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Synopsis of system approaches to environmental research – German contribution to ecosystem management

by

Dipl.-Ing. Konstanze Schönthaler*
Dr. Felix Müller**
Dr. Jan Barkmann***

* Bosch & Partner Ltd, München
** Ökologie-Zentrum der Christian-Albrechts- University, Kiel
*** University Göttingen

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The italic paragraphs within the text deal with concrete examples from ecosystem research projects, details or longer quotations, which give prove to statements prior to the italic paragraphs.

Abbreviations

ABAG	General Soil Loss Equation
ACSYS	Arctic Climate System Study
AOPC	Atmospheric Observation Panel for Climate
AOT	Accumulated exposure Over a Threshold of 40 ppb
ARTERI	Arctic-Alpine Terrestrial Ecosystems Research Initiative
BAHC	Biospheric Aspects of the Hydrological Cycle
BALTEX	GEWEX Baltic Sea Experiment
BERMS	The Boreal Ecosystem Research and Monitoring Sites
BFA-Fi	Federal Research Institute for Fisheries
BfG	German Federal Institute for Hydrology
BfN	Federal Nature Conservation Office
BIODEPTH	Diversity and Ecological Processes in Terrestrial Herbaceous ecosystems
BIOGEST	Biogas Transfer in Estuaries
BITÖK	Bayreuth Institute for Terrestrial Ecosystem Research
BMBF	Federal Ministry for Education and Research
BMU	Federal Environmental Ministry
BMVEL	Federal Ministry for Consumer Protection, Food and Agriculture
BNatSchG	Federal Nature Conservation Law
BOREAS	Boreal Ecosystem-Atmosphere Study
CACGP	Commission on Atmospheric Chemistry and Global Pollution
CBD	Convention on Biodiversity, Biodiversitätskonvention
CEOS	Committee on Earth Observation Satellites
CliC	Climate and Cryosphere
CLIPS	Climate Information and Prediction Services
CLIVAR	Climate Variability and Predictability
CLUE	Changing Land Usage, Enhancement of biodiversity and ecosystem development
DAAD	German Academic Exchange Service
DART	Dynamic response of the forest–tundra ecotone to environmental change
DBU	German Federal Foundation for the Environment

DEGREE	Diversity Effects in Grassland Ecosystems of Europe
DFG	German Research Association
DWD	German Weatherservice
ECOMONT	Ecological Effects of Land-Use Changes on European Terrestrial Mountain Ecosystems
EMERGE	European Mountain lake Ecosystems: Regionalisation, diagnostic & socio-economic Evaluation
ESS-P	Earth System Science Partnership
EU	European Union
FAM	Munique Agricultural Ecosystem Research Community
FAO	Food and Agriculture Organization of the United Nations
FOREM	Forest Ecosystem Monitoring
FTZ	Research and Technology Centre Westcoast
FWZ	Forest Ecosystem Research Centre at the University of Göttingen
GAIM	Global Analysis, Integration and Modelling
GAME	GEWEX Asian Monsoon Experiment
GAW	Global Atmosphere Watch
GCIP	GEWEX Continental-scale International Project
GCOS	Global Observing System
GCP	Global Carbon Project
GCSS	GEWEX Cloud System Study
GCTE	Global Change and Terrestrial Ecosystems
GECAFS	Global Environmental Change and Food Systems
GECHS	Global Environmental Change and Human Security
GEWEX	Global Energy and Water Cycle Experiment
GIS	Geographic Informationsystem
GLOBEC	Global Ocean Ecosystem Dynamics
GLORIA-EUROPE	The European dimension of the Global Observation Research Initiative in Alpine Environments
GSF	GSF-Forschungszentrum für Umwelt und Gesundheit/Neuherberg
GODAE	Global Ocean Data Assimilation Experiment.
GOOS	Global Oceanic Observing System
GOSIC	Global Observing Systems Information Center
GPCP	Global Precipitation Climatology Project
GTOS	Global Terrestrial Observing System
GVaP	Global Water Vapour Project
HIBECO	Human interactions with the Mountain Birch Forest Ecosystems
IAMAS	International Association of Meteorology and Atmospheric Sciences
IBP	International Biological Program
ICP	International Co-operative Programme
ICSU	International Council for Science
IDGEC	Institutional Dimensions of Global Environmental Change
IGAC	International Global Atmospheric Chemistry
IGBP	International Geosphere-Biosphere Programme
IGFA	International Group of Funding Agencies for Global Change Research

IGOS	Integrated Global Observing Strategy
IHDP	International Human Dimensions Programme on Global Environmental Change
ILTER	International Long Term Ecological Research
IOC	Intergovernmental Oceanographic Commission
ISCCP	International Satellite Cloud Climatology Project
ISLSCP	International Satellite Land-Surface Climatology Project
IT	Industrial Transformation
ITEX	International Tundra Experiment
IUBS	International Union of Biological Sciences
IUCN	The World Conservation Union
IUMS	International Union of Microbiological Societies.
JGOFS	Joint Global Ocean Flux Study
JWP	Joint Water Project
LOICZ	Land-Ocean Interactions in the Coastal Zone
LTER	Long Term Ecological Research
LUCC	Land-Use and Land-Cover Change
LUNG	Mecklenburg State Office for Environment, Nature Conservation and Geology
MAB	Man and the Biosphere
MLUR	Brandenburg State Ministry for Agriculture, Environmental Conservation and Landuse Planning
MOLAR	Measuring and Modelling the Dynamic Response of remote Mountain Lake Ecosystems to Environmental Change
NASA	National Aeronautics and Space Administration
NGO	Non governmental Organisation
NSF	National Science Foundation
NSN	Northern Sciences Network
NSSE	Nordic Subarctic-Subalpine Ecology
OECD	Organisation for Economic Cooperation and Development
OOPC	Ocean Observation Panel for Climate
PAGES	Past Global Changes
PIRATA	Pilot Research Array of buoys in the Tropical Atlantic und
PROTOS	Production and transport of organic solutes
R+D	Research and Development
RENMAN	The Challenges of Modernity for Reindeer Management
ROBUST	Role of buffering capacities in stabilising coastal lagoon ecosystems
SBSTTA	Subsidiary Body on Scientific Technical and Technological Advice
SCOR	Scientific Committee on Oceanic Research
SCOPE	Scientific Committee on Problems of the Environment
SFB	Research Field defined by the German Research Association
SOLAS	Surface Ocean-Lower Atmosphere Study
SPARC	Stratospheric Processes And their Role in Climate
SRU	The German Council of Environmental Advisors
SSC	Scientific Steering Committee
StaBA	Federal Statistical Office
STAR	Special Target Areas of Research

START	System for Analysis, Research and Training
TA	Technical Instructions
TCO	Terrestrial Carbon Observation
TERI	Terrestrial Ecosystem Research Initiative
TERICA	Terrestrial Ecosystem Research Initiative Concerted Action
TERN	Terrestrial Ecosystem Research Network
TMAP	Trilateral Monitoring and Assessment Program
TOGA	Tropical Ocean and Global Atmosphere
TOROS	Tinto Odiel River Ocean Study
TUHH	Technical University at Hamburg-Harburg
UBA	German Federal Environmental Agency
UFZ	Centre for Environmental Research Leipzig-Halle
UGR	Economic Environmental Accounting
UNCED	UN Conference on Environment and Development
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UQZ	Environmental Quality Targets
USLE	Universal Soil Loss Equation
UST	Environmental Quality Standard
UVP	Environmental Assessment
UVPG	Law on the Environmental Assessment
WAVES	Water Availibility and Vulnerability of Ecosystems – North Eastern Brazil
WCDMP	World Climate Data and Monitoring Programme
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
MWF	North-Rhine Westfalian State Ministry for Education, Science and Research
WWW	World Weather Watch
ZALF	Centre for Agricultural Landscape and Land Use Research

SUMMARY

Background and target objectives

In order to enable the conceivement and enforcement of efficient measures for environmental precaution and protection, it is necessary to undertake an environmental systems analysis. Against the background of this assumption, a concept for a federal ecosystem research program has been initiated by the Federal Ministry of the Interior in 1978. Cooperating on this project was the Federal Ministry of Research and Agriculture. On this basis, ecosystem research projects have been implemented by the Federal Ministry of Education and Research and the Federal Environmental Ministry, in Berchtesgaden, Munich, Bayreuth, Göttingen and Kiel. The latest joint project of the Federal Environmental Ministry - the Ecosystem Research Project on the Wadden Sea - has been promoted in cooperation with the States of Schleswig-Holstein and Lower Saxony and with the Federal Ministry for Education and Research. The project has been completed in 1999.

The completion of these research projects brought up the following questions:

- Which contribution did the German ecosystem research make to the international discussion on a systems oriented environmental management?
- In which areas did politics, planning and consultancy profit from the methods and results of ecosystem research and what are the reasons for the current insufficient use of their potentials?
- Which recommendations can be derived from these experiences for the conceptional, organizational and methodological alignment of potential future research projects?

The research and development project “Synopsis of Approaches to Environmental Research – German Contribution to Ecosystem Management“, which has been commissioned by the German Federal Environmental Agency in 2001, was aimed at a clarification of these question. The project has been implemented in cooperation of Bosch & Partner and the Ecology-Centre in Kiel. It has been completed in March 2003.

What is ecosystem research?

In the following, ecosystem research projects are understood as projects, that comprise an integrated examination of biotic and abiotic ecosystem components as well as a combination of examinations on different environmental media, that consider water and element flows as well as energy transformations and that use empiric methods. Moreover, an important characteristic of ecosystem research projects is, that several working groups cooperate within an interdisciplinary working schedule and that they subsume the partial results under a project synthesis.

Methods

Informations on the worldwide conducted ecosystem research projects and on the incorporation of their results into environmental politics and environmental management stem from the following sources:

- **Questionnaire**

Within the frame of the R+D project, a questionnaire has been carried out in the beginning of 2002.

The questionnaire, which is subdivided in three parts, has been sent away by e-mail to 190 German and international experts between February and April 2002. Addressed were: known experts in ecosystem research (among others project supervisors from the world wide inquired ecosystem projects have been contacted);professors and university employees that are responsible for teaching and education and have insight into ecosystem research; representatives from environmental politics, administration – or planning (f.i. from planning offices or the environmental administration or from public authorities and institutions in the area of environmental observation and environmental reporting)

The questionnaires, which have been filled in by 35 interviewees, have been analysed against the background of the project‘s central problem

- **Research on the internet and of research literature**

Broad research on the internet and of research literature has been conducted with the aim, to gain an overview on completed and ongoing ecosystem research projects. The information on the researched projects has been systematized with the use of a database. Currently, the database offers information on 275 projects, the respective research institutions, the projects' finances, their duration, their conceptional and methodological focal points, the location of the researched areas as well as details on the contact persons, publications and addresses on the internet. It is principally open for further information.

- **Workshop**

From October 22-24 2002, an international workshop has been organized, that took place at the Cultural Center Salzau, nearby Kiel. At the workshop, about 60 experts from research, planning and administration debated about the results and the perspectives of ecosystem research. Besides participants from Germany, even representatives from Italy, the Netherlands, Denmark, USA, Canada, Lithuania and Russia have taken part in the workshop. The workshop was structured in plenum sessions with key-note lectures and four working groups, that focused on "Conceptional, Methodological and Strategic Experiences and Problems within Ecosystem Research", "Ecosystem Research and Ecosystem Management – Guidelines for an Integrative Environmental Practice", "Experiences and Problems from Politics and Planning" as well as on "The Future Ecosystem Research". The discussions were supported by a theory paper and have been summarized in reports.

