velocity, water level, erosion etc.) can be described comprehensively.

<u>Outlook and practical application:</u>
The test flume offers the possibility to investigate the behaviour of coppice stocks under natural habitat conditions. This means that the planted bush willows and tree willows can develop equally to those at other streaming waters. For those people planning and working at streams and rivers, these results show the importance of making a difference between bank protection and structuring measures.
In order to guarantee an adequate bank protection, hydraulically smooth bioengineering constructions like brush mattresses, branch packing and fascine rows are needed, which grow densely and guarantee a rapid growth of coppice. From a diameter of 4 cm onwards, first maintenance measures have to be taken (cut down to the stump).
In order to keep the cost for maintenance low, the selection of coppice should only include bushes, and mainly those kinds that are flexible, like e.g. the common osier, the almond-leaved willow, the black willow and the purple willow (FLORINETH, F., MEIXNER, H., RAUCH, H.P., VOLLSINGER, S., 2003).

RipFor Case Study

Typical monitoring results - Wien river:

- *Local velocity measurements:*

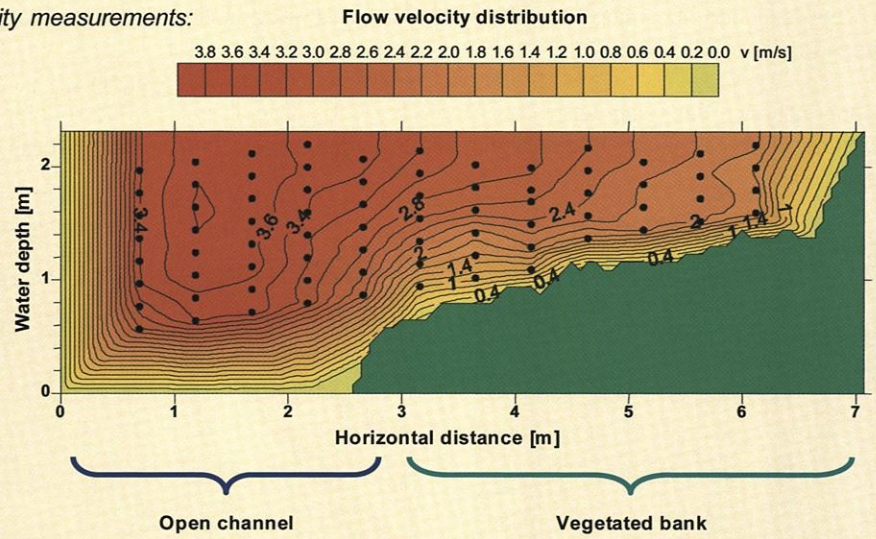

Fig. 91: Wien river results: flow velocity distribution in a cross section

- *River gauges:*

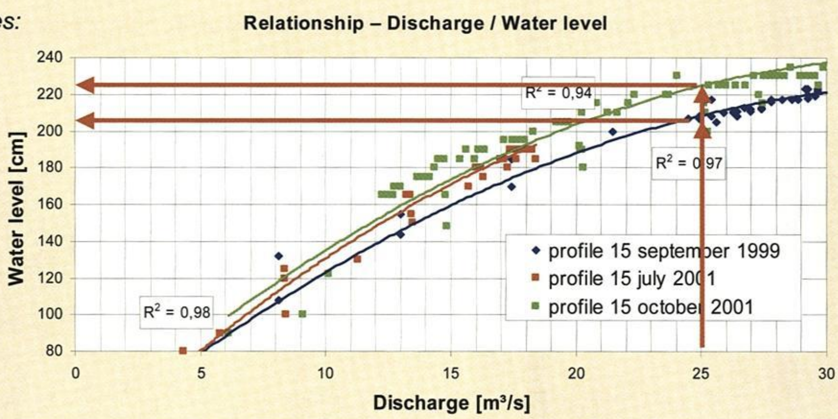

Fig. 92: Wien river results: relationship between the observed water levels and the discharge over a period of several years

- *Complete vegetation mapping:*

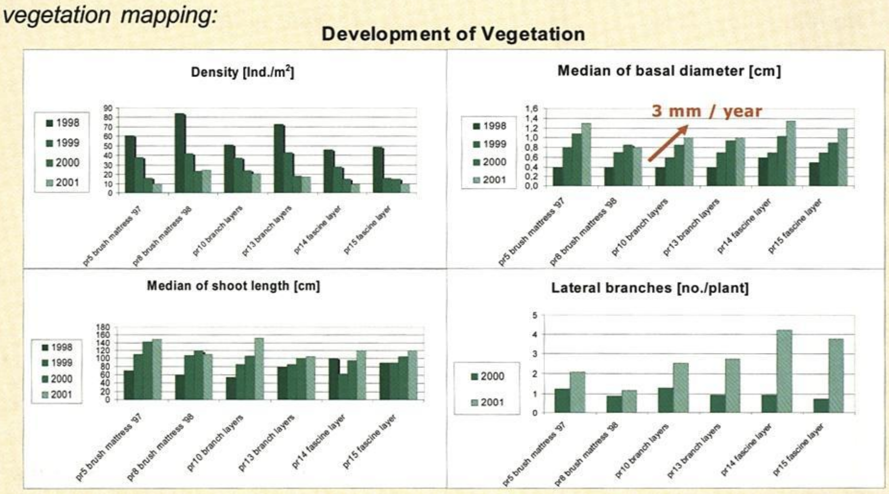

Fig. 93: Wien river results: development of observed parameters over several years. Comparing the annual data provides an overview of the development of the bank vegetation

Case Study

Enz - River restoration

The river Enz restoration has the character of a pilot project for restoration in Germany. Therefore, monitoring was an obligatory task to analyse and document the impacts of the realised measures together with its resulting practical experiences.

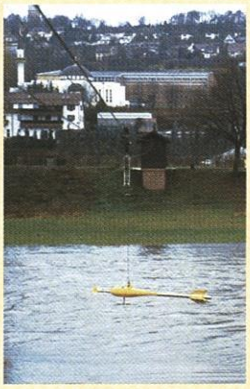

Fig. 94 (left): Local velocity measurements Local velocity measurements with a propellermeter mounted on a cableway at the gauging station

Fig. 95 (middle): Floating debris mapping The maximum water level during a flood event was reconstructed (light blue layer in the picture) by analysing the boundary of debris deposition (in this case mainly leaves)

Fig. 96 (right): Periodical mapping and levelling of cross sections Periodical mapping and levelling of cross sections to identify erosion and aggregation processes related to vegetation growth and flood

Methods used in monitoring:

- *Permanent mapping of water level by multiple pressure gauges*
- *Local velocity measurements with propellermeters*
- *Local bedload and suspended load measurements by adding tracer sediments to the flow*
- *Periodical photographs to document the development of the entire restoration*
- *Vegetation mapping*
- *Mapping of floating debris deposition to reconstruct water level*
- Application of compound channel formula to back-calculate changes in roughness due to vegetation

Development of vegetation:

Fig. 97: River Enz restoration after realisation in 1991

Beginning of vegetation growth on the blank floodplains and diversified hydraulic structures (e.g. flow velocities and currents)

Fig. 98: River Enz three years after realisation (1993)

Berm vegetation of mostly flexible willow bushes came up. The floodplains were maintained by mowing in order to support the growth of tree plantings.

Fig. 99: River Enz twelve years after realisation (2002)

Berm as well as floodplain vegetation has grown to larger bushes and trees with rigid properties.
At this point maintaining measures (cutting, pruning) are important to decrease the hydraulic roughness and discharge capacity.

4. CONCLUSION

Riparian Forest Management is largely in an experimental stage. Site-specific or local conditions must be considered to be successful. Design criteria, standards and classifications therefore should be for the specific project in a specific physical, climatic, geographical locations. They should however work with, rather than against the larger systems of which they are an integral part.

These guidelines were developed with the focus on hydraulic, sedimentary, and ecological aspects of the riparian forest management. They fill an essential gap in the existing drafts for riparian forest management and are a further step towards a comprehensive understanding of riparian forest processes and management principles.

5. References

5.1 Figures and tables

APPA, Agenzia Provinciale per la Protezione Dell'Ambiente, Italy

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Department of Earth Sciences, Institute of Geographical Sciences, Freie Universität Berlin

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Department of Soil Bioengineering and Landscape Construction, University of Agricultural Sciences, Vienna

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Tables: 1, 2, 5

GERHARD, H.: The River Rhine – Anthropogenic impact on the runoff regime. In: Deutsches Nationalkomitee für das Internationale Hydrologische Programm (IHP) der UNESCO und das Operationelle Hydrologische Programm (OHP) der WMO (Hrsg.): IHP/OHP-Berichte, Sonderheft 9; Koblenz 1996

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Gewässerdirektion (GWD) Südlicher Oberrhein/Hochrhein, Projektgruppe Breisach: The Integrated Rhine Programm, Lahr 1997

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Institute of Water Resources Management, Hydraulic and Rural Engineering, University of Karlsruhe

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LADINIG Gernot (2001), *Der neue Wienfluss*, Magistrat der Stadt Wien

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Landschaftsarchitekturbüro Geitz + Partner GbR

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Regierungspräsidium Freiburg, Abteilung 2, Wirtschaft, Raumordnung, Bau-, Gesundheits- und Sozialwesen; Referat 21, Raumordnung, Baurecht, Denkmalschutz, http://www.rp.baden-wuerttemberg.de/freiburg/index

Figures: 17, 18, 19

5.2 Bibliography

Including references of annex

AG BODEN (1994): Bodenkundliche Kartieranleitung - „KA4“, 4. verb. u. erw. Aufl., ber. Nachdruck (1996), Hannover, 1994

AKADEMIE F. RAUMFORSCHUNG U. LANDESPLANUNG (1994): Handwörterbuch der Raumordnung, Hannover 1994

ALBERTZ, J. (2001): Einführung in die Fernerkundung, Grundlagen der Interpretation von Luft und Satellitenbildern, Darmstadt, 2001

ASCHWANDEN, H., WEINGARTNER, R. (1985): Zur Abschätzung der Abflüsse in ungemessenen schweizerischen Einzugsgebieten, Geogr. Inst. Der Univ. Bern, Abt. Physik, Georg. Gewässerkunde, Publikation Gewässerkunde Nr. 66

BARKMAN, J.J. (1988): A new method to determine some characters of vegetation structures, In: WERGER, M.J.A. (ed.): The study of vegetation, Dr. W. Junk Pibl., The Hauge

BARSCH,H., BILLWITZ, K., BORK, H.-R. (Hrsg.) (2000): Arbeitsmethoden der Physiogeographie und Geoökologie. Gotha, 2000

BIRKELAND, P.W. (1984): Soils and Geomorphology, New York, Oxford, 1984

BITTERLICH, W. (1949): Die Winkelzählprobe, Dissertation an der Hochschule für Bodenkultur Wien

BITTERLICH, W. (1984): The Relascope Idea - relative measurements in forestry, Commonwealth Agricultural Bureaux, London

BLYTH, F.G.H., FREITAS, M.H. (1973): A Geology for Engineers, Edward Arnold, London

BÖLSCHER, J. (2002): Oral communication, Berlin, 2002

BONHAM, C.D. (1989): Measurements for terrestrial vegetation, Wiley & Sons, New York

BRAUN-BLANQUET, J. (1964): Pflanzensoziologie, Grundzüge der Vegetationskunde, Springer Verlag, Wien, 1964

BWG - BUNDESAMT FÜR WASSER UND GEOLOGIE - SCHWEIZ (2003): Geologische Karten, In: http:/ /www.bwg.admin.ch/themen/geologie/d/karten.htm,Biel, Ittigen, 2002

CANSIER, D. (1993): Umweltökonomie, Stuttgart,1993

CASLEY, D. J., KUMAR, K. (1987): Project monitoring and evaluation in agriculture, Baltimore and London: Johns Hopkins University Press (published for the World Bank

CHOW, V. T. (1959): Open-Channel Hydraulics, McGraw-Hill Book Company, New York

CUNGE. J.A., HOLLY, F.M.Jr, VERWEY, A. (1980): Practical Aspects of Computational River Hydraulics, Pitman Advanced Publishing Program, Boston, London, Melbourne

DIERSCHKE, H. (1994): Pflanzensoziologie – Grundlagen und Methoden, Ulmer Verlag Stuttgart, 1994

DOLKE, M. (1994): Der Einfluss der Schafbeweidung von Kalkmagerrasen in der Südlichen Frankenalb auf die Insektenfauna (Tagfalter, Heuschrecken), Agraökologie, 10:126

DRIESSEN P.H. & DUDAL R. (1991): The major soil of the world, Agricultural University of Wageningen, Katholike Universiteit Leuven, New York, 1991

DVWK (Deutscher Verband für Wasserwirtschaft und Kulturbau e.V.) (1991): Merkblätter zur Wasserwirtschaft, Hydraulische Berechnungen von Fliessgewässern, DK 551.51/54, DK 532.543, Verlag Paul Parey, Hamburg und Berlin, 1991

FAO-UNESCO (1987): Soils of the World, Food and Agriculture Organization and United Nations Educational, Scientific and Cultural Organization, New York, 1987

FLORINETH, F., MEIXNER, H., RAUCH, H.P., VOLLSINGER, S. (2003): Gehölze an Fließgewässern - Eigenschaften, hydraulischer Einfluss und Verhalten, Landnutzung und Landentwicklung, Volume 44, Blackwell Verlag, Berlin, 2003

FRANKENBERG, P. (1982): Vegetation und Raum, UTB Schoningh, Paderborn, München, Wien, Zürich

FUJITA, I., NAKASHIMA, T. (1999): Image-Based Technique for River Monitoring Proceedings of the 28th Congress of IAHR, S. 425

GEITZ, KUSCHE, KAPPICH (2000): Musterunterhaltungsplan Enz für den Streckenabschnitt der naturnah ausgebauten Pilotstrecke in Pforzheim (Erläuterungsbericht). Landschaftsarchitekturbüro Geitz + Partner GbR, Stuttgart

GERSTBERGER, P., ZIEGLER, W. (1993): A laser- densiometer for measuring horizontal vegetation density, In: Bayreuther Institut für Terrestrische Ökosystemforschung (BITÖK) (Hrsg.): BITÖK Forschungsbericht 1993: 219-221

GRAF, H.G. (1971): Hydraulics of Sediment Transport. McGraw-Hill Book Company, New York

GRIMM, F. (1968): Das Abflussverhalten in Europa – Typen und regionale Gliederung, Wiss. Veröff. D. Inst. f. Länderk., N. F. 25/26: 18-180

HAKE, G. (1982): Kartographie – Teil 1, Allgemeines, Erfassung der Informationen, Netzentwürfe, Gestaltungsmerkmale, Topographische Karten, Berlin, New York 1982

HAKE, G. (1985): Thematische Karten, Atlanten, kartenverwandte Darstellungen, Kartenredaktion und Kartentechnik, rechnergestützte Kartenherstellung, Kartenauswertung, Kartengeschichte, Berlin, New York 1985

HAKE, G., GRÜNREICH, D. (1994): Kartographie, Berlin, New York, 1994

HENTSCHEL, B. (2000): Hochgeschwindigkeitsvideokamera im wasserbaulichen und geotechnischen Versuchswesen, Mitteilungsblatt der Bundesanstalt für Wasserbau Nr. 82, S. 119 – 121

HERSCHY, R.W. (1985): Streamflow Measurement, Elsevier Applied Science Publishers, London, New York

HIGGITT, D.L., WARBURTON, J. (1999): Applications of differential GPS in upland fluvial geomorphology, Geomorphology 29, Issues 1 - 2. S. 121 – 134

HYDRAULIC MODELING OF CIVIL ENGINEERING STRUCTURES (1982): BHRA Fluid Engineering, Coventry, England

HYDRAULICS RESEARCH, WALLINGFORD (1988): Assessing the hydraulic performance of environmentally acceptable channels, Report EX 1799, Wallingford

IWK (1989): Wasserbauliches Gutachten "Renaturierung der Enz in Pforzheim", Auftraggeber Stadt Pforzheim/Wasserwirtschaftsamt Freudenstadt, vormals Institut für Wasserbau und Kulturtechnik (IWK), Universität Karlsruhe (TH)

IWK (2000): Bewertung der morphologischen und hydraulischen Auswirkungen der Hochwasserereignisse 1999 im Rhein zwischen Märkt und Breisach. Institut für Wasserwirtschaft und Kulturtechnik (IWK), Universität Karlsruhe (TH)

IWK (1998): Untersuchungen zum Vorlandabtrag zwischen Märkt und Karpfenhod (Schlußbericht). Institut für Wasserwirtschaft und Kulturtechnik (IWK), Universität Karlsruhe (TH)

IWK (1999): „Gewässerunterhaltung", Umdrucke zur Vorlesung, Institut für Wasserwirtschaft und Kulturtechnik (IWK), Universität Karlsruhe (TH)

JESSEL, B., TOBIAS, K. (2002): Ökologisch orientierte Planung, Eine Einführung in Theorien, Daten und Methoden- UTB Nr. 2280, Verlag Eugen Ulmer, Stuttgart, (Buchveröffentlichung in der mittleren UTB-Reihe, ISBN 3-8252-2280-2)

KAMPHUIS, J.W. (1974): Determination of sand roughness for Fixed Beds. IAHR, Journal of Hydraulic Research, Vol. 12, No. 2, 1974

KENT & COCKER (1992): Vegetation Description and Analysis, London: 363

KEULEGAN, G.H. (1938): Laws of turbulent flow in open channels, J. Res. Nat. Bureau of Standards, 21(6), pp. 707-741

KLAPP, E. (1930): Zum Ausbau der Graslandsbestandsaufnahme zu landwirtschaftlich-wissenschaftlichen Zwecken, Pflanzenbau, 6: 197-210

KLUCZKA, G. (1980): Grundlagen, Entwicklung und Probleme der Raumordnung, Geogr. Rundsch. 31: 140-145

KREEB, K-H. (1983): Vegetationskunde- Methoden und Vegetationsformen unter Berücksichtigung ökosystematischer Aspekte, Verlag Eugen Ulmer, Stuttgart, 1983

LAWLER, DAMIAN (2002): Automated monitoring of Bank erosion dynamics: new developments in the Photoelectronic Erosion Pin (PEEP) System, In: Erosion and Sediment Transport Measurement in Rivers: Technological and Methodological Advances, Volume of Extended Abstracts from the International Workshop in Oslo, Norway, 19 – 21 June 2002

LEOPOLD, L.D., WOLMAN, M.G., MILLER, J.P. (1964): Fluvial Processes in Geomorphology, Freeman, San Fransisco, 1964

LINDNER, K. (1982): Der Stroemungswiderstand von Pflanzenbestaenden, Mitteilungen Leichtweiss- Institut für Wasserbau, Heft 75, TU Braunschweig

LONDO, G. (1976): The decimal scale for releves of permanent quadrats, Vegetatio, 33: 61-64

LONGLEY, P.A., GOODCHILD, M.F., MAGUIRE, D.J., RHIND, D.W. (2001): Geographic Information Systems and Science, New York 2001

MAAS, D., KOHLER, A. (1983): Die Makrophytenbestände der Donau im Raum Tuttlingen, Landschaft + Stadt, 15(2): 49-60

MAIDMENT, D.R. (1992): Handbook of Hydrology, McGraw-Hill Book Company, New York

MEIXNER, H., RAUCH, H.P., SSCHREIBER, J., VOLLSINGER, S., (2002): Sediment transport on vegetated bank of the soil bioengineering test flume at the Wien river, In: European Geophysical Society (Ed.): Geophysical Research Abstracts, Vol.4, 27th General Assembly

MEIXNER, H., VOLLSINGER, S., RAUCH, H.P. (2002): Artificial Flooding of the Soil Bioengineering Test Flume at the Wienfluss River, 2nd International Conference „New Trends in Water and Environmental Engineering for Safety and Life: Eco-compatible Solutions for Aquatic Environments", 24th - 28th, Capri (Italy); ISBN 88-900282-2-X

MERTENS, W. (1989): Zur Frage hydraulischer Berechnungen naturnaher Fließgewässer, Wasserwirtschaft 84, H3

MEYER-PETER, E., MÜLLER, R. (1948): Eine Formel zur Berechnung des Geschiebebetriebs. Schweizerische Bauzeitung , 67.Jahrg., Seiten 29-32

MUELLER-DOMBOIS, D., ELLENBERG, H. (1974): Aims and methods of vegetation ecology, Wiley, New York

MÜHLENBERG, M. (1993): Freilandökologie, 3. überarbeitete Auflage - UTB für Wissenschaft 595, Quelle & Meyer, Heidelberg, Wiesbaden

MURAWSKI, H. (1992): Geologisches Wörterbuch, München, 1992

NAUDASCHER, E. (1992): Hydraulik der Gerinne und Gerinnebauwerke, Springer Verlag, Wien, New York

NAWA, R.K., FRISSELL, C.A. (1993): Measuring Scour and Fill of Gravel Stream Beds with Scour Chains and Sliding-Bead Monitors, In: North American Journal of Fisheries Management 13. S. 634-639

NIEDERSÄCHSISCHES LANDESAMT FÜR BODENFORSCHUNG (2002): Arbeitsblatt Methoden zur Standorterkundung, In: Schriften zu Abfallwirtschaft und Altlasten, Hannover, 2002,

NUDING, A. (1991): Fließverhalten in Gerinnen mit Ufergebüsch, Mitteilungen, TH Darmstadt, H35

OPPERMANN, R. (1989): Ein Meßinstrument zur Ermittlung der Vegetationsdichte in grasig-krautigen Pflanzenbeständen, Natur und Landschaft, 64: 332-338

PARDÉ, M. (1947): Fleuves et Rivieres, 3. Aufl. Paris, 1947

PASCHE, E. (1984): Turbulenzmechanismen in naturnahen Fließgewässern und die Möglichkeit ihrer mathematischen Erfassung, Diss. RWTH Aachen

PASCHE, E., ROUVE, G. (1985): Overbank flow with vegetatively roughened floodplains, Journal of the American Society of Civil Engineers, Hydraulics Div.; 111(9):1262-1278

PERRY, S.G., FRASER, A.B., THOMPSON, D.W., NORMAN, J.M. (1988): Indirect sensing of plant canopy structure with simple radiation measurements, Agric. For. Meteorol., 42:255-278

PLATE, E. J., QURAISHI, A. A. (1965): Modeling velocity distribution inside and above tall crops, J. Appl. Meteorology, 4(3), pp. 400-408

POLLANSCHÜTZ, J. (1974): Formzahlfunktionen der Hauptbaumarten Österreichs, Allgemeine Forstzeitung Jg. 85

PRESS, F., SIEVER, R. (1985): Earth, New York, 1985

PRODAN, M. (1965): Holzmesslehre, Verlag J. D. Sauerländer, Frankfurt am Main

RAUCH, H.P, MEIXNER, H., VOLLSINGER, S. (2002): Installation and hydraulic impact of close to nature structures at the Wienfluss River, In: Gesellschaft für Erdkunde zu Berlin (Hrsg.), Hydrology working group meeting, Gesellschaft für Erdkunde zu Berlin, 10. März 2002, Berlin, 10-15, Berlin

ROSSITER, D.G. (2001): Principles of Soil Classification, ITC Enschede, 2001

RUBIN, D.M. et al. (2001): Use Of Rotating Side-Scan Sonar To Measure Bedload. Proceedings of the Seventh Federal Interagency Sedimentation Conference, Nevada, USA, 2001

RUKAVINA, N A (2000): Sedimentology of Contaminated St Lawrence River Sediments at Cornwall, Ontario National Water Research Institute Contribution No. 00-052. Ontario, 2000

SCHACHTSCHABEL, P., BLUME, H.-P., BRÜMMER, G., HARTGE, K.-H. & SCHWERTMANN, U. (1998): Lehrbuch der Bodenkunde, Stuttgart, 1998

SCHLICHTING, E., BLUME, H.-P. & STAHR, K. (1995): Bodenkundliches Praktikum, 2. neubearb. Auflage, Berlin, Wien, 1995

SCHNEIDER, K-J (1997): Bautabellen für Ingenieure, Werner Verlag, Düsseldorf

SCHOLLES, F., (1997): Abschätzen, Einschätzen und Bewerten in der UVP, Weiterentwicklung der Ökologischen Risikoanalyse vor dem Hintergrund der neueren Rechtslage und des Einsatzes rechnergestützter Werkzeuge, 273 S., Dortmund (UVP-Spezial, 13)

SCHULZ, G. (1991): Lexikon zur Bestimmung der Geländeformen in Karten, Berliner geographische Studien, Band 28, Berlin, 1991

SMITH, J. R. (1997): Introduction to Geodesy: The History and Concepts of Modern Geodesy (Surveying & Boundary Control), John Wiley & Sons, New York

STEIDL, T. (1991): Typologie und Abflußverhalten österreichischer Fließgewässer – Hydrologisch hydrographische Einteilung und regionale Gliederung, Diplomarbeit an der Universität für Bodenkultur

STEIGER, J. (1996): Untersuchungen zur aktuellen fluvialen Dynamik und Auenentwicklung eines mäandrierenden Flachlandflusses: Die Garonne in SW Frankreich, Inaugural-Dissertation zur Erlangung der Doktorwürde des Fachbereiches Geowissenschaften der Freien Universität Berlin, Berlin 1996

STERBA, H. (1984): Holzmesslehre – nach der Vorlesung von H.Streba, 2. Korrigierte Auflage, Berichte aus der Abteilung Holzmesskunde und Inventurfragen des Inst. F. forstl. Ertragslehre der Univ. f. Bodenkultur Wien, Wien, 1986

STERBA, H. (1991): Berichte aus der Abteilung Holzmesskunde und Inventurfragen, 3. Auflage, Eigenverlag des Instituts für Forstliche Ertragslehre der Universität für Bodenkultur, Wien

STORM, P.-C., BUNGE, T. (1988): Handbuch der Umweltverträglichkeitsprüfung (HdUVP) - Losebl.-Ausg. Berlin 1988

SUNDERMEIER, A., MEISSNER, A. (in Vorb.): The Structure Measuring Tube a method for quantitative and qualitative investigation of vegetation structure

U.S. DEPARTMENT OF THE INTERIOR, U.S. GEOLOGICAL SURVEY, CENTER FOR COASTAL GEOLOGY (2002): Remote Video Monitoring - About the Remote Video Monitoring System -.In: http://coastal.er.usgs.gov/rvm/about.html

UBA - UMWELTBUNDESAMT (1998): Handbuch des vegetationsökologischen Monitorings – Methoden, Praxis, angewandte Projekte – Teil A: Methoden, Umweltbundesamt, Wien, 1998

USDA – Soil Survey Staff (1999): Soil Taxonomy, A basic System of Soil Classification for Making and Interpreting Soil Surveys, Agriculture Handbook Nr. 436, US Dep. Agric. Soil Conserv. Service, Washington D.C., 1999

USDA (1996): Keys to soil Taxonomy, US Dep. Agric. Soil Conserv. Service, Washington D.C., 1996

VAN DER MAAREL, E. (1970): Vegetationsstruktur und Minimum-Areal in einem Dünen-Trockenrasen, In: TÜXEN, R. (Hrsg.): Gesellschaftsmorphologie, Ber. Int. Symp. Int. Ver. Vegetationskunde, Rinteln 1966: 218-239

VOLLSINGER, S., MEIXNER, H., RAUCH, H.P. (2002): Development and hydraulic action of vegetation growing from soil bioegnineering structures, In: European Geophysical Society (Ed.): Geophysical Research Abstracts, Vol.4, 27th General Assembly

WEHRKAMP, G. (1954): Ein neues Flussprofilmessgerät, Mitteilungsblatt der Bundesanstalt für Wasserbau Nr. 3, S. 5 – 13

WEIMANN, J. (1995): Umweltökonomik, Eine theorieorientierte Einführung, Berlin, 1995

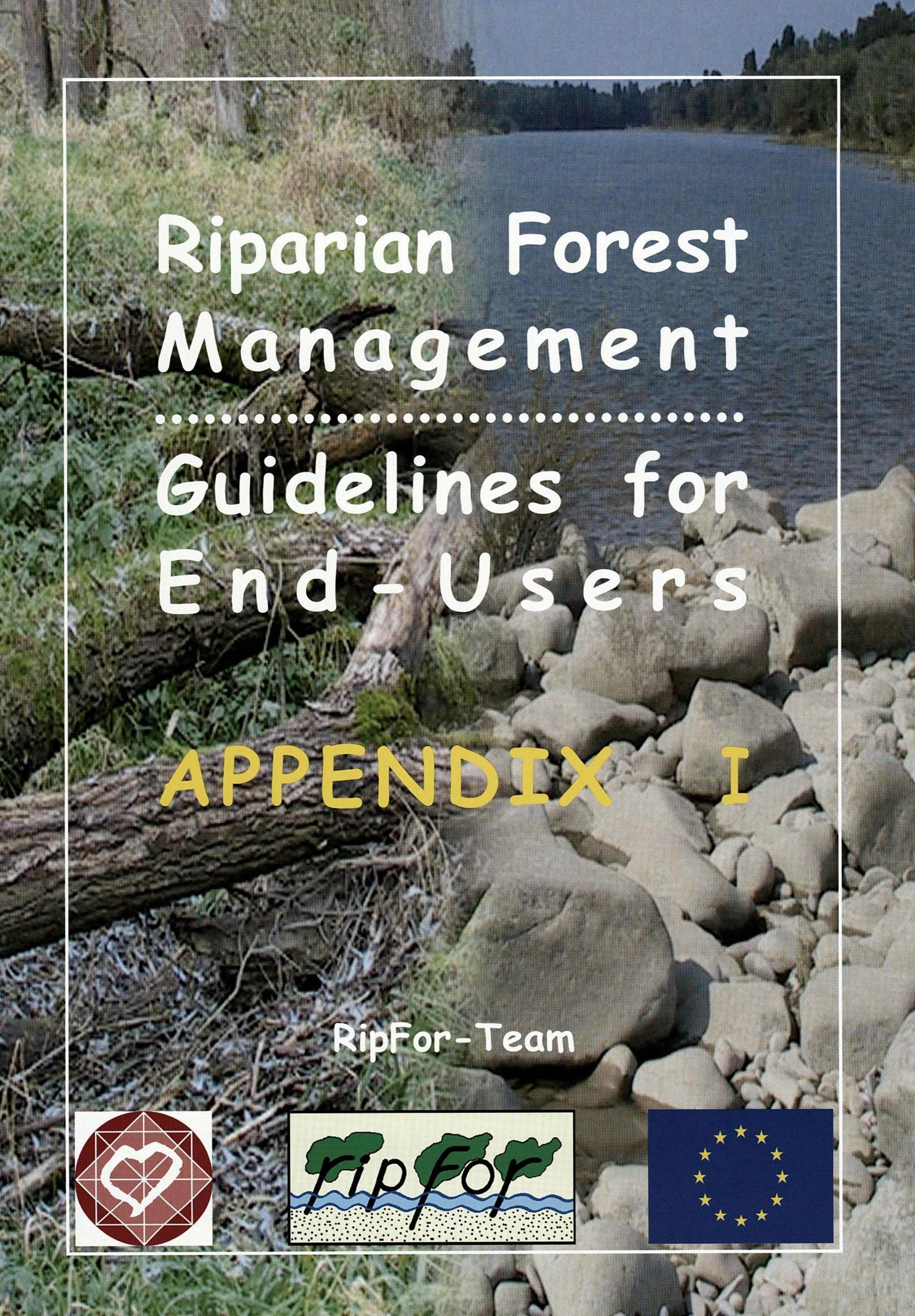
WESSELS, A.C.E. (1986): Measuring Techniques in Hydraulic Research, Delft Hydraulics Laboratory

WICKE, L. (1989): Umweltökonomie, 2.Auflage, München, 1989

WITTE, A. (1994): Untersuchungen zur Bimassenentwicklung und Rauminanspruchnahme von ausgewählten Pflanzen in einem Magerrassen in Abhängigkeit eines Nährstoffgradienten unter Einbringung von Urtica diocia, Unveröff. Diplomarbeit Univ. Stuttgard, Inst. f. Landschaftsplanung u. Ökologie: 95

WITTE, A., HERRMANN, S. (1995): Untersuchungen zur oberirdischen Bimassenentwicklung und Rauminanspruchnahme von Pflanzen in einem Halbtrockenrassen unter Nährstoffeinfluß, Verh. GfÖ, 24:577-580

YALIN, M.S. (1971): Theory of hydraulic models, The Macmillan Press, London and Basingstoke



Riparian Forest Management

Guidelines for End-Users

APPENDIX I

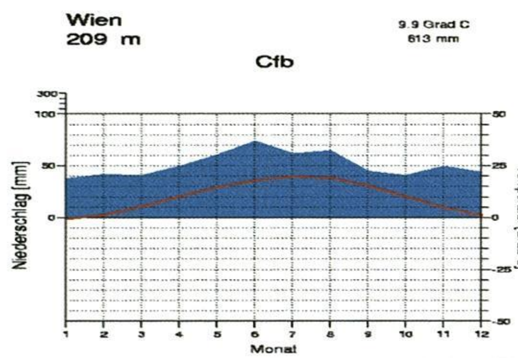
RipFor-Team

Table of Contents - Appendix I

1. General characterisation

1.1 Description of catchment area

Description of catchment area		
River name		
Stream km		
Source level	Altidudinal typology	Lowland:<200 m
		Mid: 200-800 m
		High: >800 m
	Geographical region	
Catchment area	Small: 10 - 100 km²	
	Medium: 100 - 1000 km²	
	Large: 1000 - 10000 km²	
	Very large: >10000 km²	
River length	Upstream of project area	
Climate of catchment area		



Dominant geology of catchment area	Basement	
	Sedimentary	Siliceous
		Calcareous
		Organic

To describe the catchment area no support is necessary.

1.2 Description of project area

Description of project area		
1. General description		
Name		
Location	Country / Region / Community	
Project area	Extension stream km	
	Area	
	Length / Width	
	Elevation	
2. Hydrology / Geomorphology		
Hydrology	Discharge statistics	NNQ / MMQ
		MQ
		MHQ / HHQ
	Discharge regime	
Geo-morphology	Geology	
	Relief	
	River course / Valley contour	
3. Ecology		
Ecoregion	According to EWFD	
Biocenotical type / Fish zone		
Vegetation	Altitudinal characterisation	
Wildlife protection area		
Land use / Function (Valley floor)		
Water quality	Water quality map	
4. Historical development		
River channel	Description	
River corridor		
Floodplain		

Support for:

Discharge statistics:

Literature: e.g. Hydrological Yearbook

Discharge regime:

Hydrological regimes reflect the water balance and its changes in the course of time, and they are the result of the interaction of all flow determining factors of a certain catchment area.

Literature: PARDÉ (1947); KRESSER (1961); GRIMM (1968); ASCHWANDEN & WEINGARTNER (1985); STEIDL (1991) MADER, WIMMER, STEIDL (1998)

2. Description of methods

2.1 Methods - Hydrology and Hydraulics

	Methods	River gauges (stations)	Floodplain gauges	Statistical Analysis of existing discharge data	Basic hydraulic formula	GMS universal flow formula	Colebrook-White universal flow formula	Könemann compound channel formula	Einstein/Horton compound roughness formula	Lindner (DVWK) flow formula for rigid vegetation	Mertens (DVWK) vegetated trapezoidal channel formula	Pasche (DVWK) vegetated compound channel formula	Nuding vegetated compound channel formula	Roughness of aquatic vegetation	Formula for aquatic (submerged) vegetation	Bed roughness formula (logarithmic law)	Flow attack (momentum equation)	Woody debris mapping/levelling	Local velocity measurements	Physical modeling	Numerical modeling
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Goal	Discharge	x	x	x	x															x	x
Goal	Flow velocity				x	x	x	x	x	x	x	x	x	x	x	x			x	x	x
Goal	Waterlevel	x	x		x													x		x	x
Goal	Bed roughness															x				x	x
Goal	Bed stability																x			x	x
Goal	Roughness of macrostructures					(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)							x	x
Goal	Roughness of vegetion									x	x	x	x	x	x					x	x
Goal	1d (depth- and width-averaged)	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x		x
Goal	2d (depth-averaged)				x						x	x	x						x		x
Goal	3d-approach				x											x	x		x	x	x
Area	River	x		x	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x
Area	Floodplain		x		x	(x)	(x)	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scale	Test site	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scale	Project area	x	x	x														x		x	x
Scale	Catchment area			x																	x
Connection	Hydrology and Hydraulics																				
Connection	Morphodynamics																				
Connection	Vegetation science																				
Connection	Specific ecological science																				
Connection	Socio-Economics																				
Application	Stage of Project	3.2 / 3.4 / 3.7 / 3.9	3.2 / 3.4 / 3.7 / 3.9	3.2 / 3.4 / 3.3 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.9	3.2 / 3.9	3.2 / 3.5 / 3.6 / 3.7	3.2 / 3.5 / 3.6 / 3.7

1. River gauges (stations):

⇒ Water level, discharge

There are different types of river gauges (staff gauge, float gauge, pneumatic gauge, electromagnetic gauge, Archimedes-gauge) that are able to measure the water level or water depth. In many cases gauging stations with data loggers are built at important control sections of rivers, whereby the control-cross section is a stable concrete profile. For this profile, calibration can be performed to get a steady discharge-water depth relation.
Literature: MAIDMENT, D.R. (1992)

2. Floodplain gauges:

⇒ Water level, discharge

Basically, floodplain gauges use the same techniques as river gauges. But they have to consider specific floodplain conditions such as periods of drought and a temporal and spatial resolution high enough to record the dynamics of floodplain flows.
Literature: MAIDMENT, D.R. (1992)

3. Statistical analysis of existing discharge data:

⇒ Discharge occurrence and annuality

Statistical discharge of floods is essential for prediction of flood risk and within all stages of river management. Statistical analysis needs discharge over time recordings (e.g. from gauging stations) to calculate occurrence and annuality of flood events. In most cases, the data is available for public use from water authorities and gauging station operators.
Literature: MAIDMENT, D.R. (1992)

4. Basic hydraulic formulae (continuity, momentum and energy equilibrium):

⇒ Fundamental hydraulics

The three profound formulae of continuity, energy and momentum equilibrium are used in almost every hydraulic consideration.
Literature: CHOW, V. T. (1959)

5. GMS universal flow formula:

Geometry, hydraulic roughness ⇒ discharge, flow velocity

$$V = k_{St} \cdot R^{2/3} \cdot I_E^{1/2}$$

k_{St} = *Strickler* coefficient

The GMS-formula (developed by GAUCKLER, MANNING and STRICKLER, 1923) one of the most practical and widely used empirical flow formulas to calculate discharge and flow velocities from channel roughness and geometrical data (such as hydraulic radius, water depth and longitudinal slope). Of major importance is the determination or estimation of the *Strickler* coefficient "k_{St}", that superposes the roughness of the bed, vegetation or obstacles to a single overall coefficient. The "k_{St}"-value can roughly be estimated from literature for a lot of different situations and channel types. Due to its simplicity, the GMS-formula is not able to account for complex vegetation and flow interactions (e.g. momentum transfer processes in compound vegetated channels, that is important for the morphology and hydraulics of the riparian corridor of a river).
Note that in English literature, *Manning's* "n" defined as the reciprocal of the *Strickler* coefficient is used as friction coefficient (n = 1/k_{St}).
Literature: CHOW, V. T. (1959)

6. <u>COLEBROOK-WHITE universal flow formula:</u>

Geometry, hydraulic roughness ⇒ discharge, flow velocity

$$V = \sqrt{\frac{8g}{f}} \cdot R^{2/3} \cdot I_E^{1/2}$$

f = resistance coefficient

Colebrook and *White's* formula (developed 1937) is based on pipe flow physics and has been adapted for open channel hydraulics. Similar to the GMS-formula, a roughness coefficient "f" was defined by *Darcy/Weisenbach* to quantify the roughness of the channel walls. This friction coefficient is non-dimensional and can be used independent of the unit length system. A second advantage compared to GMS is that linear superposition can be applied for multiple roughness layers (e.g. the roughness of the bed and the vegetation cover can be summarized to one value).