Results

Due to ecosystem research, the knowledge about the ecology of systems, populations and organisms has increased. In a lot of areas, ecosystem use has fundamentally changed with the increase in knowledge and awareness. Ecosystem research produced and proliferated knowledge on the economic and social consequences of changes within ecosystems. Even if many productive impulses have emanated from ecosystem research to the science system and the environmental practice in the past, in many cases the results are indirect and hard to quantify. In many areas there are still very strong efforts to put into the transformation of ecosystem results into practice, and great potentials are still awaiting a concrete implementation.

- **Impulses from ecosystem research to the science system**

Ecosystem research has made a major contribution to the stimulation of networked thinking and acting, it has promoted interdisciplinary ways of thinking and, thus, has had a strong impact on the science system. The consideration of the „human“ aspect, and, thus, a broadening of the object of investigation, came along with the ecosystem research. The characteristic combination of measurements and model construction as well as the scientific and practical expert knowledge and the cooperation of different faculties have changed research practices in general.

- **Impulses from ecosystem research to environmental politics**

With regard to environmental politics and environmental management, ecosystem research has promoted a more integrative view and treatment of environmental problems. The increased awareness of the complexity and interactivities of ecosystems has had the effect, that no longer narrow solutions stand in the focus of debates. Due to the knowledge from ecosystem research, environmental development nowadays is understood as a dynamic process, that hardly can be controlled by the determination of „hard“ goals and by the implementation of single measures. But the influence of ecosystem research on environmental politics can only be proven by a few concrete examples. The influence is rather implicit, theoretical and indirect, and it leads to „collective“ effects as f.i. the increasing acceptance of the idea of sustainability and a growing readiness for the consideration of possible consequences following environmental use. The potentials of ecosystem research for concrete changes in the actions of politics and administration, has not yet been fully tapped.

- **Significance of ecosystem research for environmental planning**

Following the debate of the models for sustainable development and the stronger orientation of environmental planning on this model, the ecosystem way of thinking has become more important for environmental planning. Central conceptional demands, that are connected with the idea of sustainability, can only be met by using ecosystem approaches. Examples are f.i. the development of target concepts respectively environmental quality goals or the determination of ecosystems‘ carrying capacities. Planning has also profited from the methodological instruments and technical aids for the description and evaluation of ecosystems and for a prognosis of changes, which have been developed by ecosystem research. The area-wide introduction of Geographical Informationsystems within planning and their competent use can be assigned to the successful advancement and application of these instruments by ecosystem research.

In spite of the positive examples for the transformation of research results into environmental planning, the interface research-planning still needs to be developed. The demands set by the Law on Environmental Assessment and the EU guideline on strategic environmental assessment, that refer to the solution of planning problems on the basis of ecosystem approaches, have not yet been realized in a satisfactory.

- **Contribution of ecosystem research to environmental observation/environmental monitoring and the derivation of indicators**

The important result from ecosystem research, that the environment as a complex system can only be understood by using interdisciplinary approaches, has directly led to the demand for an integrated sector spanning environmental observation. Environmental observation, as it exists now, is focused on single problems and sectors, which leads to the fact that the demand for effect statements and trend prognoses cannot be fulfilled. Reasonable interactions between environmental observation and ecosystem research are especially seen in the conceptional, methodological and technical input, that ecosystem research gives for the development of observation programs and measuring networks, as well as for the evaluation of observation results. On the other hand, environmental observation can only be used for a long-term testing of the models and theories from ecosystem research and for a determination of the need for research.

There are a lot of examples for the transformation of research projects into the every day practice of environmental observation. One of the most known examples is the Forest Ecosystem Research, f.i. within the frame of the ICP, that led to the Forest Monitoring (Level I and II). Still, even in this area, many possibilities for interaction remain open. The causes can be ascribed to financial, organizational, technical and methodological problems, but another reason is, that environmental observation is regarded as an uninteresting field of work by many researchers. A consequence is, that there is a lack of creative ideas for environmental observation. Within the routine business of environmental observation, sometimes the understanding and the readiness for an acceptance of the results from ecosystem research as well as for the formulation of demands to research, is missing.

- **Contribution of ecosystem research to the indicator discussion**

Especially since the Rio Conference in 1992, methods and approaches are attempted to be found, that are able to describe the environmental situation and their changes due to quantitiy and quality and in order to control the fulfillment of environmental and developmental goals. Chapter 40 of the Agenda 21, which has been signed by representatives from the community of states at the Conference in Rio de Janeiro, demands the development and the application of measurement sizes and evaluation criteria, with which national and international developmental processes are to be examined, following the question, if they account for the goal of sustainable development. At the latest since such catalogues of measurement sizes have been started to be worked at by the OECD in 1993, the term „indicator“ is mentioned in this connection.

The determination of reasonable indicators for political consulting and public relations is – especially with regard to the multiple and sometimes contradictory demands to indicators – the result of a selection process, for which also normative criteria are important. Therefore, contribution of ecosystem research for the development of indicator systems cannot be exactly determined. This applies for indicators, that are based on a very high data, respectively indicator aggregation. Key indicators or headline indicators and aggregated indicators are some of these indicators, because for their selection, professional aspects play a major role (knowledge on the special significance of certain measures within the ecosystem as well as the correctness and traceability of aggregation).

- **Impulses from ecosystem research for environmental education and public relations**

The importance of system oriented ecosystem research on the level of ecological systems and ecosystem complexes will not be acknowledged by the public and by political decision makers. Thus, the strengthening of its societal and political acceptance and relevance for all target groups by using a preferably clear presentation and by keeping the information constantly flowing, has to be a main interest of ecosystem research. Apart from this, ecosystem research is a suitable field for the learning and training of system oriented thinking, i.e. the consideration of coherences, interactions and feedback-loops, as ecosystem research and its understanding principally crave the combination of very different talent and knowledge.

In the past, there have been cases, where the combination of ecosystem research, environmental education and public relation has not been accomplished. One reason for this has been the lack of personnel and financial resources for qualified educational and public related work, as these resources have not explicitly been considered in the project proposal, respectively in the research program. In a lot of cases, education and public relations were restricted to single, regionally limited activities, while long-term oriented educational and information strategies have not been developed.

- **Impulses for “ecosystem management“**

Ecosystem research has made major contributions to the development and specification of concepts and guidelines of “ecosystem management“. The “ecosystem approach“ of the Convention on Biodiversity f.i. has been largely influenced by the results from ecosystem research. This does also apply for the idea of “ecosystem health“ and the guideline “ecological integrity“.

Recommendations

For a forward-looking continuation of ecosystem research – even with concern to the financial provision - it will be necessary to develop attractive structural and conceptional perspectives for ecosystem research. Within the questionnaire and within the scope of the workshop, structural and conceptional perspectives for ecosystem research have been debated.

Basically, both researchers and users want a closer, interactive communication. Research activities should much more integrate the empiric knowledge from the users of landscape. This does imply a stronger orientation of ecosystem research on application-oriented issues, but it does not at all reject fundamental research. Only if it is possible to continue working on basic issues without being pressured to consider the direct possibilities for application, theoretical, so far unsolved problems can be worked at, that could open up important perspectives for application in the remote future.

As concerns recommendations for methods, especially methods and techniques for the transformation of research results to regions, that are not yet investigated much, are desired. Also the prognoses from ecosystem research could be improved by methodological advancement.

The most desired conceptional ideas are (on the part of the experts) the investigation of the significance of (genetic) biodiversity for the long-term functioning of ecosystems as well as an increase of knowledge on the generation and prediction of catastrophes and on global changes of ecosystems with the respective consequences. With regard to a stronger connection between ecological research and social sciences, ecosystem research should dwell on the problems as the value of material ecosystem goods (as drinking water from pure ground water) or ecosystem services (f.i. flood protection) to society, or the ecosystem relevance of politics and programs.

So far, ecosystem research has set a main focus on ecosystems of the temperate zone, for which ecosystem types a lot of surveys are existing. But there are still large deficits with concern to research and knowledge on ecosystems in development or newly industrializing countries, especially in the tropics and the subtropics. In these regions, there is a blatant disproportion between the knowledge about ecosystems and the serious problems that come about with the changes in land use. Besides a regional enhancement of ecosystem research to these climate zones, the experts recommend a regional, rather than a conceptional intensification of research.

Ideas for the improvement of structure and organization within ecosystem research are especially directed towards the creation of suitable conditions for a strengthening of interdisciplinarity and for a more effective knowledge transfer from ecosystem research to practical application.

The future of ecosystem research is closely linked with the provision of financial resources. In this context it will be decisive, if ecosystem research succeeds in diversifying their financing (FBE 2002). On the part of research, a more stringent orientation on application as well as an increased endeavoring for the production of applicable results, that react to demands on the part of planning, environmental observation, politics etc, could be the key component for the opening up of new financing sources. Furthermore, it is recommended, to stimulate an intensified communication between basic and application-oriented research, in order to profit from the positive interactions. A precondition for this would be a more intense cooperation of promoting institutions, as f.i. the German Research Association, the Federal Environmental Agency or the German Federal Institute for Hydrology.

The provision with new financial resources for ecosystem research could, according to the expert's judgement, also be supported by a consequent and transparent evaluation of the ecosystem research practice. Conceptional ideas for such a measure are already existing.

1 INTRODUCTION

1.1 Initial situation and project directive

In order to enable the conceivement and enforcement of efficient measures for environmental precaution and protection, it is necessary to undertake an environmental systems analysis. Against the background of this assumption, a concept for a federal ecosystem research program has been initiated by the Federal Ministry of the Interior in 1978. Cooperating on this project was the Federal Ministry of Research and Agriculture. On this basis, ecosystem research projects have been implemented by the Federal Ministry of Education and Research and the Federal Environmental Ministry, in Berchtesgaden, Munich, Bayreuth, Göttingen and Kiel. The latest joint project of the Federal Environmental Ministry - the Ecosystem Research Project on the Wadden Sea - has been promoted in cooperation with the States of Schleswig-Holstein and Lower Saxony and with the Federal Ministry for Education and Research. The project has been completed in 1999.

Ecosystem research was assigned

- to operationalize definitions and demands central to environmental legislation and to develop convenient scientifically founded methods for the realization of the legislative requirements
- to introduce knowledge about the interactions in environmental management procedures and
- to work out and optimize strategies for sustainable landscape management.

The R+D (Research and Development) project "Synopsis of system approaches to environmental research – German contribution to ecosystem management" had the aim to work out the contributions, that German ecosystem research makes to the international discussion on systemic environmental management. A special focus has been set on indications and advices for the use of ecosystem research results in politics, planning and consultancy. The alignment of potential future research projects with contents, organization and methods has been another focal point of the project. Already at the very beginning it became evident, that the intention could not be a scientific evaluation of the German ecosystem research results based on a detailed analysis of the international level of awareness. This is, why the original project title "Synopsis on worldwide approaches to ecosystem research – German contribution to the international ecosystem research discussion" has been adjusted accordingly. The activities within the scope of the R+D project have been structured into the following modules:

- Modul 1 – Analysis of national and international ecosystem research projects: This modul contains a partitioned collection of information on world wide ecosystem research projects. The data has been subsumed in a database structured by ecosystem types / by biomes.

- Modul 2 – Evaluation of national and international ecosystem research projects – methods and results: The aim of this evaluation was to critically confront the expectations concerning international ecosystem research with the actually delivered research results. It was examined, to what extent ecosystem ways of thinking have been put into every day practice of the environmental management and how well they have proven to be. The evaluation was based on a questionnaire and on investigations in research literature.

- Modul 3 – Implementation of an international workshop: At this workshop, the evaluations of the completed ecosystem research projects focusing on their contributions to national and international environmental management, have been reflected on. Future focal points of ecosystem research and its implementation into practice have also been discussed.
- Modul 4 – Working up the results of the workshop, advices for action: Based on the results of the synopsis (Modul 1) and the workshop (Modul 3), it has been the task of this modul to work out advices for action. Advices for a future main focus in national ecosystem research essentially are a matter of contents and methods, but also a matter of location. The potential of ecosystem approaches for environmental politics and planning has been assessed, and starting points for a practical implementation of ecosystem research methods and results have been derived.

1.2 Ecosystem research as object of investigation

The introduction of the ecosystem term by A. Tansley in 1935 has undoubtedly been a cornerstone in the historical development of ecology as ecosystem science[1]. In the following years, Tansley´s concept found a steadily growing following - researchers, mainly stemming from those environmental sciences that dealt with the complex interactions between organisms and their environment, often on the basis of system analytic approaches (McIntosh 1985, Trepl 1987, Likens 1992, Golley 1993). Following this concept, ecosystem research centers around the interplay between organisms of a habitat and their abiotic environment[2]. The ecosystem aspect can thus be seen as an abstract view on our complex environment. Using theoretical and system analytic methods, an integrated view on the structural, functional, process-related and organizational properties of the spatial units of environment is attempted to be achieved. The concept of integration therefore can be seen as a basic demand to ecosystem research designs: The central point of interest is not the single element in a section of nature, it is the network of the element´s relations to the habitat´s other components, it is the elements´ mutual influences and the external steering mechanisms of their interactions.

As ecosystem research developed, it involved the awareness that a lot of environmental problems cannot be understood or even solved, if they are analyzed from a very reductionist point of view – as isolated phenomena. In fact, a lot of recent environmental problems, as f.i. the analysis of forest damage, the eutrophication of terrestrial and aquatic ecosystems or the understanding of ecotoxicological effects, require media and sector spanning concepts in order to account for the manifold indirect, chronic and delocalized effects of ecological interactive networks. A lot of investigations have shown, that these indirect networked effects, due to their non-linear linkages, can have a much stronger influence on the development of

[1] “As it appears to me, the more fundamental conception comprises the whole system (in terms of physics), not just the organism complex, but also the whole complex of physical factors that build the biome’s environment – the main factors in the broadest sense. From the ecologist’s point of view, the systems that can be characterized accordingly, represent the basic units of nature. We can call these units « ecosystems ». Ecosystems are of the most different kinds and sizes. They build a category of manifold physical systems within the universe, reaching from the universe as a whole down to the single atom.“ (Übersetzung aus Breckling & Müller 1997).

[2] A discussion of the many different current definitions of the ecosystem term can be found in Breckling & Müller (1997).

ecosystems than simple linear relationships (JØRGENSEN 1992, PATTEN 1994, FRÄNZLE 1998a, ULRICH 2001). Thereof the demand for a great analytical complexity, which leads to a stronger use of modeling techniques in addition to integrative empirical task schedules by the ecosystem research projects and institutions, can be derived. The use of models allows us to understand the systems´ structures, to generate and to examine hypotheses and to evaluate risks in terms of resilience and disburden. (JØRGENSEN 1986, BOSSEL 1992, BRECKLING & ASSHOFF 1996).

In the scope of this concept, ecosystem research can be summarized as "media spanning research of element and energy cycles, of structure and dynamics, of control mechanisms and of criteria for ecosystem stability" with the aim "to learn how to understand steering and feedback processes". This includes "the explanation of causal functional chains illustrated by precise problems from environmental politics" (BMBF 1991). Ecosystem research "analyzes the interactions of biological ecosystem components with each other, with their inanimate environment and with man. It delivers basic knowledge on structure, dynamics, element and energy flows, stability and resilience. It is the precondition for the understanding of the respective state of an ecosystem and [...] indispensable for ecosystem aligned environmental politics"(KAISER et al. 2002).

On the international level, ecosystem research has substantially been shaped by the international ecological research frame programs IBP (International Biological Program) and MAB (Man and the Biosphere).

In 1961 the "Commission on Ecology", the "International Union for Biological Science" initiated IBP with the aim to stimulate und intensify the exploration of ecosystems in as many countries as possible (LE CREN & LOWE-MCCONNEL 1980, GOLLEY 1993). On the surface, IBP´s purpose within the scope of its main issue "The Biological Basis of Productivity and Human Welfare" was to create the basis for an increase of productivity while protecting the natural resources as far as possible. In 1974 IBP was completed. In order to implement the program national committees, that had not been organized and supported by the governments but by corporations for research promotion, had been built up in most of the countries. Germany had taken part in IBP with the Solling project. On the basis of this project important insights on novel damage to forests and the effect patterns had been worked out.

IBP subsumed seven main issues:

1. productivity of land-biocenoses, especially of forests, of types of pastures and fields,
2. sub-processes of production (photosynthesis and the binding of nitrogen from the air),
3. protection and conservation of land-biocenoses, especially those that are endangered because of economical intensification,
4. productivity of freshwater-biocenoses, especially of lakes, ponds and reservoirs,
5. productivity of marine biocenoses with main focus on coastal parts of the sea,
6. use and cultivation of biological resources with awareness of their sustainability,
7. human adjustment to special conditions of living and nourishment, f.i. in the high mountains.

Until the early 60s of the last century, ecology (as separate from biology) had been a nearly unknown field of science. The implementation of IBP led to a sudden increase in knowledge about ecosystem structures and the processes occurring with them.

The MAB program, an UNESCO initiative, started in 1971 (DEUTSCHES NATIONALKOMITEE 1989). The experience with IBP gave an important impulse to the program. IBP´s results had, because of the underestimated need for synthesis, not in all cases been able to meet the expectations (GOLLEY 1993). The interdisciplinary oriented research approaches of MAB aimed at an intensification of the knowledge on ecosystems worldwide. They focused also on the analysis of mutual interdependencies between human society and its natural – even if increasingly changed – environment (DI CASTRI et al. 1981, FRANZ 1984, HABER 2002). Being aware of the fact that man cannot not just be seen as disturbing influence on ecosystems – at least in man-made-environment – but that he legitimately claims his interests in using spatial and environmental functions for himself, his actions concerning the environment were to become an integrative part of ecological research approaches. Thus, apart from the classical natural and ecological disciplines of science, humanities and economic sciences were also asked to be part of the MAB research project. In order to be able to accomplish the capacious MAB topic, the program was divided into 16 project areas. On the one hand these areas treated the essential biomes in the biosphere (as tropical and temperate forests, leas, oceans, inland water, agriculturally shaped areas, mountains and large cities). On the other hand special issues as environmental perception are analyzed (HABER 2002: 7). In most countries the MAB program addressed itself to the governments, it has not been carried out by independent research promoting corporates as it has been the case with IBP.

The main focus of the MAB program has been set on the following topics:

- derivation of specification factors for determination of a respective habitat´s ecological carrying capacity,
- evaluation of ecological and socio-economic consequences at the condition of intensification, extensification or conveyance of land-use, or of technical interference into the ecosystem,
- investigations on societal processes, that determine people´s attitudes and behaviour towards their habitat and towards the natural resources.

Furthermore the program deals with:

- the advancement of methods and instruments in ecosystem research and
- problems of public relations and environmental management.

In order to coordinate the German contribution to the MAB program a MAB national committee has been established in 1972. Under the auspices of this program the following projects have so far been carried out:

- the MAB-6 project "Man´s influence on the high altitude ecosystem at the Alps – and Nationalpark Berchtesgaden" (1984 to 1991), to be simultaneous with the first interdisciplinary joint project of the BMU (KERNER et al. 1991),
- forest ecosystem research, evolving from the BMBF Forest Ecosystem Research Center at the University of Göttingen, implemented in cooperation with institutions outside university within the scope of several projects (WIEDEY 1998) as well as
- the MAB pilot project "Ecosystem research in Lake Bornhöved District in Schleswig-Holstein", a BMBF joint project (BLUME et al. 1994, FRÄNZLE 1998b).

The key objectives of ecosystem research in Germany have been worked out and enhanced on the basis of demands from the German Council of Environmental Advisors (SRU, 1978), ELLENBERG et al. (1978) and within the framework of a concept for an "Ecological Information and Evaluation System" consisting of three parts – ecosystem research, environmental observation, Environmental Speciment Bank. The objectives of ecosystem research have been listed in the expose as follows:

- registration of ecosystem effect interrelationships in representative main areas of research,
- evidence on the natural state of balance of ecosystems and their resilience by interior and exterior disturbances,
- quantitative assessment of ecosystem volumes of energy and element,
- explanation of interactions between diversity, stability and productivity in ecosystems,
- exploration of interactions between ecosystems,
- development of forecast models relevant to practice,
- integration of comparative ecosystem research, ecological environmental observation, environmental monitoring and Environmental Speciment Bank.

As ecosystem research includes more and more research about man and his economic activities[3], as it predicts ecosystem behavior with environmental change, works out criteria and indicators for integrated ecosystem protection and participates in working out concepts for a sustainable use of ecosystems[4], further basic objectives come into existence.

In addition to this, multiple applications of ecosystem knowledge and methods, some of which will be described in detail on the following pages, have come to be part of ecosystem research.

German ecosystem research has been fundamentally formed by the ministries BMU and BMBF (the former BMFT – Federal Ministry of Science and Technology) that are financing and organizing research projects. Moreover, the German Research Association has taken an active part in realizing ecosystem research by installing and defining research areas - "Sonderforschungsbereiche".

In order to promote ecosystem research in systems characterized by agriculture, the BMVEL (Federal Ministry for Consumer Protection, Food and Agriculture) and the state Brandenburg´s MLUR (State Ministry for Agriculture and Environment), established the Centre for Agricultural Landscape and Land Use Research (ZALF) in 1992. ZALF consists of seven institutes that are primarily operating disciplinary and that are working on integrative research problems of agriculture and land use within the research community "Sustainable Development of Landscape – North Central Europe 2020". In order to realize the above named federal ecosystem research program (ELLENBERG et al. 1978), ecosystem research centers have been established at universities and research institutions of major size by the BMBF.

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[3] http://www.uft.uni-bremen.de/oekologie/indexgfoe3.htm
[4] http://www.bitoek.uni-bayreuth.de

These centers are the Forest Ecosystem Research Center (FWZ) that has been founded at the University of Göttingen in 1984, the Project Center for Ecosystem Research at the University of Kiel, that has been established in 1988, the Agricultural Ecosystem Research Community Munich (FAM), that has been originated cooperatively by the Munich Technical University and the GSF National Research Center for Environment and Health at Neuherberg in 1990, and the Bayreuth Institute for Terrestrial Ecosystem Research (BITÖK) that has been founded in 1990. The Centre for Environmental Research Leipzig-Halle (UFZ) has been established by the BMBF (90% of financing) and Saxony State as well as Saxony-Anhalt (each 5 %).

The FWZ, BITÖK and FAM have merged under the auspice of TERN (Terrestrial Ecosystem Research Network, MÜHLE & EICHLER 1997), that has existed since 1988 and has been promoted by BMBF. FWZ, BITÖK and FAM cooperate firmly with the institutes of the ZALF (Müncheberg), the Potsdam Institute for Climate Impact Research and the Centre for Environmental Research. The TERN ecosystem research centers take part in the IGBP.

In order to realize federal ecosystem research programs, the BMU financed broad interdisciplinary joint projects. Building on already existing research structures and being co-financed by the states in which the research areas have been situated the projects focused very much on the aspect of application (KAISER et al. 2002). The above mentioned German contribution to the MAB-6 program “Man´s influence on high altitude ecosystems in the Alps – and Berchtesgaden Nationalpark“ has been one of these broad joint projects. BMBF had also taken an active part in the wadden sea ecosystem research that in part consisted of projects in the Schleswig-Holstein and Lower Saxony wadden sea and has been established in 1986.The BIOLOG program, that has been financed by BMBF, comprises several research projects in the area of biodiversity, that operate on ecosystem research in terms of this survey´s definition (e.g. Biodiversity and ecosystem functions in grassland areas at BITÖK).