Literature: CHOW, V. T. (1959)

7. <u>KÖNEMANN compound channel formula:</u>

Geometry, hydraulic roughness ⇒ discharge, flow velocity

$$Q = \sum (A_i \cdot k_{sti} \cdot R_i^{2/3} \cdot I_{Ei}^{1/2})$$

The *Könemann* formula is an easy approach for compound channels, that calculates flow velocities and discharge by separating cross sections with quasi-uniform velocity distribution (in many cases main channel, left and right floodplain). The influence of momentum exchange (interaction) between the separated areas is thereby neglected. The roughness of the compound channel sections is represented by *Strickler* coefficients. The wetted perimeter of the vertical separating lines have to be added on the wetted perimeter of the deeper part of the channel (e.g. the main channel).

Literature: SCHNEIDER, K-J (1997)

8. <u>EINSTEIN/HORTON compound roughness formula:</u>

Geometry, hydraulic roughness, isovelocity structure ⇒ discharge, flow velocity

$$k_{st} = \left(\frac{U}{\sum (U_i / k_{st}^{3/2})} \right)^{2/3}$$

This formula is useful for compact channels or channels with compound roughness (e.g. trapezoidal channel with different roughness of the banks). Based on isovelocity maps, the cross section is separated along zero-shear lines (orthogonally to the isovelocity lines) into areas with uniform roughness conditions. There upon the discharges and mean velocities of the multiple sections can be calculated.

Literature: NAUDASCHER, E. (1992)

9. <u>LINDNER (DVWK) flow formula for rigid floodplain vegetation:</u>

Geometry, vegetation structure ⇒ roughness, discharge, flow velocity

$$f_P = \frac{4h_P \cdot d_P}{a_x \cdot a_y} \cdot c_{WR}$$

d_P, a_x, a_y = vegetation properties

c_{WR} = form resistance coefficient

This formula has been developed for cylindrical non-submerged vegetation, that can be characterized by means of stem diameter and spacing (bed area covered by a single plant). The approach assumes that the vegetation acts like rigid cylinders and no streamlining or compression of the vegetation occurs. Still it provides reliable results and a first approach to many different types of vegetation. The formula calculates a *Darcy/Weisbach* friction coefficient for the vegetation using the drag force approach, wherein the non-dimensional drag coefficient has to be estimated.

Literature: LINDNER, K. (1982)

10. MERTENS (DVWK) vegetated trapezoidal channel formula:

Geometry, hydraulic roughness, vegetation structure ⇒ discharge, flow velocity

$$\sqrt{\frac{8}{f_T}} = \frac{V_m}{\sqrt{g \cdot b_{III} \cdot I_S}} = 2{,}5 \cdot \ln\left(\frac{b_{III}}{k_T}\right) + 6{,}27$$

b_{III} = width parameter

f_T = flow resistance of the separation plane

k_T = roughness of the separation plane

MERTENS (1989) developed a formula for compact trapezoidal channels with vegetated banks, wherein the influence of momentum transfer between the vegetated banks and the main channel is covered. The basic idea (same as explained in *Pasche*'s method) is to separate the half cross section in five areas: Area I (in the main channel) only influenced by the bed roughness of the main channel, Area II (main channel towards the floodplain) influenced by bed roughness of the main channel and the momentum transfer interactions, Area III (floodplain towards the main channel) influenced by the vegetation and the interaction, Area IV (centre floodplain) influenced only by vegetation and Area V (floodplain banks) influenced by bank roughness and vegetation.

The difficulties arise from the estimation of the friction coefficient of the apparent shear layer between Area II and III. The greatest importance is attached to the so-called „cooperating width“ (width of Area III), that has to be iterated using data of plant properties (density, stem diameter). The formula results in a *Darcy/Weisbach* friction coefficient for the roughness of the apparent shear layer.

Literature: MERTENS, W. (1989)

11. PASCHE (DVWK) vegetated compound channel formula:

Geometry, hydraulic roughness, vegetation structure ⇒ discharge, flow velocity

$$\frac{1}{\sqrt{f_T}} = -2 \cdot \lg\left[0{,}07 \cdot \left(\frac{b_m}{b_{III}}\right)^{1{,}07} \cdot \Omega\right]$$

b_m, b_{III} = width parameter

Ω = vegetation parameter

PASCHE (1984) developed a formula for compound channels with vegetated floodplains. Therein the influence of momentum transfer between the floodplains and the main channel is considered. The basic idea (same as explained in *Merten*'s method) is to separate the half cross section in five areas: Area I (in the main channel) only influenced by the bed roughness of the main channel, Area II (main channel towards the floodplain) influenced by bed roughness of the main channel and the momentum transfer interactions, Area III (floodplain towards the main channel) influenced by the vegetation and the interaction, Area IV (centre floodplain) influenced only by vegetation and Area V (floodplain banks) influenced by bank roughness and vegetation.

The difficulties arise from the estimation of the friction coefficient of the apparent shear layer between Area II and III. The greatest importance is attached to the so-called „cooperating width“ (width of Area III), that has to be iterated using data of plant properties (density, stem diameter). The formula results in a *Darcy/Weisbach* friction coefficient for the roughness of the apparent shear layer.

Literature: PASCHE, E. (1984); PASCHE, E., ROUVE, G. (1985)

12. NUDING vegetated compound channel formula:

Geometry, hydraulic roughness, vegetation structure ⇒ discharge, flow velocity

Bush:

$$\frac{1}{\sqrt{f_T}} = \frac{K}{4{,}24} \cdot \frac{1}{\lg\left(\frac{c_\alpha \cdot u_{m,0,F}}{u_{m,v}}\right)} \cdot \sqrt{\frac{h_T}{R_V}} \cdot \sqrt{\frac{b_F}{b_m}}$$

Tree:

$$\frac{1}{\sqrt{f_T}} = \frac{1}{2} \cdot \left(\frac{1}{\lg\left(\frac{c_\alpha \cdot u_{m,0,F}}{u_{m,V}}\right)} \right) \cdot \sqrt{\frac{h_T}{R_v}} \cdot \sqrt{\frac{b_F}{b_m}}$$

c_α = correction value

h_T, b_F, b_m = vegetation parameters

This formula is a further development of *Pasche*'s approach. NUDING (1991) included branched structures of vegetation.

Literature: NUDING, A. (1991)

13. Roughness of aquatic vegetation:

Geometry, vegetation structure ⇒ discharge, flow velocity

$$n_c = n + b \cdot \frac{K}{Fr}$$

n = Manning coefficient

$b \approx 0{,}2$

K = vegetation parameter

This formula is needed to estimate the influence of aquatic, submerged vegetation on the channel discharge and velocities.

Literature: HYDRAULICS RESEARCH, WALLINGFORD (1988):

14. Formula for aquatic (submerged) vegetation:

Geometry, vegetation structure ⇒ discharge, flow velocity

$$\sqrt{\frac{1}{f}} = A \cdot \ln \frac{h}{k_v} + B$$

A, B = vegetation parameters

k_v = vegetation resistance coefficient

This formula is needed to estimate the influence of aquatic, submerged vegetation on the equivalent roughness and flow resistance, especially in narrow beds. The selection of the parameters A, B and k_v will obviously have an effect on the value of the resistance coefficient f. A and B depend on vegetation type and on vegetation state. k_v represents the roughness given by vegetation.

Literature: KEULEGAN, G.H. (1938); PLATE, E. J., QURAISHI, A. A. (1965)

15. Bed roughness formula (logarithmic law):

Equivalent sand roughness, geometry ⇒ hydraulic roughness

$$\frac{v_m}{v^*} = \sqrt{\frac{8}{f}} = \frac{1}{\kappa} \cdot \ln\left(\frac{R}{k_s}\right) + B_r$$

v_m = averaged velocity

v^* = shear velocity

κ = constant of Kármán

B_r = constant of integration

k_s = equivalent sand-roughness

f = resistance coefficient

This formula calculates *Darcy/Weisbach* friction coefficients from equivalent sand roughness and geometry data (e.g. water depth or hydraulic radius).

Literature: CHOW, V. T. (1959)

16. Flow attack (momentum equation):

Geometry ⇒ flow attack

$$\tau = \rho \cdot g \cdot R \cdot I_S$$

$\tau =$ shear stress

$I_S =$ bed slope

The easiest way to calculate the flow attack on the river bed is to apply the momentum equation.
Literature: CHOW, V. T. (1959)

17. Woody debris mapping/levelling:

Levelling, mapping ⇒ water level

After flood events with woody debris transport, it is possible to define the maximum flood water level by mapping and levelling the maximum height of woody debris accumulation within the present riparian vegetation. Mapping results in the appropriate flood waterlines.
Literature: SMITH, J. R. (1997)

18. Local velocity measurements:

Local velocity measurements, geometry ⇒ velocity, discharge

There are different methods to measure the flow velocities locally in a river:

- Floats: Easy, inexpensive, quickly ready for action
  Disadvantages: Measures only water surface velocity, is wind-influenced)
- Propellermeter: Easy to handle, quickly ready for action
  Disadvantages: Propeller vulnerable to mechanical stress (e.g. woody debris)
- ADV/ADCP: Acoustic method, contactless and undisturbed high-resolution-measurements of multiple velocity components (Acoustic Doppler Velocimeter) or velocity profiles (Acoustic Doppler Currency Profiler)
  disadvantages: expensive, elaborate calibration and data storage/ processing acquired, only conditional field-suitable
- Electromagnetic Flowmeter: rugged, quickly ready for action, capable to measure within vegetation
  Disadvantages: Expensive, elaborate calibration
- LDV: Laser-optical method, contactless and undisturbed high-resolution-measurements of multiple velocity components (Laser Doppler Velocimeter)
  Disadvantages: Expensive, elaborate calibration and data storage/ processing acquired, only conditional field-suitable, vulnerable to mechanical stress
- Dilution (e.g. salt) and tracer (e.g. uranite) methods: Independent of boundary conditions (e.g. vegetation, macrostructures), applicable for most flows, discharge can be determined directly
  Disadvantages: Tracer chemicals are added to the flow, elaborate calibration and collection of samples (tracer method)

The discharge within a cross section can be calculated from local velocity data by applying the continuity equation. For a high accuracy, it is recommended to collect a representative magnitude of local velocities within sufficiently long enough space and time intervals.
Literature: HERSCHY, R.W. (1985); WESSELS, A.C.E. (1986)

19. Physical models:

⇒ Fundamental hydraulics

Physical models provide an useful tool to examine the complex interacting processes of natural river systems. The advantages of physical models are:

arbitrary reproducibility of measurements, variation and determination of the effects of single or multiple parameters, fixed setup and installation of instruments, widely independent of outer circumstances (e.g. climate, season, flood events) and natural impacts.

Literature: YALIN, M.S. (1971); Hydraulic Modeling of Civil Engineering Structures (1982)

20. Numerical models:

⇒ Fundamental hydraulics

Numerical models are useful predictive tools for a variety of flows. It should be kept in mind that a growing complexity of flow and boundary conditions also leads to superproportional efforts and required hardware resources. The bandwidth of numerical models ranges from 1d- up to 3d-flow analysis as well as diffusion and erosion/sedimentation related processes. Commercial programs are available for many practical applications.

- 1d-models steady and unsteady water table calculations (in many cases used for flood prediction),
- 2d-models provide depth-averaged numerical calculations (velocity, flow depth) and information about the spread of e.g. river channel bed,
- 3d-models provide the most detailed information about the flow field with regard to complex boundary conditions (e.g. geometry, vegetation). The spatial and temporal resolution of the turbulent motion and vorticity depends strongly on the volumetric extensions of the calculation and is therefore limited by the potential of the computer hardware.

Literature: CUNGE. J.A., HOLLY, F.M.Jr, VERWEY, A. (1980)

2.2 Methods - Morphodynamic

morpho-
logical
data

		Methods																									
		Equivalent sand-roughness formulae	Bed resistance formulae (incipient motion)	MPM sediment transport formula	Suspended load formula	Local bedload sampling	Local bedload measurements	Local suspended load sampling	Local suspended load measurements	Sieve analysis (grain size distribution)	Multifrequent echo sounding	Side scanning radar	Geochronology	Soil survey by USDA, FAO, KA 4	Sounding and Coring	Geological maps	Photo Electronic Erosion Pin	Erosion chains	Sediment traps	Echo sounding	Geodetic survey - actual and historical data	Video and photo monitoring / historical data	Remote sensing	Topographical maps (actual & historical)	Thematic maps	Geomorphological mapping	Geographical Information System GIS
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Goal	Bed material					x	x		x	x	x		x	x	x	x						x	(x)			x	
	River geometry										x	x				(x)				x	x		x	x		x	x
	Floodplain geometry										(x)	(x)				(x)				x	x		x	x		x	x
	Area floodplain (active / former)												(x)		(x)	(x)					x	(x)	x	x	x	x	x
	Bed roughness	x				x	x	x	x	x	x	x		x	x	(x)			x	x	x	x	x			x	
	Roughness of macrostructures	(x)									x	x		x						x	x	x	x	x		x	x
	Erosion and sedimentation	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	(x)	x	x
	Sediment transport	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x		(x)	x	
	Habitat structures					x				x	x			x	x	(x)		x	x	x	(x)	x	x	x	x	x	x
	Historical conditions									x			x	(x)	x	x					(x)	x	x	x	x	x	(x)
	Historical geometry												x		x	x					x	x	x	x	x	x	x
Area	River	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x	x	x	(x)	x	x	x
	Floodplain	x	x	x	x	x	x	x	x	x	(x)	(x)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scale	Test site	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x		x	x	x	
	Project area	x	x	x	x					x	x	x	x	x	x	x				x	x	x	x	x	x	x	x
	Catchment area										x		x		x	x				x		x	x	x	x	x	x
Connection	Hydrology and Hydraulics	■	■	■	■	■	■	■	■	■	■	■					■	■	■	■	■		■	■	■		■
	Morphodynamics	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Vegetation science										■	■	■	■	■						■	■	■	■	■	■	■
	Specific ecological science										■	■	■	■	■						■	■	■	■	■	■	■
	Socio-Economics										■	■											■	■	■	■	■
Application	Stage of Project	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.3 / 3.7 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.3 / 3.9	3.2 / 3.3 / 3.9	3.2 / 3.9	3.1 / 3.2 / 3.3 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.2 / 3.9	3.1 / 3.2 / 3.3 / 3.9	3.2 / 3.3 / 3.9	3.1 / 3.2 / 3.3 / 3.8 / 3.9	3.1 / 3.2 / 3.3 / 3.9	3.1 / 3.2 / 3.3 / 3.9	3.2 / 3.3 / 3.9	3.1 / 3.2 / 3.4 - 3.9

1. **Equivalent sand-roughness formula:**

Grain size distribution ⇒ equivalent sand roughness

Many authors have proposed easy empirical relations to determine the equivalent sand roughness from a typical grain size diameter and for different hydraulical-morphological structures (e.g. bed forms).

Author	empirical relation	area of application
Einstein (1942)	$k_s = d_{65}$	Sand bed rivers
Garbrecht (1961)	$k_s = d_{90}$	Sand bed rivers
Engelund / Hansen (1966)	$k_s = 2{*}d_{65}$	Sand-gravel bed rivers
Hey (1979)	$k_s = 3{,}5{*}d_{84}$	Coarse Gravel bed rivers
Kamphius (1974)	$k_s = 2{*}d_{50}$	
Mertens (1997)	$k_s = 2{,}5{*}d_{50}$	Sand-gravel bed rivers
Dittrich (1998)	$k_s = 3{,}5{*}d_m$ $k_s = 3{,}5{*}d_{84}$	Gravel Coarse gravel, stones

Literature: KAMPHUIS, J.W. (1974)

2. **Bed resistance formulae (incipient motion):**

Grain size distribution, geometry ⇒ bed stability

$$\tau_{0C} = C \cdot (\rho_S - \rho) \cdot g \cdot d_k$$

τ_{0C} = bed resistance

C = constant

ρ_S = sediment density

d_k = typical grain size diameter

River bed stability is defined hydraulically as the maximum resistance of the present bed structure against flow attack, just before movement of single grains occur. In literature, there is a wide collection of approaches to determine the maximum stability for non-cohesive sediments. Most approaches have in common, that the maximum stability is defined via a maximum bearable shear stress and uses a characteristic grain diameter to define the grain structure. There are formulae for different bed structures and their status (e.g. with/ without armour layer or pavement, transient conditions).

Literature: CHOW, V. T. (1959)

3. **MPM sediment transport formula:**

Geometry, grain size distribution, discharge, roughness ⇒ bed load transport rate

$$\tau_{0C} = 0{,}047 \cdot (\rho_S - \rho) \cdot g \cdot d_{mA}$$

τ_{0C} = bed resistance

d_{mA} = grain size diameter

ρ_S = sediment density

The formula of *Meyer-Peter/Müller* of 1948/49 is easy and very common for practical purposes. The basic idea is to link the shear stress due to flow attack with the critical bed stability. Note that MPM formula was developed for uniform grain size distributions (no armouring of the bed).

Literature: MEYER-PETER, E., MÜLLER, R. (1948):

4. **Suspended load formula:**

⇒ Grain size distribution

Suspended load concentration has a strong gradient over the water depth. Therefore, the total suspended load transport rate has to be determined over the water depth by multiplying the concentration with the average flow velocity for each vertical step. In literature there are some typical profiles that can be applied to estimate the suspended load concentration as a function of the non-dimensional *Rouse*-number „Z".

Literature: GRAF, H.G. (1971)

5. Local bedload sampling:

⇒ Bedload grain size distribution, bedload transport rate

There are two basic methods to determine the bedload transport in rivers: mobile bedload samplers (e.g. BfG-type, *Helly/Smith*-type, *Mühlhofer*-type) and stationary sediment traps. Bedload samplers are dropped down on the river bed and trap the moving bedload within their cage. The mouth of the cage has to be large enough to guarantee that the maximum grain diameter can pass through. Furthermore the cage has to bear tightly on the river bed. Stationary sediment traps are more expensive but easier to maintain. They store larger amounts of sediment for longer periods in time and in many cases across the whole river width.

Literature: GRAF, H.G. (1971)

6. Local bedload measurements:

⇒ Begin of bedload transport, transport length

Local bedload measurements can be divided into acoustical and tracer methods. Acoustical measurements use underwater-microphones to record sounds generated by bedload movement and can thereby determine the begin of bed instabilities. Tracer methods use radioactive, magnetic or luminescent marked grains that are counted by passing a control section and provide data about the transport length.

Literature: GRAF, H. G. (1971)

7. Local suspended load sampling:

⇒ Suspended load concentration

Suspended load can be analysed by collecting water samples. Many different types of traps and collectors have been developed.

Literature: GRAF, H.G. (1971)

8. Local suspended load measurements:

⇒ Suspended load concentration

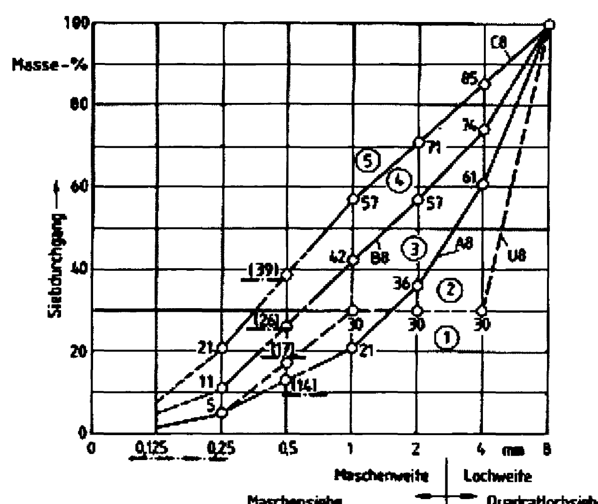
Measurements of suspended load can be performed with optical or radioactive methods. The optical method measures the tarnish of the water by passing a light barrier. The so-called „Gamma“-probes measure the tarnish via long-lived radioactive isotopes.

Literature: GRAF, H.G. (1971)

9. Sieve analysis (grain size distribution):

⇒ Grain size distribution

Sieve analysis is important for quantifying the grain size and grain size distribution of river sediments. It is important, that a representatively large amount of samples or grains is taken. The sieving procedure can be conducted in sieves with round or quadratic meshes and under dry (larger grains) or wet (fine grain diameters < 0.63 mm) conditions.



Literature: BLYTH, F.G.H., FREITAS, M.H. (1973)

10. Multifrequent echo sounding:

Riverbed sediments can get surveyed by using echo-sounding systems from a boat with different transducers operating at frequencies between 30 kHz and 200 kHz. The echo-sounder must be connected to a seabed classification systems. This uses echo-sounder data to classify the bottom as one of the following types: mud, muddy sand, sand, coarse sand, gravel, boulders/hard, weeds on soft, weeds on hard. For the calibration it is necessary to run an adequate number of tests and compare it to samples and cores. The accuracy can vary, but if the test results are satisfying it is possible to do sediment mapping for long river reaches with a maintainable effort.

Literature: RUKAVINA, N.A. (2000)

11. <u>Side scanning rada:</u>

Side Scan Sonars survey the bottom in great detail and use high frequency sound to produce images of e.g. seafloors or riverbeds. Side Scan Sonars consists of three components: the towfish, the transmission cable and the processing unit. The near the bottom dragged towfish gives sound pulses and receives echoes from the riverbed. Data are collected parallel to the way of the towfish and transmitted to the processing unit. The processing unit stores the data and displays images. The results contain information about sediment type and roughness as well as riverbed features and habitat complexity. The depth is not recorded by Side Scan Sonars.

Literature: RUBIN, D.M. et al. (2001)

12. <u>Geochronology:</u>

A wide variety of geochronological tools or methods can be employed to estimate quantitative and qualitative dating of rocks and sediments. Techniques exist to date all geological materials, from billions of years to historical records. U-series dating is the most reliable method for dating Quaternary (the last 2 million years) sedimentary carbonate, silica, and fossil material. Quaternary dating provides a record of climate change and geologically recent changes in environment. $^{40}Ar/^{39}Ar$ provides isotopic ages ranging from 10,000 years to billions of age with 01-05% precision. ^{14}C dates material with organic carbon, and has a maximum range of 100,000 years. Thermoluminescence provides ages within a range of 100-800,000 years. ^{210}Pb has a short half-life, and dates material from the past 150-200 years. For Quaternary palaeobotany, the study of lake sediments, pollens and microfossiles provides information to determine ancient climate and vegetation.

Literature: BARSCH, H., BILLWITZ, K., BORK, H-R. (2000)

13. <u>Soil survey by USDA, FAO, KA 4:</u>

<u>*USDA (The United States Department of Agriculture), Soil Taxonomy:*</u>

This system was first published in 1975, and has undergone 8 revisions since. It is a hierarchical classification that tries to group similar soils into increasingly general categories. It was designed to support soil survey in the USA, specifically the correlation of soil series and the provision of map unit names at various levels of cartographic detail. It has pretensions of universality, but the main aim has always been to group soils of the USA.

The Soil Taxonomy organises soil series in increasingly-general groups for interpretations and facilitate correlation within and among regions: the more similar the soils, the closer they should be in the classification. The structure is multicategoric, increasingly general as going upwards. The differentiating criteria are observable or measurable. Soil moisture and temperature are used for soil classification.

Literature: ROSSITER, D.G. (2001); USDA (1996); USDA – Soil Survey Staff (1999)

FAO (Food and Agriculture Organisation of the United Nations). World Reference Base:

The WRB borrows heavily from modern soil classification concepts, including Soil Taxonomy. The classification system is based mainly on soil morphology which is thought to express the effects of soil genesis. A major difference with Soil Taxonomy is that soil climate is not part of the system. The WRB is a two-level classification:

1. Reference Soil Groups (30)
   Intermediate in conceptual level between Soil Taxonomy orders and suborders; Examples: Histosl, Fluvisols, Luvisols.
2. Second level subdivisions
   Using any defined combination of 121 qualifiers. It is possible to use either a single qualifier (the most important) or all relevant qualifiers. Similar in detail to Soil Taxonomy great groups (one qualifier) or subgroups (multiple qualifier). Examples: Leptic Umbrisols, Chromi-Vertic Luvisols.

The subdivisions do not take into account all possible differences among soil map units. In particular: climate, parent material, vegetation, depth of water table or drainage, and physiographic features such as slope, geomorphology or erosion are not considered as such, except insofar as they have affected soil morphology. These features can be used locally to defined mapping phases, but they are not considered soil properties to be classified as such.

Some detailed internal properties are also not considered at this level of detail, namely, substratum layers, thickness and morphology of solum or individual horizons. These can be used to define series or forms locally, for detailed soil survey.

Literature: FAO-UNESCO (1987); DRIESSEN, P.H. & DUDAL, R. (1991)

Deutsche Bodenkundliche Gesellschaft (Germany). Bodenkundliche Kartieranleitung-KA 4:

The german classification system got adjusted to the WRB during the last years, so it is possible to assign german soils now to WRB soils and contrary. The german classification is based on diagnostic characteristics and divided in different horizons and subdivisions. Additional information can lead to further subdivisions.

Literature: AG BODEN (1994); SCHACHTSCHABEL, P., BLUME, H.-P., BRÜMMER, G., HARTGE, K.-H. & SCHWERTMANN, U. (1998); SCHLICHTING, E., BLUME, H.-P. & STAHR, K. (1995)

14. Sounding and coring:

Coring is the removal of continuous formation sample from a wellbore. To the extent possible, core samples are recovered undamaged, preserving the physical and mechanical integrity of the rock or of sediments. The formation material may be solid rock, friable rock, conglomerates, unconsolidated sands, coal, shales, gumbos, or clays. Coring can be conducted by various methods with a variety of tools in a wide range of hole sizes. Through coring, scientists gain access to accurate and representative reservoir information to enhance geological models. Data on the formation's lithology, flow characteristics, storage capacity and production potential can be obtained by a successful coring program.

The Seismic Cone Penetration Test (SCPT) is a technique to determine in situ seismic wave velocities. The seismic test method consists of measuring the travel times of body waves propagating between a wave source on the ground surface and an array of geophones in an in situ seismic cone penetrometer. These body waves comprise shear waves (S-waves) and compressional or primary pressure waves (P-waves). Seismic wave velocities give an indication of soil characteristics. Seismic wave velocities also allow correlation of seismic profiling data and geotechnical borehole and CPT results.

Literature: AG BODEN (1994); Niedersächsisches Landesamt für Bodenforschung (2002); BIRKELAND, P.W. (1984) ; PRESS, F., SIEVER, R. (1985):

15. Geological maps:

Geological maps give information on the superficial layers of the earth's crust and show the distribution of geological features, including different kinds of rocks and faults. The geological formations are listed according to their composition (lithology), their age (stratigraphy) and their structural position (tectonical). They are placed on a topographical base (map) using different graphical elements (symbols, figuratives and colors). The choice of scale depends on the geological content and the intended objective of the map. The use of geological maps in river morphology provides a background for the development of specific situations (course of the river in quaternary sediments like alluvial fans or in bedrock) and shapes e.g. incised, braiding or meandering rivers.

Literature: MURAWSKI, H. (1992); Bundesamt für Wasser und Geologie (BWG), Schweiz (2003); HAKE, G. (1982); HAKE, G. (1985); HAKE, G., GRÜNREICH, D. (1994); SCHULZ, G. (1991)

16. Photo Electronic Erosion Pin (PEEP) System:

The PEEP sensor is a simple optoelectronic device containing a row of overlapping photovoltaic cells connected in series, and enclosed within a waterproofed, transparent, acrylic tube. The sensor generates an analogue voltage proportional to the total length of PEEP tube exposed to light. A reference cell adjusts outputs for variations in light intensity. Small networks of PEEP sensors are normally inserted into carefully pre-augered holes in the bank face, and connected to a nearby datalogger set to record PEEP mV outputs at 15-min intervals, though any frequency is possible. Subsequent retreat of the bank faces exposes more cells to light, which increases sensor voltage output. Deposition reduces voltage outputs. Data recovered from the loggers thus reveal the magnitude, frequency and timing of individual erosion and deposition events much more clearly than has been possible before.

Literature: LAWLER, DAMIAN (2002)

17. Erosion chains / Scour Chains:

Scour chains provide a method of assessing the depth to which bed load transport has occurred at a particular location. A piece of chain is implanted vertically into the stream bed and anchored in place. The chain is cut so that it is flush with the surface. After the occurrence of a flood event (ideally just one), the chains are dug out. If the chains are bent over, this indicates that sediment transport did occur.

The depth to which movement of bed material occurred can be determined, as can changes in the bed surface elevation.

Literature: NAWA, R.K., FRISSELL, C.A. (1993), LEOPOLD, L.D., WOLMAN, M.G., MILLER, J.P. (1964)

18. Sediment traps:

Sediment traps are devices to determine the quantity of sediment appearing at a spot in time. The construction can vary from traps to measure aeolian deposition to hydraulic deposition. To measure hydraulic deposition predefined horizontal surfaces are exposed to the water body. The quantity of sediment accumulation can be determined by gauging the layer thickness and weight.

Literature: STEIGER, J. (1996), BÖLSCHER, J. (2002)

19. Echo sounding:

An echo-sounder without providing further information deduces bathymetry. The echo-sounder generates a sound wave, mostly from a moving boat. This acoustic wave radiates towards the riverbed. The acoustic signal bounces off of the riverbed and returns to the echo-sounder-receiver. The elapsed time is related to the depth of the riverbed. Different sediments can limit the accuracy to which bathymetry can be measured. If an Differential Global Positioning System (DGPS) is running parallel to the echo-sounder the results can get interpolated later on in a Geographical Information System (GIS).

Literature: WEHRKAMP, G. (1954)

20. Geodetic survey - actual and historical data:

To obtain additional data in micro and meso scale it is sometimes necessary to measure subsidiary geodetic data. This is be done by the use of a DGPS (Differential Global Positioning System), a echo-sounder and a tachymeter. The spatial data can get interpolated in a Geographical Information System to create digital terrain models for further analysis of e.g. slope, volume or position. Historical data get used to document changes in land use and interdependencies with the environment.

Literature: HAKE, G. (1982); HAKE, G. (1985); HAKE, G., GRÜNREICH, D. (1994); HIGGITT, D.L., WARBURTON, J. (1999)

21. Video and photo monitoring / historical data:

The interpretation of graphical material offers the chance of comparing historical and current data to discover and to trace processes running off. The graphical material can consist off aerial photography.

Literature: FUJITA, I., NAKASHIMA, T. (1999), HENTSCHEL, B. (2000), U.S. Department of the Interior, U.S. Geological Survey, Center for Coastal Geology (2002); ALBERTZ, J. (2001)

22. Remote sensing:

Remote sensing is the science and art of obtaining information about a phenomena without being in contact with it. Remote sensing deals with the detection and measurement of phenomena with devices sensitive to electromagnetic energy such as:

- Light (cameras and scanners)
- Heat (thermal scanners)
- Radio Waves (radar)

It provides a unique perspective from which to observe large regions. Sensors can measure energy at wavelengths which are beyond the range of human vision (ultraviolet, infrared, microwave). Global monitoring is possible from nearly any site on earth.

Literature: ALBERTZ, J. (2001)

23. Topographical maps (actual & historical):

The distinctive characteristic of topographical maps is that the shape of the Earth's surface is shown by contour lines. Contours are imaginary lines that join points of equal elevation on the surface of the land above or below a reference surface such as mean sea level. Contours make it possible to measure the height of mountains and steepness of slopes. The map also includes symbols that represent such features as streams, streets, buildings and woods. These symbols are constantly refined to better relate to the features they represent, improve the appearance or readability of the map, or to reduce production cost. Compared to geological maps topographical maps show the recent situation of river morphology.

Literature: HAKE, G. (1982); HAKE, G. (1985); HAKE, G., GRÜNREICH, D. (1994)

24. Thematic maps:

Thematical maps illustrate particular themes, trends, features, or concepts to describe the spatial patterns of specifically phenomenons. Examples are historical maps, land use maps, demographical maps, hydrological maps, geological maps, vegetation maps and climatological maps. The most important thematical maps in river morphology are hydrological maps. Hydrological maps give information about existence of superficial and subterranean water, and the usage. Data about the location of climatological and hydrometrical stations are provided, as well as rivers, streams, ponds, dams, tacks, wells, springs and channels. The combination of different thematical maps, e.g. in a Geographical Information System gives further information about coherences and dependencies.

Literature: HAKE, G. (1982); HAKE, G. (1985); HAKE, G., GRÜNREICH, D. (1994)

25. Geomorphological mapping:

Geomorphological mapping describes the interpretation of a topographic map. At any map's interpretation the first step is to indicate the highest and lowest areas. The second step is to do the general interpretation of the form's position, size, and shape. One can differentiate between mountainous, plain, and concave forms. The third step is to indicate and to interpret the geographical distribution of the forms. Sense of purpose is to receive information about the formation, the current processes, and the potential for future development of an area.

Literature: SCHULZ, G. (1991)

26. Geographical Information System:

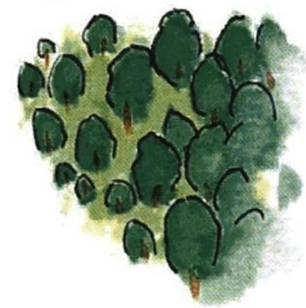
GIS stands for Geographic Information Systems. A Geographic Information System is a combination of elements designed to store, retrieve, manipulate, and display geographic data - information about places. It is a package consisting of four basic parts: hardware, software, data and a thinking operator. Practitioners also regard the total GIS as including the operating personnel and the data that go into the system. Spatial features are stored in a coordinate system (latitude/longitude, state plane, UTM, etc.), which references a particular place on the earth. Descriptive attributes in tabular form are associated with spatial features. Spatial data and associated attributes in the same coordinate system can then be layered together for mapping and analysis. GIS can be used for scientific investigations, resource management, and development planning.

Literature: LONGLEY, P.A., GOODCHILD, M.F., MAGUIRE, D.J., RHIND, D.W. (2001);

Further Information by: ESRI, Canada http://www.esri.com/

2.3 Methods - Vegetation science

vegetation data



	Methods																		
		Ecological-Structural Methods												Yield Sampling Methods					
		Braun-Blanquet Method	Point-Quadrat-Method	Line-Intercept-Method	Point-Centered-Method	Leaf-Category after Vareschi	Photographic Method	Vegetation Density Profile	Structure Measuring Tube	Light Methods	Aerial View Analysis	Method after DVWK	Complete Vegetation Sampling	Complete Yield Sampling	Harvesting Method	Phytomass Rate Estimation	Point Sampling	Fixed Sample Plot Size	Sampling Plot System
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Goal	Abundance / Frequency / Density	x	x	x	x[4]			x[5]	x		x[7]	x	x	x	x		x	x	x
	Coverage	x	x[1]	x	x		x	x			x		x						
	Vatiety of species	x	x	x		x		x[6]	x		x[7]	x[6]	x	x	x	x	x	x	x
	Crown diameter				x						x[7]		x						
	Leaf-Area-Index - LAI							x[2]		x					x				
	Phytomass / Timber volume												x	x	x	x	x	x	x
	Diameter at breast height				x							x	x	x			x	x	x
	Plant height / Canopy height							x			x[8]	x	x	x	x		x	x	x
	Average plant distance		x[2]		x[2]						x[7]	x	x	x[2]			x[2]	x[2]	x[2]
	Pattern of vegetation	x	x[3]			x		x	x	x	x	x	x						
	Type of vegetation	x	x			x		x[6]	x		x[7]	x[6]	x	x	x	x	x	x	x
Area	River																		
	Floodplain	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scale	Test site	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x
	Project area	x		x	x		x				x	x		x			x	x	x
	Catchment area										x						x	x	x
Layer	Tree layer	x	x[1]	x	x	x				x	x	x	x	x			x	x	x
	Shrub layer	x	x[1]	x	x	x				x	x	x	x						
	Herb layer	x	x	x	x	x	x	x	x	x	x		x		x	x			
Connection	Hydrology and Hydraulics																		
	Morphodynamics																		
	Vegetation science																		
	Specific ecological science																		
	Socio-Economics																		
Application	Stage of Project	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9

Indices:

1 Point-Intercept-Method (see Annex)
2 Additional calculation necessary
3 Multi-Cubus-Stratimeter (see Annex)
4 Calculation of frequency possible
5 Structureanalysis after Barkman (see Annex)
6 Possible result
7 Applicable for tree layer
8 Stereo aerial photography

2.3.1 General information

In botany, methods of survey are most of the time used to survey the prevailing phytocenosis. Different conclusions can be drawn from this result, be it concerning the habitat, environmental influences, or anthropogenic interference.

First is a short outline concerning the application of vegetation survey methods (timing, numbers of survey, choosing and limiting the sample plot, as well as general data of survey). Afterwards, there will be a short description of different vegetation survey methods and cite necessary topic-related literature.

Different vegetation survey methods can be applied to the management of the lowland forest depending on objective and definition of problem. Therefore, a wide range of different survey methods was chosen to illustrate the possibilities.

The mentioned parameters and results obtained from the different methods must no be considered rigid. Additional calculations may lead to differing parameters that are not indicated in this paper.

The intent is to give an outline concerning:

- Existing vegetation survey methods
- Their general application
- The problems for which these surveys should provide answers
- The prevailing results

2.3.1.1 Timing

Stocktaking should always be implemented at a time when all the species of the vegetation are, if possible simultaneously, fully developed. This is the case from June onwards for most types of vegetation in Europe. Then plants are in full bloom or yield fruits. This circumstance makes it easier to define the species, a fact that is of special advantage when it comes to grasses and spring annual grass. Mosses and lichens can be surveyed throughout the whole year.

2.3.1.2 Number of vegetation surveys

The number of surveys depends on the survey method itself, as well as on the vegetation and on the objective of the analysis.

The full range of species can only be deducted from a certain number of surveys. As a consequence, there should be at least ten surveys available of every type of specie, preferably 20-30 (compare DIERSCHKE, 1994).

2.3.1.3 Choosing and limiting the sample plot

The habitat conditions of the survey plots have to be uniform and homogenous within their limits.

In order to obtain a sufficient size of an area, one can successively double the area starting from 1 m^2 (2 m^2, 4 m^2, 8 m^2,...) and continue following this scheme until no new species are added. The result can be seen as a minimum area, which is the smallest possible area where all the species that form a stock are represented.

There are three possibilities to arrange the sample probes in the area of investigation:

1. randomly selecting areas
2. evenly distributed according to a raster
3. following subjective intuition

Choosing the areas according to the two methods first mentioned seems to be more objective. However, these methods only provide useful results for large areas. This is due to the fact that peripheral effects are not included.

Knowledge of vegetation types increases proportionately to the number of surveys, which also affects and improves the selection procedure (DIERSCHKE, 1994).

2.3.1.4 General data of survey

Every survey record shall contain a survey head with the most important data pertaining to the location that is to be investigated. Therein, the area is closely characterized, which makes it possible for another investigator to find the place. The following data has to be mentioned in the survey head:

1. Number of survey and date
2. Name of the investigator
3. Indication of place and location
4. General characterization of the site, altitude, exposure, gradient of slope, relief form
5. Density of stock
6. Exploitation method
7. Stratification
8. Geological data
9. Pedological data
10. Age of stock

2.3.1.5 Used parameters in the table

- ***Abundance (pieces) / Density (pieces/ m²)/ Frequency (%):***

These three parameters were grouped under one point because they are based on the number of individuals, i.e. the abundance, starting from which the remaining parameters can be derived. The number of individuals per area unit is referred to as density; frequency is the calculated probability to encounter a certain specie on the investigated area.

- ***Coverage (%) / Canopy closure:***

The percentage of coverage defines the relative area that is occupied by a plant or specie in order to absorb light. These parameters are grouped due to the high degree of similarity between coverage and canopy closure. The canopy closure indicates the area covered by the canopy in percentage.

- ***Variety of species:***

By mapping the species, the variety of species can be classified, which characterizes the state of a system.

- ***Crown diameter (m):***

For this parameter, the largest horizontal expansion of the canopy, i.e. the diameter, is recorded.

- ***Leaf area index (LAI):***

The leaf area index is an indication for the leaf area that the plant can use for photosynthesis.