In order to determine the objects to be part of this survey, several basic demands founded on the above named characteristics of ecosystem research have been formulated to set the frame for the synopsis that has been carried out in the present project.

The selection was the only way to extract from a vast multiplicity of ecosystem oriented projects those, that are of immediate importance for this survey. The characteristics are as follows

- integrated examination of biotic and abiotic components of ecosystems,
- interlinking of examinations with several environmental media,
- inclusion of water -, element -, and energy flows,
- cooperation of working groups within an interdisciplinary work plan,
- use of empirical methods,
- compilation of results to form a final synthesis of the project.

With regard to German activities, a lot of projects and institutions meet these demands. This holds especially for such concepts applying for projects within the above named IBP, the MAB program, the “International Geosphere-Biosphere Program” or the research community TERN (KAISER et al. 2002).

The following projects and institutions have been picked out of a great variety of activities and IBP and MAB projects to serve as examples:

- “Lake Constance project” (see f.i. ELSTER 1997),
- Research Community Agricultural Ecosystems (see f.i. HANTSCHEL et al. 1998),
- Ingolstadt Model Survey on Landscape Ecology (see f.i. BACHHUBER et al. 1984),
- Research project landscape ecology “Schönbuch Natural Park“ (see f.i. EINSELE 1986),
- Bavarian Institute of Terrestrial Ecosystems (see f.i. GOLLAN & HEINDL 1998),
- “Saarbrücken Eco-model“ (see f.i. MÜLLER 1984),
- Centre for Environmental Research Leipzig (see f.i. FRITZ 1999),
- Müncheberg Centre for Agricultural Landscape and Land Use Research (f.i. WIGGERING 2001),
- Berlin megalopolis forest ecosystems (see f.i. CORNELIUS et al. 1997),
- Ecosystem Research on the Wadden Sea (see f.i. KAISER 1998) in Schleswig-Holstein (see f.i. KELLERMANN et al. 1998) and in Lower Saxony (see f.i. DITTMANN et al. 1998).

2 CONSTITUENTS OF THE SYNOPSIS RESEARCH PLAN

2.1 Investigations on the internet and of research literature

An inquiry of worldwide ongoing and completed ecosystem research projects has been carried out within the scope of Modul 1 of the survey. The results have been documented systematically in a project database.

As there has been a broad spectrum of environment related research projects, there had to be made limitations, thus, the first step had to be to define criteria for the selection of projects to be searched for.

- The projects had to be able to be found within the scope of our research (presented on the internet or in research literature).
- Priority has been put on ecosystem projects in the temperate zone, as they were especially suited to give information about German activities contributing to world wide ecosystem research.
- Only projects that could be assigned to the following working definition of “ecosystem research” have been taken into consideration.

  Research activity to be subsumed under “ecosystem research” are activities

  - that are devoted to biotic and abiotic components of the ecosystem,
  - that are media spanning, i.e. examinations of at least two different environmental media,
  - that consider element -, water – and energy cycles,
  - that take place in working groups operating on an interdisciplinary basis using interdisciplinary working methods and an interdisciplinary work plan,
  - that use empirical methods,
  - that merge in a synthetic evaluation of the different results (meaning that the participants independently select and evaluate the project results and reflect on their applicability).

The projects have been described according to the characteristics in table 1.

Tab. 1: Data items describing ecosystem research projects in the project database

Data items	Example: FAM (Munich Research Community Agricultural Ecosystems)
Country:	Germany
Institute:	Munich-Weihenstephan Technical University, GSF National Research Center for Environment and Health, research area defined by the German Research Association: “Nature conservation”, University of Marburg
Financing:	BMBF, the institutes´ own resources, Bavaria (State Ministry of Education and Culture, Science and Art) has taken on the costs for rent and husbandry of Scheyern experimental good for 15 years
Start:	1990, Duration: 0 years
Cause:	Problems with an intensely used agricultural landscape
Methods:	Steering mechanisms: input and interference in land use systems at the sites (integrated and ecological tillage, grassland economy, successions). Measuring and modeling of processes in order to record effects of the steered interferences on land use systems (balances of N, C, water, element, economy and organisms); Field measurements, complementary experiments on lots, reviewing of field analyses in the laboratory, examination

Data items	Example: FAM (Munich Research Community Agricultural Ecosystems)
	and exploration of important processes in soil and in plants using model ecosystems (soil profiles), examination of the chemical and physical components of soil, recording plant and animal species and observing their development (especially dispersed behavior, food webs); evaluation (economical and ecological) of effects being caused on the process level; working out basic guidelines for planning, for instruments (indicators), documentation.
Location:	Scheyern cloistral good , 40 km north of Munich, easting: 11,5°O, northing: 48,5°N<
Type of system:	Agricultural
Focal points:	Examination of ecological consequences of two different farming systems applied to a part of landscape. Aim is to find ways of husbandry that combine economical land use with conservation and recovery of the agricultural landscape´s natural living conditions.
Project supervisor:	Prof. Dr. J. C. Munch
Institute:	Munich-Weihenstephan Technical University, GSF- Research Center for Environment and Health, specialist area nature conservation of the University of Marburg
Documentation:	Press releases, gsf-magazine “mensch+umwelt” (man and environment), FAM-reports, annual reports
Communication:	Part of the MAB
Development:	
Contact:	PD Dr. Peter Schröder
Address :	FAM-Sekretariat GSF-Forschungszentrum für Umwelt und Gesundheit GmbH, Ingolstädter Landstraße 1 85764 Neuherberg
Internet:	http://fam.weihenstephan.de/ , **E-mail:** peter.schroeder@gsf.de
Literature:	
Remarks:	None
Identification:	A3

Important results of the projects have only been researched by the use of the questionnaire. Thus, the opportunity for self-evaluation of the research results has been given to the project supervisors.

Respective information about the projects named in the addendum (see “materials” 9) can be drawn from the returned and completed questionnaires. In the project database the activities have been sorted by the following types of ecosystem respectively biome:

- forest ecosystems (incl. taiga / boreal ecosystems),
- agricultural ecosystems,
- wetland ecosystems,
- limnic systems,
- marine ecosystems and coastal ecosystems,
- high altitude ecosystems (incl. alpine forests),
- tropic ecosystems (incl. tropic wet forests),
- ecosystems of arid and cold areas (savannah, steppe, prairie, tundra) and
- polar ecosystems.

The investigations have primarily been carried out via internet. They have been complemented by inquiries in research literature. Additionally, projects about which information has been gained by the questionnaire (see chapter 3) have been included into the database.

The entries in the database are not complete, as the inquiry had to be submitted to limitations. It has been the aim, though, to record the most important current projects (research was terminated in March 2001). A documentation of project examples from the database can be found at the end of this report in “materials“. It is possible to use the publicly accessible database for research inquiries. The internet address, containing not only projects but also a detailed bibliography, can be found at http://www.ecology.uni-kiel.de:8080/synopse/Projekte. The database has been designed in such a way that it can be updated interactively via the world wide web if necessary.

2.2 Questionnaire

An important objective of the project was - apart from the inquiry of national and international ecosystem projects (see Modul 1, chapter 2.1) - to critically confront the expectations concerning ecosystem research with the actually received results. Furthermore it has been the task to verify, to what extent ecosystem ways of thinking have been put into every day practice of environmental management and how well they have proven to be.

Shortcomings and recommendations for actions are to be deduced from this analysis. Besides inquiries in the internet and in research literature, a questionnaire has been used as research tool. Experts from the area of ecosystem research as well as from public authorities and planning have been asked about their experiences and conclusions from their work within ecosystem research projects and/or with the results of ecosystem research in practice as well as about their desires and their visions concerning the future design of ecosystem research.

The following superordinate questions have been the guidelines for the questionnaire:

- Do the concepts, methods and results of ecosystem research in general prove to be fit for practical applications in the different areas of environmental management?
- Which positive examples for such practical realization and application of research can be named from the area of nature conservation?
- Is it possible to draw conclusions and recommendations from these applications and experiences for the methodological and organizational development and future focusing of ecosystem research?

The questionnaire, that is subdivided in three parts, has been sent away by e-mail to 190 German and international experts between February and April 2002. Addressed were:

- known experts in ecosystem research (among others project supervisors from the world wide inquired ecosystem projects have been contacted);
- professors and university employees that are responsible for teaching and education and have insight into ecosystem research;
- representatives from environmental politics, administration – or planning (f.i. from planning offices or the environmental administration or from public authorities and institutions in the area of environmental observation and environmental reporting)

Separate questionnaires with partly specific questions have been worked out for the three groups. The following listing allows an overview over the different questions. In “materials” 2 the questionnaires are documented at full length.

Questions of questionnaire 1 (addressed were representatives from ecosystem research)

1 Significance of ecosystem research in the scientific system

1.1 In your opinion, which contribution has ecosystem research delivered to the change in approach and interpretation in the environmental and system sciences (e.g. considering chain reactions and reaction nets, or linearity of processes to non-linearity)?

1.2 Is there such a contribution from 'your' ecosystem research project/s?

2 Contribution of ecosystem research to the organisation of environmental policy and to the formulation of environmental politicy objectives

2.1 In your opinion, which contribution has ecosystem research delivered to the change in approach and interpretation in environmental politics and environmental management (e.g. restricted department strategies or single problem focus or interdisciplinary focus on sustainable development)?

2.2 Can you in general recognise a relevant influence of results from ecosystem research on the formulation of (specific) politicy objectives (e.g. on enacting conventions, such as the biodiversity convention)?

2.3 According to your knowledge and with emphasis on 'your' project/s, were or will be results produced used for the formulation and specification of environmental objectives (environmental quality targets, environmental standards and best practice guidelines)?

2.4 At the beginning of the project or during the project, were there targeted ideas for later application of the research results in the framework of environmental policy? Was the project planned with a specific application in mind, e.g., the revision of environmental standards for the emission of pollutants?

2.5 At which scale (e.g. national, regional etc.) do you see the most important influences of ecosystem research on environmental policy?

2.6 Were there surprising applications, which according to the original research concept were not anticipated or which stood out as they exceeded expectations (e.g., applications of non-planned technical innovations)?

3 Significance of ecosystem research for environmental planning

3.1 Can you, in principle, recognise a relevant influence of the results of ecosystem research on environmental planning (e.g. on the development of planning methods, or the use of particular techniques in planning, such as scenario techniques or the use of geographical information systems)?

3.2 Do you know of specific applications of research results produced in 'your' project/s in environmental planning?

3.3 At the beginning of the project or during the project, were there targeted ideas for later application of the research results in environmental planning (e.g. for management problems concerned with the expansion of a protected area)?

3.4 At which scales (e.g. national, regional, etc) do you see the most important influences of ecosystem research on environmental planning? Were there, e.g., influences on the demarcation of protected areas?

3.5 Do the current applications of research results in planning correspond to your ideas or the ideas of other research participants?

3.6 Were there surprising applications in planning, which according to the original research concept were not anticipated (e.g. applications of technical innovations)?

4 Contribution of ecosystem research to environmental monitoring and surveillance

4.1 How do you value the significance of a close link a) conceptionally and b) practically between ecosystem research, environmental monitoring and environmental surveillance?

4.2 Have specific technical innovations resulted from 'your' project/s that are used or could find a use in routine environmental monitoring during data <u>collection</u> (e.g. applied measuring and process techniques)?

4.3 Have specific conceptional and methodological innovations resulted from 'your' project/s that are used or could find a use in routine environmental monitoring in data analysis/synthesis (e.g. correlation analysis, scenario technique)

4.4 Has/have 'your' project/s produced ideas of a more strategic and structural nature that lead to the initiation or reformulation of environmental monitoring programs?

4.5 Does/do 'your' project/s lead (directly) to an environmental monitoring program or is this planned (e.g., with reduced sampling costs compared to a research program)?

4.6 Which problems do you see that hamper the 'transfer' from a research program to a regular environmental monitoring program?

5 Contribution of ecosystem research to environmental training, public relations and environmental reporting

5.1 Are you of the opinion that ecosystem research should be closely linked with environmental training, especially at universities, and with 'pro-environment' public relations efforts?
5.2 Do you think that this link existed in the past to a satisfactory level?
5.3 Do you know of positive examples (as well from 'your' ecosystem research project/s) of such links of ecosystem research with environmental training and public relations)? Were there or are there e.g. open discussion forums, are there/was there guided tours of field plots, are there accompanying publications in local media?
5.4 Did 'your', or does 'your' ecosystem research project produce ideas for environmental reporting? Are these conceptions of a strategic and structural nature or of a methodological nature?
5.5 Has ecosystem research, according to your opinion, delivered significant contributions to the indicator discussion (e.g. choice of predictive indicators, or to the formulation of aggregated indicators)?

6 Critical reflection of ecosystem research projects

6.1 Does your/do 'your' project/s critically reflect its organisational structure and strategic approach (e.g. was discussed whether the organisational structure was suitable in order to achieve a synthesis of project results)?
6.2 Which are the most important specific results of 'your' ecosystem research project that – in the context of environmental science – have stimulated the field or effected important progress (name e.g. in point form what you consider to be the 10 most important results)?[5]
6.3 At the end of the project/s, were further research needs described, or – if the project
6.4 From your own experience, how do you judge the problem of interdisciplinary research? Was interdisciplinary work in 'your' project/s practiced?
6.5 Do you see model development (development of concept and computer models) as a substantial task of ecosystem research?
6.6 What do you consider, in brief, to be the greatest advantages and disadvantages of ecosystem research and its greatest problems?

7 What do you hope for from ecosystem research in the future?

8 Other

Complementary or different questions from questionnaire 2 (addressed were representatives from environmental politics, administration – or planning):

complement 3 Significance of ecosystem research for environmental planning

Are there particular ecosystem research projects, which have in your opinion delivered an outstanding contribution to methodological and technical advancement in environmental planning and which have particularly enriched your work?
Would you in principle wish for a greater applicability of ecosystem research?

complement 4 Contribution of ecosystem research to environmental monitoring and surveillance

Would a close (also spatial) link between ecosystem research and environmental monitoring be in your opinion desirable?

complement 6 Critical reflection of ecosystem research projects

Do you believe that the organizational structure and the strategic approach of ecosystem research projects as well as the selection of the main research objectives were satisfactorily reflected in the past and the present?

Complementary questions for questionnaire 3 (addressed were representatives from ecosystem research and environmental politics, administration – or planning or employees within teaching and education):

Linking of ecosystem research with teaching/education

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[5] We understand that such a brief portrayal of the scientific essence of 'your' project/s must remain unsatisfactory, and does not allow any kind of evaluation. However, we would like to include the significant results of your research in the final report.

In your opinion, how could the cooperation between differing natural sciences be best supported in tertiary/university education?
In your opinion, which significance have system analysis and environmental informatics for academic education as far as the competencies for interdisciplinary work are concerned?
How should cooperation between ecological scientific disciplines on the one hand, and economic and social science disciplines on the other hand be organised in education?
Do you see an innovative potential for academic education by working on real case studies with stake holder participation (transdisciplinarity),e.g. regarding case studies in nature and landscape planning?
Do you see a deficit in the training of competences for ecological evaluations and assessments (e.g. normative fundaments for environmental assessments, decision theory, processes for the definition of environmental objectives)?

The questionnaires exist in hybrid form so that the interviewed persons had two different options to choose from. As they have used either one of the versions, not all questionnaires are available in digital form.

35 questionnaires have been filled in and returned to the project executives which is ca 18% of all questionnaires that have been sent away. Table 2 gives an overview over the feedback of questionnaires. Some of the addressed persons have filled in more than one questionnaire. 21 questionnaires type no. 1, 3 questionnaires type no. 2 and 11 questionnaires of type no. 3 have been available for evaluation. Moreover, 20 interviewees have sent in complementary information on ongoing or completed ecosystem research projects, that could be included in the project database.

Tab. 2: Feedback of questionnaires

Name		Flyback of questionnaires	Questionnaire 1	Questionnaire 2	Questionnaire 3	More projects or complements
1	DeAngelis, Prof. Dr. Donald L.	3/2	x			x
2	Baron, Ph.D. Jill S.	3/7	x			x
3	Bastian, Dr. habil Olaf	2/25	x			x
4	Bendoricchio, Prof. Dr. Giuseppe	March	x			x
5	Bredemeier, PD Dr. Michael	5/14	x			x
6	Buchmann, PD Dr. Nina	5/15	x			x
7	Franz, Helmut	February			x	
8	Fränzle, Prof. Dr. Otto	3/7	x			x
9	Gaedke, Prof. Dr. Ursula	4/26	x		x	x
10	Haber, Prof. Dr. Dr. hc Wolfgang	3/18	x	x	x	
11	Hauhs, Prof. Dr. Michael	4/10	x			x
12	Haussmann, Thomas	3/15	x			x
13	Hoffman-Kroll, Dr. Regina	3/22		x		
14	Hoppenstedt, Adrian	4/12			x	
15	Jessel, Prof. Dr. Beate	3/15			x	
16	Junk, Prof. Dr. Wolfgang Johannes	4/26	x			x
17	Kainz, Dr. Maximilian	4/30	x			x
18	Kellermann, Dr. Adolf	3/19	x			x

Name		Flyback of questionnaires	Questionnaire 1	Questionnaire 2	Questionnaire 3	More projects or complements
19	Scherer, Dr. Bernd					
20	Gätje, Dr. Christiane					
21	Köppel, Prof. Dr. Johann	3/13			x	
22	Kopsik, Serguei V.	3/11	x			x
23	Loose, Dr. Carsten	2/15		x		
24	Marques, Prof. Dr. João Carlos	3/20	x			x
25	Matzner, Prof. Dr. Egbert	2/18	x			
26	Mengel, Dr. Andreas	3/11			x	
27	Mose, Prof. Dr. Ingo	4/29			x	
28	Neumann, Frank	5/10	informal response			
29	Printz, Andreas	5/13			x	x
30	Regier, Prof. Dr. Henry	2/16	x			
31	Schönwitz, Roswitha	✓			x	
32	Sündermann, Prof. Dr. Jürgen	4/11	x			x
33	Tobias, Prof. Dr. Kai	2/17			x	x
34	Trepel, Dr. Michael	4/26	x			x
35	Wielgolaski, Prof. Dr. Franz-Emil	3/15	x			x
gesamt			21	3	11	20

The intention with the questionnaire has not been to work out an representative survey, it served as collection of experiences and experts´ evaluations. Anonymity concerning the questionnaire´s evaluation has been granted to the interviewed persons.

2.3 Workshop

As a part of Modul 3 an international workshop has been hosted taking place at the Salzau Cultural Center (nearby Kiel) from October 22-24 2002. During the course of the workshop, approximately 60 experts out of the areas of research, planning and administration have debated about results and prospects of ecosystem research. In addition to German participants, representatives from Italy, the Netherlands, Denmark, USA, Canada, Lithuania and Russia have attended the meeting.

The workshop was subdivided into plenum sessions with 11 keynote-lectures (the English abstracts of the lectures are bundled in “materials” 7) and in four working groups that put a special weight on the following aspects:

- Working group A: Conceptional, methodological and strategic experiences and problems in ecosystem research;
- Working group B: Ecosystem research and ecosystem management – guidelines for an integrative environmental practice;
- Working group C: Experiences and problems with ecosystem research in the area of application; requirements to politics and planning;

- Working groups D: The future of ecosystem research.

Before the workshop had started, theses and questions have been formulated by the project executives, and a theory paper has been composed out of them (see “materials“ 6, chapter 6.1). The paper helped to structure the workshop and to subdivide and stimulate the discussions within the working groups. The results of the questionnaire (see chapter 2.2) built the basis for the formulation of the theses. With regard to the theses and according to the respective working group´s topic, guiding questions have been worked out to support the discussions within the groups (see “materials“ 6, chapter 6.2).

The rapporteurs of the working groups worked out profitability reports that were presented to the plenum on the last day of the workshop. These reports built – as well as the questionnaire – the basis for the texts in chapter 4 and 5 of this survey (the reports can be found at “materials” 8).

3 SYNOPSIS

3.1 Overview on the researched contents of the database

In the context of this survey, a database on worldwide ecosystem research projects has been worked out with 275 data sets included. Due to the fact that a lot of research projects are not restricted to just one single type of ecosystem respectively biom, it is not possible to assign them unambiguously to one of the categories named in chapter 2.1 (types of ecosystem respectively bioms). Research on alpine forests f.i. can be matched with the category forest ecosystem research as well as alpine ecosystem research. This is why 419 matches have been found overall. The database does also give information about research programs that are investigating very diverse, unequal ecosystems, finally it contains a small remaining quantity of data set entries that cannot be matched with any category at all.

Figure 1 summarizes the classified data sets in accordance with chapter 2.1. The percentage appearing in the figure refer to the 275 data sets. As a lot of projects/data sets have been assigned to several types of ecosystem at the same time, the sum of the number of percentage is more than 100.

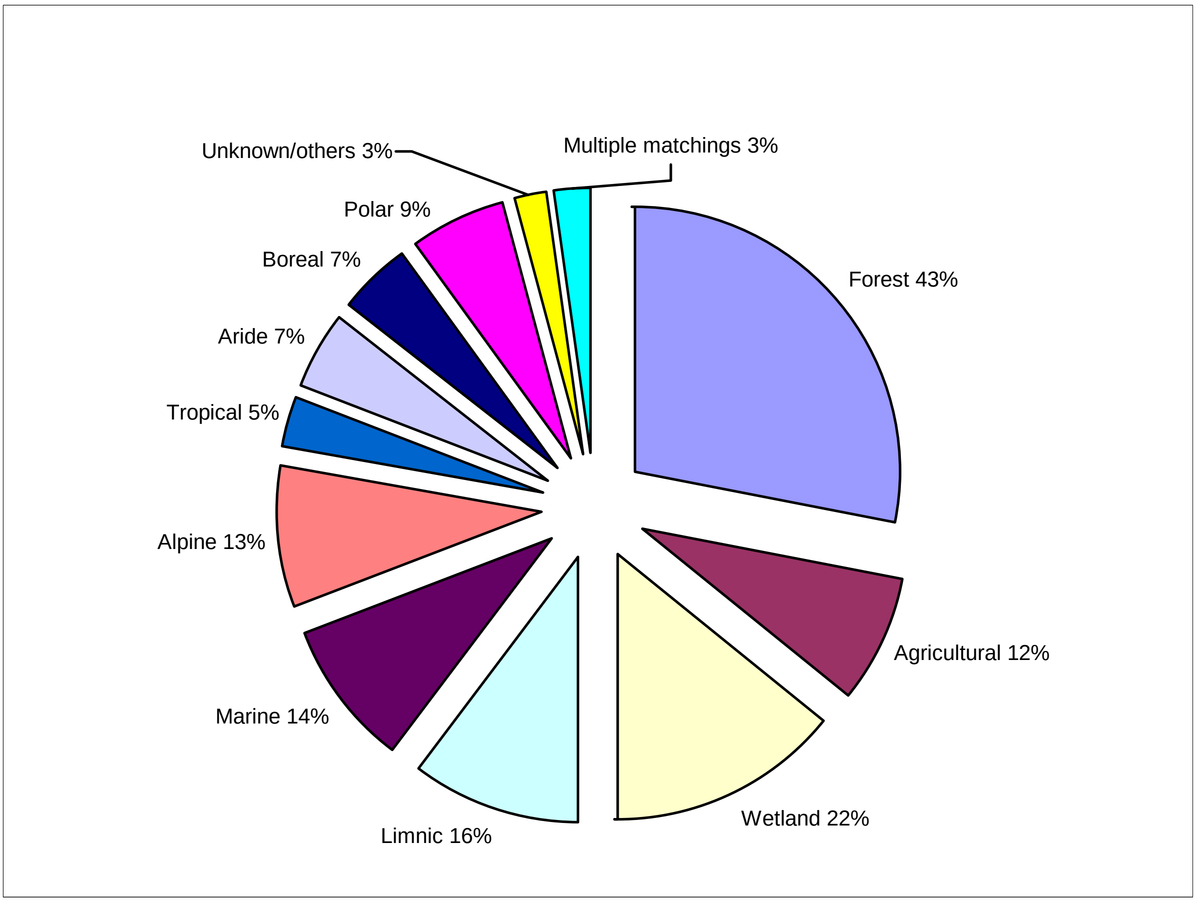

Fig. 1: Distribution of research projects from the database according to types of ecosystem/biom (471 ecosystems in 275 data sets; the percentages apply to the data sets)

A lot of research projects that have been analyzed as part of the database (42%) investigate forest ecosystems. As the next capacious category wetland ecosystems can be named (22%). Taken the wetland, limnic (16%) and marine (14%) ecosystems together, a percentage of 42% sums up. Thus 42% of all projects are dealing with aquatic or semi-terrestrial ecosystems. 13 % of all research projects are addressed to alpine ecosystems. Only 5% of all research projects that are named in the database refer to tropical ecosystems.