- ***Phytomass:***

The phytomass is the mass of the plants on the area that is to be investigated.

- ***Diameter at breast height (m):***

The diameter at breast height indicates the calculated or measured diameter of the trunk at breast height of a grown-up.

- ***Plant height (m) – Canopy height:***

Indicates the absolute height of the recorded plants. Moreover, the parameter of canopy was added.

- ***Average plant distance (m):***

A mean value is calculated based on the measured plant stocks. This value is then listed in a table as average plant distance.

- ***Pattern of Vegetation:***

This parameter is marked when a method maps the pattern, either horizontally, vertically or both ways. The pattern should illustrate the actual state of the on-site vegetation.

- ***Type of Vegetation:***

The type of vegetation indicates a plant society in its characteristic composition of species.

2.3.2 Methods

The following list is not exhaustive and should only provide an outline of the current vegetation survey methods. Furthermore it should be stated that differing parameters could be obtained when using the different methods with continuative measurements and/or calculations. Enumerating these parameters would definitely go beyond the scope of this paper and fail the proper topic.

Survey methods are separated into and assigned to two groups:

- Ecological-structural methods
- Yield sampling methods

2.3.2.1 Ecological-structural methods

1. <u>BRAUN-BLANQUET Method:</u>

The Braun-Blanquet method is one of the most frequently used methods to classify vegetation. This method allows the classification of abundance, i.e. the number of individuals or frequency as well as dominance. By means of a raw table (ordinal table) all the relevant parameters for the vegetation stratum that is to be examined are defined. It has to be said that by means of this method and continuative calculations or modifications of the investigation, additional interesting data can be obtained. As already mentioned in the beginning, the sample plot is being estimated concerning the dominance and abundance of the individual species of its vegetation stratum. The table is divided into rather raw classes, so as to facilitate its practical applicability and reduce time exposure. A disadvantage can be seen in the fact that only drastic changes of dominance can be observed.

Table 1: BRAUN-BLANQUET Table (1964)

r	only a very small number of individuals (1-5)
+	few available, small rate of coverage
1	great abundance, less than 5%
2	5-25% partly also great number of individuals
3	25-50%
4	25-50%
5	75-100%

The data obtained can be further processed, e.g. in order to classify the habitat. This could be achieved by using Ellenberg´s pointer value.
This survey method is especially applied to large plots of permanent investigation (larger than 100 m^2), in order to be able to observe the succession, i.e. the sequence of plant communities. It is especially useful for large ecosystems of forests.
Literature: BRAUN-BLANQUET, J. (1964); UBA (1998)

The following method is derived from the BRAUN-BLANQUET Method. It is not mentioned in the table of methods:

<u>Modified table after LONDO (1976):</u>
The table after BRAUN-BLANQUET was changed by other authors and adjusted to the different needs and requirements.
The modified table after Londo is the basis for the classification of dominance of the species. This table is a valuable compromise between fine and broad scale.
This table is also referred to as decimal table due to its graduation.

Table 2: Table after LONDO (1976)

Table	Coverage [%]
.1	<1
.2	1 - 3
.4	3 - 5
1	5 - 15
2	15 - 25
3	25 - 35
4	35 - 45
5	45 - 55
6	55 - 65
7	65 - 75
8	75 - 85
9	85 - 95
10	95 - 100

The table can be completed using the following letters, which classify the abundance of the individual species:

Table 3: Table after LONDO (Range of table: .1-.4)

r	sporadic, in most cases only one example
p	few examples
a	many examples
m	very many examples

This survey method is especially suitable for small and manageable plots. It can also be recommended for plots of permanent investigation.

Literature: LONDO, G. (1976); UBA (1998)

2. Point-Quadrat-Method:

The point-quadrat-method primarily measures the frequency that correlates with coverage in point measurements.

In this connection, one differs between the absolute frequency, i.e. the abundance of a species and the relative frequency, i.e. the abundance of a species as percentage of all individuals (has to be classified using the following calculation).

The survey is conducted as follows: one uses a frame of the size of 1 m² that is subdivided into quadrats the size of 10x10 cm being limited by nylon threads. Only those individuals are being counted and classified that hit the crossing points of the nylon threads in imaginative projection.

This method of frequency determination was changed for different purposes. However, in its original form, it is especially suitable for evaluating low vegetation coverage, i.e. meadows and similar.

In case the coverage is being measured exactly with help of the frame, this method is being referred to as Quadrat-Charting-Method and is used very frequently in the United States. This time-consuming survey method does not only pay off for permanent quadrate observations of successive stages.

Literature: UBA (1998)

The methods listed below are either modified original methods or methodically related in terms of their implementation:

Frequency determination:

Frequency determination classifies, as the name suggests, the frequency of a species of a stock. Processing varies only slightly from the methods mentioned above.

Again, a frame is used and placed horizontally over the vegetation. This time, however, holes are drilled with evenly spaced distances. Sticks are inserted into the holes, so as to stand vertically over the vegetation forming a required pattern. Again, only those individuals are being counted that hit the sticks in order to obtain a representative result of the prevailing species.

The thickness of the sticks can lead to systematic errors. The thicker the stick that reaches into the vegetation cover, the more plants are hit.
Due to its setup, this method is often being used for the classification of the herb layer.
Literature: DIERSCHKE, H. (1994); UBA (1998)

Bayonet Method:
This method, which is also very easily applied and handled, is also used for frequency determination. Again, plants are only being counted if they are touched, in this case by the bayonet, but only touching the sharp edge counts as a hit. The knives are stuck into the ground at regular distances .
This method is again especially suitable for the classification of the herb layer.
Literature: DIERSCHKE, H. (1994); UBA (1998)

Vegetation barrier after MÜHLENBERG (1993):
This method also classifies the frequency of species in a stock.
The processing is as follows: two wooden slats are stuck into the ground at a distance of 30 cm. These slats have drilled holes at the height of 2 cm, 5 cm and 40 cm, where wires are inserted. The plant is again only counted if contacting the wires .
This method of frequency determination requires 10 minutes for every random sample. Especially incomplete meadows can be classified satisfactorily by using this method.
Literature: DOLKE, M. (1994); MÜHLENBERG, M. (1993); UBA (1998)

Multi-Cubes-Stratimetres after WITTE & HERRMANN (1995):
Detailed data concerning growth habit on species level can be collected using this method.
A cube, i.e. a wired cage with the measurements 100 x 100 x 50 cm, that is based on quadrats the size 10 x 10 cm and with subdivisions in the altitude every 20 cm, is set in the stock at the beginning of the vegetation period, where it can stay for the rest of the investigation (one season). It is counted how often the plants hit the imaginative side surfaces of the cube.

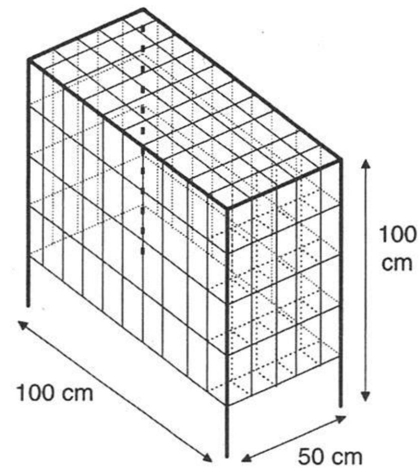


Fig. 1: ***Multi-Cuben-Stratimetres after WITTE & HERRMANN (1995)***

This method is applied to classify the vegetation frequency, be it vertically or horizontally. Growth habit of individual species can also be closely observed. Due to the fact that this survey is very time-consuming, it should only take place at representative areas.
Literature: UBA (1998); WITTE, A. (1994); WITTE, A., HERRMANN, S. (1995)

Point-intercept-method:
The point-intercept-method is used to classify the crown canopy of a tree population, but is methodically related to the methods mentioned above and therefore deserves being indicated in this list. Again, points of contact are taken into consideration.
A periscope is erected in the stock, pointing upwards. Then, a transparent film with a regular point pattern is stretched over the periscope. A point of the grid is only counted when contacting a crown. Instead of the periscope, one can also use an all around photography with a fish eye lens. In that

case, this method can also be applied to small stocks. A two-dimensional examination, unfortunately, can neither document the crown depth nor the crown height. This data could however be of interest for the investigator.
Literature: DIERSCHKE, H. (1994)

3. Line-Intercept-Method:

This method in its original form defines the coverage of the stock. This method can of course also be extended so as to survey other parameters as well (e.g. frequency, canopy etc.).
The processing is as follows: the Line Intercept method consists of horizontal, linear measurements of plant intercepts along the course of a line (tape). Distances can be indicated as coverage percentages, referring to the whole transect line (often 10 m). The percentage of coverage can be calculated with the simple formula mentioned below:

$$coverage\,[\%] = \frac{sections\ with\ vegetation}{total\ length} \cdot 100$$

For herbal vegetation, distances up to 50 m are recommended, for bushes and trees more than 50 m.
Generally speaking, it is necessary to implement the vertical projection as accurately as possible. In connection with tree stocks, one can use a slat or a periscope.
This method is especially suitable for measuring the coverage of tree stocks. However, other easily limitable growth forms like bushes, rosette plants and bigleaf macrophytes can also be surveyed using this method.
Literature: BONHAM, C.D. (1989); KENT & COCKER (1992); MAAS, D., KOHLER, A. (1983); UBA (1998)
Another method has to be mentioned, which is closely related to this method but not indicated in the table of methods.

Point-Line-Method:
This method helps to classify an essential parameter of vegetation layer, namely coverage, by means of a tape.
Regular dot measurements (e.g.: every 50 cm) are carried out along a line and the points of contact are recorded. The degree of coverage can be calculated as follows:

$$coverage\,[\%] = \frac{number\ of\ hits}{total\ number\ of\ plants} \cdot 100$$

As already mentioned above, this is again a method for coverage determination.

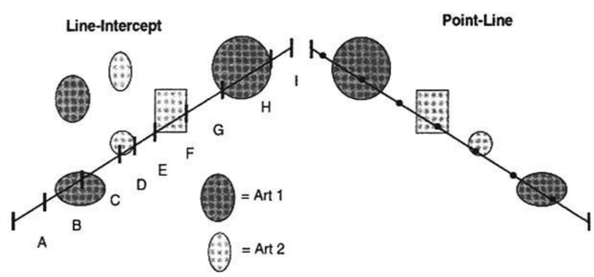


Fig. 2: Comparison between Line-Intercept- and Point-Line-Method

Literature: UBA (1998)

4. Point-Centered-Method (Wiscosin Distance-Method):

This method calculates the average empty area. It is based on the assumption that distance and average frequency are somehow related.
A cross separates the area, i.e. two lines crossing in a right angle, the crossing point being the point of observation. In each of the 4 sectors, the distance to the nearest individual of the species that is to be investigated is recorded. Great distance indicates low coverage, and the same applies vice versa. Then the average of the obtained data is calculated and coverage can be calculated using

the following formula:

$$density = \frac{1}{d^2}$$

d = mean value of the 4 distances measured

If frequency is calculated, coverage can also be obtained by recording the basal area or the crown diameter, the mean values are then multiplied with the frequency.

This method can be applied to well visible species (trees, bushes and clump grasses). Starting from coverage of 35%, this method is only partly suitable.

Literature: BONHAM, C.D. (1989); FRANKENBERG, P. (1982); MUELLER-DOMBOIS, D., ELLENBERG, H. (1974); UBA (1998)

5. Leaf category and number of diversity after VARESCHI:

In this method, leaf organs are investigated to classify the diversity and the state of development of a stock.

The further away a habitat is from its optimal conditions, the more extreme is the adjustment of the species. The leaf shape is a good indicator for that. Leaf shapes are classified according to size and form.

Using these indicators, one can calculate the number of diversity with this formula:

$$c_d = a \cdot f$$

c_d = coefficient of diversity

f = leaf shape index

a = species index

As mentioned above, this method helps to classify how far away the stock is from optimal conditions and how diverse it is.

Literature: KREEB (1983)

6. Photographic Method:

This method helps to record time series from an area of permanent investigation, so as to illustrate the development of a stock.

A camera with an optical estimation frame is placed vertically above the area. A photographed area of 10 x 10 cm is suitable for grasses and herbs, the upper limit is 50 x 50 cm. Afterward, the picture can be digitalized. The coverage can be calculated using appropriate software, starting from the shape of the plants.

This method is especially suitable for the classification of coverage in low stocks. When it comes to the classification of stocks with several layers, this method cannot be applied because coverage cannot be recorded for the low layers due to shadows and limited depth of focus.

Literature: UBA (1998)

7. Vegetation Density Profile after VAN DER MAAREL (1970):

VAN DER MAAREL (1970) suggested conducting the estimation of entire coverage according to separate layers.

Vertical vegetation density is estimated following height intervals: 0-cm; 1-3 cm; 4-10 cm; 11-25 cm; 26-60 cm; 61-150 cm. At the beginning, the height of the vegetation is recorded, then it is separated into height intervals and at the same time, the coverage is estimated. One always starts at the top layer. Six to eight minutes are needed per sample and expenses are rather low.

This method is suitable for estimating vegetation density profiles on an area of 50 x 50 cm. Records should be taken from outside the area that is to be investigated, e.g. from a chair or a stable board, in order to prevent destroying the vegetation with footsteps.

Literature: UBA (1998); VAN DER MAAREL, E. (1970)

Another method has to be mentioned, which is closely related to this method but not indicated in the table of methods.

Structure analysis after BARKMAN (1988):

The structure analysis after BARKMANN allows a horizontal as well as a vertical estimation of vegetation density.

Four slats with drillings at intervals of 5 cm are stuck into the ground forming a rectangle of 0,10 x 1 m. Round sticks with a diameter of 1 cm are inserted into these drillings. Two sticks that are marked with colour every ten cm are needed.

This allows the classification of the vegetation density vertically as well as horizontally (in intervals of 10 cm). At the same time, the coverage can be estimated. After the top layer has been estimated, the sticks are moved down and the vegetation above is harvested. Then the whole process can start anew.

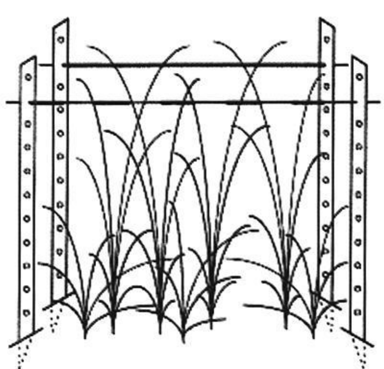


Fig. 3: ***The slats can be displaced horizontally, which allows an exact estimation and collection of each layer (UBA, 1998)***

This rather time-consuming method (12-14 minutes without harvesting) helps to calculate the LAI (leaf area index) per layer.

Literature: BARKMAN, J.J. (1988); UBA (1998)

8. Structure Measuring Tube after SUNDERMEIER & MEISSNER:

The objective of this method is to calculate the vegetation density profile and the frequency of species. To do so, a structure measuring tube is needed, as described below.

This measuring device consists of a tube (plastic) with a length of about 25 cm and a diameter of 16 cm. The end of the tube is covered so as to keep an area of 10 x 10 cm free. On this area, there are two close counting frames with 25 fields. At the other end, there is a mirror with an angle of inclination of 45 degrees.

Processing is as follows: The tube is placed into the vegetation. At a distance of 10 cm, there is a white canvas, in order to increase the contrast to vegetation. This renders a good view at the lower layers of vegetation possible, even from a quite comfortable position.

This method helps to classify vegetation density and the frequency of herbal vegetation. It is especially suitable for the observation of microhabitats.

Literature: SUNDERNEIER, A., MEISSNER, A. (in Vorb.); UBA (1998)

9. Light Methods:

Indirect Structure Characterization using Light Sensors:

With this method, the structure of vegetation can be quantified. Three proceedings can be grouped under this method:

- Punctiform light sensor: This sensor is held into the stock at different intervals to measure the photosynthetic, active radiation or entire radiation per layer. Another sensor above the stock provides reference values. Measuring has to take place while light conditions are constant.
- Sunfleck-Ceptometer: 40 or 80 punctiform light

sensors respectively are installed in a stick with intervals of 1 cm. At every measurement, the mean value is indicated.

- LAI-Analyzer: A fish eye lens pointing upwards is used for this method. Light hitting the lens at an angle from 0 to 74 degrees is transferred to 5 detectors. Only light hitting the detector at a certain angle is being measured.

These are very easily conducted methods, which do not harm the vegetation that is to be investigated. The light that is of use for the plants can be excellently measured in the lower layers.
Literature: PERRY, S.G., FRASER, A.B., THOMPSON, D.W., NORMAN, J.M. (1988); UBA (1998)

Vegetation Stratimeter after OPPERMANN (1989):
This method allows measuring the light conditions in the stock independently from those conditions currently prevailing.
The stratimeter consists of two plates the size 40 x 10, which stand in front of each other at a distance of 22 cm. On the one plate, there are 110 light emitting diodes installed, sending the light. On the other plate, there are Si-solar cells installed, receiving the sent light. The percentage of sent light hitting the plate with the solar cells is measured.
The light conditions in the stock are measured with this method. From the obtained data, one can also conclude the vegetation frequency as well as the weight, be it in dry or fresh state.
Literature: OPPERMANN, R. (1989); UBA (1998)

Laser-Densitometer after GERSTBERGER & ZIEGLER (1993):
This method, which is being conducted with a laser, can also measure vegetation frequency.
The size of the stratimeter is 25 x 25 x 10 cm. Four rolls that are installed at a cabinet hold the stratimeter on a metal bar, so as to shift it horizontally. Proportionately to the way, the laser is sending impulses. Every laser beam gets horizontally through the stock that is to be investigated and either hits a reflecting canvas at a certain distance or is scattered by parts of the plants. Those light beams hitting the canvas unhindered are mirrored back to the device and registered. The quotient from the non-reflected and the sent laser beams is an indicator for the horizontal vegetation frequency. This method can be applied to incomplete and dense stocks likewise. However, singular culms and panicles of grasses cannot be spotted. For stocks with a height under 20 cm, measurement is going to be problematic because the device has to be able to move on the metal bar and is often hindered by vegetation.
Literature: GERSTBERGER, P., ZIEGLER, W. (1993); UBA (1998)

10. Aerial View Analysis:

This method is especially suitable for defining types of vegetation of large areas by means of flying over the area in question, because there mostly is a low frequency and also a low standard of route network.
First of all, one needs an overview of the vegetation of the area that is to be investigated. Of special concern is also the planning of the flight route. This requires a good preparation and a lot of experience. Helicopters are especially suitable for these surveys because they allow varying the speed. A scale of the aerial view of 1:5.000 and 1:15.000 is recommended and the most apt flight height is 2000 - 4000 m. Moreover, a short exposure time of 1/ 1000 sec and an average focal distance of = 20 - 30 cm should be installed so as to conclude from the pattern on the picture the type of vegetation.
A large number of parameters can be obtained by means of aerial view interpretation, of course de-

pending on the equipment.

Literature: UBA (1998)

The Russian School deserves to be mentioned in this context as a completion because it is also very suitable for the mapping of large areas.

The new Russian School:

Due to the fact that processing after the BRAUN-BLANQUET-Method would not be possible for the large areas in Russia, which in most cases are difficult to access, the method of the Russian School was developed to define types of vegetation.

This process does not define a type from the basis upward, i.e. the species, but the other way round. First, the climatic zone is investigated, which defines itself by the following information:

1 average temperature (course of average temperature)
2 annual precipitation
3 duration and intensity of arid period(s)
4 duration and intensity of humid period(s)
5 conditions of frost

Then one can make a floristic distinction: first vegetation type, then formation class, followed by formation group. One can further distinguish between formation, association group and finally association.

An example:

Vegetation type	Forests
Formation class	Coniferous forests
Formation	Spruce forests: Piceeta
Association group	Piceeta hylocominosa
Association	Piceeta myrtillosum

This method can be applied to large areas that are nearly untouched and difficult to access in order to define plant species.

Literature: KREEB (1983)

11. Method after DVWK:

This method tries to characterize the hydraulic efficiency of plants in the flooded area of the lowland forest by means of recorded parameters.

Generally speaking, vegetation is separated into 3 categories:

- Small vegetation: compared to water depth, vegetation is so small that it can be considered a ruggedness of the wall. It is flooded.
- Medium vegetation: the height of vegetation corresponds to the depth of water, vegetation is partly flooded and partly flowed through. Processing is not entirely examined for this type of vegetation of streams. „It is recommended to consider the resistance generated by vegetation in form of the k_s-value in the coagulation, where middle vegetation appears, or to process in case of a high relation h_p/h as with big vegetation." (DVWK, 1991)
- Big vegetation: 3 directly definable parameters are being surveyed:
  - ax distance of vegetation elements in the direction of flow
  - ay distance of vegetation elements transverse to the direction of flow
  - dp diameter of vegetation elements transverse to the direction of flow

Big vegetation is considered rigid. With this data and the appropriate formulas, one can calculate the power of resistance and the resistance coefficient of vegetation.

This method was especially developed for the hydraulic evaluation of the vegetation of riparian forests near streams.

Literature: **DVWK (1991)**

12. **Complete Vegetation Sampling:**

In the area that is to be investigated or in profiles that are chosen in a representative manner, all plants are recorded with regard to the relevant parameters. According to the objective, characteristics that are to be taken down are defined:

- Exact position in order to be able to locate the plant when conducting future investigations (x- and y- coordinate in permanently marked coordinate systems)
- Length of the shoot or height of the tree, respectively
- Diameter of the shoot or of the tree at the basis, respectively
- Diameter of the shoot or of the tree in a height of l = 100 cm or BHD
- Tree species
- Base of crown
- Shape of the crown: screen area, number of beater, number of side shoots
- Wildlife damages
- Other damages

When choosing the profile or sample points, one has to pay attention to random distribution and representative distribution and also keep an eye on a possible peripheral problem.

2.3.2.2 Yield Sampling Methods

13. Complete Yield Sampling:

The processing is as follows: for all tree species, the breast height diameter (BHD) of every tree that exceeds a certain limit (callipering limit) is recorded separately and classified according to their incidence (e.g. 4 cm steps).
In order to receive a representative height for each BHD-class, height graphs are used. Therefore, one has to measure about 20 trees per hectare of the main tree species concerning their height and allocate them to the respective BHD-Class. These heights are input parameters in height graphs that were developed for different regions and different stock types. The height graph of PRODAN (1965) is considered especially apt to examine selection forest, i.e. forests of different age classes:

$$h = \frac{d^2}{a_0 + a_1 \cdot d + a_2 \cdot d^2} + 1{,}3$$

h = mean height for diameter class
d = diameter
a_x = coefficients

With the average height and the respective BHD, one can calculate the volume per area (solid cubic meter of stock per hectare, Vfm/ha), either by using a volume function (form factor function) (e.g. POLLANSCHÜTZ, 1974) or a volume table.
Literature: STERBA , H. (1984); STERBA, H. (1991); PRODAN, M. (1965); POLLANSCHÜTZ, J. (1974)

14. **Harvesting method:**

This is a destructive method that calculates the biomass. This means that the investigated stock cannot be calculated anew after having conducted the investigation.
The vegetation is harvested layer after layer, by not only taking plants that root in the area that is to be investigated but also those plants whose parts reach into the area. Then, the plants are sorted according to species, life forms or growth types and weighed both in a fresh and dry state. This is how the freshweight and dryweight can be obtained. It has to be mentioned that the result heavily depends on the accuracy of the harvest. The smaller the area, the bigger the errors caused by peripheral effects.
This method is of special importance for grassland ecologists. It is the only method for defining the phytomass and the leaf area index (LAI). A disad-

vantage is that this method is very time-consuming, in the field as well as in the laboratory.
Literature: UBA (1998)

15. Phytomass Rate Estimation:

This estimation method developed by KLAPP (1930), i.e. the mass estimation of individual species, is especially suitable for the grassland.
An estimation of the share of each species or group of species concerning the phytomass is conducted. This is texture identification, because spatial distribution is not taken into consideration. This method is easily reproducible because the estimation of all species has to result in 100 %.
As mentioned above, this method serves to estimate the harvest in grassland.
Literature: KLAPP, E. (1930); UBA (1998)

16. Point sampling, Variable Radii-Method (BITTERLICH, 1948):

This method developed by BITTERLICH in the year 1939 revolutionized stocktaking procedures all around the globe (STERBA, 1991).
The basis of this procedure is to choosing the sample diameter of each stem differently, namely proportionately to its BHD. This can be softened by only counting those stems that are broader than a certain measurement.
Every tree falling into the point sampling represents-independently from its size- the same density, i.e. the same stem circle area/hectare.
In practice, the mirror relascope (BITTERLICH, 1984) is often being used for the point sampling. By means of the mirror relascope, there moreover is the possibility to automatically correct the slope.
Point sampling has the great advantage of taking the trees depending on their diameter while taking the area surface. This means that small trees are not taken that frequently, a fact that reduces time and expense. If the shares of the area surface in a mixed stock have to be allocated to the tree species, one has to conduct several measurements of sample circles and to count the valid trees of respective species. The volume of wood per hectare is deducted from the BHD and height of the sample trees with formula tables.
Literature: BITTERLICH, W. (1948); BITTERLICH, W. (1984); STERBA (1984); STERBA (1991)

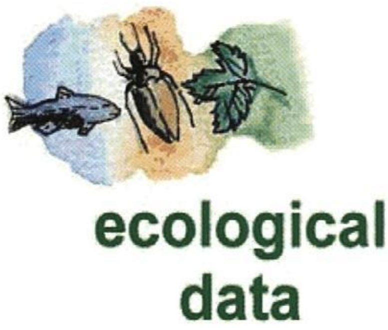
17. Fixed Sample Plot Size:

A grid is placed over a stock. A circle of defined area is placed around each grid point and all trees that fall into this area are recorded according to their relevant parameters: BHD, height, base of crown, upper diameter, tree species, damages to the trunk.
By grossing up the sample areas to hectares, one can calculate area parameters related to harvest.
Literature: STERBA (1984); STERBA (1991)

18. Sampling Plot System:

Starting from every grid point, a fixed number n of the nearest sample stem is examined concerning all relevant parameters. This prevents differing accuracies due to differing number of individuals per sample circles.
According to experience, accuracy does not increase after having taken the 6th tree, so usually a 6-tree-random sample is being conducted in connection with the harvest.
Basically, with all the random sample procedures (Methods 16, 17, 18), accuracy considerations have to be undertaken, on the basis of which the size of the sample probe has to be chosen. Random distribution of the sample points as well as the peripheral problem also has to be taken into consideration.
Literature: STERBA (1984); STERBA (1991)

2.4 Methods - Specific ecological science

		Methods			
		1 FFI (Fluvial Functioning Index)	2 Leaf packs methodology	3 Short term organic matter retention measurements	4 Benthos quantitative sampling
Goal	Quality of ecosystem	x		x	x
	Biodiversity		x		x
	Morphological diversity	x		x	
	Self-equration capacity	x	x	x	x
	Ecological network		x		
	Land planning criteria	x			
	River management	x			
Area	River	x	x	x	x
	Floodplain				
Scale	Test site		x	x	x
	Project area	x		x	
	Catchment area	x			
Connection	Hydrology and Hydraulics				
	Morphodynamics				
	Vegetation science				
	Specific ecological science				
	Socio-Economics				
Application	Stage of Project	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9	3.2 / 3.4 / 3.9

1. **Short term retention measurement:**

   ⇒ Retention mechanisms, organic matter demolition

The organic matter retention can be measured as the quantity of material transported in a stretch of stream compared to the initial quantity of the material released in the stream.
For this study we use *Ginko biloba* leaves because it is an exotic plant and its leaves have a particular shape and maintain the yellow colour for a long time, for this reason these exotic leaves cannot be confused with autochthonous leaves. The leaves were soaked before being used because dry leaves float on the surface of the running water and cannot be trapped by the streambed under cobbles, boulders of bedrocks. We release one thousand leaves at the top of a stretch of river of 100 meter, and we count the leaves that arrive at the transverse end line of the stretch, after 1, 2, 3, 4, 7, 10, 15, 20, 40 and 60 minutes after the release. In this way, it is possible to compare the retention of each site and to elaborate some hypothesis on retention feature. Retention mechanisms, which retain CPOM in the system, are very important, because they allow it to be processed rather than transported downstream in a coarse particulate form. The knowledge and the measurement of organic matter retention stream features constitute an important step to understand the dynamics that regulate the formation of specific macroinvertebrate community; moreover retention can be related to the biotic colonisation dynamics of substrates and to organic matter demolition.

2. **Leafpack methodology:**

   ⇒ Organic matter demolition, detrital processing analysis

For the formation of the leafpack (called LP) alder (*Alnus glutinosa*) leaves are used because it is a riparian plant and the leaves are rapidly stroyed.
The leaves, after dehydration in an oven at 40°C, are made into packs weighing 5±0.1 grams.
The LPs prepared like this are taken to the site of the investigation and softened with stream water. Subsequently some LPs (generally 7) are fixed onto nylon cords with plastic staples. In each site 5 cords with the LPs are anchored onto the bed.
In total 35 LPs per site are positioned whereas 5 LPs are inserted into plastic bags with stream water to determine leaching after 48 hours in the labo-

ratory. At weekly intervals 5LPs are removed, one for each cord, collecting everything with a small-meshed net (200-300m). The washed leaves are then dehydrated in an oven at 40°C. The weight of each dried LP is measured with a precision of ±0.1 grams.
As temperature influences the processes of bacterial demolition, at the moment of sampling the temperature of the water is ascertained and then transformed into degree/day, multiplying the average daily temperature for the time between the two samples.
The LP weight data is worked out as indicated in literature (Peterson and Cummins, 1974),
Packs are an initial step in the loading of detritus in the stream ecosystem. Determining their dynamics and ecology is fundamental to understanding detrital processing.

3. Benthos quantitative sampling:

⇒ Macrobenthos distribution, population dynamics and productivity estimation

For quantitative sampling on compact substrata surber is the most used sampler: it consists of an aluminium frame that defines a fixed area of 0.1 m^2 of riverbed. The frame support a net to collect organisms washed into it from the sample area. The net is about 90 cm long, whit the first few centimetres constructed of heavier material; the mesh size is 10 threads/cm. The net was lifted out of the water and all organisms were washed into a plastic bottle put at the end of net.
Macroinvertebrate quantitative collection consists of jabbing the surber sampler in the riverbed. Surber is thrust into the target habitat and cobbles present into surber are swept and cleaned for a fixed period (5 minutes). Reliability of mean density estimates depends on a great number of variables, such as number and size of samples, substratum typology or macrobenthos distribution on the substratum. Choice of sampling sites is made in areas where substratum is homogeneous.
With this methodology abundance of community can be correlated with a fixed area of the riverbed. Quantitative sampling allows population dynamics and productivity estimates.

4. FFI - Fluvial Function Index:

⇒ River morphological and ecological features analysis

The FFI is a development of the RCE-2, the first draft of which was drawn up by Siligardi and Maiolini (Siligardi & Maiolini, 1993) which in its turn derives from the Riparian Channel and Environmental Inventory (RCE-I) drawn up by Peterson from the Institute of Limnology of Lund University (Peterson, 1990).
The current FFI record was further refined and foresees 14 questions, with 4 predetermined answers to each question, concerning almost all the ecological characteristics of a watercourse. The answers have a numerical expression by classes of numbers with a minimum of 1 and a maximum of 30, capable of expressing the qualitative differences between individual replies. From the mathematical point of view there is no justification of the attribution of the numeric weight of the answers, but only statistical-ecological motivations which are based on the mutual relations existing between the concepts contained in the answers, making the method substantially more stochastic and less deterministic.
The compilation of the record terminates with the calculation of the sum of the different weight given to the answers identified (one is compulsory for each question) and hence with the definition of the SCORE which can be from a minimum of 14 to a maximum of 300 and which has been translated into 5 quality classes, giving each a rating and a colour according to the points band, with the scope both of illustrating a map and of making interpretation easier also for those not in the field.

2.5 Methods - Socio-Economics

		Methods										
		Examination, analysis and interpretation of topographical maps	Design, analysis and interpretation of thematic maps	Remote sensing	Geographical Information System	Investigation, analysis and interpretation of land use / land use mapping / design and use of land utilisation plans	Investigation of landscape framework / conservation plans	Investigation, analysis of regional planning targets, plans and current procedures	Investigation about legislation / entitlements and contracts / rights of use and enjoyment	Investigation/survey of economical and demographical data	Cost-benefit analysis local and regional	Public opinion poll / survey
		1	2	3	4	5	6	7	8	9	10	11
Goal	Density of population	(x)	x	(x)	x	(x)		(x)		x		
	Existing and future infrastructure	x	x	x	x	x		x	x			
	Existing/planned technical construction	x	x	x	x	x		x	x			
	Intensity of land use	x	x	x	x	x	x	x	(x)	(x)		x
	Ownership and utilisation	(x)	x	(x)	x	x		x	x			
	Recreation and tourism	(x)	x		x	x		x		x		x
	Economical performance	(x)	x		x			x	(x)	x		(x)
	Economical value and function	x	x		x	x	(x)	x		x	x	(x)
	Nature protection areas	(x)	x	(x)	(x)	x	x	x	(x)			
	Jurisdiction and competence	(x)	x	(x)	x	x	x	x	x			
	Social, political and economical acceptance enforceability of obj.	(x)	(x)		(x)	x	x	x	x	x	x	x
	Identification of potential retention and flooding areas	x	x	x	x	x	x	(x)	(x)			(x)
	Risk / Prevention of flood induced human damages	x	x	x	x	x		x				
	Risks and costs of flood damages / Prevention	x	x	x	x	x		x			x	
	Costs and benefits of measures	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	(x)
Area	River	(x)	x	x	x	x	x	x	x	x	x	x
	Floodplain	x	x	x	x	x	x	x	x	x	x	x
Scale	Test site		x	x	x							x
	Project area	x	x	x	x	x	x	x	x	x	x	x
	Catchment area	x	x	x	x	x	x	x	x	x	x	x
Connection	Hydrology and Hydraulics					(x)		(x)	(x)		(x)	
	Morphodynamics											
	Vegetation science					(x)						
	Specific ecological science											
	Socio-Economics											
Application	Stage of Project	3.1 / 3.2 / 3.3 / 3.5	3.1 / 3.2 / 3.3 / 3.9	3.1 / 3.2 / 3.3 / 3.8 / 3.9	3.1 / 3.2 / 3.4 - 3.9	3.2 - 3.5 / 3.6 / 3.8 / 3.9	3.1 - 3.3 / 3.5 / 3.6 - 3.9	3.1 - 3.3 / 3.5 - 3.9	3.1 - 3.3 / 3.5 - 3.9	3.1 - 3.3 / 3.5 - 3.9	3.1 - 3.3 / 3.5 / 3.6 / 3.8	3.1 - 3.9

1. **Examination, analysis and interpretation of topographical maps:**

The distinctive characteristic of topographical maps is that the shape of the Earth's surface is shown by contour lines. Contours are imaginary lines that join points of equal elevation on the surface of the land above or below a reference surface such as mean sea level. Contours make it possible to measure the height of mountains and steepness of slopes. The map also includes symbols that represent such features as streams, streets, buildings and woods. These symbols are constantly refined to better relate to the features they represent, improve the appearance or readability of the map, or to reduce production cost. Compared to geological maps topographical maps show the recent situation of river morphologies.

Literature: HAKE, G. (1982); HAKE, G. (1985); HAKE, G., GRÜNREICH, D. (1994), **SCHULZ, G. (1991)**

2. **Design, analysis and interpretation of thematic maps:**

Thematical maps illustrate particular themes, trends, features, or concepts to describe the spatial patterns of specific phenomenon's. Examples are historical maps, land use maps, demographical maps, hydrological maps, geological maps, vegetation maps and climatological maps. The most important thematical maps in river morphology are hydrological maps. Hydrological maps give information about existence of superficial and subterranean water, and the usage. Data about the location of climatological and hydrometrical stations are provided, as well as rivers, streams, ponds, dams, tacks, wells, springs and channels. The combination of different thematical maps, e.g. in a Geographical Information System gives further information about coherences and dependencies.

Literature: HAKE, G. (1982); HAKE, G. (1985); HAKE, G., GRÜNREICH, D. (1994)

3. **Remote sensing:**

Remote sensing is the science and art of obtaining information about a phenomena without being in contact with it. Remote sensing deals with the detection and measurement of phenomena with devices sensitive to electromagnetic energy such as:

- Light (cameras and scanners)
- Heat (thermal scanners)
- Radio Waves (radar)

It provides a unique perspective from which to observe large regions. Sensors can measure energy at wavelengths which are beyond the range of human vision (ultraviolet, infrared, microwave). Global monitoring is possible from nearly any site on earth.

Literature: ALBERTZ, J. (2001)

4. **Geographical Information System:**

GIS stands for Geographic Information Systems. A Geographic Information System is a combination of elements designed to store, retrieve, manipulate, and display geographic data - information about places. It is a package consisting of four basic parts: hardware, software, data and a thinking operator. Practitioners also regard the total GIS as including the operating personnel and the data that go into the system. Spatial features are stored in a coordinate system (latitude/longitude, state plane, UTM, etc.), which references a particular place on the earth. Descriptive attributes in tabular form are associated with spatial features. Spatial data and associated attributes in the same coordinate system can then be layered together for mapping and analysis. GIS can be used for scientific investigations, resource management, and development planning.

Literature: LONGLEY, P.A., GOODCHILD, M.F., MAGUIRE, D.J., RHIND, D.W. (2001);
Further Information by: ESRI, Canada http://www.esri.com/

5. Investigation, analysis and interpretation of land use / land use mapping / design and use of land utilisation plans:

In areas with high population density quantifying, monitoring and managing land use becomes increasingly important. Land use mapping is used for modeling urban growth, determining land suitability for future development, monitoring how land use changes affect the environment, understanding land use patterns and developing policies concerning land use development. Especially in hydrology the understanding of land use in catchment areas provide evidences for water budget in quality estimations. Because of an increasing demand of land use information remote sensing plays an important role in making large scale maps.
Literature: ALBERTZ, J. (2001); HAKE, G. (1982); HAKE, G. (1985); HAKE, G., GRÜNREICH, D. (1994)

6. Investigation of landscape framework / conservation plans:

The landscape framework plans must embody and supplement the representations in the regional development plan to protect and develop nature and landscape at regional level. Their conversion into appropriate local assessments and measures is the function of landscape plans and other nature conservation procedures. As landscape framework plans, area development plans should work towards the special care and development of cultural landscapes. They should safeguard the spatial criteria for the protection and development of characteristic biotopes, landscape structures and land uses. Within valuable cultural landscapes, core areas and regional level interlinking elements of biotope conservation should be represented as "nature conservation zones". Other open-space functions should largely be safeguarded by means of "landscape conservation zones".

These goals of the landscape framework plan are to be translated into subsequent landscape plans mainly through the representation of appropriate development goals and the designation of specially protected parts of nature and landscape and the measures required to develop, care for and improve them. As a landscape framework plan, the area development plan presents the regional requirements and measures to conserve nature and care for the landscape. It is the task of area development planning to set forth and supplement the areas shown in a very generalised way in the Regional Development Plan and include regional requirements and the latest state of knowledge.
Literature: AKADEMIE F. RAUMFORSCHUNG U. LANDESPLANUNG (1994); JESSEL, B., TOBIAS, K. (2002)

7. Investigation, analysis of regional planning targets, plans and current procedures:

REGIONAL PLANNING:

Regional planning comprises land use planning as well as development local, regional, and national level. Regional planning describes the coordination of spatially effective human activities and the control of these activities over a longer period of time and covers the spatial principles and planning activities at the federal level in Germany. Thereby the planning agencies at the different levels have to attune themselves to each other in all spatially relevant fields (environment, economy, transportation, settlement, etc.). The very beginning of Raumordnung in Germany dates back to the first decades of the 20th century. After World War II, Raumordnung was legally established in the Federal Republic of Germany (FRG) in the 1960's. Since the 1990's, Raumordnung faces new challenges due to German reunification and European integration.