The percentage figures do not allow general assumptions about the representativeness of the different ecosystems in international ecosystem research. But as there have been used comparable research methods for surveying the types of ecosystem, certain conclusions can be drawn from the results with regard to the question, which type of ecosystem recently has been investigated most. Especially research on the tropics as well as ecosystem research on arid areas, that comprise only 7% of all projects recognized in the database, is poorly documented on the internet. The surveyed data sets on arid areas are almost entirely restricted to examinations in the USA and are primarily dealing with the natural prairies.

Ecosystems from the boreal areas are also represented with 7% in the database. In this case it is necessary to notice that a strict demarcation line could not always be drawn between the category of boreal and of temperate forests.

Polar ecosystems have been represented in a relatively high degree – 9%. This category includes even those research projects that deal with marine areas around the Antarctica and projects dealing with packed ice areas in the arctic. The number of analyzed terrestrial polar projects is rather small.

The category “unknown and other ecosystems“ mainly comprises research projects which main focus could not be subsumed under the given categories, f.i. projects investigating urban ecosystems. Projects of global character are the prime content of the category “multiple investigations“ (Fluxnet, MAB, NASA programs). Useful web-pages about larger research programs, that are not research projects in terms of this survey, have been included into this category, as well.

The distribution of data sets with regard to continents has been visualized in table 3.

Tab. 3: Distribution of data sets with regard to continents

Number	Continent
1	Europe
2	North America: Canada, United States of America
3	South America: Mexico, Middle America and South America
4	Africa
5	Antarctica
6	Asia: Oceania, Middle East, areas east of the Ural
7	Unkown/global
8	Australia

The distribution of those research projects, that have been included in the database is illustrated in figure 2. From 275 data sets analyzed, 281 matchings with countries could be deduced.

This matching does not allow the conclusion that the research projects are supported by the Scientific Community of the respective country, as the analysis does not refer to the executive institution but to the country where the research is taking place.

The main areas of research are - according to the projects named in the database - primarily situated in Europe (45%) and in North America (39%). The large percentage of European projects can partly be explained by the fact that these projects have been presented very detailed on the internet and have been in the main focus of the survey. Inside Europe, especially Central Europe and the area of the European Union stand out. Only a small number of Eastern European projects have been recorded. A large part of recent research activity can be linked with the Euroflux program.

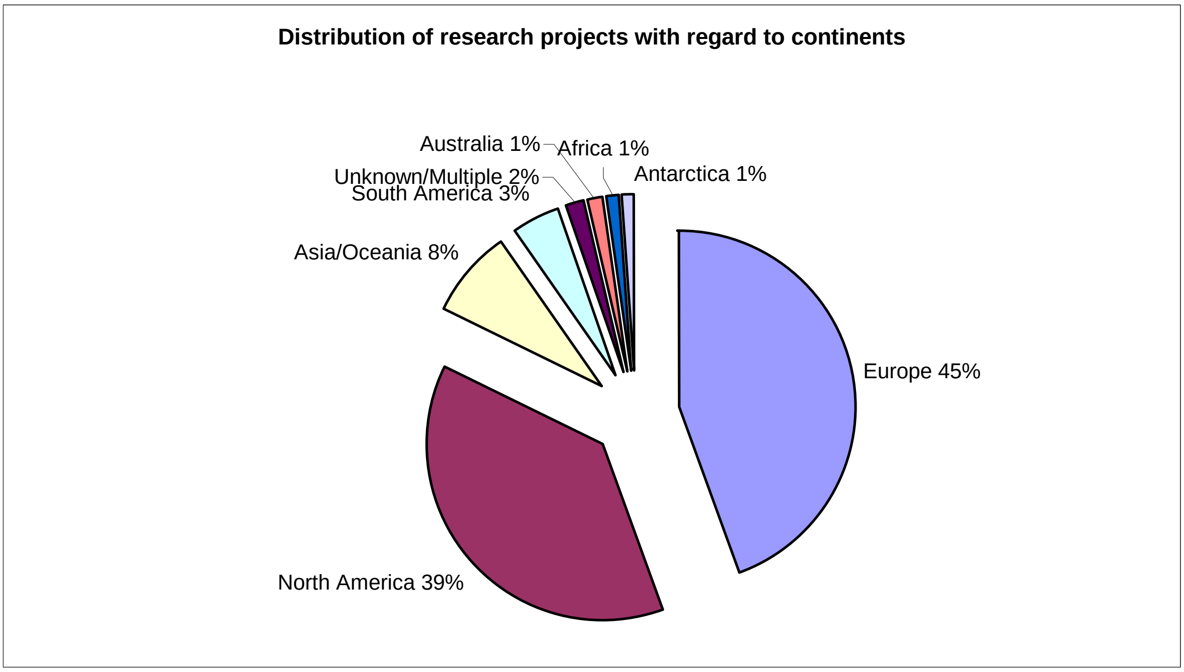

Fig. 2: Distribution of analyzed ecosystem research projects with regard to continents (recorded data sets: 275, research spots: 283)

In North America, a large part of research activity can be brought in connection with the Ameriflux and the LTER (Long Term Ecological Research) program.

Asia/Oceania is represented in the database with 8% of all projects. This number suggests that great research efforts are being undertaken, but the predominant part of research is carried by the Asiaflux program which focuses mainly on Japan.

3% of all projects are taking place in South America. This percentage is probably undervaluing the actual number of projects, as a great apportion of information has only been available in Spanish or Portuguese but not in English.

2% of the projects from the database are continental spanning programs. Even the large research programs´ homepages have been included into this category, as f.i. fluxnet, ILTER (International Long Term Ecological Research) or NASA.

Africa, Australia and Antarctica are represented with each 1% in the database.

3.2 International research programs and research communities

As it cannot be considered reasonable to summarize all research projects, that have been included in the database, only the large international/continent spanning ecosystem research programs or research communities will be introduced in the following paragraphs. The descriptions are applying to recent initiatives (from the 1990s) and do – as well as the other data sets - not claim to be complete. The documentation is sorted alphabetically. In chapter 1.2 it has already been referred to the IBP and the MAB program that have made a considerable contribution by forming especially the German ecosystem research. Other details, exceeding the description given in the project database on the large German ecosystem research projects, can be found in “materials“ 9 in the addendum of this survey.

Being aware of the increasing importance of global environmental changes, the large international/continent spanning ecosystem research programs or research communities are mainly devoted to issues of global climate change, its causes and consequences for the ecosystems.

3.2.1 Earth System Science Partnership

In the 1980s and 1990s, four large international research programs have been originated with the aim to investigate global environmental change. These programs have merged to form the Earth System Science Partnership (ESS-P):

- the International Geosphere-Biosphere Program (IGBP),
- the International Human Dimensions Program on Global Environmental Change (IHDP),
- the World Climate Research Program (WCRP) and
- DIVERSITAS.

These four large programs have set themselves the goal to work out research priorities, show gaps within research, to initiate research activities and to affiliate ongoing projects – each program is going to work on these tasks within its own main focus of work.

The offices of the named programs are internationally recognized platforms for the coordination and strengthening of research dealing with the causes and effects of global environmental changes and with the suggestion of problem solutions. The national scientific contributions for the realization of the programs are financed by national and regional institutions. The offices mobilize additional financial support, though.

3.2.1.1 IGBP

IGBP was founded by the International Council for Science (ICSU) in 1986. Its main scientific objective is to describe and to come to a better understanding of the mutual effects of physical, chemical and biological processes regulating the global ecosystem. The global ecosystem´s changes and the human influences on it are also part of the research objective.

The international IGBP office is situated in Stockholm. The current IGBP structure is framed by two main activities:

- Global Analysis, Integration and Modeling (GAIM) and
- The System for Analysis, Research and Training (START) cofinanced by IHDP and WCRP

as well as nine crucial points:

- International Global Atmospheric Chemistry (IGAC),
- Biospheric Aspects of the Hydrological Cycle (BAHC),
- Global Change and Terrestrial Ecosystems (GCTE),
- Land-Use and Land-Cover Change (LUCC),
- Land-Ocean Interactions in the Coastal Zone (LOICZ),
- Joint Global Ocean Flux Study (JGOFS),
- Global Ocean Ecosystem Dynamics (GLOBEC),
- Past Global Changes (PAGES) and
- Surface Ocean-Lower Atmosphere Study (SOLAS) that has only recently been originated and is cofinanced by WCRP, the Commission on Atmospheric Chemistry and Global Pollution (CACGP) the International Association of Meteorology and Atmospheric Sciences (IAMAS) and the Scientific Committee on Oceanic Research (SCOR).

The German national IGBP committee has started its work as “Working Group for the International Geosphere-Biosphere-Program (IGBP)“ in 1987 on the initiative of the German Research Association’s Senate committee. The national IGBP program has been presented internationally in October 1988. Since 1990 the research activities are coordinated by the national IGBP office.

3.2.1.2 IHDP

IHDP is an international, interdisciplinary, non-governmental research organization. It deals with the problems of global environmental change from the perspective of the social sciences. It is attempted to come to a broader understanding of global environmental changes with regard to the role of man, who is causing the changes and at the same time is affected by them.

IDHP was founded by ICSU and the International Social Science Council (ISSC) of UNESCO[6] in 1996.

The IHDP office has a key function for the establishment and the organization of world wide networks for research on global environmental changes. It coordinates four scientific main projects:

- LUCC (in cooperation with IGBP, project office in Belgium),
- Global Environmental Change and Human Security (GECHS, project office in Canada),
- Institutional Dimensions of Global Environmental Change (IDGEC, project office in the USA),
- Industrial Transformation (IT, Project office in the Netherlands).

As a joint initiative of IHDP and its partner programs IGBP, WCRP and DIVERSITAS that are viewing the problems from the scientific perspective, three more projects came to exist:

- Global Environmental Change and Food Systems (GECAFS),
- Global Carbon Project (GCP),
- Joint Water Project (JWP).

The WCRP also takes part in the organization of the START program. The German IHDP office in Bonn receives financial support from BMBF and from the North-Rhine Westphalian

[6] http://www.ihdp.uni-bonn.de

State Ministry of Education, Science and Research (MWF). The office is hosted by the University of Bonn.