The main goals are:

- Providing equivalent conditions of living in all regions of the Federal Republic of Germany
- Promoting the integration of Germany into Europe
- Protecting and maintaining the natural resources of living

The general guidelines of the ROG were formulated as extremely general statements in order not to restrict the sovereignty of the federal states and the municipalities. On the other side special aims were cemented into the program of federal regional planning (Bundesraumordnungsprogramm (BROP) in 1975.

The regional planning system of Germany can be seen as an example for planning in a federal state. The organizational responsibility for Raumordnung, for example the development of the programs of Raumordnung (Raumordnungsprogramme), is carried by the Federal Ministry for Transportation, Construction and Housing (Bundesministerium für Verkehr, Bau- und Wohnungswesen). In 1968, the Minister Conference for Raumordnung (Ministerkonferenz für Raumordnung (MKRO)) was set into action as an authority between the federal and the state level. It is responsible for harmonizing the conceptual ideas of spatial planning at the federal states level. At this level the legal competence is carried by the state parliaments (passing the state planning laws, and establishing the state planning programs). The central planning agencies of the federal states have the duty to harmonize the contents of the single regional plans. The main task of regional planning then, is the horizontal harmonization of municipal planning and adjusting the municipal plans towards the targets set by the federal state for spatial planning. The whole planning system is basically orientated along the so-called countercurrent principle (Gegenstromprinzip), which is seen as a distinct characteristic of the spatial planning system of the FRG.

Literature: KLUCZKA, G. (1980); AKADEMIE F. RAUMFORSCHUNG U. LANDESPLANUNG (1994)

Environmental Impact Assessment:

Environmental Impact Assessment is the assessment of environmental effects which may arise from a major project. The Environmental Impact Assessment comprehends the coverage, description and the valuation of impacts from a project on human, flora, fauna, soil, water, air, climate and landscape. The essential information get collected in environmental impact studies. The information provided will be considered by the planning authority prior to determination of the application. In Germany the assessment procedure is under federal law, with citizens participation, concentrating the pertinent permit procedures (e.g. pursuant to nature conservation and water legislation) and no formal link to spatial planning laws (of the states). The Environmental Impact Assessment is not an independent procedure but embedded in the administrative procedure that assesses a projects legitimacy.

Literature: JESSEL, B., TOBIAS, K. (2002); SCHOLLES, F., (1997); STORM, P.-C., BUNGE, T. (1988)

8. Investigation about legislation / entitlements and contracts / rights of use and enjoyment:

Existing contracts and usage rights have to be considered in time in the planning process to prevent further conflicts with involved parties. Legal usage rights furthermore are protected by law and cannot get changed easily.

Further information and examples:

Richtlinie 92/43/EWG des Rates vom 21. Mai 1992 zur Erhaltung der natürlichen Lebensräume sowie der wildlebenden, Tiere und Pflanzen (ABl. EG Nr. L 206 S. 7)

Richtlinie 79/409/EWG des Rates vom 2. April 1979 über die Erhaltung der wildlebenden Vogelarten (ABl. EG Nr. L 103 S. 1)

Gesetz über Naturschutz und Landschaftspflege Bundesnaturschutzgesetz – BnatSchG. Fassung vom 21. September 1998. (BGBl. I 1998 S. 2994; 27.7. 2001 S. 1950, 2001 S. 2331, S. 2785 Art. 205), Bundesrepublik Deutschland

9. Investigation / survey of economical and demographical data:

The investigation of economical and demographical data is helpful for every project to appreciate the economical value and performance of the region. This should be considered in terms of public acceptance and enforceability of the project. Those data can be obtained at the local and regional authorities and at the federal statistical office.

Literature: CANSIER, D. (1993)

10. Cost-benefit analysis local and regional:

In general the cost benefit analysis is the calculation of the cost benefit ratio of social activities expressed in monetary units. The expression cost benefit analysis often is the generic term for all kinds of economical evaluation studies.

Literature: CANSIER, D. (1993); WEIMANN, J. (1995); WICKE, L. (1989)

11. Public opinion poll / survey:

Opinion polls are helpful to find out the acceptance for projects that get controversial discussed in the population. It is also a contribution that enhances participation of affected population groups.

Literature: CANSIER, D. (1993)

Riparian Forest Management

Guidelines for End-Users

APPENDIX II

elaborated by the RipFor NAS partner
University of Bucharest
according to
Contract No QLK5-CT-1999-01229, Amendment No 1

RipFor-Team

Preface

This final report of the NAS partne r in RipFor project is designed as an Appendix of the main RipFor Guidelines for the management of riparian forests.

While the main Guidelines focus on principles and methods for the management of riparian forests *per se* (site specific management), the Appendix Guidelines provides information for preserving the role of riparian forests in the production of **biogeochemical and species diversity services** by river basins and ecoregions (large scale management).

The management of the natural capital at macrolandscape level is a public institutional issue, is currently in view of sustainable development, and supposes a **co-management approach**. In order to provide a clear understanding of the co-management approach, we referred to the relationship between large scale management and site specific management. In this way there is a direct connection, and not only a complementarity with the main Guidelines.

The target groups of the Appendix Guideline include all the potential partners in a co-management approach: **the public institutions, the private users and the civil society**.

Projects at macrolandscape level are large projects, having as result many **co-ordinated site specific projects**. Large projects are resources intensive and require complex and comprehensive project management methods. We have not introduced in the report such general managerial methods, and direct the user to the main Guidelines and to other existing documents such as EC Project Cycle Manual and Handbook[1]. Depending on the financing agency envisaged for the macrolandscape planning project, other specific documentation sources may be needed.

Here we have focused on the **general structure of the approach** for managing the riparian forests in a macrolandscape context, on how to establish the **optimum portfolio of objectives**, and on the **measures** to be taken in order to reach the objectives. Thus, the Appendix Guidelines is to be seen as one of the tools needed for designing projects at macrolandscape scale.

Virgil Iordache

CONTENT

Overall structure conception: Virgil Iordache
Chapters written by: 1-3, 7 Virgil Iordache, 4 Virgil Iordache and Aurora Neagoe based on syntheses performed by RipFor-NAS contributors, 5 Virgil Iordache, Florian Bodescu, Aurora Neagoe, 6 Virgil Iordache and Florian Bodescu
Cover page photo: RipFor team
Text photos: Virgil Iordache

[1] Both documents are available at http://europa.eu.int/comm/europeaid/evaluation/methods/pcm.htm

1. Introduction

The sustainable development (UNCED 1992, EU 2001, Guvernul Romaniei, 1999) requires an adequate management of all types of capital on which the functioning of socio-economic systems (SESs) depends.

SESs strongly depend in their structure and functioning on natural resources and services, which are produced by the natural capital (NC). The production of resources and services is the result of the structure and functioning of the natural capital[2]. Both the SESs and the NC have a nested hierarchical structure (Allen and Star 1982, Botnariuc and Vadineanu 1982, Eldredge 1985, Salthe 1985, O'Neill et al. 1986, 1989, Odum 1993, Klijn and de Haes 1994, Vadineanu 1998, Botnariuc 1999, Iordache 2002a).

Riparian forests (figure 1) are part of the NC used by SESs, provide specific resources and services, and **have a role in the production of resources and services done by the NC systems which include them (micro- and macrolandscapes)**[3]. Adequate management of the riparian forests, as required by sustainable development, means a management which

- maximize the offer of resources and services provided by riparian forests, and
- **preserve the role of riparian forests** in the production of resources and services made by NC systems which include them (micro- and macrolandscapes),
- within the constraints imposed by given individual and societal objectives

Which are the organizations[4] interested in developing and implementing the plans for the management of riparian forests in a macrolandscape context?

What kind of knowledge do they need to acquire in order to design appropriate management plans?

And how should they interact in designing and implementing the management plans?

Figure 1 Riparian forest in the Lower Danube floodplain (Small Island of Braila National Park) during spring flood.

Providing correct answers to these questions is essential, because will directly influence the structure of the portfolio of management objectives, and thus the management effectiveness. Towards the needed answers and their practical illustration, the following chapters will follow:

- The overall structure of SES-NC systems
- The systemic approach in managing macrolandscapes
- The role of riparian forests
- Principles for managing the riparian forests in a macrolandscape context
- Case study: the fluvial macrolandscape of the Lower Danube River

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[2] Thus, the natural capital *is not* the natural resources and services.
[3] Examples of NC systems which include riparian forests are floodplains, river basins, and ecoregions.
[4] Management plans are instruments used for reaching *organisational* goals.

2. The overall structure of SES-NC systems

As already mentioned, both NC and SESs have a nested hierarchical structure. However, there are different views about how this hierarchical structure is organized. Here we use the concept model presented in figure 3. Adopting a simpler concept model[5] would simplify the managers tasks, but will also decrease the effectiveness of the management. Box 1 and 2 present key elements concerning the structure and functioning of socio-economic systems.

There are two different hierarchies of systems, one of the natural ecological systems and one of the socio-economic systems. As source of natural resources and services, the natural ecological systems represent natural capital for the SESs. A riparian forest can be included both in an integrating natural macrolandscape (for instance a fluvial system, an ecoregion, or a river basin) and in a socio-economic system. However, the role of the riparian forest in the different integrating systems will be sustained by different energy and matter fluxes (figure 2). There is not necessarily a spatial (geographic) superposition between the systems integrating the riparian forest. Most frequently the integrating systems have not superposed spatial limits. Just think to the map of ecoregions in a country, of river basins, and of local SESs (an example, for the case of Romania, is presented in figure 4). Some of the systems integrating riparian forests have sharp limits (river basins, socio-economic systems), other rather diffuse limits (ecoregions). The identification of the ecological systems which are not sharply delineated by steep gradients is influenced by subjective factors, including political ones (Nassauer 1992). Fortunately, in Europe the indicative limits of the major high order ecoregions are already publicly accepted (Fauna, Flora and Habitats (FFH) Directive), as well as those of lower order ecoregions in most countries (for Romania, as described in Vadineanu et al. 1992, figure 4).

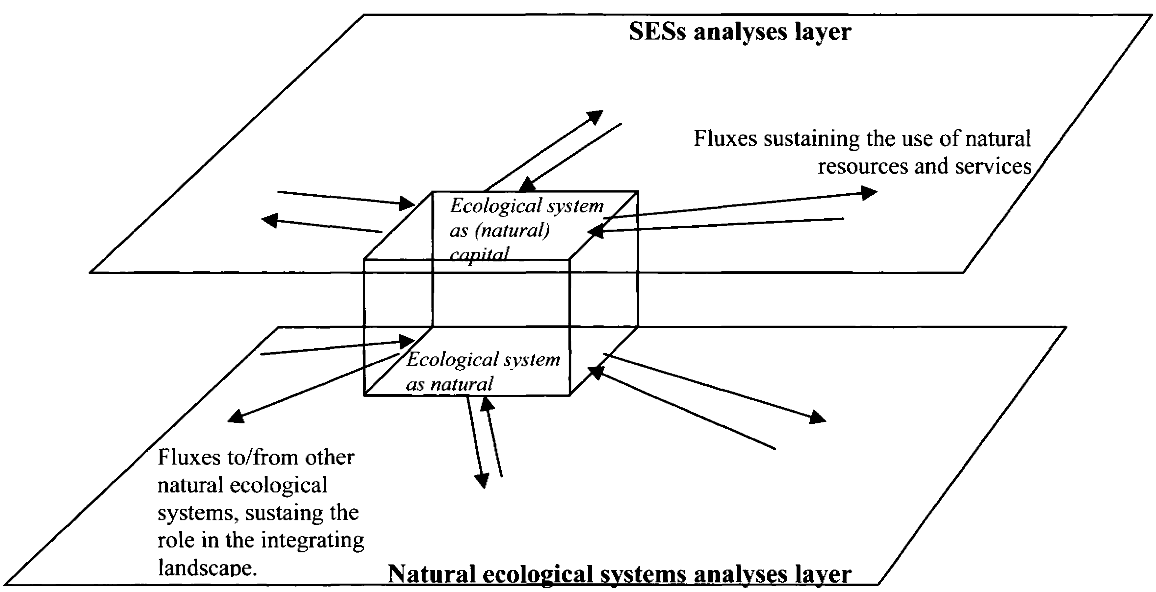
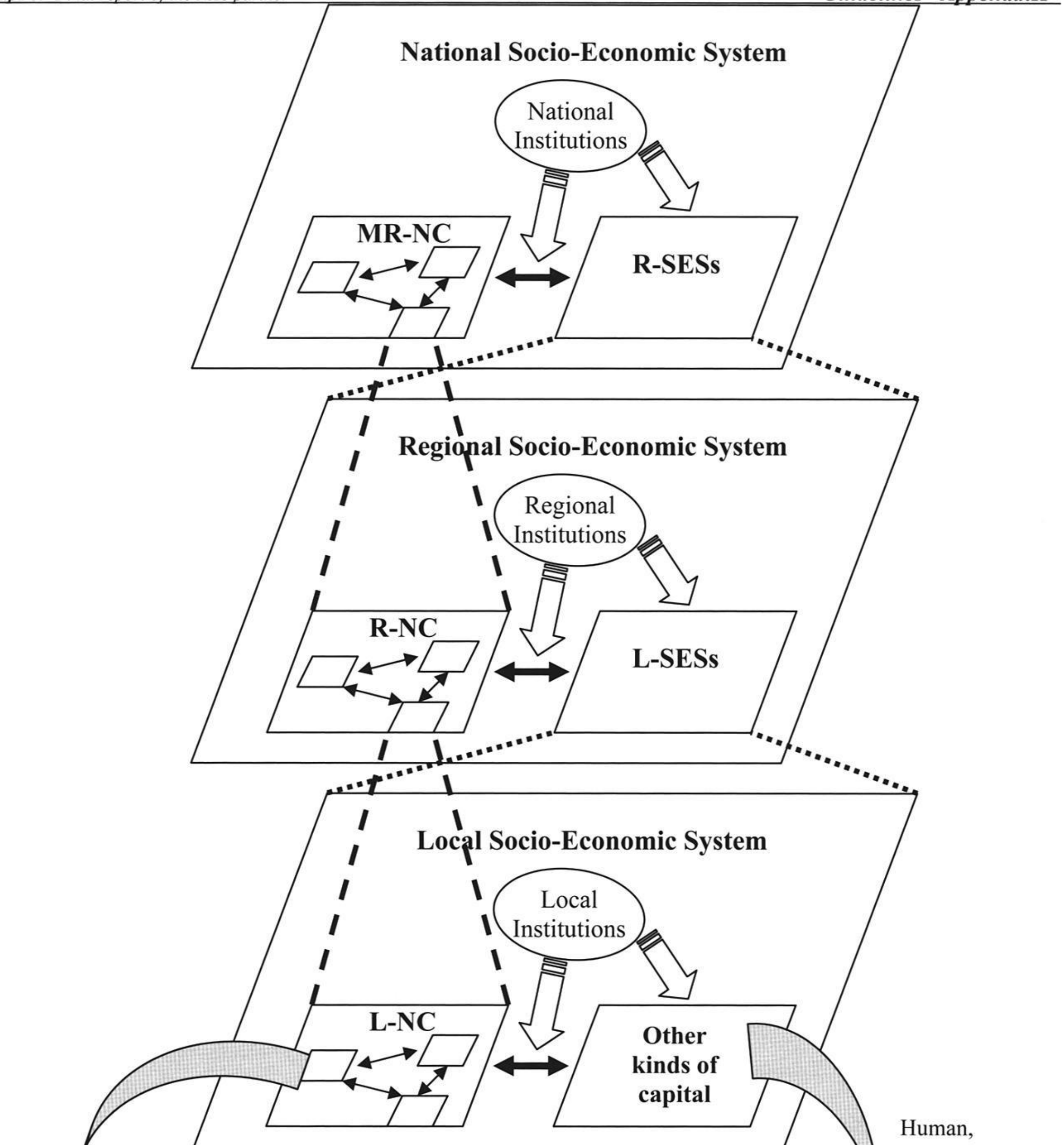


Figure 2 The double inclusion of a riparian forest (the cube, in this schematic representation) in the integrating natural and socio-economic systems

[5] In one of the concept models the natural capital consists in natural resources and service, and subsequently what one needs is a pure sectoral management of natural resources and services. The other concept model is more elaborated, considering that the natural capital is a hierarchy of ecological systems, but missing the point that natural ecological systems are also included in the SESs as natural capital. According to the views of those holding this second concept model, the fact that NC and SESs are separate hierarchies leads to the conclusion that there are clear spatial, geographical limits between NC and SES (e.g. Odum 1993), or, in other terms, that a natural capital component, such as a riparian forest, is *outside* the SES. The view is intuitive and apparently acceptable at low hierachical level (a village vs. the nearby forest). However, the view is not according to the reality, if one looks, for instance, to the administrative boundaries of the village and to the ownership relations. Its inappropriatenes becomes even more obvious if one goes up in the hierachies, to ecoregions and river basins vs. counties and countries.



Kind	Functional modules	i/j	1	2	3	4	5	6	7
Private organisations	ISPC	1	x	x	x	x	x	x	x
	Extraction of natural resources	2	x		x	x		x	x
	Processing of natural resources	3	x			x	x	x	x
	Services production	4	x	x	x	x	x	x	x
	Conceptual objects production	5	x	x	x	x	x	x	x
Public organisations	Public services production	6	x	x	x	x	x	x	x
	Public conceptual objects production	7	x	x	x	x	x	x	x

Figure 3 Schematical representation of the structure of a country (national socio-economic system). At the local level a simplified connection matrix (corresponding to a homomorphic model) is presented, as a framework for analyzing the relationships between the functional modules (groups of organizations) of a local socio-economic system. *Legend:* NC = natural capital, MR = macroregional, R = regional, L = local, ISPC = individual system of production and consumption, flux i,j = outflow, flux j,i = inflow, (e.g. flux 1, 2-7 = flux of human resource (work), flux 1,1 = services provided between individuals).

Box 1 Key elements concerning the structure and functioning of socio-economic systems.

Basic assumptions

1. One system ca be included in more integrating systems at the same time. *The mechanism of this multiple inclusion is linked to the structure of the integrated system, which allows the system to participate with different fluxes of energy matter and information in the integrating systems.*

2. Value is a relational property. *Emergent properties of systems are intrinsic (due to the functioning of the system) and relational (due to the interaction of the system with other systems). Value is a relational emergent property appearing when a biological individual having needs as intrinsic properties interacts with other systems able to satisfy its need (i.e. to provide resources and services to the biological individual).*

3. Each biological individual tends to maximize the overall satisfaction of its needs.

4. Individuals of some species are characterized by an altruistic need, consisting in needing to help other individuals of the same or other species. *Selection of altruistic need as an intrinsic property of the individuals took place due to advantages at group level (fewer resources spent on conflicts, higher productivity of the group with altruistic individuals). The "intrinsic value" (of natural capital or whatever else) is a conceptual object used by individuals to satisfy their altruistic need*

Aspects concerning the structure of SESs

1. Each human individual and its resources (property) make up a system producing services (and, eventually, resources) and consuming other services and resources. Let us call this system an individual system of production and consumption (ISPC);
2. The basic units of SESs are organisations. The organisations are components of SESs consisting of a human part (human capital), a non-human part (different types of non-human capital, including natural capital), having as role to transfer the raw material, energy and information flows originating in the natural capital (goods and services) and in ISPC (services), in an unprocessed (services production) or processed (goods and services production) form, to their ecological consumer (ISPC). ISPC is a special type of organisation.
3. Natural capital is part of SESs in the sense that it consists of natural ecological systems with value (providing resources and services needed by ISPC). By other kind of fluxes, the natural ecological systems are integrated at the same time in the hierarchy of natural ecological systems. Natural capital at lower hierarchical levels (ecosystem, local landscape) can be owned by organisations, but at higher levels (regional, macroregional) cannot be owned, thus requiring specially designed organisations for its management.
4. The ecological systems identification (Pahl-Vostl, 1995) applied to SESs leads to a homomorphic model in which organisations are grouped (using as criteria the time constant, the space-time location and the functional niche) in functional dynamic modules (FDM)
5. Similarly to the case of natural ecological systems, the emergent properties of a SESs can be structural and functional. Functional dynamic modules consisting of organisations characteristic exclusively to integrating SESs are their emergent structural properties (e.g. the state organisations in a national SES, or global organizations in the global SES). The emergent functional property of regional, macroregional and global SESs is the enhanced productivity of goods and service as a result of the new FDMs and of the exchanges of goods and services between included SESs through the organisations from their structure.

Aspects concerning the functioning of SESs

1. All the production of goods and services in a SES takes place within the organisations.
2. A market is a subsystem consisting in an upstream functional module and a downstream functional module, the last one intercepting the goods / services produced by the first one.
3. The transfer of goods / resources takes place in a market by exchange; plunder takes also place in SESs, which is the natural form of transfer of resources.
4. The transfer of material goods between FDMs (mediated by the included organisations) represents a transfer of structural components. The significance of the material goods transfer is material, energetic, and also informational.
5. The providing of services is valued not from material or energetic point of view, but from an informational one (at the level of the self-regulating function); it has as consequence the maintenance of the control parameters of the organisation or SES in a given range of values, acceptable for the proper functioning of the system.
6. Organisations can produce not only material goods, but also conceptual goods (e.g. languages, scientific theories, political ideologies, development models – such as the sustainable development model). Some of the conceptual goods have well defined producers, other are historical products (such as a language). Conceptual goods are either private or public. The mechanism of the services providing and conceptual goods production has a material support.
7. Conceptual goods are involved in the information and selfregulation function of the socio-economic systems, and have indirect consequences on the energy flow and cycling of matter functions of these ecological systems.
8. The emergence of new organizations at national and international levels is tightly linked with the production of conceptual goods such as sociological, political, ecological theories. Such organizations emerge because some needs of the individuals can be better satisfied by putting private resources together (e.g. management of natural capital at upper than regional level)

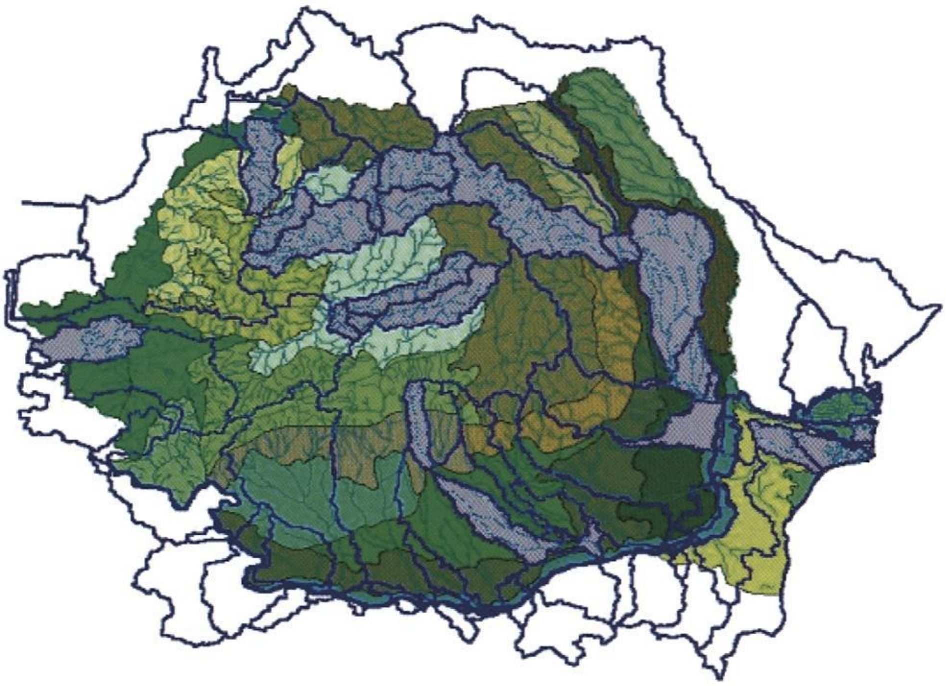


Figure 4 Distribution of river basins (blue contour) and ecoregions in Romania. The basins colored in gray are relatively homogenous from ecoregional point of view (superpose mainly over one ecoregion). The other basins superpose over several ecoregions.

A riparian forest can be included in two natural integrating systems at a time, for instances in a river basin and in an ecoregion. The inclusion in the river basin takes place mostly by hydrological mediated fluxes, and the inclusion in the ecoregion by biologically mediated fluxes. More details about the inclusion mechanisms are provided in chapter 4 ("The role of riparian forests").

Beside its ecological significance (in terms of connecting fluxes of energy and matters) the integration of NC in the SESs has also a cultural meaning, in terms of the characteristics of the property rights. Knowledge about this cultural meaning is essential for designing efficient and effective management measures.

Table 1 presents the characteristics of property rights (adapted from Bromley 1989, Charles 2001), and their presence in the case of ecotones/ecosystems, microlandscapes, and macrolandscapes. Full ownership involves the presence of all characteristics. Full ownership is present in the case individual ownership of riparian forests (ecotones/ecosystems) when there are no recognized public rights concerning the landscapes in which these forests are located. Once such public rights are recognized (at local, county, national, or international level), the private ownership of the riparian forest is constrained to some extent by the management right held by the public institution. This public management right will allow management measures cocerning the landscape structure in order preserve the public services provided by that landscape. The prohibition to harmful use at individual level is the basis for justifying the acceptance of landscape management rights at public institutions level.

Depending on the right holder one can have private ownership (property owned by individuals or group-held property), common property (property owned by the members of the community of a local SES, and managed on behalf of its members by the local institutions), and state property (property owned by the members of the nation of a national SES, and managed on behalf of its members by the state institutions). Groups holding common property have collective choice rights: management rights, exclusion rights (rights to allocate use rights), alienation rights (rights to transfer or sale the other collective choice rights). The special case of non-property (lack of property rights) does not currently characterize riparian forests[6]. Limitations on access and use, an important type of top-down constraint used by the public institutions for influencing the behaviour of social actors, can be performed under any property rights regime.

Table 1 The characteristics of the property right and their presence in the case of the natural capital at different hierarchical levels. Brackets indicate that the right at private level is constrained when there are public management rights at landscapes level.

Characteristic of property right	Comments	Present with regard to:		
		Ecotone/ ecosystem	Micro-landscape	Macro-landscape
The right to possess	In the absence of this there is no ownership	x	x	x
The right to use	Related to use right (access rights and harvest rights)	(x)		
The right to manage	Related to management rights	(x)	x	x
The right to the income	i.e. to receive the income accruing from owning property	x		
The right to the capital	i.e. to alienate, consume or destroy it	(x)		
The right to security	Notably immunity from arbitrary appropriation	x		
Transmissibility	The ability to transfer the right to a successor	x		
Absence of term	Full ownership runs into perpetuity	(x)		
The prohibition to harmful use	Ownership does not include the ability to harm others	x		
Liability to execution	The liability of the owner's interest to be used to settle debts	x		
The right to residuary character	To govern situations when ownership rights lapse	x		
Rights holder		Private (individual p., group p. – corporate or common, state p.)	private or local public	(currently) regional public, and macroregion al public

We end this chapter by underlining the rather counter intuitive fact that having rights over the integrating systems (ecoregions, river basins) does not involve, in our views, having rights over the subsystems (such as riparian forests or other types of ecological systems), because ecoregions and ecosystems are different natural objects, with their own existence status[7]. However, the fact the their functioning is interdependent due to the nested hierarchies to which they belong obligate to a cooperation between those holding rights on systems higher up in the hierarchy, and those owning the riparian forests. Thus, a cooperation between public institutions and private owners. The principles of this cooperation are discussed in the next chapter.

[6] It has characterized, for instances, 'high seas' fish stock.

[7] To negate the existance status of ecoregions would be reductionism, and to negate that one of the ecosytems would be holism. To accept both of them, but recognize their interdependence, is systemism.

3. The systemic approach in managing macrolandscapes

We don't manage ecosystems, we manage natural capital[8]. The reason for which we manage it is the production of natural resources and services. When we can have private control over this production, we don't need to recognize those services as public and to create and pay institutions for managing them. This is the case of the resources produced in small and medium sized ecological systems, which can be owned in the fullest sense. However, the production of resources and services by large and very large natural systems cannot be *de facto*, in most of the current socio-economic systems, controlled by private actors. When every one is interested in these resources and services, the management of the systems producing them (ecoregions and river basins as public goods) will be a public matter, in the name of the public interest. This management is a public service in itself, and will be performed by public institutions, with resources obtained from the private contributors. Figure 5 presents the relationships between the categories of stakeholders involved in the management of macrolandscapes (private users, public institutions, and the civil society), and table 2 shortly describe each category.

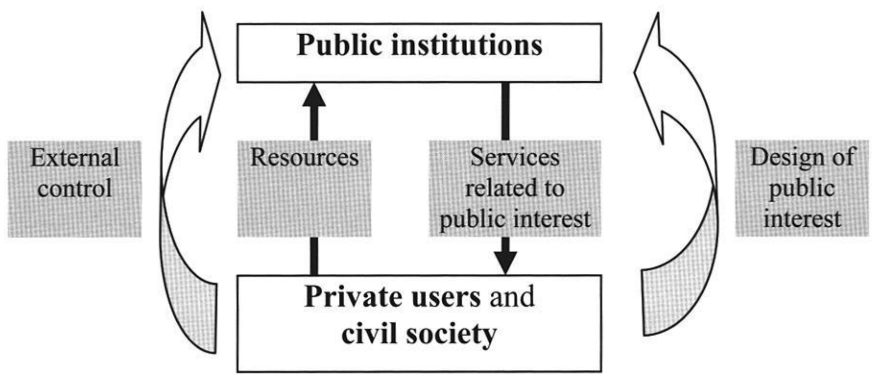


Figure 5 The relationships between the categories of stakeholders involved in the management of macrolandscapes. Block arrows indicate the role of the civil society.

Table 2 Short description of the categories of stakeholders interested in the management of macrolandscapes.

Category of stakeholder	Description
Private users	Private stakeholders interested in using the riparian forests for economic and non-economic purposes (including satisfaction of emotional needs). Examples: economic organizations involved in resources harvesting and in the post-harvest sector, individuals (individual systems of production and consumption - ISPC), households, NGOs promoting ecocentric values
Public institutions	Public stakeholders responsible for promoting the recognized public interests related to the maintenance of the natural public services provided by macrolandscapes.
Civil society[9]	Private stakeholders (ISPC, NGOs (think tanks), political organizations), involved in: ▪ the continuous process of restructuring the recognized public interest, by promoting the acceptance of new public services, or the elimination/adjustment of recognized public services which proved to have been misconceived. ▪ the external control of the efficiency and effectiveness of the public institutions in using the resources provided by private stakeholders for promoting the recognized public interest

[8] i.e. ecosystems with value as a relational property rezulted by their interaction with humans.
[9] The concept of civil society is here larger than usally, by including the political organisations (e.g. parties)

The changes in the structure of the recognized public interest related to natural public services are promoted by:

- the public institutions, as assisted by public and private research and development organizations,
- the civil society, after accessing the scientific knowledge produced by public and private research and development institutions.

The general goal of managing macrolandscapes is:

- the enhancement of the quality of life.

The general principles for managing macrolandscapes are:

1. The management of the macrolandscape should be seen as the management of a **SES-NC system**.
2. The management objectives, instruments and measures for the macrolandscape should take explicitly into consideration the **conflicting goals** of the involved stakeholders. No one of the extreme goals of economic return maximization, social equity maximization, or natural capital full conservation should be institutionally adopted, but a **publicly accepted balance** of them.
3. The management plan should be **inter-sectoral** (explicitly linked to the relevant sector programs), should address the **cross-cutting issues**, and be subject to **strategic impact assessment**.
4. The management measures (e.g. regulations, economic instruments) taken by public institutions in order to promote a certain landscape structure should be complemented by **full compensations** of the unequally distributed decrease in the benefits of the private owners due to the constraints imposed to their property rights.
5. The management objectives and measures should be based on the **best available scientific knowledge** about the production of natural resources and services **publicly accepted in that socio-economic system**; when this knowledge has established the existence of a resource / service, but there are uncertainties about the human impact on its production, a **precautionary approach** should be adopted.
6. The management measures should take into account the **traditional ecological knowledge** available in the local socio-economic systems.
7. The portfolio of management objectives, instruments and measures at a certain socio-economic level should be adaptive, able to react to the natural relationships between the subsystems of the macrolandscape, to their natural dynamic, to the natural dynamic of the macrolandscape, and to the dynamic of the lower level socio-economic systems (**adaptive management**)
8. The public institutions involved in the macrolandscape management should **institutionalize the process of continuos knowledge and data production** with regard to the SES-NC system.
9. The public institutions involved in the macrolandscape management should be **self-regulative, and open to external control** by the civil society.
10. The public institutions involved in the macrolandscape management should be at **the lowest socio-economic level** relevant for that macrolandscape; when this is not operationally possible due to lack of expertize, the management should be at the lowest most effective level (**subsidiarity principle**), and **capacity building measures** should be promoted by the institutions of the integrating socio-economic system.
11. The public institutions should develop decision-taking mechanisms allowing the involvement of the other stakeholders in **co-management, at the highest possible participation** (that is, should share as much as possible the management rights with the stakeholders); when this is

not operationally possible due to lack of expertise, **capacity building measures** should be promoted as a public service.

12. The natural capital at ecotone/ecosystem level owned by public institutions (i.e. private state property, very extended in the Eastern Europe) should function as **pilot areas** for a management maximizing the overall public benefits, including the production of public natural services by the integrating landscapes.

The general structure of the approach for the elaboration of a management plan for a macrolandscape is presented in figure 6, and specific steps in box 2.

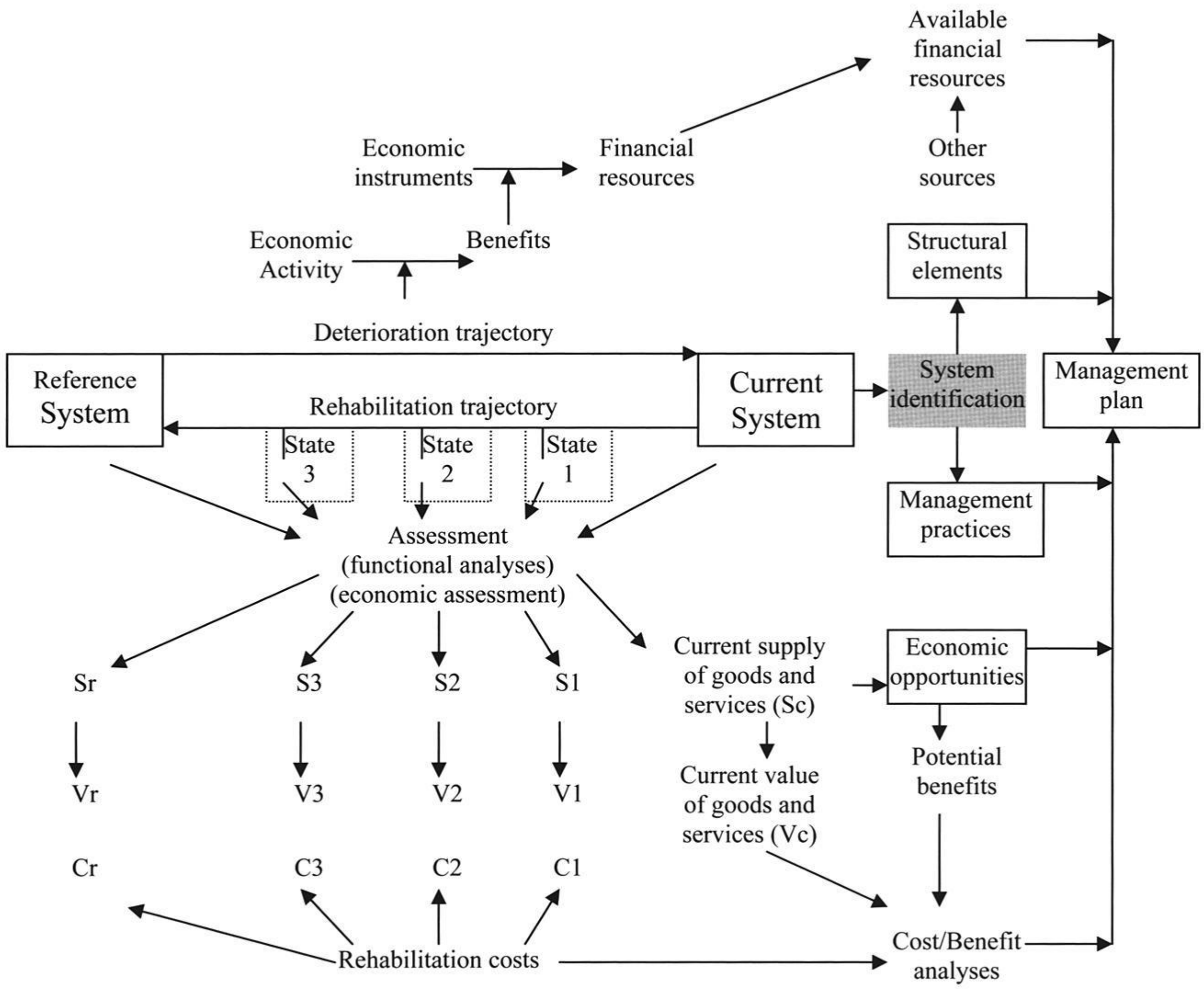


Figure 6 The general structure of the approach for the elaboration of the management plan for a macrolandscape. The grey box indicates system identification both of the natural capital and of the socio-economic systems. ***Legend:*** S1 - S3 = offer of goods and services, V1 - V3 = value of the system functioning in different rehabilitation scenario to reference system (Sr, Vr).

As one can see, having as much information as possible about the structure of the pristine natural system (reference system), as well as about the current structure of the SESs using the natural capital, is needed in order to design scenarios for landscape restructuring. There is a large array of methods to be used in the elaboration of such a management plan, ranging from systems identification, to social analyses, to ecological economics, and to general and special management methods.

In the next chapter we will focus on the **best available scientific knowledge** about the production of natural resources and services by macrolandscapes, on the role of riparian forests in this production, and on the human induced deterioration pathways. Based on this knowledge, management objectives related to public natural services at macrolandscape level can be conceived. The management implications of this scientific knowledge are not currently fully accepted by the relevant public institutions. Consequently, the endusers of the guideline can be, beside institutional actors, members of the civil society interested in promoting the restructuring of the recognized public interest. They can also be private stakeholders interested in having the knowledge enabling them to effectively participate in a comanagement of the macrolandscapes.

Box 2 Steps for designing a plan for the management of a macrolandscape.

1 Accessing the decision support system (DSS)

1.1 The specific information system

1.1.1 **The knowledge base.** Identification of the natural capital (NC) and socio-economic systems (SESs). Set of rules, laws, models, on which depends the assessment of the natural resources and services, and the strategies, tactics, and operational activities for the natural capital management

1.1.2 **The data base.** Values of the state parameters describing the natural capital and socio-economic systems on the which depends the same issues as mentions above in the case of the knowledge base

1.2 Applying the methods for the economic valuation of the natural capital

1.2.1 **Functional analyses of the natural capital**

1.2.2 Monetary analyses of the natural capital

1.3 Characterization of the state of the DSS components which cannot be restructured by management at local SES level (legislation, regulations, human resource formation, institutional infrastructure at regional and macroregional SESs level)

2 Designing the set of alternative solutions (packages of management objectives) concerning the restructuring of the natural capital, the restructuring of the SESs or their functional modules, and/or the restructuring of the management practices (concerning SES-NC relationships), with the final goal of using the NC below the support capacity and valorizing its full range of resources and services.

3 Assessment of the set of alternative solutions

3.1 Assessment of the restoration costs

3.2 Cost benefit analyses of the alternative solutions

3.3 Identification of all kind of resources needed for implementation, and design of the set of applications (projects)

4 Preparation of the set of recommendations for the decision makers.

4. The role of riparian forests

There are many excellent books and reviews dealing explicitly or implicitly with the structure and functioning of riparian forests (e.g. Mitsch and Gosselink 1986, Amoros and Petts 1993, Maltby et al. 1996, Naiman and Decamps 1997, Brinson and Verhoeven 1999). However, few of them discuss the role of riparian forests in the integrating macrolandscapes. But first of all let us define the riparian forests and their position in the integrating landscapes.