3.2.1.3 WCRP

WCRP has been founded by ICSU and the World Meteorological Organization (WMO) in 1980. Since 1993 it receives financial support from the Intergovernmental Oceanographic Commission (IOC) of UNESCO. Some of the program´s main goals are to broaden the scientific comprehension of the physical climate system and the climatic processes, to improve the predictability of climatic changes and of extreme events and to register the anthropogene influences on the climate[7].

WCRP coordinates the following projects:

- Arctic Climate System Study (ACSYS) respectively Climate and Cryosphere (CliC),
- Climate Variability and Predictability (CLIVAR) as continuation of the completed Tropical Ocean and Global Atmosphere (TOGA) project,
- Global Energy and Water Cycle Experiment (GEWEX) being connected with regional process studies as f.i. the GEWEX Continental-scale International Project (GCIP, Mississippi river basin), the GEWEX Asian Monsoon Experiment (GAME) or the Baltic Sea Experiment (BALTEX), with detail analyses as f.i. the International Satellite Cloud Climatology Project (ISCCP), the International Satellite Land-Surface Climatology Project (ISLSCP), the Global Water Vapour Project (GVaP), the Global Precipitation Climatology Project (GPCP) and the GEWEX Cloud System Study (GCSS),
- Stratospheric Processes And their Role in Climate (SPARC) study,
- World Ocean Circulation Experiment (WOCE).

In addition, WCRP takes part in the Global Observing System (GCOS of ICSU, WMO, IOC, the United Nations Environment Program UNEP). In cooperation with the Global Ocean Observing System (GOOS) WCRP finances the Ocean Observation Panel for Climate (OOPC) and with GCOS as cofinancer it promotes the Atmospheric Observation Panel for Climate (AOPC). In order to develop START, WCRP has started cooperative work with the IGBP and the IHDP.

3.2.1.4 DIVERSITAS

DIVERSITAS is an integrative program with representatives from currently six international, governmental as well as non-governmental science organizations: IUBS (International Union of Biological Sciences), SCOPE (Scientific Committee on Problems of the Environment), UNESCO-MAB, ICSU, IGBP-GCTE and IUMS (International Union of Microbiological Societies). After its establishment in 1991, even before the convention on biodiversity had been adopted, the Scientific Steering Committee (SSC) had its first regular meeting in 1996. The first extensive Operational Plan came into being. DIVERSITAS has the objective to coordinate, network and initiate research on biodiversity on a global level. It is the first international biodiversity program taking an interdisciplinary approach that combines biological diversity

[7] http://www.wmo.ch/web/wcrp/about.htm

(on all levels from genetic to ecosystem level) with other aspects of global change and of "human dimensions"[8].

Within the conceptional framework of the DIVERSITAS program, the examination of processes connected with global change and their effects on biological resources, the naming of focal points and the identification of gaps in research are demanded. Included are five "Core Program Elements":

- biodiversity´s functioning in ecosystem processes,
- biodiversity´s origin, continuation and alteration,
- systematics: inventory and classification of biodiversity,
- registering of biodiversity and
- conservation, regeneration, and sustainable use of biodiversity

and five "Special Target Areas of Research – STARs":

- biodiversity of soils and sediments,
- marine biodiversity,
- biodiversity of micro organisms,
- biodiversity of fresh water ecosystems,
- man and biodiversity.

The DIVERSITAS office is housed at the UNESCO headquarter in Paris. Voluntary national funds from the USA, Germany, Switzerland, the Netherlands, from Norway, Mexico, Sweden, Austria and England account for a large part of the finances of DIVERSITAS (90%). ICSU, SCOPE, IUBS and IUMS resources sum up to about 10% of the financial support.

DIVERSITAS Germany has set the goal to take an inventory of the research on biodiversity in Germany and to develop strategic concepts for the protection and the sustainable use of biodiversity. Beyond this the BIOLOG research program[9] has been established in 1999 financing 93 projects in Europe and in Africa. Research activity started in the years of 2000 and 2001. BIOLOG has - with regard to contents - the objective to investigate terrestrial biodiversity and to promote biodiversity informatics.

3.2.2 Research program of the European Union

Since a few years ago, European ecosystem research has received large scaled promotion by the European Union. Within the fourth supporting program of the European Commission (1994-1998) f.i. the following projects have been sponsored:

- **MOLAR** (Measuring and Modeling the Dynamic Response of Remote Mountain Lake Ecosystems to Environmental Change, since 1994) investigates the reactions of mountain lake ecosystems to environmental changes (especially S- and N-deposition), using field studies and modeling techniques. The 12 research sites are situated alongside a north-south and west-east acid deposition gradient in Europe. In addition to this, four sites in the French Pyrenees, in the Austrian Alps and in South Tyrol out of the gradient´s range have been established.

[8] http://www.biologie.uni-hamburg.de/diversitas

[9] Beck et al. (2001) http://www.dlr.de/PT/Umwelt/F70000/F73000/Status%20Report%202001/Status% 20Report%202001-update-II.pdf

- **BIOGEST** (Biogas Transfer in Estuaries, duration: 1996-1999) had the objective to describe the distribution of biogases in surface water of European Estuaries (Elbe, Rhine, Ems-Dollard, Themse, Wester-Schelde, Loir, Gironde, Douro and Sado) and to quantify the relationship between the appearance of biogases and atmospheric changes.
- **ROBUST** (Role of buffering capacities in stabilizing coastal lagoon ecosystems, duration: 1996-2000) was dealing with the ecology of coastal lagoon systems and their functions as buffer areas for environmental changes. Examined were seaweed meadows within the Arcachon Basin (Atlantic) and at the Sacco di Goro (Adriatic Sea).
- **TOROS** (Tinto Odiel River Ocean Study, duration: 1996-1999) As a cooperation of eight institutes from four European countries the program investigated hydrodynamics of the Gulf of Cadiz in Spain. TOROS had the aim to use its research results for a contribution to a solution of comparable contamination problems within the Mediterranean basin, caused by mining.
- Within the scope of **EROS 21** (Biogeochemical interactions between the Danube River and the North-Western Black Sea, duration: 1996-1999) biochemical models have been developed on the basis of field and laboratory studies within the Danube basin (north-western part of the Black Sea) that were used for simulating a reduction of the eutrophication. Moreover, it has been intended to quantify the issuing volume of greenhouse gases. More than 20 institutes of different study branches from inner and outer Europe have participated in the project.

TERI (Terrestrial Ecosystem Research Initiative) has been part of the "Environment and Climate Program" of the 4th Support Program of the European Commission. The main emphasis had been laid on:

- the consequences of changes in land use,
- the results of changed climatic general conditions and a changed chemical composition of the atmosphere,
- the dynamics of organic substance in soil as well as the biogeochemical cycles and hydrological processes,
- biodiversity, population biology and its influence on the ecosystem´s functioning.

Some of the methodological challenges of TERI are the use of integrative research approaches, the overcoming of scale leaps and the working out of scenarios.

TERI comprises research projects as f.i.:

- PROTOS (Production and Transport of organic solutes: Effects of natural climatic variation, duration: 1996-1999). PROTOS researched mainly the issue "Dynamics of the organic soil substance, biogeochemical cycles and hydrological processes". Subject of examination were forest ecosystems in Norway, Germany and Spain representing typical European forests. Special attention had been paid to the role of dissolved organic matter (DOM), in ecosystems.
- ECOMONT (Ecological Effects of Land-Use Changes on European Terrestrial Mountain Ecosystems, duration: 1994-1999) focused on the consequences of the changing use of agriculture and forests in alpine areas. Examined was a north-south transect in the eastern Alps. Of special interest was research on the effects of land use changes on processes of the lower atmosphere.

- DART (Dynamic response of the forest–tundra ecotone to environmental change, duration: 1998-2002) had been realized under participation of six European countries within the Fennoscandinavian area. It had the aim to improve the understanding of ecosystem dynamics in the forest-tundra ecoton in dependence of climate and land use changes. The project is also part of the EU program TERICA (Terrestrial Ecosystem Research Initiative Concerted Action) and ARTERI (Arctic-Alpine Terrestrial Ecosystems Research Initiative).
- CLUE (Changing Land Usage, Enhancement of biodiversity and ecosystem development, Duration: 1994-1998) is a joint program of British, Dutch, Swedish, Spanish and Czech institutions. Five representative research areas have been aligned with a north-south gradient starting from the boreal zone in Sweden passing Great Britain and the Netherlands and ending at the southern Spanish Atlantic Ocean, also with a west-east gradient from Great Britain and the Netherlands to Czechia. Subject of the analysis has been, how the abandonment of land use from originally agriculturally used terrains effects ecosystems.
- The objective target of BIODEPTH (Diversity and Ecological Processes in Terrestrial Herbaceous ecosystems, duration: 1996-1999) has been the examination of natural and semi-natural grassland ecosystems with regard to changes in biodiversity and their effects on the functioning of the ecosystems.
- DEGREE (Diversity Effects in Grassland Ecosystems of Europe, duration: 1996-1998) focuses on the analysis of the coherences of biodiversity, functional diversity and redundancy. Researched were changes in the diversity of soil biocenoses in typical European lea ecosystems (tundra, heathland, steppe, marsh areas, semi-natural grassland of the temperate zone and garrique of the Mediterranean zone), with regard to climate change and the functional influence this modification has for the availability of plant nutriments.

The 5th Support Program of the European Commission “Energy, Environment and Sustainable Development“ (1998-2002) promoted f.i. :

- **EUROTROPH** (Nutrients Cycling and the Trophic Status of Coastal Ecosystems, since 2001) investigates ecosystem interrelations within different parts of coastal ecosystems (fjord, estuary, eal grass meadow) in Denmark, Belgium, the Netherlands and Spain. The project´s aim is to determine the trophic status of some European ecosystems and to examine the reasons for disturbances of the ecosystem balance due to human interference. Moreover the consultation of administrational institutions within coastal areas has been commenced.
- In the context of **EMERGE** (European Mountain Lake Ecosystems: Regionalisation, Diagnostic & Socio-economic Evaluation) remote European mountain lake ecosystems are analyzed. In order to support the implementation of the EU Wasserrahmenrichtlinie ecological reference states for the entire European mountain lakes (> 20.000 Seen) have to be calculated. For this purpose, empirical and process oriented modeling is conducted on the basis of existing data sets. Detailed and innovative socio-economic analyses are to determine the value society assigns to these ecosystems as well as costs and profits that arise in connection with the conservation or regeneration of the ecosystems.

- **RENMAN** (The Challenges of Modernity for Reindeer Management, duration: 2001-2004) deals with the problems of a sustainable forward-looking reindeer breeding in the subarctic/subalpine and boreal regions of Europe. Its aim is to improve the reindeer pasture farming and, thus, the local population´s quality of life.

3.2.3 Fluxnet-Network

The worldwide operation Fluxnet-Network concentrates on problems of the ecosystem carbon budget. The following programs take part in the Fluxnet-Network:

- Ameriflux, spatial focus on the USA,
- Asiaflux, main areas Japan, Thailand, Indonesia, Russia and Mongolia. Research areas in Alaska are taken care of in cooperation with Ameriflux,
- Carboeuroflux (Carbon and Energy exchanges of terrestrial ecosystems in Europe), research activity in Europe.

The research areas of the Fluxnet-Network are used for - in part automated - examinations on carbon fluxes in different media (vegetation, mulch and soil, including meteorology and micro meteorology). Parallel examinations are carried out on the historical development of terrain.

3.2.4 GTOS, GCOS and GOOS

GTOS (Global Terrestrial Observing System), GCOS (Global Climate Observing System) and GOOS (Global Oceanic Observing System) have set themselves the goal to globally record data on the biophysical environment, on important processes within ecosystems and on socio-economic driving powers influencing the environment. The data is going to be put into use for the promotion of effective ecosystem management.