The riparian forest is a type of riparian system, which is a type of wetland systems. Table 3 summarizes the types of riparian forest from the point of view of the hierarchical level, as well as the systems integrating riparian forests. One can identify the following situations:

1 The riparian forest is an **ecotone** between an aquatic ecosystem (lake or river), and a terrestrial one. Thus, it belongs to a **terrestrial-aquatic microlandscape** (integrating system 1), which in turn belong to a **small order basin** (integrating system 2).
2 The riparian forest is an **ecosystem** in its own, with a biocenoses different from those of the adjacent ecosystems. Such riparian forest can be found either in the floodplain of medium rivers, or in the floodplain of large and very large rivers. In the first case (**2a**) the riparian forest will belong to a **terrestrial-wetland-aquatic microlandscape**, included in the medium order river basin, as well as in a **low order ecoregion**. In the second case (**2b**) the riparian forest will belong to a **wetlands microlandscape** (such as an alluvial island with lakes, marshes and forests), which may be part of larger **fluvial macrolandscape** (floodplain), part of a medium order river basin, as well as of a low order ecoregion.
3 The riparian forest is a **microlandscape**, such as an alluvial island covered by different forests (e.g poplar forest on levees, willow forest in depressions). These microlandscapes can be found in the floodplain of medium order (3b) and high order (3a) rivers. In the case 3a, the **fluvial macrolandscape**, which include the forested riparian microlandscape, is the lower sector of the large order river system. The forested riparian microlandscapes are also directly included in **low order ecoregions** (3c). In the case of very large rivers the fluvial macrolandscape can be assimilated to a low order ecoregion, or even a high order one, depending on the specific situation.

Table 3 The natural capital directly and indirectly relevant for the management of the riparian forests. Explanation in text. *Legend:* TA microlandscape - microlandscape composed of terrestrial and aquatic systems, TWA microlandscape = microlandscape composed of terrestrial, wetland and aquatic systems.

Type of riparian forest from hierarchical point of view	Integrating system 1 and 2
1 Ecotone	TA microlandscape / small order basins
2 Ecosystem	2a TWA microlandscape / medium order basins, low order ecoregions 2b W microlandscape / fluvial macrolandscape, low order ecoregions, medium order basins
3 Microlandscape	3a fluvial macrolandscape / high order river basins, high order ecoregions 3b medium order basins / high order river basins 3c low order ecoregions / high order ecoregions

Figure 7 presents the inclusion relationships discussed above. The included systems are structural elements of those in which they are included.

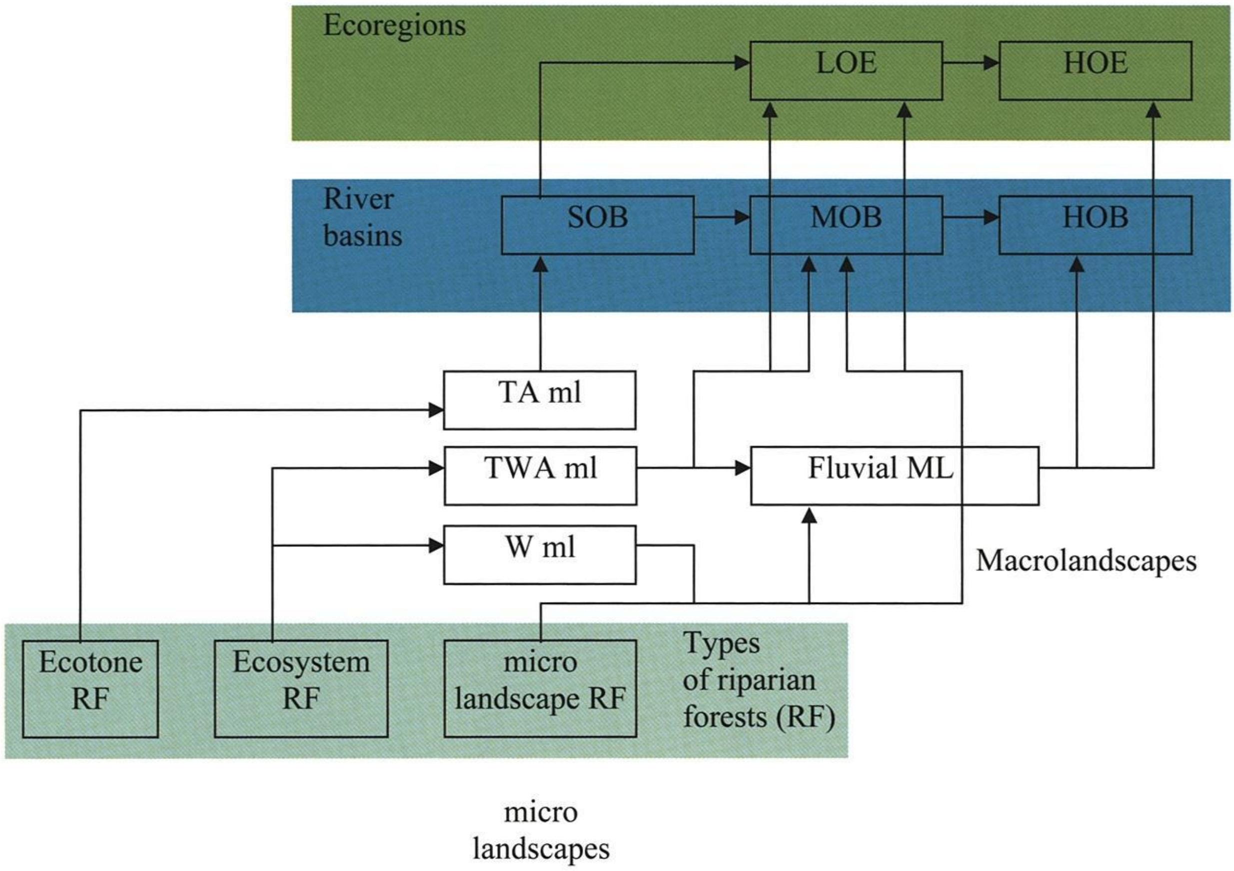


Figure 7 Inclusion relationships (black arrows) between riparian forests and their integrating systems. *Legend*: ml = microlandscape, ML = macrolandscape, TA = terrestrial aquatic, TWA = terrestrial-wetland-aquatic, W = wetland, SOB = small order river basin, MOB = medium order river basin, HOB = high order river basin, LOE = low order ecoregion, HOE = high order ecoregion.

From figure 7 it results that **at <u>low order ecoregion</u> or <u>medium order river basin</u> level all types of riparian forest should be taken into consideration** for the design of the management. At even higher level practically the full river corridor should be considered[10].

Not represented, in figure 7, but relevant, is the inclusion in the ecosphere, with consequences on the services related to the functioning of the climate system. Also not shown is the inclusion in the socio-economic systems. Local SESs usually include by their organisations (in ownership terms) all types of riparian forests, the microlandscapes including riparian forests, and in some cases small order river basins. Institutions at regional (county) and macroregional (country) SESs level are responsible for the management of the macrolandscapes (medium, and high order river basins, as well as low and high order ecoregions) Decision concerning the natural capital at continental and global level are taken usually by international institutions.

The macrolandscapes include in their structure, beside riparian forests, other types of ecological systems (aquatic, terrestrial, wetlands different from riparian forests). By interacting with these components of the macrolandscape (in terms of fluxes of matter and energy), the riparian forests contribute to the production of resources of services performed by the macrolandscape, i.e. they have a **role** in this production. We will now show which is their role case by case.

[10] a river corridor consists in the TA microlandscapes, the TWA microlandscapes, and the fluvial macrolandscapes of a river basin (notations as in figure 7)

4.1 Services provided by the landscapes integrating riparian forests

The following cases will be analyzed:

- hydrological services, in fluvial macrolandscapes and small/medium order river basins
- biogeochemical services, in fluvial macrolandscapes and small/medium order river basins
- maintenance of diversity of species and natural ecological systems diversity, in fluvial macrolandscapes and low order ecoregions.

Hydrological services

We will not insist on this type of services, as they have been extensively treated in the main RipFor Guidelines. There are two main aspects to be mentioned:

- the complementarity of riparian forests with other ecosystem types in performing flood protection in fluvial macrolandscapes and,
- the complementarity of riparian forest with upland ecosystems in the water retention in small and medium river basins.

The flood protection service (water retention) in fluvial landscapes depends on the overall structure of the system, in terms of its microlandscapes and ecosystems. Very complex microlandscapes, with lakes, marshes, and riparian forest on the levees and in the depressions, have the largest retention capacity on a short term, due to their convex overall morphometry. The average term (several months) retention capacity of flood water in Danube floodplain landscapes was 7741 m^3/ha (average value on the hole surface of the landscape) in complex microlandscapes, 1500 m^3/ha in simpler landscapes, and only 333 m^3 /ha in very simple landscapes (Iordache and Adamescu, unpublished data). The retention capacity on average term by the riparian forests on high levees was 0 (figure 8), due to the fact that the levees are flat or convex levees, but these ecosystems played an indirect hydrological role by delineating the depressions able to stock the flood water.

Figure 8 Shore of a forested high levee (left), aspect of the same high levee (right up), and aspect of the nearby forested depression (right down) after a winter flood in Danube floodplain.

The overall retention (short, average, and medium term) in complex Danubian landscapes is about 25000 m^3/ha of landscape. The overall retention capacity in the Lower Danube River System (current state) is 1.859 km^3 on the short and very short term, and 0.408 km^3 on an average term. The retention on average term is due almost completely to the few complex and very complex microlandscapes remained after the extensive polderization of the floodplain (details in chapter 6, case study).

In what concerns small and medium river basins, it is demonstrated that their water retention time increase with the degree of forestation, with profound consequences on the silvicultural practices. Many of the protection functions of forests accepted by forests managers are related to hydrological services, and soil/land stabilization against hydrological pressure (Giurgiu 1988). There is a direct relation between the forested area in the catchment and the amplitude of the variations in river discharge, with consequences on the level of soil erosion. Also, the presence of large woody debris in the channel of mountainous rivers strongly decrease the erosion rates (Bilby 1981). In the small and medium river basins located at low altitude the sediment transport associated to snow melting is up to 70% of the solid annual flow, but has much smaller values when forests are present in the basin structure (Machedon 1988).

Buffers forests for first order streams are particularly important in protecting areas downstream from flooding and pollution (Formann 1995). And the degree of forestation of the uplands of the low order river basins strongly influences the water retention time in the basin and the flooding risk downstream (Giurgiu, 1988).

However, currently the exact relationships between upland changes and river floodplain functioning are not completely understood (Bunn and Arthington 2002). But based on a precautionary approach (chapter 3), in a managerial context the long-term and long-distance cumulative impacts of hydrological changes should be evaluated against short-term economic benefits to determine the real environmental costs of the projects affecting the hydrologic regimen in river basins.

Hydrological services are also of indirect interest in riparian systems, because hydrological regimen is their main driving forces. As an example of negative effects of the changed hydrological regimen we mention that many of the floodplain forests in Romania have a deteriorated state as a result of hydrotechnical works which lowered the underground water level (Giurgiu, 1995). Iordache et al. (1997a, b) analyze the cascade effects of hydrological parameters on the functioning of the riparian systems, and propose a modeling approach. Postolache et al. (1997), Naiman et al. (2002) and Pinay et al. (2002) point out the key role of the hydrological regime on controlling the biogechemistry of fluvial systems. All the retention of elements taking place in riparian forests occurs mediate by longitudinal and lateral hydrological fluxes. Spink et al. (1998) show that together with climatic factors, the hydrological regimen is a key factor controlling plants productivity. Cristofor et al. (1997) and Nillsson and Svedmark (2002) analyze and point out the strong influence of the hydrological regimen on the plant communities structure. Thus, a production of hydrological services at natural levels will not be in contrast with the production of diversity services (the ++ situation is possible), and will be also associated with high elements retention services

Closely related to hydrological services is the contribution to regional climate improvement. Very large floodplains, like the Danube river's one, provided in the reference state important volumes of water by evapotranspiration, with favorable consequences on the regional climate. It is considered that one of the causes of the aridisation trend in Danube plain is, beside the global changes, the extensive polderization of the Danube floodplain. Currently the estimated volume of water transferred to the atmosphere from the Danube floodplain is 0.0576 km^3 /year, which would increase to 0.144 km^3 in case of extensive restoration of the riparian systems.

But the regional climate depends also on the structure of the upland landscapes. The albedo (which can be influenced by the density of riparian forests and upland forest), and the fractional partitioning of atmospheric turbulent heat flux into sensible and latent fluxes is particularly important in directly affecting local and regional weather and climate (Pielkel and Avissar 1990). Air movement induced by thermal gradients can transport surplus heat from one ecosystem to another. Thus, the reaction of the entire landscape will not be the simple sum of heat balances of individual ecosystem. The forest belts use the largest amount of energy for evapotranspiration and bare soil uses the least (Ryszkowski and Kqdziora 1987).

Biogeochemical services

Riparian forest can act as physical (by mechanic filtration of the input flows) and as biological buffers (by the involvement of the plant and microorganism populations in the substances uptake and, in some cases, transformation). There is a transversal buffering (of the fluxes from the upland) and longitudinal buffering (of the fluxes from upstream). The proportion of the longitudinal buffering compared to the transversal one increases from upstream to downstream.

The buffering of each substance/elements have its own mechanisms, reflecting the characteristics of the biogeochemical cycles of the involved substance/element (sedimentary cycle, gaseous, or mixed). The most frequently studied elements are N, P, followed by C and metals. Fewer studies refer to the buffering of complex substances such as pesticides (Lowrance et al. 1997, Grofmann 1997).

The active zone in transversal nitrogen buffering can have important seasonal movements, depending on the groundwater dynamic. The riparian zones display an annual cycle of water table elevation, but where the riparian zone was flat, the water level in the adjoining river or lake is more significant in controlling water table levels than the groundwater from the upland (Burt et al. 1992). The retention can take place mostly aboveground or belowground, depending on the specific situation (Jordan et al. 1993). Spatial care should be taken when the buffering of transversal groundwater fluxes is assessed, because of the possible dilution occurring at the contact with the river water (Pinay et al. 1998). The transfer of the nutrients from the field to the riparian area via groundwater can take several seasons (Hubbard and Lowrance 1995). The output from forested areas to groundwater is smaller than that from agricultural areas to groundwater (Vadineanu et al. 1998) thus reducing the pressure over the buffer zones.

Transversal phosphorous retention takes place especially from runoff by mechanic filtration (Gburek and Sharpley 1998), and to a lesser extent by groundwater. Plants are involved in P internal cycling, thus influencing its retention time. Studies performed in the Danube floodplain and in agricultural catchments assessed the species performances in P and N uptake and release, thus providing important information for establishing the optimal structure of the forests from a N and P retention perspective (Topa et al. 1998, 2001, Topa 2002). Such pilot studies involving native species should be performed wherever one envisages the design of riparian forested buffer zones.

Many authors hold the point that most of the retention takes place in the headwater riparian streams, compared to lower floodplains, due to their maximal land-water interface (e.g. Vallet et al. 1998). However, the situation is basin specific and should be analyses as such. At least in the lower sector of the Danube river system river channel, measures for restoring riparian forests are appropriate both in the small agricultural basins, and in the Danube floodplain.

In longitudinal buffering there is also high performance heterogeneity between different systems, depending on their succession status, and on hydrogeomorphic characteristics (Pinay et al. 1992). These three aspects are related with many internal control parameters and conditions, the elements cycling, retention capacity, and retention time (Iordache et al. 1997a, Pinay et al. 1999).

Figure 9 shows, as an example, the denitrifcation dynamic in a microlandscape from the Danube floodplain. Overall emissions from the landscape will depend on the surfaces covered by the different types of ecosystems, changeable by local management. Consequently, management for nutrient buffering in lower floodplains cannot be effectively approached by limiting ourselves to the ecosystem level, without knowledge about the landscape structure and details of functioning. But beside knowing the landscape processes, the knowledge at ecosystem level is also needed. Examples include the efficiency of different tree species in the elements uptake; this is of interest because harvesting of riparian vegetation can eliminate part of the retained substances (Mander et al. 1995). Important is also a detailed knowledge of the complex factor influencing the denitrification rate: geomorphic features, vegetation, pedology (Pinay et al. 1995).

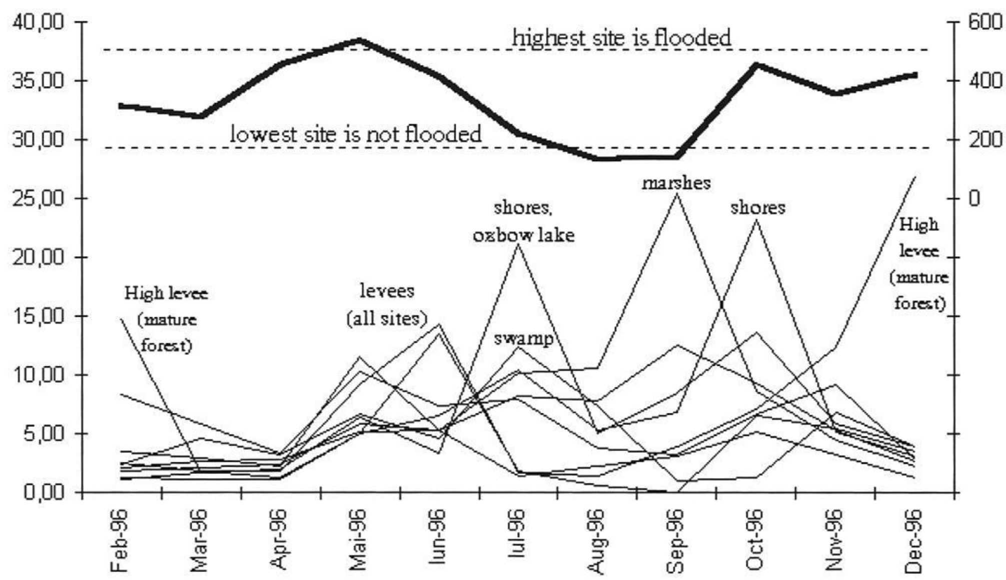
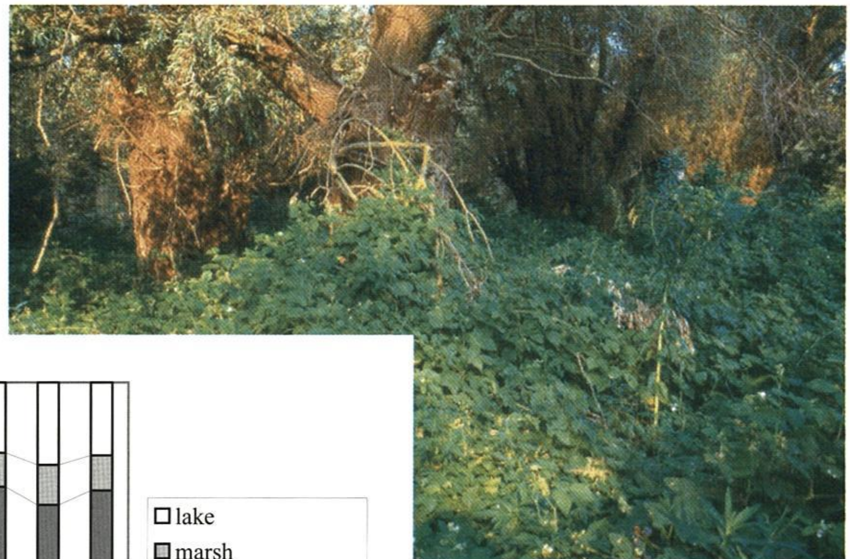
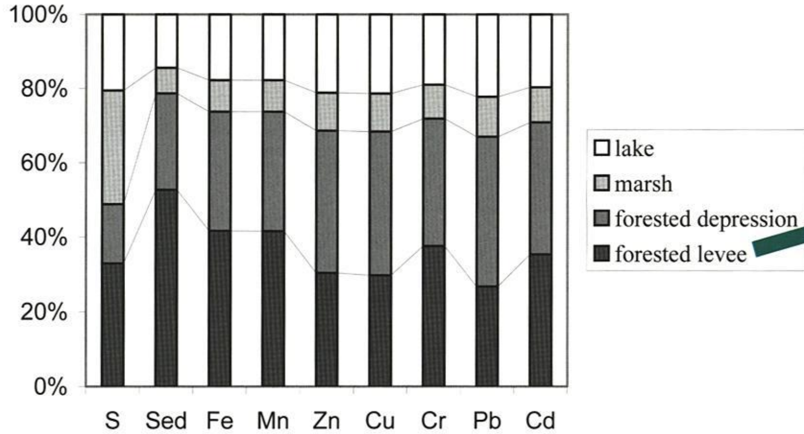


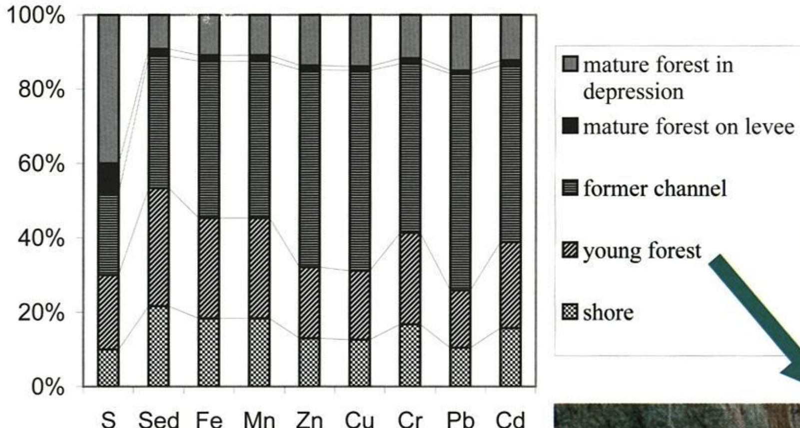
Figure 9 Dynamic of the denitrification rate in selected sites (ngN/gdw/h, left axes) and water level dynamic (cm, right axes, and upper graph). All levees are covered by riparian forest. One can remarks picks occurring at different moments in different types of systems (Iordache, unpublished data).

Flood water retention is associated with sediment retention, which range from several tenths of grams up to over 70 kg /m^2 (Dezzeo et al. 2000). In the Danube floodplain the annual sediment retention averaged 11413 kt. There are important differences between the floodplain ecosystems in what concerns the sediment retention, as well as the associated pollutants, such as heavy metals. The role that the riparian forests play in sediment and pollutants retention depends not only on the forest type, but also on the type of microlandscape to which the forest belong (figure 10). The higher metals retention in internal forest ecosystems than in the external ones is due to the high metal concentration in the fine grained sediment deposited in the internal part of the island, a pattern specific for all floodplains (example for the Danube floodplain in figure 11).

The analysis of metals in alluvial islands shows a strong retention in particulate form, but sometimes an export in dissolved form. The export by forests exploitation is low (usually less than 1 t/year/microlandscape), compared to export by hydrologically mediated fluxes (Iordache unpublished data). Heavy metals retention and that of toxic substances more generally, should be tackled with very much care, in order to not surpass the support capacity of the ecological systems (i.e. to not have ecotoxicological effects).







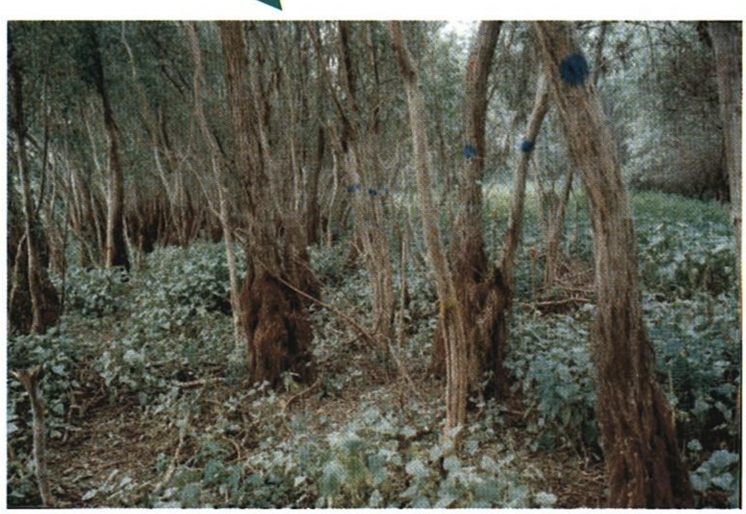


Figure 10 The relative contribution (per cent from total) of the different ecosystems from a very complex landscape (up) and a simpler landscape (down) in the retention of sediment (Sed) and of several metals in the lower Danube floodplain. The relative surface (S) is also indicated.

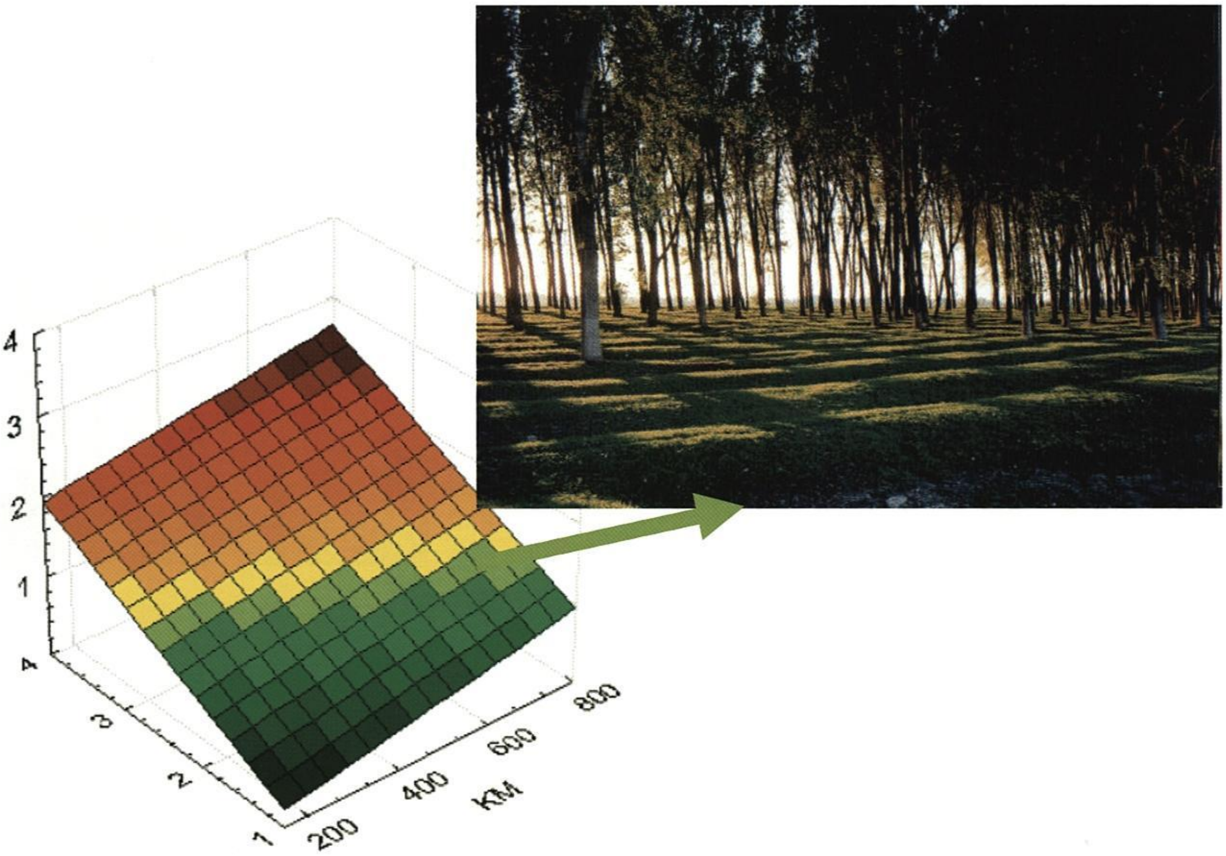


Figure 11 Longitudinal and transversal Cd distribution (ppm d.w.) in deposited sediment of the Danube floodplain in 1999 from downstream (km 200 from river mouths) to upstream (km 800), and from shores (1) to forested levees (2), forested depression (3) and marshes (4). Photo shows planted poplar forest on high levee at km 700.

As already mentioned, the fate of the stable pollutants, for instances metals, in the forest ecosystem after the retention is of interest for forest management: bioaccumulation, toxic effects (Iordache et al. 1999a,b). Studies performed in the Danube floodplain showed complex situations from the point of view metals distributions in biological compartments of the riparian ecosystems (Iordache et al. 1998, 1999c, Neagoe et al. 2001), and of their redistribution by local cycling (Iordache et al. 1999c). Toxic effects might occur in the case of some metals and Danube floodplain microlandscapes for plants, but also deficiency in the case of the metals which are micronutrients (Neagoe et al. 2000). Risk sources exist for other populations also, humans included, especially by the export of dissolved metals to surface water (Neagoe et al. 2002). Some of this export could take place by groundwater after extensive clear cutting of the planted poplar plantations, thus in direct connection with the forest management practices.

Carbon sequestration in riparian forests is not directly correlated with the hydrological fluxes in which the forest ecosystem is involved. It is directly proportional with the plants productivity (Gheorghe 2002). The percent of C varies in a low range (36-48% from the dry matter in the forests of the Danube floodplain and Romanian agricultural basins). Because C retention is strongly related to biomass production, the last one deserves to be discussed here. Seasonal flooding, with water table drawdown occurring mainly during the growing season, leads generally to fast tree growth which makes floodplain sites attractive for timber production (Brinson and Verhoeven 1999). The aboveground biomass of riparian forests ranges between 100 and 300 t/ha with few exceptions (Brinson, 1990), and have a relatively large ranging interval in the same fluvial landscape or basin (Topa 2001, Gheorghe, 2002), thus requiring site specific estimations. Leaves represent 1-10% of the total. In general belowground biomass tends to be less than aboveground biomass, ranging from 5 % to 120% of it, and published values for aboveground production range from 6.5 to 21.4 t/ha/year; litter fall averages 47% of the annual production (Neiman and Decamps 1997). No simple set of variables can exactly predict productivity in riparian areas (Mitsch et al. 1991), and this is one more reason for site specific assessment in view of managerial purposes. Biomass production is highest in early succession ecosystems, thus being compatible at ecosystems level with buffering of elements (++), but less compatible as management objective with species diversity maintenance (+-).

The elements retention by biological mechanisms occur in the early succession stages of the ecosystems development, when there is a net biomass increase (Botnariuc and Vadineanu 1982, Haycock et al. 1993, Vadineanu 1998), excepting for denitrification, which takes place also in mature floodplain ecosystems. But the highest level of species diversity maintenance services at ecosystem level occurs in mature ecosystems. On the other hand, at a time scale shorter than succession changes, mezotrophic conditions in forests coincide with high number of species per area (as in aquatic systems), and eutrophication reduce diversity (Reichholf, 1998). The patterns may be not so simple in the real system, as demonstrated by the complex relationships between soil nutrients status and plants diversity in the Danube floodplain (Vadineanu et al. 1997a). However, as a rule of thumb, from an ecosystem point of view, the objectives of elements retention and diversity maintenance are to some extent not compatible (+ - situation).

Maintenance of the diversity of species and of ecological systems

The conceptual framework for discussing the species diversity and ecological systems diversity in a macrolandscape is presented in figure 12. The key idea is that some species depend on more than one type of ecosystem or microlandscape. Thus, they may depend on the riparian forest, as well on other ecological systems from the same microlandscape or from other microlandscapes included in the same macrolandscape[11].

Riparian forests are not noted for the high species diversity of trees at ecosystem level, because of the stressful conditions due to flooding. However, at microlandcape level and fluvial system level there will be higher trees diversity, because of the different forest ecosystems associated to different hydrogeomorphic units.

The diversity of the hydrogeomorphic units, and implicitly that of the ecosystems (forests included), is controlled by fluvial dynamic processes. Ecosystems dynamics may be controlled differently in landscapes where sites are progressively created and destroyed than where recurrent disturbances affect the same ecosystem (Kupfer and Malanson 1993). One can identify various succession series, continuously renewed under the pressure of the hydrological regimen. It is the existence and the dynamic of these succession series which ensure the microlandscapes and ecosystems diversity in a fluvial macrolandscape. Each type of riparian forest contributes to the overall diversity of the fluvial macrolandscape, but the existence of the different types of riparian forests is controlled by processes occurring at higher ecological level (Enculescu 1924, Pascovschi 1967, Amoros and Petts 1993, Decamps et al. 1988). Not in all cases advanced succession stages have high species diversity. Niemala and Langos (1993) shows that early succession stages are found to support a high invertebrate species richness, mainly due to colonization, with high evenness, while old communities are strongly dominated by a few species. See also in the previous subchapter the effect of the nutrient status on diversity, which is related to the succesion processes.

[11] In technical terms, in order to perform their life cycles, they must migrate between (go and back movements) or disperse towards (movement without return) certain ecosystems from the same or from different microlandscapes. In this sense, these populations are emergent over the microlandscape or even the macrolandscape.

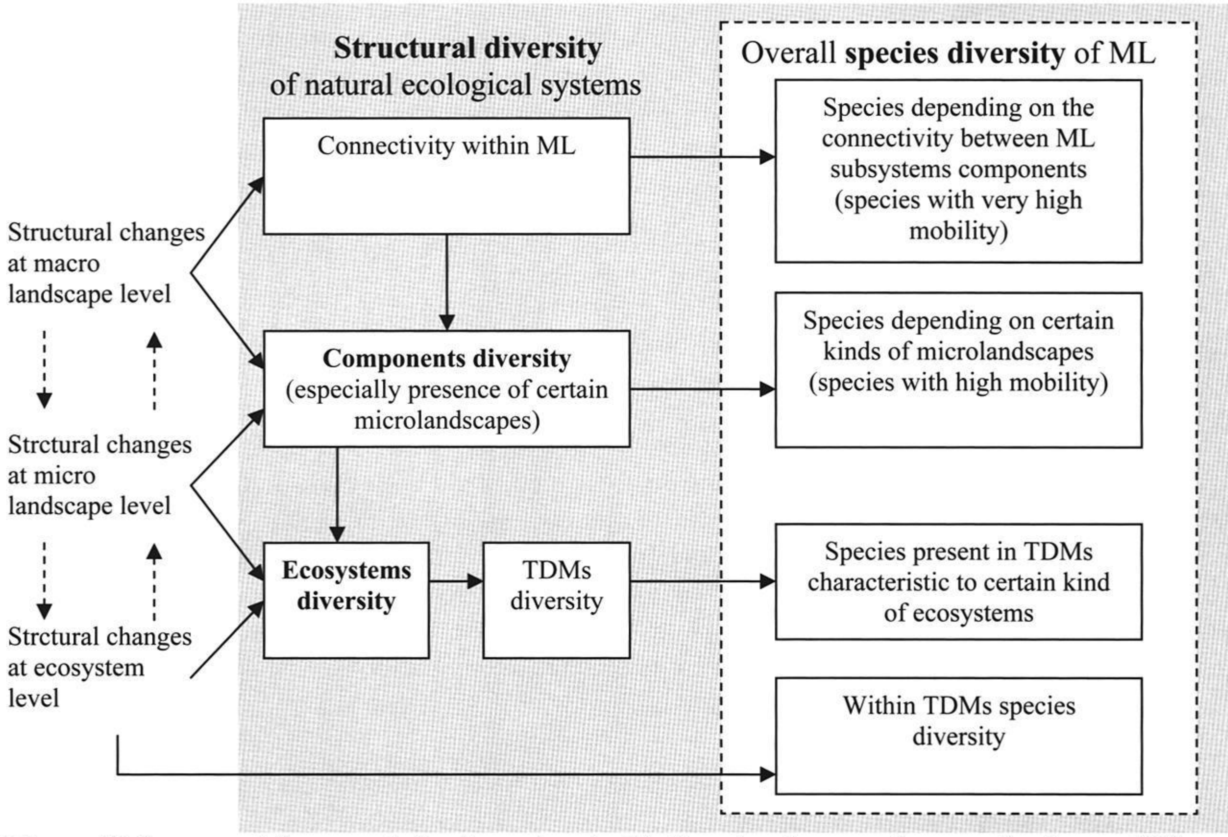


Figure 12 Conceptual framework for discussing the biodiversity changes of a macrolandscape: Effects of anthropic impact on ecological systems diversity and species diversity. Normal arrows represent control ways. Dashed arrows represent top-down effects and cumulated bottom-up effects of the structural changes. TDM = trophodynamic modules[12].

Reduced peak discharges maintained by upstream impoundment and supplemented low groundwater level due to lateral fluxes due to irrigation reduce the fluvial dynamic and consequently the microlandscapes, ecosystems, and species diversity. The fragmentation of riparian corridor forests occur more frequently in the drier zones (inundated 1-2 months per year), inducing the establishment of younger succession stages (Rudis 1995). The patch shape and dimension of the forest fragment affects the local invertebrates (Hamazaki 1996). However, one should discriminate the between human induced and the natural riparian vegetation cover fragmentation (Tabacchi et al. 1990), some of the fragmentation being natural and a result of the fluvial dynamic.

Natural changes due to succession processes played a minor role at Danube floodplain scale compared to the anthropic changes. However, at local scale they may be important, especially in early succession landscapes, such as new islands. As an example, in eight years (from 1992 to 1998), Talchia Island (small island located in upstream part of the Inner Delta, km 357) changed from an island (1) to an island (2). In 1992 four TDMs were recorded in the terrestrial phase on the island, associated to herbaceous (13 species), woody vegetation (2 species, young individuals), and piscivorous birds (Dinu and Cristofor, unpublished data, apud Vadineanu et al. 2001), whereas in 1999 it included 8 TDMs (associated to herbaceous and woody vegetation, terrestrial invertebrates, amphibians, and piscivorous birds, Ciubuc and Cogalniceanu, unpublished data, apud Vadineanu et al. 2001).

[12] TDMs are groups of populations with similar biomass recycling rate (related mainly to individuals dimension and metabolic rates intensity), spatial-temporal location, and functional niche (practically mainly referring to the trophic position).

Recent studies in Small Island of Braila (Vadineanu, et al. 2001) pointed out important vegetation species differences between naturally flooded systems connected with and without connection with diked systems. The simple natural island had 99 plant species (mainly mezohygrophytes, hygrophytes, but also hydrophyrtes, mezophytes and even mezoxerophytes), the complex natural island had 121 species (mainly hygrophytes, mezohydrophytes and hydrophytes), but the riparian landscape had 137 species (mainly mezohigrophytes, mezophytes, mezoxerophytes, and xerophytes, many of them ruderal and field-weeds plants). At a local scale, an apparent increase in species diversity may occur as a result of anthropic impact. The increase is based on herbaceous species, especially ruderal ones. Cristofor et al. (1997), Sarbu et al. (1998, 1999) showed the influence of hydrology on community, populational and individual plant parameters, with effects on the vegetation involvement in biogeochemical services production (Cristofor et al. 1998b), and in general ecosystems functioning (Cristofor et al. 1996, 1998a). Further studies performed (Topa 2001, Topa et al. 2001, Gheorghe et al. 2000, Gheorghe 2002) pointed out the patterns of the year to year dynamic of the measured plant species richness, thus emphasizing the need for medium and long term studies in these large and dynamic systems.

If one looks at the overall plant species richness, one can note that the high variety of microhabitats within floodplain ecosystems can support a broad array of plant species (figure 13). Natural forests conversion to planted forests will strongly decrease the microhabitats diversity, by homogenizing trees age class structure, eliminating coarse woody debris, and disturbing the hydrogeomorphic unit, with profound consequences not only on native plants but also on macroinvertebrates (Murphy et al. 1994), and birds. The regional list of gastropods species for Danube floodplain studied sites (without limax) includes 107 species from which 38 species were identified in studied microlandscapes (Ignat, 1997 apud Vadineanu et al 2001). There are arguments that gastropods diversity decreased within diked areas and forest plantations compared to natural systems. The carabidae species diversity was not visibly influenced by diking, grazing or forest conversion, but was lower in the ecosystems with long flooding periods (Vadineanu et al. 2001). For even more mobile species, such as Syrphine (Teodorescu, 1997 apud Vadineanu 2001) no significant differences between naturally flooded areas due to anthropic impact were remarked; however, the variation in species richness could be explained in this case by the patchiness of the planted and natural forests.

Figure 13 Old willow trunks, microhabitats for plants and invertebrates in the Danube's natural riparian forests (Small Island of Braila National Park).

Riparian corridors allow for rapid dispersion of species, which is well documented in the case of plants; in the case of animals there are few data documenting this dispersion, excepting (Decamps et al. 1987) for some bird species (and excepting, of course, the aquatic populations).

In the case of low order ecoregion[13], the riparian forests make a special contribution to the macrolandscape diversity especially when this one is dominated by drier terrestrial ecosystems (Brinson and Verhoeven 1999), which is the case in Europe. The vegetation maps, used as an element in ecoregions delineation, take into consideration the river corridor in the case of large rivers (Ivan 1992), but only in the case of very large rivers the river corridor is given ecoregional status.

Species emerging in TA and TWA (notations as in figure 7) microlandscapes are those depending on the floodplain-lotic system connection. Fish species finding in the riparian area spawning and feeding sites are an example. In low order streams invertebrates and fish depend on fluxes of organic matter from the riparian forests (litter, as source of energy), on large woody debris fallen in the channel, and on the shores stabilized by trees roots, as microhabitats. In not impacted large order streams the floodplains forests, marshes, and lakes are "invaded" by fish during high water, leading to very high fish productions (Antipa 1910). In turn, side arms (lotic and lentic systems and complex fluvial microlandscape) influence the drifting macroinvertebrates in the large rivers both directly through immigration, and indirectly, via food supply (Cellot 1996).

Shade and cover provided by the riparian trees ensure microclimate conditions needed by aquatic populations, especially in small order streams. On the other hand, in medium order rivers and warmer climate and seasons, riparian forests may influence stream discharge through evapotranspiration, which in turn may cause physiological difficulties for organisms preferring cooler temperatures (Hicks et al. 1991).

Some amphibians spend most of their life cycle outside the riparian forest, but depend on wetter areas for reproduction. In arid regions the riparian forests my be the only parts of the landscape maintaining wet conditions. Most wide ranging upland species (large mammals) depend in riparian forests in one way or another (Brinson and Verhoeven 1999). In the lower Mississipi river, more than 60 species of mammals, about 190 species of amphibians, and about 100 species of birds were seasonally associated with riparian systems (Klimas et al. 1981)

Some bird species can be riparian obligate, while other not. Valcu (2002) performed an analyses of the bird communities in the Danube floodplain, identifying the riparian forest as key ecosystems for many of the bird species, from nesting and/or feeding point of view. For instance, from nesting point of view, 12 species were strictly depending on mature riparian forests, 23 species could use both mature and young forests, 2 species could use both mature riparian forest and reed marsh, and 12 species could use mature riparian forest and reed marsh, but also other non-riparian ecosystems. And from a feeding point of view, for example, 73 species could use between 2 and 5 riparian ecosystem types, and only one species was strictly dependent on mature riparian forest. The riparian forests and the marshes were proved to play important roles in sustaining the bird community at microlandscape and floodplain scale. The number of nesting species found in the studied microlandscapes represented 39% of the nesting birds from Romania.

Bird communities in riparian zones and adjacent uplands are interdependent; the number of shared species varies seasonally and longitudinally along the riparian corridor (Naiman and Decamps 1997), and is influenced by the fragmentation degree (Lauga and Joachim 1992). Many

[13] Other than fluvial macrolandscapes, which in some cases can be identified as low or even high order ecoregions.

wide ranging birds are attracted by riparian forests in low order ecoregions because they center their activities around riparian ecosystems, especially in terms of feeding preferences. Feeding activities have long-term consequences on the structure and functioning of riparian forests, by seeds transport from one place to another.

Some mammals use the non riparian and riparian areas alternatively as an antipredation strategy (Larue et al. 1994). Amphibians, reptiles, and mammals species richness in the floodplain of small and medium order rivers increase with the increasing forest ecosystems dimensions in the nearby upland area (up to 2km distance, according to Findlay and Houlahan 1997, while increased paved road density in the same area decreased species richness). Hower the needed width of the riparian corridor varies strongly with the vertebrate species. The management decision concerning the river corridor structure should be taken in function of the species important in the respective low order ecoregions, as well as of the socio-economic constraints.

Many macroinvertebrates are depending both on riparian forests and on the upland forests. The shape, the dimension of the forest, the distances between forest ecosystems, as well as the presence of hedgerows, is also of importance (Burel 1989), with important interspecific differences (Pither and Taylor 1998). Few typical species of mobile invertebrates such as carabids are found in small remnants of forests, they requiring larger ecosystems (Fahrig 1985, Fournier and Loreau 2001). Thus, a mosaic of connected small woody remnants and young open hedges will never be sufficient to replace true large forests. Ancient, stable forests are mainly inhabited by invertebrate species with low dispersal power (Wissinger 1997). But this is not the case when remnants are too small and isolated, they are highly disturbed due to edge effect, or are disturbed by wood cutting and other human perturbations. The conservation of the so-called "area sensitive" species requires the maintenance of large areas of continuous ecosystem (Robinson et al. 1995).

The morphometric features of the landscape are also important for many bird species (Dorp and Opdam 1987, Opdam 1991, McIntyre 1995), and to a smaller extent for small mammals (Szacki and Liro 1991). Structurally complex hedgerows are preferred significantly over intermediate or simple structures by many types of small mammals (Merriam and Lanoue 1990) and have important consequences on the populations' viability (Heinen and Merriam 1990). The permanent resident species are not so much influenced by the shape, but mainly by the area of the forest (Gutzwiller and Anderson 1992), and by its quality in terms of resources (Verboom and Apeldoorn 1990), being very sensitive to forest fragmentation (Bennet 1990). For birds and lepidopterans, the most important factors affecting the species richness is landscape heterogeneity, while other factors, such as the specific composition of land use, play a secondary role (Atauri and de Lucio 2001). On the other hand, richness of amphibians and reptiles is more closely related to the abundance of certain land-use types.

Thus, there are sufficient arguments to consider that the fact that individual animals interact with their environment over a rather limited area and that most resources are discontinuously distributed in the landscape, can make the spatial arrangement of these resources a crucial factor in the use that animals make of them (Estades 2001). Organisms respond to environmental heterogeneity at different scales and in different ways. These differences are consequences of how the movement characteristics of animals - their movement rates, directionality, turning frequencies, and turning angles - interact with patch and boundary features in landscape mosaics. The interactions of movement patterns with landscape features in turn produce spatial patterns in individual space-use, population dynamics and dispersion, gene flow, and the redistribution of nutrients and other substances (Johnson et al 1992). Critical thresholds are transition ranges across which small changes in spatial patterns produce abrupt shifts in ecological responses. Landscape connectivity depends not only on the abundance and spatial patterning of subsystems, but also on subsystems specificity and dispersal ability of species. Habitat specialists with limited dispersal capabilities presumably have a much lower threshold to fragmentation the highly vagile species, which may perceive the landscape functionally connected across greater range of fragmentation severity (With and Crist 1995).

The presence of forest ecosystems in the upland landscapes enhance species diversity in steep regions also by litter fluxes, which maintain and even accentuates the gradient of soil fertility (Boerner and Kooser 1989). The sharpness of ecotones between ecosystems is related to the degree to which the ecosystems are linked through the flow of water and sediment (Wondzel et al. 1996), and influence the species distribution patterns.

Managing the ecosystems of the landscape in order to enhance the food supply for the envisaged species is another important aspect, reducing the detrimental effect of fragmentation (Robinson 1998) because it may enhance the dispersal movements and increase the colonization rates (Berg 1997, Estades and Temple 1999, Mazzerole and Villard 1999). For instance, a poplar plantation will provide much less food to birds than a natural floodplain forest.

It is worthy mentioning that maintaining the invertebrates' diversity by appropriate landscape structure (with forests and hedgerows) provides the possibility of better controlling the pest insects by their natural consumers. It is documented that in completely deforested landscapes insects outbreaks appear more frequently (Dale et al. 1990). The idea of including forest belts between land fields for insects control is also sustained from the farmers' direction (Altieri 1994).

Then, if one is to take management measures in order to enhance the overall diversity of the macrolandscapes, which kind of measures should be taken at ecosystem, and which at higher level? The answer to this question will be provided in chapter 5.

Syntheses of the information related to services and deterioration pathways

Table 4 shows compatibility matrix between the production of the services at riparian forest and macrolandscape level. Table 5 presents the services performed by macrolandscapes and the complementarity between riparian forests and other macrolandscape components in the production of the services. Table 6 resumes the deterioration pathways affecting the production of services by macrolandscapes. Synergism between the different deterioration pathways may occur, such as nutrient loading and global warming, or between chronic and acute stress, which is an important reason for adopting an adaptive management, and the appropriate managerial institutions (see chapter 3).

Table 4 Compatibility matrix between the maximizations of the production of different natural services at riparian forest level (above the diagonal) and macrolandscape level (below the diagonal). C= compatible, N = not compatible, NR = not relevant

	1	2	3	4	5	6
1 Hydrological services		C (1)	C	C (2)	NR (3)	C
2 Regional climate improvement	C		C (2)	C (2)	NR (2)	C (2)
3 N, P, toxic substances retention	C	C		C (4)	N (4)	N (4)
4 C sequestration / biomass production	C	C	C		N	N
5 Ecological systems diversity maintenance	C	C	C (3)	C		C
6 Species diversity maintenance	C	C	C (3)	C	C	

(1) at local level only microclimate improvement takes place
(2) forests with high floodwater retention capacity (forested depressions) have however lower productivity than sites on levees.
(3) relevant to some extent only for riparian forests at microlandscape level
(4) compatible only within the support capacity of the riparian systems

Table 5 The complementarity between riparian forests and other types of ecological sytems in the macrolandscapes production of the natural services.

Services	Complementarity of riparian forests (ecotones, ecosystems, or microlandscapes) with:
Flood protection	▪ upland forests, especially those natural (in river basins) ▪ all other ecological subsystems (in fluvial macrolandscapes; a full example is provided in chapter 6)
Groundwater recharge	▪ non-riparian wetlands and upland forests (in river basins) ▪ all other subsystems (in fluvial macrolandscapes)
Regional climate improvement	▪ upland forests (in river basins) ▪ all other ecological subsystems in fluvial macrolandscapes
N, P, toxic substances retention	▪ non-riparian wetlands and hedgerows (in small and medium order river basins in plain areas) ▪ all other subsystems in fluvial macrolandscapes
C sequestration / *wood production*	▪ *upland forests* and non riparian reed marshes (in river basins) ▪ reed marshes (in fluvial macrolandscapes) ▪ bogs, fens (in higher latitude macrolandscapes)
Diversity of ecological systems (1)	▪ other types of microlandscapes, reflecting in their structure succession processes, and subject to large scale/long term dynamic under natural driving forces (in low order ecoregions and fluvial macrolandscapes - river corridors)
Diversity of species	▪ all other ecological subsystems (in fluvial macrolandscapes – river corridors) ▪ other upland ecosystems and microlandscapes (in low order ecoregions)

(1) applicable only to riparian forests at microlandscape level

Table 6 Deterioration pathways affecting the production of services by macrolandscapesm which should be assessed in view of macrolandscape management.

Hierarchical level	Deterioration by:
Macrolandscape	▪ change (+, -) in the abundance of upland / riparian microlandscape types ▪ full removal of upland /riparian microlandscape types ▪ introduction of new upland /riparian microlandscape types ▪ quantitative / qualitative change in the fluxes (abiotic, biotic) connecting the microlandscapes ▪ modification of the natural driving forces controlling the microlandscapes dynamic
Microlandscape	▪ change (+, -) in the abundance of ecosystems types ▪ conversion of ecosystems from natural to human controlled ▪ full removal of ecosystem types ▪ introduction of new ecosystem types ▪ quantitative / qualitative change in the fluxes (abiotic, biotic) connecting the ecosystems ▪ modification of the natural driving forces controlling the ecosystems dynamic
Ecosystems	▪ change of the hydrogeomorphic unit by abiotic resources exploitation or pollution ▪ change of the biocenoses structure by overexploitation, species elimination or species introduction ▪ change of the populations structural parameters (genetic diversity included)

5. Principles for managing the riparian forests in a landscape context

The maintenance (at publicly desired levels) of the production of the natural resources and services described above will be tactical management objective for the organizations/institutions involved in the management of the macrolandscape. Operational objectives such as the restoration of floodplain, of the main channel, or management and maintenance of existing riparian forests, as described in detail in the main RipFor Guidelines, will be indispensable for putting into practice the tactical management plans, but coupled with other ones in the upland. Especially when there are incompatibilities in the maximization of different resources/services production by a riparian forest, they should be over passed by action on the river basin structure (for objectives related to biogeochemical and regional climate services), on the ecoregion structure (for services related to diversity services), or on both (for C sequestration and timber production).

It is important to underline that at this public level the tactical portfolio includes also other objectives, not directly related to the natural capital. An example is provided in chapter 6 (the development of the socio-economic system associated to the lower Danube river using by enhancing the productivity of the current natural capital through restoration).

The portfolio of managerial objective will differ from one situation to another, and it is essential to be realistic, adapted to existing socio-economic conditions (Ehrenfeld 2000). Not reaching over ambitious objective undermines the credibility of the whole approach within non-experts groups. International organizations adopt the same point of view, but sometimes scientists, confusing ecology (science) with green activism (ideology), miss the point. FAO (1990) postulates that the tree planting should take place in suitable areas defined by land use plans (a political result) and forestry strategies, and not on theoretical targets. Some equilibrium with the theoretical aspects can be obtained by increasing the scientific knowledge transfer towards decision makers, in order to allow decide for land-use plan in accordance with the public interest.

Most of the resources produced by riparian forests are private, and most of the services produced are public. Consequently, the public institutions (at county, country or international level) will look especially for objectives linked to the production of services. Thus, the public interest should normally be related to the production of natural services, at least as long as a natural resources (timber, wildlife) is not regarded as of strategic national interest.

No single riparian systems will provide all services and resources[14]. But an adequate planning of the landscape structure and attention to maintaining its natural dynamic as much as possible will maximize the production of natural resources and services. Such a set of principles is in tune also with the climate change problems, for the following reasons: it will increase the retention time of water in the river basins, it will improve the regional and micro-climate, and it will facilitate the species dispersion from regions becoming more arid to regions where they find optimal conditions. For instances, a combination of diversity services and CO_2 binding, despite their apparent antagonism, could be realistic if sufficiently large microlandscapes with forests in different succession stages can be part of a macrolandscape, together with plantations having a goal structure as native as possible, able to maximize soil protection and hydrological services (Reichholf 1998)

As another example, measures for mitigation river basins eutrophication should include: actions at agricultural field level (minimizing the output of nutrients to groundwater and by runoff), actions for minimizing runoff inputs to riparian areas (by maintaining a network of hedgerows),

[14] A simplified functional analyses procedures is recommended to be applied for a first screening of the services perfromance (Maltby et al. 1998, Cristofor et al. 1998).

actions by minimizing the secondary input to groundwater (by maintaining non-riparian wetlands), actions at the level of the small streams riparian areas (for transversal buffering), and actions at the level of lower floodplains (for longitudinal buffering). P export may be most efficiently managed by focusing primarily on control of the soil P levels in hydrological active zones most likely to produce surface runoff (Gburek and Sharpley 1998), especially in the area close to the stream channel, < 150m (Tufford et al. 1998). Maintenance of waterlogged condition in the riparian area is a precondition for the effective retention of nitrogen (Pinay et al. 1993).

The Chesapeake Bay program, directed toward the nutrients buffering services, recommended at the level of the small streams riparian area: a grassed zone next to the fields to disperse the overland flow, a zone with trees that can be harvested, and a forested zone without harvesting. This methodology has been generalized as methodology for American agricultural catchments (Sheridan et al. 1998). The exact dimensions to be established in other cases should be determined based on specific studies, taking into consideration the intensity of fluxes to be buffered and the local hydrogeomorphic setting. There are developed mathematical models allowing the calculation of the buffer characteristics (Collier et al. 1995). The buffering of transversal fluxes can be as effective as 100 % (Vought et al. 1995), at least in the short term, is usually higher in riparian forests than in meadows (Haycock and Pinay 1992), with, in the case of nitrogen, maximal values in the growing season (Pinay et al. 1998). Periodic, selective tree harvesting may be necessary to keep forests highly productive where net nutrient uptake is high. If harvesting is done with a minimum of soil disturbance during the dry season, it will have little detrimental effect on pollution control by riparian systems (Lowrance et al. 1985). Fetherstone et al. (1995) recommends that in mountainous areas the stream side zone should be maintained with mature forest such that the minimum buffer width equals the height of the tallest trees that is the width of the forest with no cutting should be at about 25 m on each bank. The specific width of the river corridor depends also on the density of the rivers in the managed macrolandscape: areas with low streams density should have wider river corridor microlandscpes, while in high stream density areas the width should be smaller, but complementary with more extended measures in the upland.

When the focus is on species diversity maintenance services, the population ecology of the species intended to be protected should be thoroughly taken into consideration. However, rather than maximizing certain species abundance is better managing to avoid extinction of populations by identifying thresholds of acceptable fluctuations for a wide array of wildlife (Smyth et al. 2002). Restoring many small parts of the riparian system instead of several large and continuos ones is a poor solution, because it will not be reached the structural complexity needed for preserving the production of resources and services (Iordache et al. 2002) and because the risk of lack of ecosystems recover after natural disturbances is higher (Baker 1992). There is an overall trend in the public administration of forests to increase the percent of forest surfaces allocated to the production of natural services. In Romania, for instances, this surface increased from 14.2 % of the total in 1955 to 49% percent of the total in 1995 (Machedon 1988).

Macrolandscapes restoration is a long term process, thus requiring a stable political and societal will behind him, which can be achieved only by an effective co-management. Hupp (1992) estimates at 65 years the recovery duration of the riparian forest, which is however shorter than the period needed for restructuring upland forests (up to 200 year, in difficult conditions, according to Mayer 1977 apud. Vlad et al. 1997). An important aspect to be underlined here is thus the very large time scale of the implementation of management plans associated to restructuring the macrolandscape by action at forests level. The feed-back loop practically does not close in the same human population generation. Consequently, for ethic reasons, these plans should reduce the inherent associated risks by using the best available scientific knowledge and adopting the precautionary principle.

The techniques of restoration to a particular forested condition, and the further forest treatment, use silvicultural practices common in other types of forests (Vlad et al. 1997). The cutting patterns and treatments maintaining the highest production of natural services, while maintaining also the timber production, are the most expensive ones, and adopted on small surfaces in Europe (0.9 % Germany, 3% Austria), but in higher percent in Switzerland (10-15%). The landscape connectivity is especially affected by cutting patterns (Li et al. 1993, Zipperer 1993). Cutting patterns with smaller impact on the landscape structure and functioning have higher management costs (for example, are associated with the checkerboard system). A basic road network must be created for the entire landscape early in the cutting cycle and be continuously maintained because silvicultural activities are dispersed rather than concentrated. On the other hand, extensive clearcutting of a drainage basin over a short time could create severe problems, such as floods after rain-on-snow storms (Franklin and Forman 1987). At forest ecosystem level, Giurgiu (1997) puts an accent on silvicultural measures directed toward maintaining the native, as natural as possible, composition and structure, and using biological technologies for the protection from diseases and insects. But the organizations involved in management and harvesting are seldom opened to such elements because of the higher associated costs. The high costs not possible to be covered may undermine the credibility of some landscape restructuring plans, as correctly points out Vlad et al. (1997). However, practices such as focusing on the reduction of the trees harvesting age and modifying criteria for the inclusion of forest ecosystems in different categories (mainly for timber production vs. mainly for services production), are not related to the high costs incurred by intensive silvicultural practices, but rather to short term maximizing behavior. These are not issues easy to tackle and require a healthy democracy, and a well designed co-management, in order to be overpassed. Last but not least, they require adopting a macrolandscape vision, the principles from chapter 3 and this one, and following the steps presented in box 3.

Most difficult in the restoration of riparian landscape is the restoration of the geomorphic and hydrologic processes (an example is provided in chapter 6), because of technical reasons and societal commitment to an altered state (Gore and Shields 1995). However, in many macrolandscapes the restoration of river corridor would be more acceptable than that of the uplands, and in this context the management of river corridors appears to be a priority important both from river basin and ecoregional point of view (IUCN 1995, Jongman and Troumbis 1996, Vos et al. 2001, Vadineanu et al. 2001).

Where to propose forest restoration? Which are the most appropriate areas? First of all, the areas where land use changes are easier to accept are those without economic efficiency. For instance, Machedon (1988) points out that the official reforestation plans in Romania envisage especially the "degraded areas". On the other hand, past management decisions concerning the extensive diking of the floodplains have proved to be errors. Some of the areas in this situation are recognized as such, and included in the restoration plans, others are subject of discussion, despite the scientific proofs concerning their inefficiency. They may be still kept at efficient levels by public agricultural subsidies (Iordache et al. 2002b), and usually there are strong lobbies for their maintenance in the current state.
Reforestation and afforestation cannot limit in principle to degraded lands. Beside the fact that many lands are so degraded that the vegetation is affected (Zaharia 1999), the main reason for not limiting the reforestation to such areas comes from preserving the needed production of natural services at macrolandscape level. The solution should be a case specific one, depending on the structure of the natural capital and of that of the local socio-economic systems. For each macroregional landscape one will need modeling studies GIS based to produce the scenario of landscape structure. Such studies have been neglected by now, as well as the interface tool for transferring the information to decision makers (Opdam et al. 2002), but there are efforts for

constructing appropriate information systems (Bodescu 2001) and other decision making tools (Vadineanu 1999, Iordache et al. 2001).

In Europe clearing the land of forests for agricultural and other uses virtually ceased by the end of the 1970s, and afforestation of arable land and grassland has been furthered in the framework of the Common Agricultural Policy as a long term mean to reduce the surplus of agricultural production (Weber 1998). Up to now there are few examples of afforestation for natural services production reasons (excepting for Spain, in order to control soil erosion). For instances, planting new forest to affect CO_2 emissions is still an exception. The planting was done without regard to the landscape and choice of tree species (op. cit.).

A key issue related to the financing method for landscape restructuring is adopting the incremental cost format (GEF 1995): public sources from a certain (x) hierarchical level will finance at the lower socio-economic (x-1) level only additional actions beyond what is required for making the natural system to produce resources and services manageable at level x-1. In other terms, the management cost for producing natural resources and services manageable at level x-1 will be covered by sources of the level x-1. Of course, for this technique to work one needs recognition of the natural services as having a public character, as well as an acceptance of covering maintenance costs, which is highly variable across socio-economic systems. The utility of this method is indirectly recognized also by foresters interested to promote reforestation for climate change control. Ciesla (1996) recommend that the new forest would produce net benefits separate from those which may ultimately arise in the climate change context.

Another important issue is to overpass the sectoral approach in designing the projects related to macrolandscapes. Each type of public land use (forests, waters) has its own administrators, and one would need public mechanisms to make them cooperate in view of the macrolandscape management. For instance the restoration of the lower Danube floodplain is subject now to two independent approaches: the Green corridor approach, promoted by administrators of water quality and species diversity services, and the forests restoration, promoted by. Measures designed and negotiated separately are frequently insufficient with respect to the overall restoration of the potentially public services provided by the floodplain (e.g. Schneider, 2002), not last because the lobbying forces interested in restoration are distributed among different categories of interests.

It is time now to mention the concept of multifunctional farming, as tool for overpassing the sectoral approaches in agricultural landscapes. Traditional farmers had maintained on their ownership natural ecosystems (forests, lakes, meadows, wetlands), and used them for producing abiotic and biotic resources within their support capacity. Indirectly and not intended they allowed the microlandscape natural capital of the farm to function in natural conditions, thus providing also natural services, and an enhanced production of natural resources as a result of connecting fluxes between ecosystems (Altieri, 1991, 1995; Denevan, 1995). Curently there is an international institutional trend to promote such multifunctional farming (e.g. FAO, 1999).

Most of the foresters' recommendations for the sustainable development of silviculture (e.g. Giurgiu 1997) are compatible with the management at macrolandscape level: (re)forestation of degraded and economically inefficient lands, hedgerows for agricultural field, and for transportation infrastructure, protection forests for human settlements, and restoration of river corridors. But the proposed measures are not related to all categories of land uses by arguments based on the services provided by the macrolanscapes, and consequently may lead to conflicts with those envisaging the sustainable development of the sectors related to other land uses (mainly water bodies management and agriculture). The adequate interpretation of the respective regulations in order to show the points of conceptual and managerial connection will be a priority for the next future. This report might be useful from this point of view, because it proposes elements for interpreting the relationship between the management of river basins and ecoregions.

It seems that the civil society have still to work hard in order to promote the public interest related to the macroregional services and the sustainable development of the socio-economic system to which they belong. Such a guidelines user should compare the publicly recognized services at macrolandscape level with those presented here, identify the differences, and promote their attenuation. There might be a need for related, coherent, public policies concerning the management of different subsystems of the macrolandscapes (riparian forests included). These policies, by their programs would influence the behavior of the socio-economic actors towards maintaining a macrolandscape structure desirable from public point of view. But without direct action of the macroregional institutions at local level, excepting for the cases of the ecosystems/microlandscape under public property (chapter 3, principle 12). The same holds at European level, with a not (yet) explicit connection between the ecoregions approach in view of species and habitats diversity maintenance (Natura 2000 network), and the river basin approach, in view mainly of hydrological and biogeochemical services.

Thus, riparian forests management should be explicitly related to:

- the managements objective at the level of local landscapes which include riparian forest ecosystems
- the management objectives at the level of macrolandscapes: river basins (via Water Framework Directive) and ecoregions (via FFH Directive and Natura 2000 network)
- the global management objectives to which measures concerning forests are relevant (especially carbon sequestration).

And the general principles for designing the macrolandscape structure are:

1. all lotic systems require a **natural riparian area with forests in its structure**;
2. the **natural dynamic** in the floodplain should be preserved as much as possible
3. all parts of the restored river corridor should include a portion of **forested upland**, and eventually an **ecotonal grassland** at the field limits.
4. The **wider a river corridor is, the better** is for maintaining species diversity
5. The **non-riparian lakes and wetlands should have a similar buffer zone** as the lotic systems
6. The non riparian and riparian systems should be connected by a **network of structurally complex hedgerows**.
7. The upland should include **small and large terrestrial forest ecosystems** to the highest extent possible.
8. Afforestation/reforestation at ecosystems level should have **multiple objectives** to the maximum extent possible
9. The **portfolios of objectives** concerning ecosystems/microlandscapes **should be complementary** such as to maximize the heterogeneity of the set of objectives at macrolandscape level.
10. Most of the forests for **timber production should be in the upland area**; the riparian corridor should be dedicated mainly to the production of services and secondary to biological resources.

6. Case study: the lower Danube river system

The lower Danube river system (LDRS) is a fluvial macrolandscape extended over the lower stretch of the Danube river. We have used this macrolandscape as a model for applying the methodology described in the previous chapters. First of all an identification of the structure of the natural capital was performed, in terms of the subsystems (ecosystems, microlandscapes types) and their relationships (chapter 6.1). Then we made an analyses of the resources and services provided by various subsystems of LDRS. A synthetic view of this is provided in chapter 6.2, at semiquantitative level. Based on this, and previously existing information, we were able to propose the restoration areas and their surface extent. Elements related to the portfolio of management objectives, and the designed tactic for catalyzing the civil society involvement in the restoration of LDRS are mentioned in chapter 6.3. Finally we addressed one of the microlandscapes proposed for restoration and produced restoration scenarios (chapter 6.4).

6.1 Structure of the LDRS

The Lower Danube River System (LDRS) is extended along both sides of the last stretch of 1080 km of the Danube River and comprises nine major macro hydrogeomorphological units (figure 2a) and the respective microlandscapes (figure 14A). A homomorphic model of LDRS (compartments and main fluxes connecting them) is presented in figure 14B. Table 7 and 8 present LDRS ecosystems and local microlandscapes diversity. The criteria used to describe it ecosystems diversity were related to major features of local hydrogeomorphic unit (HGMU) (1), landscape position and connectivity (2), details of HGMU, details of bioceonoses, origin, and human control (3). Six basic kinds of ecological components of LDRS were identified, from which islands and riparian systems of different complexity are most important from riparian systems point of view. Typical insular systems are indicated in figure 15. HGMU heterogeneity and local landscapes diversity (criteria 1 and 2) sustains 22 ecosystems kinds. Figure 16 presents the homomorphic model of complex insular system, indicating the fluxes which sustain ecosystems diversity (at the level of HGMU or trophodynamic modules) through enhanced connectivity. Further refinement of ecosystems classification can be obtained by including in the analyses criteria related to details of HGMU, biocenoses, functioning and origin of the ecosystems (table 6). Overall (based on criteria 1, 2, and 3), a minimum number of 67 ecosystem kinds have been identified in LDRS (table 6). This high ecosystem diversity underpins and is sustained by the trophodynamic modules (TDMs) diversity. 27 types of TDMs are present in LDRS ecosystems, (table 9A). It is worth noticing that the ecosystems having highest TDMs diversity (21 and 22 TDMs in forested depressions and marshes, respectively) are those under natural flooding regime. Large islands have been diked and their current structures include agricultural farms, grasslands, intensive fish farms, salted depressions, marshes, and anthropogenic components of the local social-economic systems. Part of the riparian floodplain remained in natural flooding conditions, having a much simpler landscape structure as before diking (table 8, part B), was turned into planted forests (mainly poplar and willow). Small islands have not ben diked, because they have small surfaces and complexity compared to large islands, and would have been not economically efficient turn them into polders. On most small islands (as well as on the Danube-dike areas) the high levees were transformed into poplar planted forests. The smallest and simplest islands remained under natural conditions. In the inner Danube is located Small Island of Braila (170 km^2), a natural reserve which includes the last remains of the former natural floodplain (figure 16), as well as the two main large islands diked (Borcea island and Big Ialomita Island).

The number of TDMs in ecosystems structure changed (table 9B) through the following mechanisms:

1. Reduction of longitudinal connectivity
2. Elimination of the flooded phase in diked ecosystems
3. Simplification of the natural microlandscapes structure
4. Simplification of the micro-habitat structure by conversion of natural to planted forests.
5. Eutrophication of shallow and very shallow lakes.

Forest conversion impacted all TDMs specific to not flooded or to both phases (flooded and not flooded) through simplification of the lower and upper vegetation layers and indirect effects of this.

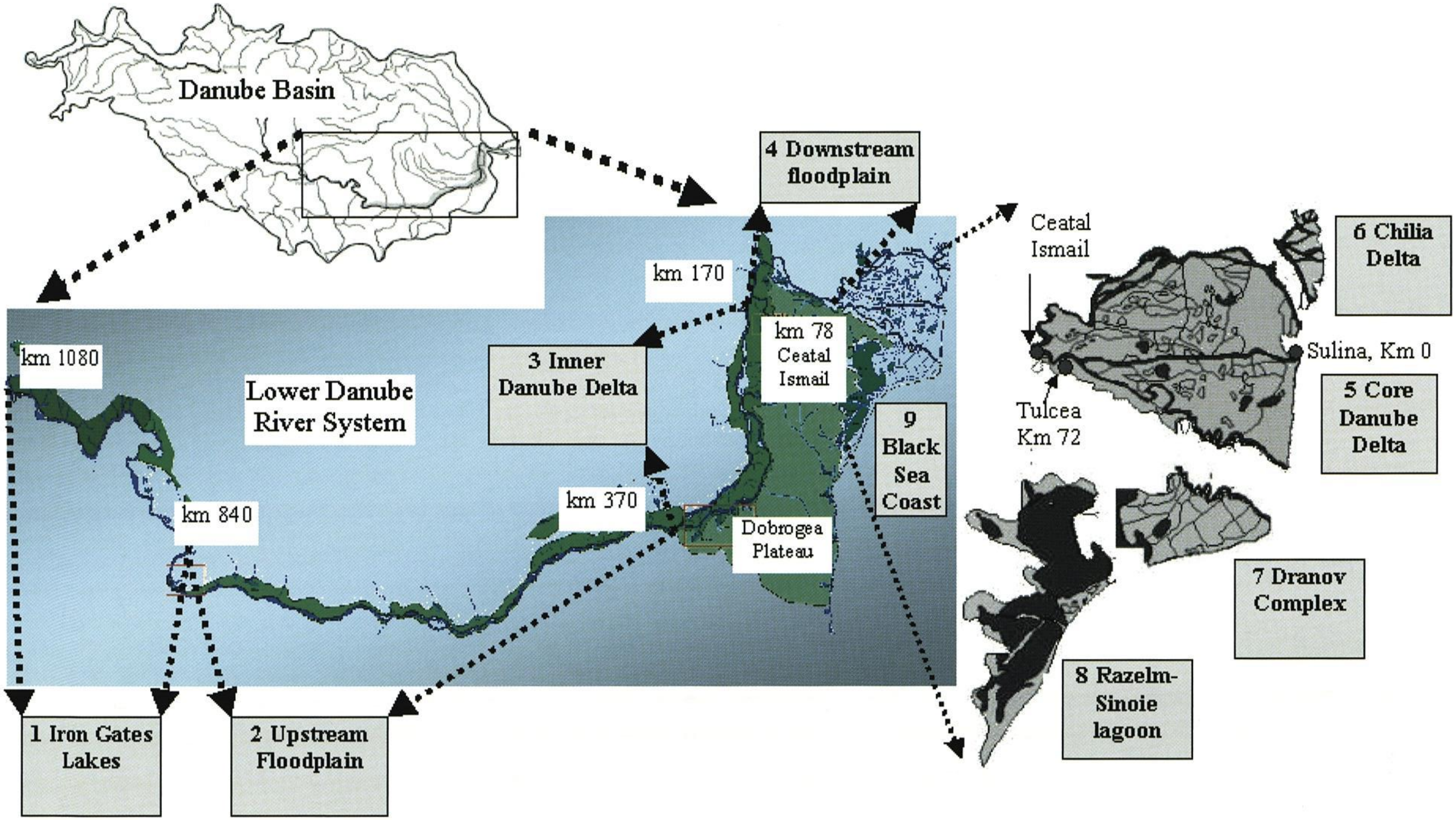


Figure 14 A Position of lower Danube river system in the Danube Basin, and location of its macro hidrogeomorphic units (grey boxes, from 1 to 9).

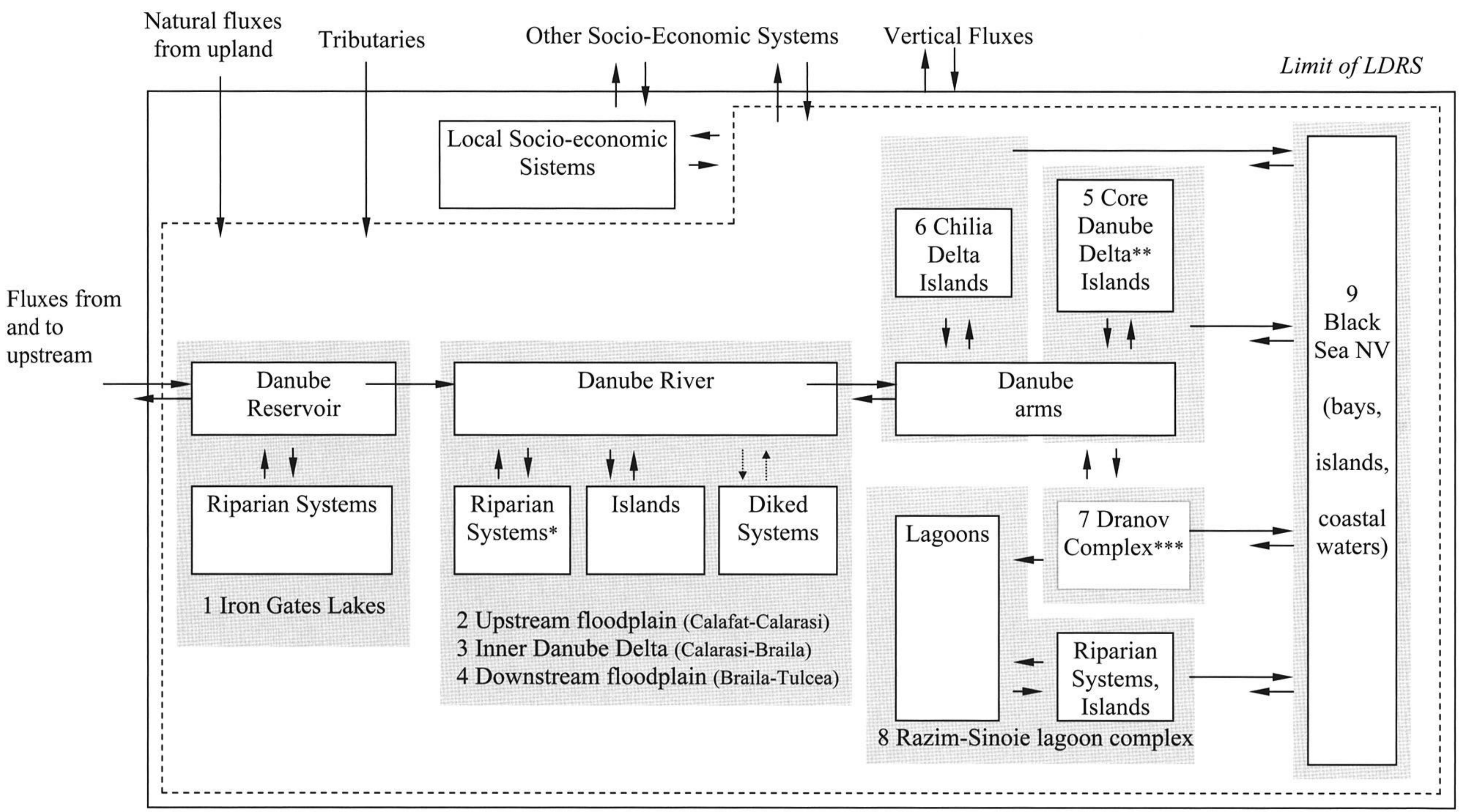


Figure 14B Homomorphic model of the Lower Danube Rivers System showing its ecological components (white boxes, details in table 8), the major HGMUs supporting them (from 1 to 9, grey areas), and the main connections. SES-NC relations just suggested. (*Notes*: * adjacent riparian systems are connected by lateral biological fluxes, ** diked systems within Core Delta not represented, *** Dranov complex includes islands, riparian systems and diked systems).

Table 7 Ecosystem kinds based on criteria related to major features of HGMU (1), landscape position and connectivity (2) details of HGMU, details of bioceonoses, origin, and human control (3). Man induced structural changes at local landscape level (gray areas) are indicated by ecosystems presence in reference (Rf; before 1890) and current (Cr) state. ***Legend***: 1 to 3 = increasing presence (Rf vs. Cr; ecosystems kinds are not comparable). ***Notes***: * not completely estimated, some of the criteria (3) may not be compatible to one another.

Ecosystem to which criteria apply	Criteria (1)		Ecosytem kind (1)	Number of kinds
	Name	Related to		
All ecosytems	Hydrogeomorphology	HGMU	Channel shaped aquatic system (C) / Shore, beach (S) / Elevation, levee, dune (L), Depression, flat area behind levees (D), Marsh (M), other aquatic systems (A), uplands (U)	7

Ecosystem kind (1) to which criteria (2) apply	Criteria (2)		Ecosytem kind (2)	Number of kinds
Channel	Longitudinal connectivity	Landscape	**Danube channel (C1; Rf3 / Cr 2)) / Danube Reservoir (C2; Rf -/ Cr1)**	3
	Position	Landscape	C1, C2 / Floodplain channels (C3; it may have reversible flow, be lentic or dry out)	
Shore, beach	Position	Landscape	Simple new island (S1) / Shore (S2; it is crossed by flows from uplands or levees, and has TDMs due to dispersion from uplands or levees	2
Elevation	Position	Landscape	Simple insular elevation (L1i), Simple riparian elevation (L1r; it is crossed by flows from upland), Complex elevation (L2; may have TDMs due to dispersion from depressions, and may include TDMs of large mammals)	3
Depression	Position	Landscape	Simple insular depression (D1i), Simple riparian depression (D1r; it is crossed by underground flows from upland), Complex depression (D2; it may have TDMs due to colonisation from marshes, and may include TDMs of large mammals	4
	Lateral connectivity	Landscape	**D1i, D1r, D2 (Rf 3 / Cr 1) / Diked depression (D3; it has not aquatic phases; Rf - / Cr 3)**	
Marsh	Position	Landscape	Simple insular marsh (M1i), Simple riparian marsh (M1r; it may receive flows from uplands). Complex marsh (M2; it may have TDMs due to colonisation from lakes, and may include TDMs of large mammals)	4
	Lateral connectivity	Landscape	**M1i, M1r, M2 (Rf 3 / Cr 1) / Diked marshe (M3; it is not flooded; Rf - / Cr 3)**	
Other aquatic systems	Position	Landscape	Insular lake (A1) / Riparian lake (A2; it receives flows from upland) / Lagoon (A4) / Coastal Sea (A5)	5
	Lateral Connectivity	Landscape	**A1, A2 ((Rf 3 / Cr 1) / Diked lakes (A3; it has controlled surface flows connection with Danube; Rf - / Cr 3)**	

Ecosystem kind (1, 2) to which criteria 3 apply	Criteria (3)		Ecosytem kind (3)	Number of kinds
	Name	Related to		
Channels (C1)	Depth (Altitude)	HGMU	Main / secondary channel	2
Channels (C3)	Depth (Altitude)	HGMU	Active channel, former channel, oxbow lakes	5
Active channel	Human control	Functioning	**Natural (Rf3/Cr 1) / controlled natural (1 / 3), artificial (-/2)**	
New island (S1)	Fluvial / Marine	Origin	Alluvial/coastal new islands	4
Shore (S2)	Erosion / Deposition	HGMU	Steep /flat shores	
Levees (L1i,r L2)	Depth (Altitude)	HGMU	High / low levees (L1r only high)	*min 16
	Vegetation cover	Biocenoses	Vegetation units (forested, not forested, details in text)	
Low levees	Fluvial / Marine	Origin	Alluvial levees, coastal sand bars	
Forested high levees	Human control	Functioning	**Natural (3 / 1) / planted forest (- / 3)**	
Depressions (D1i,r D2,3)	Vegetation cover	Biocenoses	Vegetation units (details in text)	*min 16
	Salinity	HGMU	**Salted (1 / 2) / not salted areas (2 / 1)**	
	Human control	Functioning	**Natural (3 / 1) / planted forest, agricultural polders (- / 3)**	
Marshes (M1i,r M2)	Depth (Altitude)	HGMU	High / low marshes	6
Lagoon (A4)	Salinity	HGMU	**Freshwater (- / 1) / brackish lagoons (2 / 1)**	2
Coastal sea (A5)	Closeness	HGMU	Open sea / bays	3
	Depth (Altitude)	HGMU	Shallow / deep coastal sea	
Lakes (A1,2,3)	Depth (Altitude)	HGMU	very shallow / shallow lakes	10
Lakes (A1,2,3)	Trophic state	Functioning	**Mezo-eutrophic (3 / 1) / hypertrophic lakes (- / 3)**	
A1 shallow	Fluvial / Marine	Origin	Fluvial / marine lakes (only AI)	
A2 shallow	Salinity	HGMU	Freshwater / brackish lakes	
A3 shallow	Human control	Functioning	**Lakes (3 / 1) / ponds (- / 2)**	
Uplands (U)	Substrate	HGMU	Ecoystems on rocks / on dunes, etc	3
Ecosystems on dunes, etc	Human control	Functioning	Natural systems / human settlements	

Minimium number of ecosystem kinds in current LDRS (based on criteria 1, 2, and 3)	**35 (67)**

Table 8 Structure of the LDRS ecological components (A) and structural changes (indicated by gray areas; B) at regional landscape level, assessed by the presence of ecological components in the major sectors of LDRS (from 1 to 9, as indicated in figure 14A,B). ***Legend*:** LL = local landscape; 1-3 = increasing presence; other codes as in table 1. ***Notes:*** [1] uplands may be present in some of the local landscapes, [2] Island and Riparian (6) refer to local landscapes with large surface and number from each kind of ecosystems, and supporting populations of large mammals [3] when the riparian area is an ecotone, it is included in the structure of the Danube River. [4] islands not included, * Romanian part.

A

LDRS component		Ecosystem kinds in the structure of the component (based on criteria 1 and 2)						
Level	Name							
Danube River								
Ecosystem	Channel, Reservoir	C1, C2	-	-	-	-	-	-
Islands of increasing complexity								
Ecosystem	Island (1)	-	S1	-	-	-	-	-
Ecosystem, LL	Island (2)	-	S2	L1i	-	-	-	(U)[1]
Local landscape	Island (3)	C3	S2	L2	D1i	-	-	-
Local landscape	Island (4)	C3	S2	L2	D2	M1i	-	-
Local landscape	Island (5, 6[2])	C3	S2	L2	D2	M2	A1	(U)
Riparian systems of increasing complexity								
Ecosystem	Riparian (1[3])	-	S2	-	-	-	-	-
Ecosystem, LL	Riparian (2)	-	S2	L1r	-	-	-	-
Local landscape	Riparian (3)	C3	S2	L2	D1r	-	-	-
Local landscape	Riparian (4)	C3	S2	L2	D2	M1r	-	-
Local landscape	Riparian (5, 6[2])	C3	S2	L2	D2	M2	A2	-
Local landscape	Diked system	C3	-	-	D3	M3	A3	
Ecosystem	Lagoon	-	-	-	-	-	A4	-
Local landscape	Coastal Sea[4]	-	-	-	-	-	A5	-

Number of Components kinds in current LDRS	6 (17)

B

	Presence in the sectors of LDRS, in reference (Rf, before 1890) and current (Cr) state																	
Components	1		2*		3		4		5		6		7		8		9	
	Rf	Cr	Rf	Cr	Rf	Cr	Rf	Cr	Rf	Cr	Rf	Cr	Rf	Cr	Rf	Cr	Rf	Cr
Danube Channel	1		1	1	1	1	1	1	1	1	1	1						
Reservoirs		1																
Islands (1)	1		1	1	1	1												
Islands (2)	1		1	1	1	1									1	1	1	1
Islands (3)			1	1	1	1												
Islands (4)					1	1			1		1	1						
Islands (5)					1	1							1	1				
Island (6)					3	1			3	2								
Riparians (1)	1	1			1	1												
Riparians (2)			1	3	1	2	1	1		1				1	1	1		
Riparians (3)			1	2	1	3		2		1				1	1	1		
Riparians (4)			2	1	1	1									1	1		
Riparians (5)					2	1							1	1	2	1		
Riparians (6)			3	1	3		3	2										
Diked areas				2		3		2		2				1		1		
Lagoons															1	1		
Coastal sea																	1	1

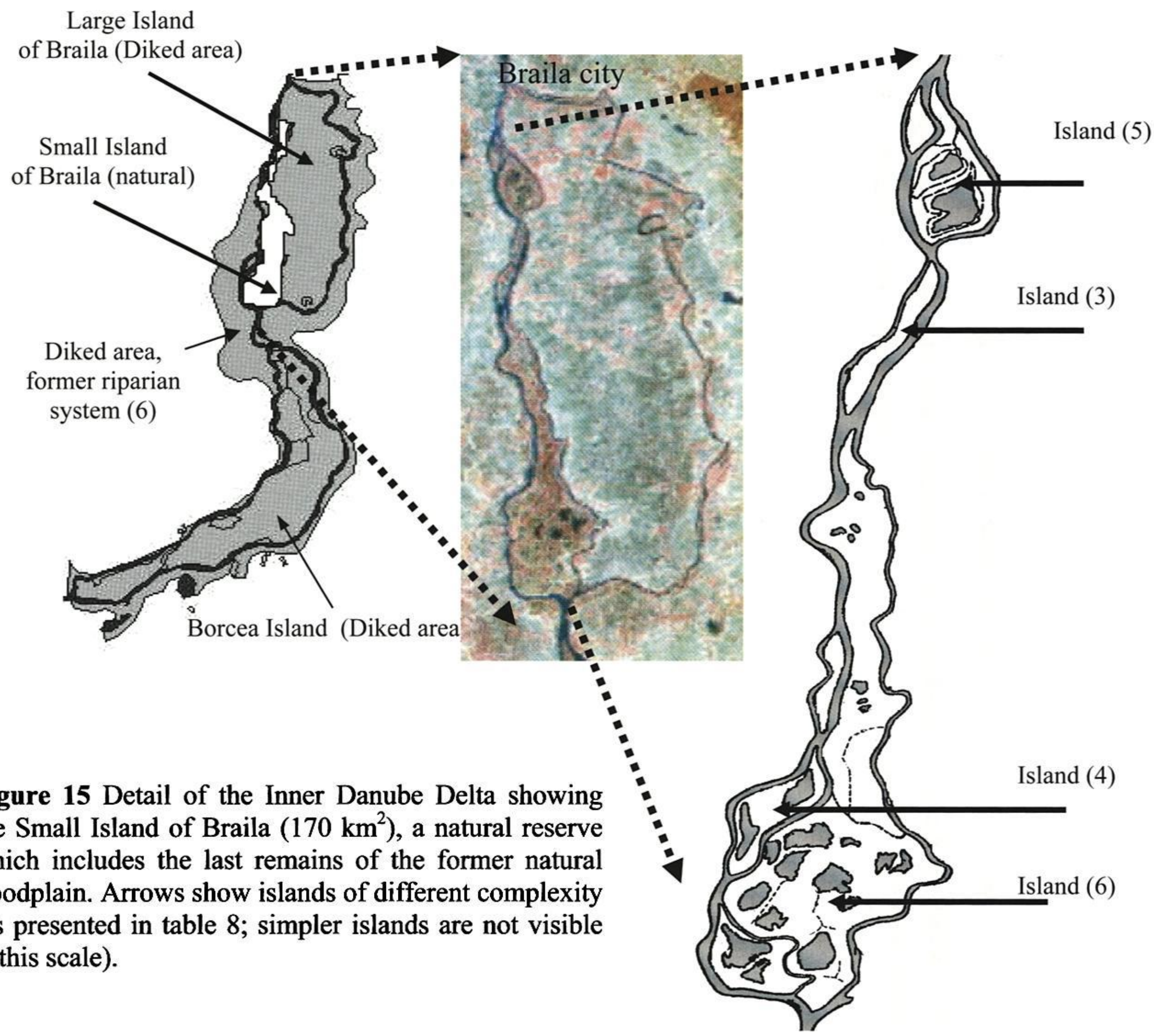


Figure 15 Detail of the Inner Danube Delta showing the Small Island of Braila (170 km^2), a natural reserve which includes the last remains of the former natural floodplain. Arrows show islands of different complexity (as presented in table 8; simpler islands are not visible at this scale).

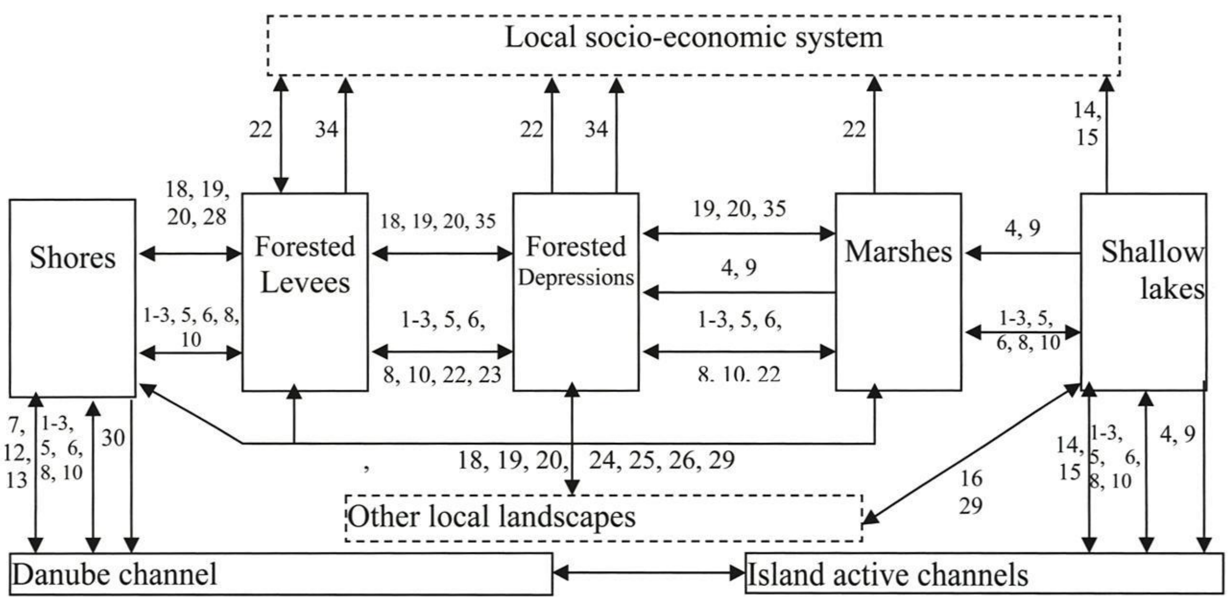


Figure 16 Homomorphic model of an island (6) showing ecosystems and fluxes connecting them. Fluxes are mediated by ecosystems compartments numbered as in table 9. Former channels and oxbow lakes are not represented. The model of simpler islands is limited to a part of this model. Model structure of riparian landscapes is similar, but includes fluxes from uplands. Diked areas models do not include shores and levees, have simpler connections with Danube, more complex connections with the local socio-economic system, and may include fluxes from uplands.

Table 9 Abiotic compartments and TDMs in the structure of the homomorphic models of LDRS kinds of ecosystems (A) and structural changes at ecosystem level (grey areas; B) estimated by the presence of TDMs in reference (Rf, before 1950) and current (Cr) state, and by changes within compartments. Secondary kinds of ecosystems (identified by criteria 2 and 3, table 1), may not include all presented compartments. ***Legend:*** Ecosystem codes as in table 1, excepting for C (limited to active channels) and A (includes all other aquatic systems); PP = compartments at the base of type 1 food chains (primary producers), Dt = compartments at the base of type 2 and 3 food chains (detritus and dissolved organic carbon consumers), Cs = other consumers, UHGM = abiotic compartments; 1-3 = increasing presence (Rf vs. Cr; TDMs are not comparable) or changes, NE = not estimated. ***Notes***: * minor importance within ecosystem, but important by transfer to other ecosystems.

A | B

No	Compartment / Ecosystem	C	S	L	D	M	A	U	Presence in Rf and Cr state		Within compartment changes
	Specific to flooded phase (**bold x**)								Rf	Cr	
1	Water column (UHGM)	**x**	**x**	**x**	**x**	**x**	**x**		-	-	2
2	Suspended particulate matter (UHGM)	**x**	**x**	**x**	**x**	**x**	**x**		-	-	3
3	Dissolved organic matter (UHGM)	**x**	**x**	**x**	**x**	**x**	**x**		-	-	2
4	Aquatic plants and epiphyton (PP)				**x**	**x**	**x**		3	1	3
5	Phytoplankton (PP)	**x**	**x**	*	**x**	**x**	**x**		2	1	2
6	Bacterioplancton (Dt)	**x**	**x**	*	**x**	**x**	**x**		2	1	NE
7	Benthic deposit feeders (Dt)	**x**	**x**				**x**		2	1	2
8	Zooplankton 1 (Cs)	**x**	**x**	*	**x**	**x**	**x**		2	1	3
9	Phytophylous fauna (Cs)				**x**	**x**	**x**		1	1	NE
10	Zooplankton 2 (Cs)	**x**	**x**	*	**x**	**x**	**x**		3	1	3
11	Planktivorous larvae of insects and vertebrates (Cs)				**x**	**x**	**x**		NE	NE	NE
12	Bivalvia (Cs, Dt)	**x**	**x**				**x**		2	1	2
13	Benthic predator fauna (Cs)	**x**	**x**				**x**		2	1	2
14	Omnivorous fishes (Cs)	**x**					**x**		2	1	3
15	Predator fishes (Cs)	**x**					**x**		3	1	3
16	Ichtyophagous birds (Cs)	**x**					**x**		2	1	2
	Specific to not flooded phase (normal x)										
17	Edaphic bacteriophagous and micophagous (Cs)		x	*x*	*x*	x		x	NE	NE	NE
18	Terrestrial phytophagous invertebrates (Cs)		x	x	x	x		x	2	1	2
19	Terrestrial detrito-, copro-, necrophagous invertebrates (Cs)		x	x	x	x		x	1	1	2
20	Terrestrial predator invertebrates (Cs)		x	x	x	x		x	2	1	2
21	Small rodents (Cs)			x	x	x		x	NE	NE	NE
22	Livestock (horses, pigs, sheep) (Cs)			x	x	x		x	1	2	NE
23	Game species (Cs)			x	x	x		x	3	1	NE
24	Granivorous and frugivorous birds (Cs)		x	x	x	x		x	2	1	2
25	Insectivorous birds (Cs)		x	x	*x*	*x*		x	2	1	2
26	Predator birds (Cs)			x	x	x		x	3	1	3
	Specific to both phases (*italic x*)										
27	Soil/sediment, including sedimented POM (UHGM)	*x*	*x*	*x*	*x*	*x*	*x*	x	-	-	-
28	Underground water (UHGM)	*x*	*x*	*x*	*x*	*x*	*x*	x	-	-	1
29	Atmosphere (UHGM)	*x*	*x*	*x*	*x*	*x*	*x*	x	-	-	NE
30	Detritus (litter, necromass, feaces) (UHGM)	*x*	*x*	*x*	*x*	*x*	*x*	x	-	-	NE
31	Soil/sediment microorganisnms (PP, Dt)	*x*	*x*	*x*	*x*	*x*	*x*	x	NE	NE	NE
32	Vegetation (underground) (PP)		x	*x*	*x*	*x*		x	NE	NE	NE
33	Vegetation (aboveground; herbaceous) (PP)		x	x	x	*x*		x	1	1	3
34	Vegetation (aboveground; shrubs, trees) (PP)			*x*	*x*			x	2	1	3
35	Amphibiens (Cs)		*x*	*x*	*x*	*x*	**x**	x	2	1	NE
	Number of aggregated TDMs (max)	11	17	15	22	21	15	15			
	Number of abiotic compartments (max)	7	7	7	7	7	7	4			

6.2 Resources and services provided by LDRS

It has been established that, in order to significantly decrease the nutrients input into the Black Sea, as constrained by international agreements, at least 120000 ha of wetlands should be restored in the Lower Danube River System, and especially in the Inner Delta (Vadineanu et al. 2002).

In order to see how this surface should be structured We applied the FAEWE/PROTOWET procedure (Maltby, 1998) adapted to the Danube system conditions as recommended by previous studies (Vadineanu et al. 1997). 15 wetland landscapes of LDRS (current state) were investigated. The landscapes were selected in order to cover the complexity range. The landscapes names can be found in the head of table 2. They are located between km 175 and km 790 of the Danube. The results of the assessment were expressed as follows:

- - (or score 0) = the function is not performed;
- xx (or score 2) = the function is performed to a small degree;
- xxx (or score 3) = the function is definitely being performed.

The primary results were obtained for each ecosystem (or group of ecosystems, depending of the function) from the landscape structure. Knowing the abundance (in surface terms) of the ecosystem in the landscape, and the landscape surface, one could compute the function score of the landscape as a weighted average of the scores in each ecosystem. The total score of the landscape could be compute for a landscape as the sum of the functions scores. An average score for a landscape was also computed.

Data were interpreted by looking for relationships between landscape complexity and each function or total scores. Also, knowing the dominant landscape types (in terms of the surface covered) in the current and reference state, we compared the current and reference LDRS with respect to the functions performed by its subsystems.

An example of results at microlandscape level is presented in table 10. Table 11 includes the average function scores for all studied landscapes.

The total, as well as the average score decreases with the landscape complexity, more obvious in the case of islands, in which case were analyzed very simple landscape. One can see that the functions associated to the maintenance of species diversity are strongly influenced by the elimination of very complex landscapes. Nutrient retention is related to landscape complexity only in the case of some mechanisms, such as export by denitrification. That means that for the recovering of the nutrient retention service one could rehabilitate many small landscapes, as well as a few very large landscapes. However, this solution would not lead to the recovery of the species diversity maintenance function, which requires a different strategy, consisting in the reconstruction of large and complex landscapes.

The assessment of the diked landscapes shows a low degree of functions performance, only the biomass export through harvesting being comparable with the natural landscapes. The effects of landscape changes in LDRS are illustrated in table 12. The most affected services of the LDRS were those dealing with the production of renewable biological resources and the water purification, because they are dependent on the wetlands surface and were directly influenced by the structural changes, besides which can be added the maintenance of regional microclimate, dependent on the extent of flooded areas. The function of biodiversity maintenance was better preserved due the remained natural systems.

Table 10 Results of the functional analyses in Fundu Mare Island. The island has a complex structure as described in figure 16.

Key role										x	
Relative surface of the ecosystem in the landscape (0 to 1)	0.025	0.284	0.037	0.037	0.103	0.010	0.005	0.299	0.198	0.002	
Ecosystem/landscape	Shores	Planted forest (levee)	Natural forest (levee)	Natural forest (internaldepression)	Planted forest (internaldepression)	Natural forest (external depression)	Isolated forested depression	Marshes	Lakes	Channels	Fundu Mare Isl.
ecological functions											Weighted av.
Short term water retention	3	2	2	3	3	3	3	3	3	3	2.7
Long term water retention	0	0	0	2	2	2	3	3	3	3	1.8
Sediment retention	0	3	3	3	3	3	3	2	2	0	2.4
Nutrients retention	0	3	3	3	3	3	3	2	2	0	2.4
Nitrogen export by denitrification	2	2	3	3	3	3	3	3	2	2	2.5
Nutrient export by land use	0	3	2	2	3	0	2	2	0	0	1.9
Provision of overall habitat structural diversity	2	2	3	3	2	3	3	3	3	3	2.6
Microsites for invertebrates	3	2	3	3	2	3	3	3	3	3	2.6
Microsites for fish	3										3.0
Microsites for reptiles and amphibians	0	2	3								2.6
Microsites for birds	3										3.0
Microsites for large mammals	3										3.0
Microsites for plants	2	2	3	3	2	3	3	3	3	0	2.6
Biomass production	2	3	3	3	3	3	3	3	3	3	3.0
Biomass import and export through physical processes	3	2	2	0	0	0	0	0	2	3	1.1
Biomass export through harvesting	0	3	2	2	3	0	0	2	3	0	2.5

Table 11 Results of the functional analyses in the studied landscapes. The meaning of the marked functions and main findings are pointed out below the table.

	Islands								Riparians					Diked	
Function / Landscape and complexity	Fundu Mare 5	Calnov`\ 4	P`p`dia 4	Sect. O. Popa 3	Carabulea 3	Cenghina 3	Talchia 2	Calafatul Mic 2	Cx. Rast 5	Ciuperceni 4	Gura Gârlu\ei 3	G@rcov 3	Arceru 3	Potelu	Arceru
Short term flooding water retention	2.7	2.5	2.6	2.4	2.0	2.0	2.7	2.1	2.2	2.5	2.4	2	2	0	0
Long term flooding water retention*	1.8	1.1	0.8	0.6	0.0	0.4	0.0	0.0	2.5	1.5	0.7	0.2	0.8	0	0
Sediment retention	2.4	2.1	2.2	1.5	2.9	1.5	3.0	1.8	1.7	2.1	2.7	1.1	1.2	0	0
Nutrients retention	2.4	2.1	2.3	1.2	2.8	1.6	2.3	2.0	2.6	2.1	1.9	1.8	2	0	0
N export by denitrification	2.5	2.6	2.2	3.0	2.7	2.0	0.6	0.0	2.8	1.8	2.0	2.6	2.4	2	2
N export by land use	1.9	1.4	1.6	1.3	0.0	1.2	0.0	0.0	2.1	2	2.7	2	2	3	0
Maintaining general habitat diversity	2.6	2.5	2.8	2.7	2.3	2.3	0.0	0.0	2.5	2.1	2.0	2	1.4	0.2	2
Maintaining local conditions for macroinvertebrates	2.6	2.7	2.3	2.9	2.9	2.4	0.8	2.0	3.0	1.2	2.0	2.4	1.4	0.4	2
Maintaining local conditions for fishes	3.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.5	0	0.0	0	0.4	0	2
Maintaining local conditions for amphibian and reptiles	2.6	2.4	2.8	3.0	3.0	2.0	0.0	0.0	2.6	1.8	2.0	2.5	1.2	0.1	3
Maintaining local conditions for birds	3.0	2.1	2.0	3.0	2.0	2.0	3.0	2.0	3.0	0.4	0.0	0.9	2	0	2
Maintaining local conditions for mammals	3.0	3.0	3.0	3.0	3.0	2.0	0.0	0.0	3.0	0	0.0	0	0	0	0
Maintaining plant diversity	2.6	2.1	2.4	2.9	2.0	2.4	0.6	2.0	2.8	0.4	0.6	0.8	2.2	0.4	2
Vegetal biomass production	3.0	3.0	2.8	2.9	2.5	3.0	0.6	3.0	3.0	2.4	2.9	2.8	2.6	3	3
Import and export of biomass by physical processes	1.1	0.8	0.9	0.9	2.4	0.8	2.1	2.0	0.02	0.1	0.1	0	0.6	0	0
Anthropic export of biomass**	2.5	2.1	1.7	1.3	0.0	1.2	0.0	0.0	2.1	3	2.7	3	3	3	2
Total Score	39.7	32.5	32.4	32.6	30.5	26.8	15.7	16.9	36.4	23.4	24.5	24.1	25.2	12.1	20.0
Average score	2.48	2.03	2.03	2.04	1.91	1.68	0.98	1.06	2.3	1.5	1.5	1.5	1.6	0.8	1.3

Score at ecosystem level: 0 = function not performed, 2 = function performed to a low degree, 3 = function definitely performed
Score at landscape level = average weighted at the relative area of the ecosystem

Main findings:
- the marked functions seem to be directly related with landscape heterogeneity
- nutrient retention functions are not directly related with land surface and landscape heterogeneity

Table 12 Qualitative assessment of the main functions performed by wetlands in LDRS, in terms of performance classes Reference (Rf), current (Cr), and landscapes table 7. ***Legend***: - = the function is not performed, xx = the function is being performed to a small degree, xxx = the function is definitely being performed.

	Dominant in Rf state		Dominant in Cr state	
Function / ecological component	**Island (6)**	**Riparian system (6)**	**Diked area**	**Riparian system (3)**
Short time water retention	xxx	xxx	-	xxx
Long time water retention	xxx	xxx	-	xx
Sediment retention	xxx	xxx	-	xx
Nutrient retention	xxx	xxx	-	xx
Nitrogen export by denitrification	xxx	xxx	xx	xx
Nutrient export by land use	xxx	xxx	xxx	xx
Provision of overall habitat structural diversity	xxx	xxx	xx	xx
Microsites for invertebrates	xxx	xxx	xx	xx
Microsites of fishes	xxx	xxx	xx	-
Microsites for reptiles and amphibians	xxx	xxx	xx	xx
Microsites for birds	xxx	xxx	xx	xx
Microsites for large mammals	xxx	xxx	-	-
Maintans biodiversity at: i. regional scale	xxx	xxx	-	xx
Maintains biodiversity at: ii. European scale	xx	xx	-	-
Biomass production	xxx	xxx	xxx	xx
Biomass import and export through physical processes	xx	xx	-	xx
Biomass export through harvesting	xxx	xxx	xxx	xx
Anthropic input of energy and nutrients	*low*	*low*	*high*	*low*

It resulted that if one wants to recover the hole range of resources and services produced by the reference LDRS, large and complex landscapes should be restored. Based on this, on GIS analyses and field inspections, a set of 8 restoration sites was proposed in LDRS, one of which is Big Island of Braila (figure 15). The exact restoration scenarion for each microlandscape is a different matter, and will be prezented for Big Island of Braila in sub chapter 6.4. Since then one need however, to have a look on the overall objective of the management at LDRS level (next subchapter).

6.3 Management objectives

The in details identification of the stakeholders in the LDRS part located upstream the Delta is a complex objective, tackled only in part by now. It has been done especially with regard to the inner Delta (EarthVoice 1998), and especially the Small Island of Braila (Vadineanu et al. 2002b). Based on existing information, table 13 shows elements for analyzing the influence of the potential LDRS development by restoration on the current users interests for such a development. Table 14 shows the influence of the structure of the portfolio of societal development goals on the groups potentially lobbying for or against LDRS development by restoration.

The main remarks to table 13 are:

- most local users have to be interested in the restoration, including fishers; however, their lobby potential is low, comparing with governmental users, but there is an advantage arising from the fact that increasing benefits from CN at local SES level are in agreement with the Agenda 21 principles and the National Strategy for Sustainable Development;
- foresters, with benefits mostly at governmental level, so with high lobby potential, may be interested in restoration, but to a low degree because of the long time until benefits manifestation after restoration

Table 13 Elements for analyzing the influence of the potential development of LDRS by restoration on the current users interests for such a development. *Legend:* "+, ++" = increase in the production of resource/service, NA = not applicable, MWEP = Ministry of Water and Environmental Protection, L = local (within LDRS), NL = not-local, Gov = governmental.

Resource / service	Direction of change after restoration	Time of benefits manifestation after change	Current user / manager	Level of final current dominant beneficiary
Resources				
Fish	++	medium	fishers	L
Wood and game species	+	long	foresters	NL (Gov)
Medicinal plants, honey	++	medium	villagers	L
Systematic agricultural crops	- -	NA	farmers	NL (Gov)
Traditional agricultural crops	+	medium	villagers	L
Services				
Maintenance of species diversity and ecological systems diversity	++	long	MWEP	NL
Absorption of secondary products	0	NA	industry	L
Water quality improvement	++	short/medium	MWEP	NL
Flood mitigation	++	short	MWEP	L
Regional microclimate improvement and groundwater recharge	++	medium	MWEP	NL
Conditions for tourism	++	long	none*	L
Transportation pathway	0	NA	transporters	L
Remarks	Directly related to the intensity of the user interest for restoration	manifestation after long time decreases the intensity of the interest	If there is no current user, there is no current interest	Final beneficiaries at G level are more influential than those at L level

* excepting for Danube Delta and Small Island of Braila

Table 14 Elements for choosing the portfolio of objectives which maximize the potential interest for the development of LDRS by large scale reconstruction. Legend: G = at governmental level, L = at local level, Gov = governmental, LA = local administration, MWEP = Ministry of Water and Environmental Protection.

Societal objective of the LDF management	Potentially For		Potentially Against	
	G	L	G	L
Basic objectives				
1 Sustainable production of high level of natural resources and services **2** Economic efficiency, economic viability	fisher foresters MWEP	fishers foresters	farmers	farmers
Optional objectives				
3 Distribution equity	Gov	LA		
4 Employment	Gov	LA		
5 Export promotion and generation of foreign exchange	Gov			
6 Decreasing urban-rural drift	Gov			
7 Maintaining a regional balance of development	Gov			
8 Industry diversification	Gov			

Remarks to table 13 (continued):

- farmers, with high lobby potential, may be strongly against restoration, as the benefits related to this kind of use will strongly decrease after restoration. It must be noted the economic inefficiency of many diked areas, some of them recently keeping a high profile even in the mass media, which points out, for instance the big economic problems of the administration of the Big Island of Braila. However, as long as most of the diked areas are state property, the economic inefficiency can be masked by governmental measures, so apparent benefits could arise as the result of public subsidies;
- conditions for tourism in restored areas of LDRS would be strongly improved after restoration, but there are no current users at local level to lobby for this; some support could be found only at the specific governmental level;
- water quality services will be strongly improved after restoration; however the setting of restoration for nutrients retention is already negotiated (ICPDR, 2001), even if it is not satisfactory from the point of view of other resources and services.

The main remarks to table 14 are:

- The portfolio of objectives should include at least the objectives 1-4; adding the objectives of equity and employment to the basic objectives would strongly enhance the interest at local socio-economic level;
- MAA (1999) notes that the increase in fish export is limited, beside others, by the fact that there is not, on foreign markets, a high demand for the currently offered dominant species. Restoration of LDRS might change the situation in this respect, as well as in the dimension of the stocks, thus contributing to objective 5.
- Fishery post-harvest sector development as a result of increasing stocks might contribute to objective 8;
- Objective 7 might be appropriate for the LDRS district socio-economic systems, which are suffering from economic and social problem, as well as objective 6 for the local socio-economic systems, taking into consideration their current depopulation trend (Earth-Voice Romania, 1998);
- Thus, the objectives 5 to 8 might also be included in the portfolio, in function of the conjectural governmental priorities.
- There is a potential conflict of interest between farmers and other sectors with regard to the integrated development of LDRS. Such intersectoral conflicts are recognized at governmental level in terms of conflicts between the strategies for the development of different sectors: extraction, agriculture, forestry, energetic, tourism (Ministry of Agriculture and Alimentation, 1999).

There is a governmentally recognized need to change the management system (MAA, 1999). But when the users have the feeling that they cannot control the direction of the management there is no great political pressure to be proactive. One needs, if it is allowed to speak in chemistry terms, a catalyzer to activate the advantaged stakeholder, and to promote the "reaction" of transforming an inefficient management of LDRS into an efficient one by lowering the "activation energy" due to the current potential conflicts of interests. A tactic consisting in coupling a bottom-up approach (from local level to Romanian Government) with a top-down approach (from ICPDR to the Romanian Government) was developed (Iordache 2002b). However, it is not prezented here, because the socio-economic conditions are highly variable from the CN associated to one macroregion to another and could not be extrapolated to other cases.

6.4 Restoration scenarios at microlandscape level

The structure of the socio-economic systems (SESs) was characterized through national statistics data and local interviews. Field investigations and analyses of historical maps and remote sensing images have been performed for assessing the structure of the reference and current natural capital.

Figure 17 shows the current state of the Big Island of Braila. One can remark that all the diked area is covered by agricultural fields.

The results showed that i) most of SESs components with high social impact in case of microlandscape restoration are located in the southern part of the island, ii) the economic viability of the agricultural farms is very low, and iii) in the reference state the most productive part of the natural capital was located in the northern part of the island.

Based on these findings, the northern part of the Big Island of Braila was chosen for developing the restoration scenario. A satellite image of this part of the island is presented in figure 18.

A detailed DTM based on 1:5000 maps and GPS field investigation was developed. Current land use was characterized in detail by pedological, pedochemical and agricultural maps, as well as by field studies. The dike-Danube part was analyzed by forestry maps and field investigations. The current economic efficiency was analyzed by crops production distribution maps and investments distribution maps, coupled with local interviews.

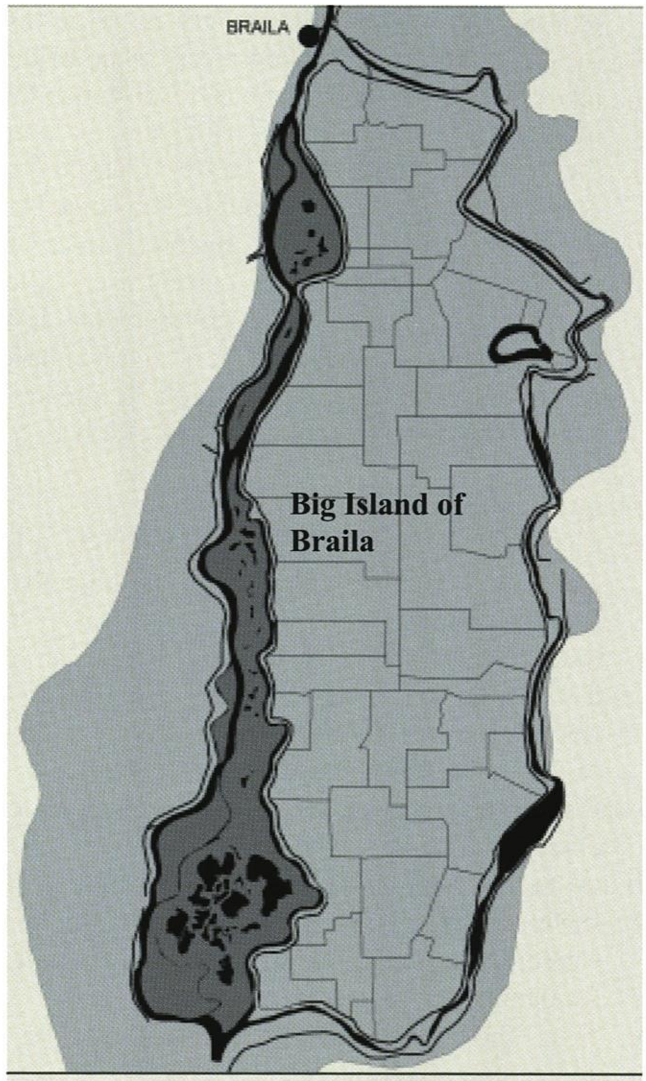


Figure 17 Current state of the Danube floodplain in the Big Ilsand of Braila Sector. Leght grey areas are diked, deepr gray areas areanot diked. Black areas are aquatic systems. Thin lines within the BIB indicate farms limits.

In order to increase the efficiency of further management scenarios implementation we developed cooperation with sectoral research institution in the field of agriculture and forestry. Big Island of Braila is state private property, so involvement of local socio-economic actor at this stage of scenario development is not needed more than at information level.

We now shortly present the main characteristics of the identified scenarios.

The scenario maximizing the interest of farmers suppose the maintenance of the current structure of the natural capital (figure 18), however with large investitions associated to the amelioration of the soil quality in terms of hydrology, salt content, land morphology, drainage network, etc.

These measures would lead to higher crops production than before, but at very high cost. They will also further deteriorate the hydrogeomorphic structure of the ecosystems, which now from geomorphological point of view is not very far from that of the reference system. Figure 19 presents the altitudes distribution, which is similar with that of the reference state excepting for the lakes which have been filled up 70-100 cm.

Figure 18 Composite image in normal colours showing the current structure of the Northern part of the Big Island of Braila.

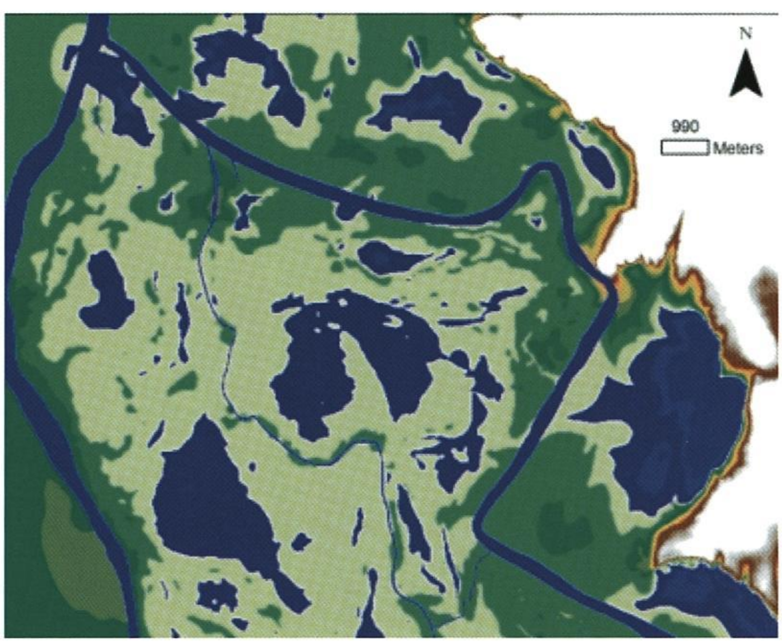


Figure 19 Current altitudinal distribution in Big Island of Braila (blue = low altitude - former lakes, deep green = higher altitudes- former levees).

A scenario with average investitions (figure 20) supposes a partial reorganization of the landscape, maintaining the dikes but allowing hydrological connections to some extent. Shallow lakes (25% of the surface), forests (35%) and agricultural fields (40 %) would coexist within the landscape and would be managed based on the concept of multifunctional farming (see chapter 5).

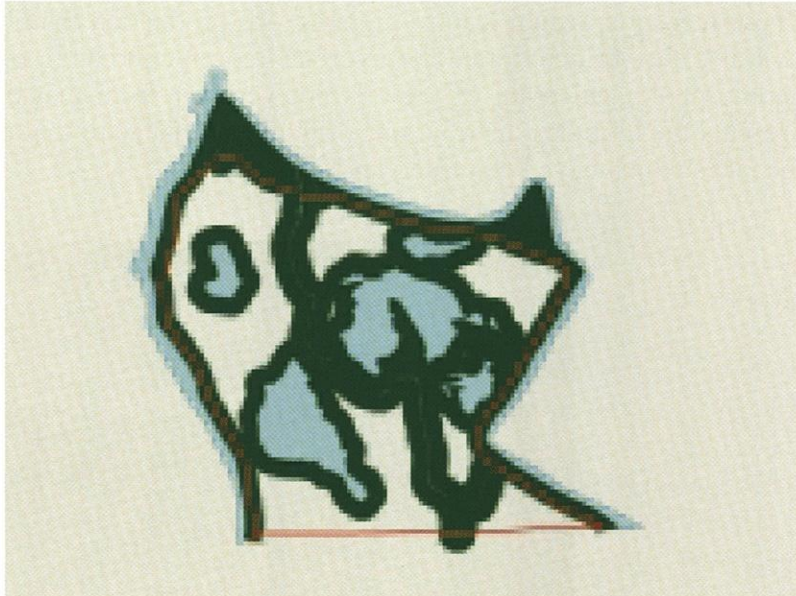


Figure 20 Restoration scenario in view of multifunctional farms. In green, riparian forests, in blue very shallow lakes.

The scenario with minimal investitions would envisage establishing similar hydrological conditions with the reference system and it would be based on the recolonisation capacity of the species. Organisms would come from the ecosystems distributed in the dike-Danube area and from small natural remnants of the currently diked area. Investitions would be needed for directing the forests development towards a desired landscape structure. The microlandscape would have with the following structure: riparian forests 60%, meadows 12 %, lakes, canals and marshes 28%.

Despite the difference from the references system (marshes percent much larger in the reference system), the benefits of such a system is estimated to be comparable with those of the references system. Figure 21 presents the structure of the landscape in this scenario.

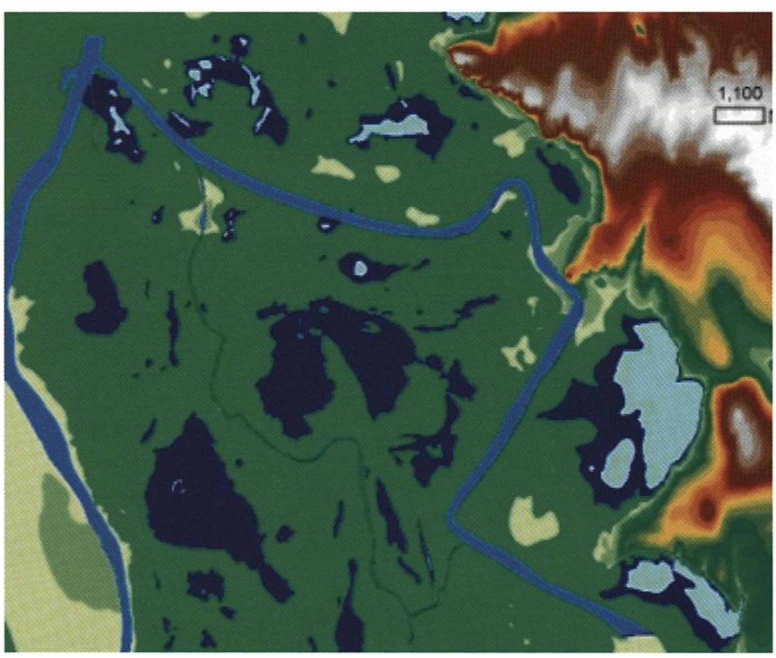


Figure 21 Landscape structure in scenario 3, dominated by riparian forests.

7. Conclusion

Which are the organizations interested in developing and implementing the plans for the management of riparian forests in a macrolandscape context? What kind of knowledge do they need to acquire in order to design appropriate management plans? And how should they interact in designing and implementing the management plans? These were the three questions which started the discussion in this guidelines/report (chapter 1). We are now able to provide the answers.

Managing forests in a macrolandscape context means managing them such as to preserve their role in the services production, and is inherently done together with the management of other types of ecological systems from the macrolandscape structure. Because these are public services (chapter 3) the organizations directly interested in designing macrolandscapes management are the public ones, or those parts of the civil society. However, private local organizations are interested in the rezulting management measures, and consequently those designing the management should involve the local level actors by adopting a comanagement approach within the large set of principles for macrolandscape management (chapter 3).

Those designing the macrolandscape management should have access to the following knowledge:

1. The place of riparian forests in the structure of microlandscapes and macrolandscapes (chapter 4)
2. The landscape mechanisms underpinning the role of riparian forests in the production of public services at macrolandscape level, and leading to compatibility between different services production, or lack of it (chapter 4)
3. The available instruments and concepts to be used for promoting the restoration of the macrolandscape (chapter 5)

Based on such knowledge one would build a specific information system for the macrolandscape in case and would develop restoration scenarios, as steps in the process of the management design (box 2, chapter 3).

After the (co-management based) decision concerning the scenario is taken, specific policies and programs will be developed in order to influence the local actors behavior towards the desired landscape structure. Sets of projects will be developed by the local actors at riparian forest level as well as at the level of other types of ecologica systems. Then operational measures will be implemented (main RipFor guideline, silvicultural measures, chapter 4).

8. References

1. Allen, T.F.H. and Starr, T.B., 1982. Hierarchy: perspectives for ecological complexity. University of Chicago Press
2. Altieri, M.A., 1991, *Traditional Farming in Latin America*, The Ecologist 21, p. 93-96
3. Altieri, M.A., 1994, *Biodiversity and pest management in agroecosystems*, Haworth Press, New York, 1994.
4. Altieri, M.A., 1999, *Agroecology: the science of sustainable agriculture*, Westview Press, Boulder
5. Amoros C., G. E. Petts, 1993. Hydrosystemes fluviaux. MASSON. Paris, 300 pages
6. Amoros C., M. Richardot-Coulet, G. Pautou, 1982, Les "ensamble fonctionnels": des entites ecologique qui traduisent l'evolution de l'hydrosysteme en integrant la geomorphologie et l'antropisation (example du Haut-Rhone), Rev. Geogr. Lyon, 57: 49-62
7. Antipa, G., 1910. Regiunea inundabila a Dunarii. Starea ei actuala si mijloacele de a o pune in valoare (Danube flooding area. Actual status and means of valorification). Instit. de Arte Grafice Carol Gobl, Bucuresti. 318 pages.
8. Atauri, J. A., J. V. de Lucio, 2001, The role of landscape structure in species richness distribution of birds, amphibians, reptiles, and lepidopterans in Mediterranean landscapes, Landscape Ecology, 16, 147-159
9. Baker, W. L., 1992, The landscape ecology of large disturbances in the design and management of nature reserves, Landscape Ecology, 7, 181-194
10. Bennett, A. F., 1990, Habitat corridors and the conservation of small mammals in a fragmented forest environment, Landscape Ecology, 4, 109-122
11. Berg, A., 1997, Diversity and abundance of birds in relation to forest fragmentation, habitat quality and heterogeneity, Bird study, 44, 355-366
12. Bilby, R. E., 1981, Role of organic dams in regulating the export of dissolved and particulate matter from a forested watershed, Ecology, 62, 1234-1243
13. Bodescu. F., 2001, Design and development and the database for the management of biological diversity and ecological diversity in the lower sector of the ecological Danube system (in Romanian), PhD theses, University of Bucharest
14. Boerner, R. E. J., J. G . Kooser, 1989, Leaf litter redistribution among forest patches within an Allegheny Plateau watershed, Landscape Ecology, 2, 81-92
15. Botnariuc, N, 1999, Evolutia sistemelor ecologice supraindividuale (Evolution of biological systems), Editura Universitatii din Bucuresti, 216 pages
16. Botnariuc, N., A. Vadineanu, 1982, Ecology (in Romanian), Ed. Didactica si Pedagogica, Bucuresti
17. Brinson, M. M., 1990, Riverine forests, in Forested Wetlands, Ed. A. E. Lugo, M. M. Brinson, S. Brown, Amsterdam/New York, Elsevier, 87-141
18. Brinson, M. M., J. Verhoeven, 1999, Riparian forests, in M. L. Hunter Jr. (ed.) "Maintaining biodiversity in forest ecosystems", Cambridge University Press, 265-299
19. Bromley, D. W., 1989, Economic interests and institutions: the conceptual foundations of public policy, Basil Blackwell, New York
20. Bunn, S. E., A. H. Arhington, 2002, Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity, Environmental Management, 30, 492-507
21. Burel, F., 1989, Landscape structure effects on carabid beetles spatial patterns in western France, Landscape Ecology , 2, 215-226
22. Burt, T.P., G. Pinay, F.E. Matheson, N.E. Haycock, A. Butturini, J.C. Clement, S. Danielescu, D.J. Dowrick, M.M. Hefting, A. Hillbricht-Ilkowska, V. Maitre, 2002, Water table fluctuations in the riparian zone: comparative results from a pan-European experiment, Journal of Hydrology, 265, 129-148
23. Cellot, B., 1996, Influence of side-arms on aquatic macroinvertebrate drift in the main channel of a large river, Freshwater Biology, 35, 149-164
24. Charles, A. T., 2001, Sustainable fishery systems, Blackwell Science, Oxford
25. Ciesla, W. M., 1996, Forstry options for mitigation predicted effects on climate change, in "Workshop on Global Warming Mitigation", 32-40
26. Collier, K. J., A. B. Cooper, R. J. Davi-Colley, J. C. Rutherford, C. M. Smith, R. B. Williamson, 1995, Managing riparian zones: a contribution to protecting New Zealand's rivers and streams, National Institute for water and atmospheric research, New Zealand
27. Comeleo, R. L., J. F. Paul, P. V. August, J. Copeland, C. Baker, S. S. Hale, R. W. Latimer, 1996, Relationships between watershed stressors and sediment contamination in Chesapeake Bay estuaries, Landscape Ecology, 11, 307-319
28. Cristofor S., A. Sarbu, A. Vadineanu, C. Postolache, G. Ignat, V. Iordache, C. Ciubuc, 1998a, Riparian plant contribution to floodplain functions in the Lower Danube River System. Proceedings of the 10th Macrophyte Group Meeting IAD/SIL, Danube Delta,
29. Cristofor S., A. Vadineanu, A. Sarbu, C. Postolache, G. Ignat, V. Iordache, M. Adamescu, F. Bodescu, 1998b, The role of riparian vegetation in eutrophication control of the Lower Danube River. In: A. Farina, G. Kennedy & V. Bossu (Eds.), Proceedings of the VII International Congress of Ecology INTECOL, Florence 19-25 July 1998 Italy: 97-98

30. Cristofor, S., A. Sarbu, A. Vadineanu, G. Ignat, V. Iordache, C. Postolache, C. Dinu, C. Ciubuc, 1997, Effects of Hydrological Regimen on Riparian Vegetation in the Lower Danube Floodplain *Internat. Assoc. Danube Res.*, 32, 40-44
31. Cristofor, S., A. Vadineanu, A. Sarbu, G. Ignat, G. Romanca, V. Iordache, 1996, Functional role of riparian plant diversity. A theoretical and applied approach for the lower Danube floodplain, Proceedings of the Macrophyte Group Meeting IAD-SIL, Bohinj, Slovenia, 82-90
32. Cristofor, S., V. Iordache, A. Vadineanu, 1999, Functional analyses of ecological systems, in Sustainable development, vol 2, (in Romanian), Bucharest University Press, 227-251
33. Dale, V.H., L.K. Mann, R.J. Olson, D.W. Johnson, K.C. Dearstone, 1990, The long-term influence of past land use on the Walker Branch forest, Landscape Ecology, 4, 211-224
34. Decamps, H., J. Joachim, J. Lauga, 1987, The importance for birds of the riparian woodlands within the alluvial corridor of the river Garonne, S. W. France, Reg. Rivers, 1, 301-316
35. Decamps, H., M. Fortune, F. Gazelle, G. Pautou, 1988, Historical influence of man on the riparian dynamics of a fluvial landscape, Landscape Ecology, 1, 163-173
36. Denevan, W.M., 1995, *Prehistoric agricultural methods as models for sustainability*, Advanced Plant Pathology 11:21-43,
37. Dezzeo, N., R. Herrera, G. Escalante, N. Chacon, 2000, Deposition of sediments during a flood event on seasonally flooded forests of the lower Orinoco River and two of its lack-water tributaries, Venezuela, Biogeochemistry, 49, 241-257
38. Dorp, van, D., P.F.M. Opdam, 1987, Effects of patch size, isolation and regional abundance on forest bird communities, Landscape Ecology, 1, 59-73
39. EarthVoice Romania, 1998, Evaluation of the sustainable turism potential of Innner Danube Delta, 60 pages
40. Ehrenfeld, J. G., 2000, Defining the limits of restoration: the need for realistic goals, Restoration Ecology, 8, 2-9
41. Eldredge, N., 1985, Unfinished synthesis: biological hierarchies and modern evolutionary thought, Oxford University Press, New York.
42. Enculescu, P., 1924, Les zones de vegetation ligneuse en Roumanie (in French and Romanian), "Cartea Romaneasca" S.A., Bucarest
43. Estades, C. F., 2001, The effect of breeding habitat patch size on bird population density, Landscape Ecology, 16, 161-173
44. Estades, C. F., S. A. Temple, 1999, Temperate-forest bird communities in a fragmented landscape dominated by exotic pine plantations, Ecol. Appl., 9, 573-585
45. EU, 2001, European Union Strategy for Sustainable Devoplement, http://europa.eu.int/comm/environment/eussd/
46. Fahrig, L. M. G., 1985, Habitat patch connectivity and population survival, Ecology, 66, 1762-1768
47. FAO, 1990, Forest resource assessment of the temperate zones, Rome
48. FAO, 1999, Proceedings of The FAO Conference – *The Multifunctional Character of Agriculture and Land*, Maastricht, The Netherlands, November 1999.
49. Fetherston, K. L., R. J. Naiman, R. E. Bilby, 1995, Large woody debris, physical processes, and riparian forest development in mountain river networks of the Pacific Northwest, Geomorphology, 13, 133-144
50. Findlay, C. S, J. Houlahan, 1997, Anthropogenic correlates of species richness in in southeastern Ontaria, Canada, Conservation Biology, 2, 1000-1009
51. Fournier, E., M. Loreau, 2001, Respective roles of recent hedges and forespatch remnants in the maintenance of ground-beetle (Colleoptera: Carabidae) diversity in an agricultural landscapes, Landscape Ecology, 16, 17-32
52. Franklin, J. F., R. T.T. Forman, 1987, Creating landscape patterns by forest cutting: Ecological consequences and principles, Landscape Ecology, 1, 5-18
53. Gburek, W. J., A. N. Sharpley, 1998, Hydrologic controls on phosphorous loss from upland agricultural watersheds, Journal of Environmental Quality, 27, 267-277
54. GEF (Global Environmental Fund, 1995), Documents for project management, UNEP web site
55. Gheorghe, I. F., 2003, Carbon dynamic in the floodplain of the Lower Danube River: the influence of the vegetation cover structure (in Romanian), PhD theses, University of Bucharest
56. Gheorghe, I., S. Topa, A. Vadineanu, 2000, Dynamics of vegetation structure in the Small Island of Braila, *Internat. Assoc. Danube Res.*, 33, 143-148
57. Giurgiu, V., 1988, Design of the forest with multiple functions (in Romanian), Ed. Ceres, Bucuresti
58. Giurgiu, V., 1995, Protection and sustainable development of Romanian forests (in Romanian), Ed. by "Progresul Silvic" Society, Bucuresti
59. Giurgiu, V., 1997, Coordinates of a sustainable development strategy for silviculture, in V. Giurgiu (ed.) 1997, "Silvology" (in Romanian), Ed. Academiei Romane, Bucuresti
60. Gore, J. A., F. D. Shields, Jr., 1995, Can large rivers be restored, BioScience, 45, 142-152
61. Groffman, P. M., 1997, Contaminant effects on microbial functions in riparian buffer zones, in N. Haycock, T. Burt, K. Goulding, G. Pinay (editors) "Buffer zones", Quest Environmental, UK
62. Gutzwiller, K. J.,S. H. Anderson, 1992, Interception of moving organisms: influences of patch shape, size, and orientation on community structure, Landscape Ecology, 6, 293-303

63. Guvernul Romaniei, 1999, National Strategy for Sustainable Development (in Romanian), Ed. Nova, Bucuresti
64. Hamazaki, T., 1996, Effects of patch shape on the number of organisms, Landscape Ecology, 11, 299-306
65. Haycock, N. E., G. Pinay, 1992, Groundwater nitrate dynamics in grass and poplar vegetated riparian buffer strips during winter, Journal of Environmental Quality, 22, 273-278
66. Haycock, N. E., G. Pinay, C. Walker, 1993, Nitrogen Retention in River Corridors: European Perspective, Ambio, 22, 340-346
67. Haycock, N. E., T. P. Burt, K. W. T. Goulding, G. Pinay (eds.), 1997, Buffer zones: their processes and potential in water protection, Quest Environmental, Harpenden, UK
68. Henein, K., G. Merriam, 1990, The elements of connectivity where corridor quality is variable, Landscape Ecology, 4, 157-170
69. Hicks, B. J., R. L. Beschta, R. D. Harr, 1991, Long-term changes in stream flow following logging in western Oregon and associated fisheries implications, Water Res. Bull., 27, 217-226
70. Hubbard, R. K., R. R. Lowrance, 1996, Solute transport and filtering through a riparian forest, Transactions of ASAE (America Society of Agricultural Engineers), 39, 477-488
71. Hupp, C. R., 1992, Riparian vegetation recovery patterns following stream chanelization: a geomorphic perspective, Ecology, 73, 1209-1226
72. ICPDR, 2001, Joint action programme for the Danube River Basin, 50 pages
73. Iordache V, S. Cristofor, A. Sirbu, M. Onete, A. Neagoe, M. Adamescu, A. Vadineanu, 1999a, The role of the vegetation in the cycling of metals in the Lower Danube floodplain, Proceedings of the 2nd IAD-Macrophyte Group Meeting, 50-60
74. Iordache V., 2002, Preliminary assessment of the pollution risk associated with the restoration of the Danube floodplain, Proceedings of the 5th International Symposium on Metal Elements in Environment, Medicine and Biology, in press
75. Iordache V., C. Postolache, A. Vadineanu, S. Cristofor, G. Ignat, M. Onete, 1997, Effects of hydrological conditions on denitrification in the lower Danube floodplain, *Internat. Assoc. Danube Res.*, 32: 404-408
76. Iordache V., C. Postolache, N. Mihailescu, A. Neagoe, G. Ignat, S. Cristofor, A. Vadineanu, 1998, Distribution patterns of metals in sediments of the Lower Danube System, Proceedings of the 3rd International Symposium on Metal Elements in Environment, Medicine and Biology, 45-53
77. Iordache V., Carmen Postolache, S. Cristofor, G. Ignat, A. Vadineanu, 1999a, Heavy metals distribution in the ecosystems of the Danube floodplain, Proceedings of the 8th Danube Delta Institute Symposium, 356-364
78. Iordache V., F. Bodescu, M. Onete, C. Florescu, A. Neagoe, M. Adamescu, A. Vadineanu, 1997a, Effects of hydrology on redox potential in the lower Danube wetlands, Proceedings of the 7th Danube Delta Institute Symposium, 449-459
79. Iordache V., M. Adamescu, F. Bodescu, S. Cristofor, A. Vadineanu, 1997b, Hydrological modeling of Fundu Mare Island (Danube floodplain), Proceedings of the 7th Danube Delta Institute Symposium, 551-562
80. Iordache V., M. Onete, A. Vadineanu, 1999b, Heavy metals dynamic in litter from the Danube floodplain, Proceedings of the 8th Danube Delta Institute Symposium, 351-355
81. Iordache, V, 2002a, The coordinates of a sytemic monitoring in Romania, Mediul Inconjurator (The Environment), 63-71
82. Iordache, V, A. Neagoe, A. Cernatoni, M. State, T. Altorfer, E. Preda, S. Cristofor, A. Vadineanu, 2000, Heavy metals in the Danube floodplain related to the Yugoslavian conflict, In: Proceedings of the 5th Symposium on Environmental Contamination, Prague, Czech Republic, CD-ROM format (7 pages)
83. Iordache, V., 2002b, Who is interested in the integrated development of Lower Danube Fisheries, Proceedings of the "Deltas and Wetlands" International Symposium, Tulcea, *in press*
84. Iordache, V., S. Cristofor, A. Vadineanu, 2002, Functional analyses of the Lower Danube wetlands by FAEWE/PROTOWET procedure, Proceedings of the "Deltas and Wetlands" International Symposium, Tulcea
85. Iordache, V., S. Cristofor, A. Vadineanu, 2001, Optimization pathways of the decision making process regarding the ecotoxicological effects in the Lower Danube River System, Proceedings of the "Deltas and Wetlands" International Symposium, Tulcea, 91-97
86. IUCN, 1995, River corridors in Hungary: a strategy for the conservation of hte Danube and its tributaries (1993-1994), IUCN, Gland, Switzerland; Budapest, Hungary
87. Ivan, D. (ed.), 1992, The vegetation of Romania (in Romanian), Ed. Tehnica Agricola, Bucuresti
88. Jacobson, M. G., 2002, Factors Affecting Private Forest Landowner Interest in Ecosystem Management: Linking Spatial and Survey Data, Environmental Management, 30, 577-583
89. Johnson, A. R., J.A. Wiens, B.T. Milne, T.O. Crist, 1992, Animal movements and population dynamics in heterogeneous landscapes, Landscape Ecology, 7, 63-75
90. Jongman, A. H. G., A. Y. Troumbis, 1996, The wider landscape for natura conservation: ecological corridors and buffer zones, MN2.7 Sub-project report, European Center for Nature Conservation, Tillburg
91. Jordan, T. E., D. L. Correll, D. E. Weller, 1993, Nutrient interception by a riparian forest receiving inputs from adjacent cropland, J. Environ. Qual., 22, 467-473
92. Klijn, F., H. A. U. de Haes, 1994, A hierarchical approach to ecosystems and its implications for ecological land classification, Landscape Ecology, 9, 89-104
93. Klimas, C. V., C. O. Martin, J. W. Teaford, 1981, Impacts of flooding regime on wildelife habitats of

bottomland hardwood forests in the lower Mississipi Valley, Tech, Rep. El-81-13, US Army Engineers Waterways Exp. Station, Vicksburg, Miss.
94. Kupfer, J. A., G. P. Malanson, 1993, Observed and modeled directional change in riparian forest composition at a cutbank edge, Landscape Ecology, 8, 185-199
95. Larue, P., L. Belanger, J. Huot, 1994, La frequentation des peuplements riveraines par le cerf de Virginie en hiver: selections de site ou pure coinciidence ? Ecoscience, 1, 223-230
96. Lauga, J., J. Joachim, 1992, Modelling the effects of forest fragmentation on certain species of forest-breeding birds, Landscape Ecology, 6, 183-193
97. Li, H., J. F. Franklin, F. J. Swanson, T. A. Spies, 1993, Developing alternative forest cutting patterns: A simulation approach, Landscape Ecology, 8, 63-75
98. Lowrance, R., G. Vellidis, R. D. Wauchope, P. Gay, D. D. Bosch, 1997, Herbicide transport in a managed riparian forest buffer system, (America Society of Agricultural Engineers), 40, 1047-1057
99. Lowrance, R., R. Leonard, and J. Sheridan, 1985, Managing riparian ecosystems to control nonpoint pollution, Journal of Soil and Water Conservation, 40, 87-91
100. Machedon, I., 1988, Research concerning the economic valuation of protection functions (in Romanian), PhD theses, University of Brasov
101. Maltby, E. (Editor.), 1998, FAEWE/PROTOWET procedures (version 1), Wetland Ecosystem Research Group, Royal Holloway, University of London
102. Maltby, E., D. V. Hogan, R. J. McInnes (editors), 1996, Functional analysis of European wetland ecosystems, European Commision, Office for the official publications of the EC, Luxembourg
103. Maltby, E., editor, 1998, FAEWE/PROTOWET procedures (version 1) Wetland Ecosystems Research Group, Royal Holloway Institute for Environmental Research, Royal Holloway, University of London
104. Mander, U., V. Kuusemets, M. Ivask, 1995, Nutrient dynamics of riparian ecotones: a case study from the Porijogi River catchment, Estonia, Landscape and Urban Planning, 31, 333-348
105. Mazzerole, M. J., M. A. Villard, 1999, Patch characteristics and landscape context as predictors of species presence and abundance: a review, Ecoscience, 6, 117-124
106. McIntyre, N. E., 1995, Effects of forest patch size on avian diversity, Landscape Ecology, 10, 85-99
107. Merriam, G., A. Lanoue, 1990, Corridor use by small mammals: field measurement for three experimental types of *Peromyscus leucopus,* Landscape Ecology, 4, 123-131
108. Ministry of Agriculture and Alimentation, 1999, Study on the fishery sector and aquatic resources of Romania, elaborated in cooperation with the Know How Fund, Bucharest, 55 pages
109. Mitsch, W. J., J. G. Gosselink, 1986, Wetlands, Van Nostrand Reinhold, New York
110. Mitsch, W. J., J. R. Taylor, K. B. Benson, 1991, Estimating primary productivity of forested wetland communities in different hydrologic landscapes, Landscape Ecology, 5, 75-92
111. Murphy, K. J., E. Castella, B, Clement, J. M. Hills, P. Obrdlik, I. D. Pulford, E. Schneider, and M. C. D. Speight, Biotic indicators of riverine ecosystem functioning, in W. J. Mitsch (ed.) "Global Wetlands: Old World and New", Elseevier Science B. V., 659-682
112. Naiman, R. J., H. Decamps, 1997, The ecology of interfaces: riparian zones, Annu. Rev. Ecol. Syst., 28, 621-658
113. Nassauer, J. I., 1992, The appearance of ecological systems as a matter of policy, Landscape Ecology, 6, 239-250
114. Neagoe A., V. Iordache, T. Altorfer, M. Pescaru, A, Vadineanu, 2000, Metals in plants of Danube floodplain: deficiency or excess ?, Proceedings of the 4th International Symposium on "Metal elements in Environment, Medicine and Biology", Timi]oara, Romania, 14-28
115. Neagoe, A., V. Iordache, F. Bodescu, S. Cristofor, A. Vadineanu, 2001, The gradient of heavy metals in new deposited sediments in the Danube floodplain, Proceedings of the "Deltas and Wetlands" International Symposium, Tulcea, 134-141
116. Neagoe, A., V. Iordache, T. Altorfer, 2002, Risk sources due to metals in the Danube floodplain, Mengen und Spuren Elemente, 22, 77-82
117. Neiman, R. J., H. Decamps, 1997, The ecology of interfaces: riparian zones, Annu. Rev. Ecol. Syst., 28, 621-658
118. Neiman, R. J., S. E. Bunn, C. Nilsson, G. E. Petts, G. Pinay, L. C. Thompson, 2002, Legitimizing fluvial ecosystems as users of water: an overview, Environmental Management, 30, 455-467
119. Niemala, J., D. W. Langos, 1993, Effects of clear-cut harvesting pn boreal ground-beetle assemblages (Colleoptera, Carabidae) in western Canada, Cons. Biol., 7, 551-561
120. Nilsson, C., M. Svedmark, 2002, Basic principles and ecological consequences of changing water regimes: riparian plant communities, Environmental Management, 30, 468-480
121. O'Neill, R. V., A.R. Johnson, and A.W. King, 1989, A hierarchical framework for the analysis of scale, Landscape Ecology, 3, 193-205
122. O'Neill, R.V., DeAngelis, D.L., Allen, T.F.H. and Waide, J.B., 1986. A hierarchical concept of ecosystems, Monographs in Population Biology 23. Princeton University Press, Prince-ton, NJ.
123. Odum, E. P., 1993, Ecology and our endangered life-support systems, Sinauer Assoc. Inc. Publishers, Sunderland

124.Opdam, P., 1991, Metapopulation theory and habitat fragmentation: a review of holarctic breeding bird studies, Landscape Ecology, 5, 93-106
125.Opdam, P., R. Foppen, C. Vos, 2002, Bridging the gap between ecology and spatial palnning in landscape ecology, Landscape Ecology, 16, 767-779
126.Pahl-Wostl, C., 1995, The dynamic nature of ecosystems, J. Willey and Sons, New York
127.Pascovschi, S., 1967, Succession of forest species (in Romanian), Ed. Agro-Silvica, Bucharest, 1967
128.Pielkel, R. A., R.Avissar, 1990, Influence of landscape structure on local and regional climate, Landscape Ecology, 4, 133-155
129.Pinay, G., A. Fabre, Ph. Vervier, F. Gazelle, 1992, Control of C,N,P distribution in soils of riparian forests, Landscape Ecology, 6 , 121-132
130.Pinay, G., C Ruffinoni, A. Fabre, 1995, Nitrogen cycling in two riparian forest soils under different geomorphic conditions, Biogeochemistry, 30, 9-29
131.Pinay, G., C. Ruffinoni, S. Wondzell, and F. Gazelle, 1998, Change in groundwater nitrate concentration in a large river floodplain: denitrification, uptake, or mixing ? J. N. Am. Benthol. Soc., 17, 179-189
132.Pinay, G., H. Decamps, R. J. Naiman, 1999, The spiralling concept and nitrogen cycling in large river floodplain soils, Large Rivers, 11, 281-291
133.Pinay, G., J. C. Clement, R. J. Naiman, 2002, Basic principles and ecological consequences of changing water regimes on nitrogen cycling in fluvial systems, Environmental Management, 30, 481-491
134.Pinay, G., L. Roques, A. Fabre, 1993, Spatial and temporal patterns of denitrification in a riparian forest, Journal of Applied Ecology, 30, 581-591
135.Pither, J., P.D. Taylor, 1998, An experimental assessment of landscape connectivity, Oikos, 83, 166-174
136.Postolache, C., V. Iordache, A. Vadineanu, G. Ignat, S. Cristofor, A. Neagoe, C. Florescu, F. Bodescu, 1997, Effects of hydrological conditions on the dynamic of nutrients in the lower Danube floodplain, *Internat. Assoc. Danube Res.,* 32: 5-10
137.Reichholf, J. H., 1998, Climate stabilisation and conservation of biodiversity – Two goals – One Way ? in Kohlmayer, G. H., M. Weber, R. A. Haughton (ed.) "Carbon dioxide mitigation in forestry and wood industry", Springer-Verlag Berlin Heidelberg, 257-268
138.Rickenbach, M. G., A. S. Reed, 2002, Cross-Boundary Cooperation in a Watershed Context: The Sentiments of Private Forest Landowners, Environmental Management, 30, 584-594
139.Robinson, S. K., 1998, Another threat posed by forest fragmentation: reduce food supply, Auk, 115, 1-3
140.Robinson, S. K., F. R. Thompson, T. M. Donovan, D. R. Whitehead, J. Faaborg, 1995, Regional forest fragmentation and the nesting succes of migratory birds, Science, 267, 1987-1990
141.Rudis, V. A., 1995, Regional forest fragmentation effects on bottomland hardwood community types and resource values, Landscape Ecology, 10, 291-307
142.Ryszkowski, L., A. Kqdziora, 1987, Impact of agricultural landscape structure on energy flow and water cycling, Landscape Ecology, 1, 85-94
143.Salthe, S.N., 1985, Evolving hierarchical systems: their structure and representation. Columbia University Press, New York
144.Sarbu, A., A. Vadineanu, S. Cristofor, C. Ciubuc, C. Postolache, G. Ignat, 1998, Vegetation dynamics in riparian ecotones of the Lower Danube Floodplain and Catchment, in A. Farina, J. Kennedy, V. Bossu (eds.), Proceedings of the 7th Internation congress of ecology, INTECOL, Florence, 371
145.Sarbu, A., S. Cristofor, G. Dumitrescu, 1999, Riparian vegetation answer to mechanical and hydrological factors, Acta Botanici Horti Bucurestiensis
146.Schneider, E., 2002, The ecological functions of the Danubian floodplains and their restoration with special regard to the Lower Danube, Large Rivers, 13, 129-149
147.Sheridan, J. M., R. Lawrance, D. D. Bosch, 1999, Management effects on runoff and sediment transport in riparian forest buffers, Transactions of ASAE (America Society of Agricultural Engineers), 42, 55-64
148.Smith, A., R. Mac Nally, D. Lamb, 2002, Comparative influence of forest management and habitat structural factors on the abundances of hollow-nesting bird species in subtropical australian eucalypt forest, Environmental Management, 30, 547-559
149.Spink, A., R. E. Sparks, M. van Oordhot, J. T. A. Verhoeven, 1998, Nutrient dynamics of large river floodplains, Regulated rivers: research and management, 14, 203-216
150.Szacki, J.,A. Liro, 1991, Movements of small mammals in the heterogeneous landscape, Landscape Ecology, 5, 219-224
151.Tabacchi, E., A.-M. Planty-Tabacchi, O. Decamps, 1990, Continuity and discontinuity of the riparian vegetation along a fluvial corridor, Landscape Ecology, 5, 9-20
152.Topa, S., 2002, Role of the vegetation cover in the cycling of N and P in small agricultural catchements and the floodplain of the Lower Danube River (in Romanian), PhD theses, University of Bucharest
153.Topa, S., I. Gheorghe, A. Vadineanu, 2001, Nutrient storage in riparian vegetation in the lower Danube floodplain, *Internat. Assoc. Danube Res.,* 33, 149-154
154.Topa, S., I. Gheorghe, D. Cogalniceanu, D. Ghioca, A. Vadineanu, 2001, Non-parametric methods for estimating species richness : a case study on herbaceous vegetation in the Danube floodplain, Acta Botanica Horti Bucurestiensis

155. Topa, S., I. Gheorghe, D. Cogalniceanu, E. Stan, O. Ciolpan, A. Vadineanu, 1998, Dynamic of natural litter decomposition in Danube floodplain (Small Island of Braila), Proceedings of the 8th Danube Delta Institute Symposium (in Romanian), 432-438
156. Tufford, D. L., H. N. McKellar Jr., J. R. Hussey, 1998, In-stream nonpoint nutrient prediction with land-use proximity and seasonality, Journal of Environmental Quality, 27, 100-111
157. UNCED, 1992, Agenda 21, http://www.un.org/esa/sustdev/documents/agenda21/index.htm
158. Vadineanu, A., S. Cristofor, G. Ignat, V. Iordache, A. Sarbu, C. Ciubuc, G. Romanca, I. Teodorescu, C. Postolache, M. Adamescu, C. Florescu, 1997, Functional assessment of the Wetlands Ecosystems in the Lower Danube Floodplain, Proceedings of the IAD conference, Viena, 463-467
159. Vadineanu, A., 1998, Dezvoltarea durabila (Sustainable Development), vol. 1, Editura Universitatii din Bucuresti, 247 pages
160. Vadineanu, A., 1999, Decision making and decision support systems for balancing Socio-Economic and Natural Capital Development, Background paper at International Conference *"Globalization, Economy and Ecology – Bridging worlds"* 24 – 26 November 1999, Tillburg, Olanda, 24 pages
161. Vadineanu, A., 2000, Lower Danube Wetlands System, in "Wetlands Handbook", edited by E. Maltby, *in press*
162. Vadineanu, A., C. Postolache, V. Diaconu, 1998, Targets concerning Socio-Economic Restructuring Emerging from Material Accounting Analysis on the National Scale (Romania), in L. Hens, R. J. Borden, S. Suzuki, G. Cocavello (eds.) "Human Ecology: an Interdisciplinary Overview", VUBPRESS, 289-314
163. Vadineanu, A., G. Ignat, M. Adamescu, C. Cazacu, F. Bodescu, S. Chirlomez-Danielescu, M. Valcu, 2002b, Integrated management plan for the Small Island of Braila, LIFE99 NAT/RO/006400, http://www.bio.unibuc.ro/ecology/life
164. Vadineanu, A., M. Oltean, P. Gastescu, V. Vajdea, G. Coldea, I. Munteanu, D. Manoleli, N. Donita, 1992, The concept of ecoregion and their differentiation for Romania (in Romanian), Mediul Inconjurator, 3, 3-6
165. Vadineanu, A., M. Oltean, P. Gastescu, V. Vajdea, G. Coldea, I. Munteanu, D. Manoleli, N. Donita, 1992a, Conceptul de regionare ecologica si diferentierea ecoregiunilor din Romania (The concept of ecoregion and their differentiation for Romania), Mediul Inconjurator, 3, 2: 3-6
166. Vadineanu, A., S. Cristofor, M. Adamescu, 2002, Preliminary solutions for sustainable management of Lower Danube Wetlands Systems, in "Wetlands Handbook", edited by E. Maltby, *in press*
167. Vadineanu, A., S. Cristofor, V. Iordache, 1997, Relationships between nutrient dynamics and plant diversity in the Danube floodplain, in Books of abstract of Symposium on wetlands Biogeocmestry, London, 55
168. Vadineanu, A., S. Cristofor, V. Iordache, 2001, Lower Danube River System biodiversity changes, In: B. Gopal, W. J. Junk and J. A. Davis (Eds), Biodiversity in Wetlands: Assessment, Function and Conservation, Backhuys Publishers, 29-63
169. Valcu, M., 2003, Assessment of the structure and role of bird communities in the landscape of Small Island of Braila (in Romanian),), PhD theses, University of Bucharest
170. Valett, H. M., J. R. Webster, P. J. Mulholland, C. N. Dahm, C. N. Peterson, P. V. Unnikrishna, 1999, N-NO_3 retention in headwater-streams: influences of riparian vegetation, metabolism, and subsurface process, Research Project
171. Verboom, B., R. van Apeldoorn, 1990, Effects of habitat fragmentation on the red squirrel, *Sciurus vulgaris* L., Landscape Ecology, 4, 171-176
172. Vlad, I., C. Chirita, N. Donita, L. Petrescu, 1997, Silviculture based on ecosystems theory (in Romanian), Ed. Academiei Romane, Bucuresti
173. Vos, C., H. Baveco, C. J. Grashof-Bokdam, 2001, Corridors and species dispersal, in "Concepts and application of Landscape Ecology in Biological Conservation", ed. by K.J. Gutzwiller, Springer-Verlag, New York
174. Vought, L. B.-M., G. Pinay, A. Fuglsang, C. Ruffinoni, 1995, Structure and function of buffer strips from a water quality perspective in agricultural landscapes, Landscape and urban planning, 31, 323-331
175. Weber, N., 1998, Afforestation in Europe: Experiences and Future Possibilities, in Kohlmayer, G. H., M. Weber, R. A. Haughton (ed.) "Carbon dioxide mitigation in forestry and wood industry", Springer-Verlag Berlin Heidelberg, 153-166
176. Wissinger, S. A., 1997, Cyclic colonization in predictability epfemeral habitats: a template for biological control in annual crop systems, Biol. Control, 10, 4-15
177. With, K. A., T. O. Crist, 1995, Critical thresholds in species responses to landscape structure, Ecology, 76, 2446-2459
178. Wondzell, S. M., G. L. Cunningham, D. Bachelet, 1996, Relationships between landforms, geomorphic processes, and plant communities on a watershed in the northern Chihuahuan Desert, Landscape Ecology, 11, 351-362
179. Zaharia, I. C., 1999, Ecological studies: influence of chemical pollution on the vegetation cover of Romania (in Romanian), Ed. Economica, Bucuresti
180. Zipperer, W. C., 1993, Deforestation patterns and their effects on forest patches, Landscape Ecology, 8, 177-184

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