Their highest priority is to strengthen communication and coordination between the different organizations within the area of global environmental observation. Accompanying measures to these “networking activities” are the development and promotion of regional observation programs and the coordination of interdisciplinary representative projects as f.i. The Net Primary Productivity (NPP) and the Terrestrial Carbon Observation (TCO)-Project (both projects are part of the GTOS).

GTOS, GCOS and GOOS co-operatively run the Global Observing Systems Information Center GOSIC. It provides with data and information and gives an overview over the structures and the programs of the three systems. At the moment, the GTOS, GCOS and GOOS are in their initiating phase.

3.2.4.1 GTOS

Starting in 1996, GTOS has been working on the basis of the following questions[10]:

1. Which influence do changes in land use and the degradation of ecosystems have on sustainable development? Will the food production be sufficient to provide 12 billions of people (predicted rate of population for the year 2050) with food?

[10] http://www.fao.org/gtos/Org.html

2. When, where and how much will the future demand for drinking-water exceed the supplies?
3. How will the climate change influence the terrestrial ecosystems?
4. Will the loss of biological resources cause irreversible damage to the ecosystems and hamper a sustainable development? Which resources will run out in which places?
5. Where and when will toxic substances interfere with the health of man and the environment and when will their impact cause more damage than the ecosystems can recover?

The European contribution to GTOS is coordinated by the EU, f.i. within the frame of the 5th Supporting Program: GLORIA-EUROPE (The European dimension of the Global Observation Research Initiative in Alpine Environments) is a network for environmental observation with the aim to register the effects of global warming in 18 regions within Europe.

3.2.4.2 GCOS

GCOS was founded in 1992 and is based on a cooperative financing of the WMO, the IOC, the UNEP and the ICSU. The GCOS office is at the WMO in Geneva/Switzerland.

GCOS has the aim[11]:

- to support the recording of climate related data,
- to improve the predictability of the climate development and to reduce the major uncertainties concerning long-term climate forecast (f.i. by developing respective models),
- to help quantify climate trends and human caused climate changes,
- to improve the availability of data for effect analyses.

GCOS does not collect data, it strengthens and coordinates observation activities of other national and international organizations. With regard to this work, GCOS builds on the following cooperating environmental observation programs and networks:

- the World Weather Watch (WWW) systems;
- Global Atmosphere Watch (GAW),
- GOOS and GTOS,
- IGBP,
- WCRP,
- the World Climate Impact Assessment and Response Strategies Program,
- the World Climate Data and Monitoring Program (WCDMP) and the Climate Information and Prediction Services (CLIPS).

The German contribution to GCOS comprises basically the activities of the German Weather Service (“Deutscher Wetterdienst“).

3.2.4.3 GOOS

The 16th meeting of the IOC convention initiated GOOS´s work in 1991. In 1992 the different organs of GOOS came into being. GOOS deals with all management aspects of the marine ecosystems and furthermore examines the role of the oceans with regard to climate change. GOOS is financed by IOC, WMO, UNEP and ICSU.

[11] http://www.wmo.ch/web/gcos/gcoshome.html

Primary goals of GOOS are[12]:

1. to identify how much data is needed as a basis for sustainable use of the oceans and of the coastal areas,
2. to stimulate an internationally coordinated data collection and a respective data exchange as well as the using and processing of data for a sustainable management,
3. to integrate GOOS in other worldwide operating observation – and management systems.

Within the Integrated Global Observing Strategy (IGOS) GOOS is involved in the marine related components of GCOS and GTOS.

In order to test the function of GOOS and to improve the GOOS structures the following pilot projects have been carried out and are carried out in selected regions:

- NEAR-GOOS pilot project (North-East-Asia) and
- EuroGOOS (Europe, with 30 institutions from 16 countries)

as well as (focusing more on the technical aspects) :

- PIRATA (Pilot Research Array (of buoys) in the Tropical Atlantic) and
- GODAE (Global Ocean Data Assimilation Experiment).

At the moment the following projects are envisaged:

- WIOMAP (Western Indian Ocean),
- SEA-GOOS (South-East-Asia),
- MED-GOOS (Mediterranean region) and
- Pacific-GOOS (South-West-Pacific).

The German part of GOOS is coordinated by the Federal Maritime and Hydrographic Agency of Germany in Hamburg. Moreover, the following institutions participate with research and monitoring projects: the Alfred-Wegener-Institute for Polar- and Marine Research (Biological Institute Helgoland), the Federal Research Centre for Fisheries (BFA-Fi), the German Federal Institute for Hydrology (BfG), the German Weatherservice (DWD), the German Centre for Aerospace, the Research and Technology Centre West Coast (FTZ), the GKSS-Research Centre Geesthacht Ltd., the State Office for Nature and Environment Schleswig-Holstein (LANU S.H.), the State Office for Environment, Nature Conservation and Geology Mecklenburg-Vorpommern (LUNG) and the Technical University Hamburg-Harburg (TUHH).

3.2.5 ICP Forests

Forest Ecosystem Monitoring (FOREM) respectively its European branch “International Co-operative Program on Assessment and Observation of Air Pollution Effects on Forests” (ICP Forests) is a broad ecosystem oriented observation study. It serves the aim to improve the documentation and description of the influences of air pollution on forest ecosystems.

The Europe-wide grid patterned monitoring network started with the so-called Level I Program in the 1980s (5.764 monitoring areas in a 16x16 km grid pattern of 30 countries). While on the Level I sites only the crown state is recorded routinely, the observation program for

[12] http://ioc.unesco.org/goos

the Level II sites, established in 1994, has been broadened towards an ecosystem oriented forest damage research. Data on all relevant environmental media (precipitation water, solid and liquid phase of the soil, plants, meteorological parameters) have been collected in a considerable amount. Nowadays, the program comprises 864 permanent research sites, 531 of these are situated in countries of the European Union. The Level II concept does not only imply data collection according to strictly harmonized standards, it also puts great efforts into a broad and largely standardized data analysis.

3.2.6 Integrated Global Observing Strategy

The Integrated Global Observing Strategy (IGOS) is another international, respectively multi-continental network promoting environmental observation on the issue of global environmental changes. IGOS creates the organizational framework for a better coordination of national observation activities and it supports the national planning[13].

The central goals of IGOS are:

- to link environmental observations that are based on remote sensing methods and in-situ techniques,
- to facilitate the transfer of research programs to practicable environmental observation programs,
- to facilitate access to data and data exchange,
- to harmonize data collection and to improve quality assurance following the aim to be able to use environmental data more effectively.

IGOS partners are:

- the Committee on Earth Observation Satellites (CEOS), coordinating the national satellite maintaining institutions,
- integrated research programs on the issue “global change“ within the WCRP and the IGBP,
- the International Group of Funding Agencies for Global Change Research (IGFA),
- international institutions that are (co-)financing globally planned observation programs; among these are: FAO (Food and Agriculture Organization of the United Nations), IOC, ICSU, UNESCO, UNEP and WMO, as well as
- GCOS, GOOS and GTOS.

The first IGOS partner meeting was held in 1998. IGOS is basically depending on national activities in environmental observation and research. IGOS is involved by supporting, in part also cooperating in these activities. Six representative projects showed the profitable co-operation on the area of global environmental observation:

- GODAE,
- Upper Air Measurements,
- Long-term Continuity of Ozone Measurements,
- Global Observation of Forest Cover,
- Long-term Ocean Biology Measurements and
- Disaster Management Support.

[13] http://www.igospartners.org

3.2.7 Long Term Ecological Research Network and International Long Term Ecological Research Network

In 1980 the Long Term Ecological Research Network (LTER) was founded by the US National Science Foundation (NSF) in order to support long-term ecological research in the United States. The network served the purpose to examine ecological processes over a long period of time and on a large spatial scale. Nationally and internationally it promotes the synthesis and comparative ecological research. One of the principal tasks of the LTER thus is to set up an archive on well organized and documented ecological long-term experiments. Currently, more than 1.100 scientists and students participate in LTER at the moment (24 LTER research sites). The network office coordinates the communication, all activities that relate to the research plans and the research results' publication.

On the initiative of LTER the International Long Term Ecological Research program (ILTER) was founded in 1993. In 2000, 21 countries have formally introduced national ILTER programs and affiliated to the ILTER network. At current, ten more countries build up national networks. The US-LTER network office continues making efforts to assist other interested countries with the building of a LTER program, and it coordinates the activities and the communication within the ILTER network. The international long-term research network has among others the following objectives:

- Promotion and improvement of the understanding of long range, border crossing ecological phenomena; elaboration of contributions to scientific fundamental research for environmental management.
- Facilitation of the interaction between participating scientists from the most different scientific fields,
- Promotion of the comparability of observations and experiments, integration of research and environmental observation; improvement of data exchange,
- Support with the performance of the educational goals of ecosystem research.

3.2.8 Further internationally operating ecosystem research initiatives

Further internationally laid out ecosystem research initiatives are (without claiming the list to be complete):

- The International Tundra Experiment **ITEX**: It has been originated as a MAB/NSN (Man-and-the-Biosphere/Northern Sciences Network) Initiative in 1990. Since then the program has been increasingly extended, today it is one of the most active international field programs for arctic ecology. ITEX has the aim to monitor the development of circumpolar plant species and plant communities in dependency of temperature changes. The basic experiment works with a targeted increasing of the surface temperature at 2-3 °C. Currently there are twenty active ITEX field sites spread on the circumpolar arctic and some alpine regions. At all research sites the standardized ITEX handbook is used. The 37 sites are supervised by research teams in 13 countries. More sites are planned in nine countries.
- **BOREAS/BERMS**: BOREAS, the Boreal Ecosystem-Atmosphere Study, duration: 1993-1996, and its successor BERMS (The Boreal Ecosystem Research and Monitoring Sites, since 1996, duration: 9 years) deal with the examination of Canadian boreal forests and

their interactions with the atmosphere, especially with regard to the CO_2 intake capacity and the effects on climate changes. Both projects have been primarily financed and co-ordinated by Canadian and US government organizations. The aim was to examine the opportunities for applying satellite data to forest monitoring purposes. Another important goal is the development of computer simulation and weather models, in order to improve the possibilities for scientific examinations of global changes.

3.3 Short conclusion

The research communities, that have been outlined in the previous chapters are interesting complementing options for a lot of national ecosystem research institutions, as concerns communication and information as well as financial resources. These institutions have not been used sufficiently – the establishment of a German ILTER group f.i. has only recently begun (see chapter 5.1.3.3).

4 EVALUATION OF NATIONAL AND INTERNATIONAL ECOSYSTEM RESEARCH PROJECTS – METHODS AND APPLICATION

4.1 Significance of ecosystem research for the science system

At the moment, both scientific basic ideas and societal standards and procedures, are undergoing a profound change. Some of the innovations and demands that are following these changes have been summarized in table 4. In environmental sciences f.i. it can be observed, that the ecosystems' complexity is more and more accepted as a basic feature of the research object and that an increasing number of R+D activities works toward an understanding of the network of relationships and interactions, using adapted, ("holistic"), methods. With these systems-oriented approaches, important modifications of conceptional aspects follow along. As a consequence, processes and structures, treated as coherent entities, are incorporated into a hierarchical overall model, which links short – and long-term scales with small and large spatial interrelationships. It is more the systems dynamics with regard to the existing or changing basic conditions that is taken into consideration, than the previously dominating idea of stability. The awareness about the restrictiveness of the potential for a quantitative prognosis of ecological development due to randomized parameter combinations, to the lack of non-linear reaction loops, to the cycling of bifurcations and because of the complex linking of effect networks, is growing. This is the reason why arguments that are explicitly taking prognostic uncertainties into consideration are more and more emphasized, while deterministic predications are becoming less important. In order to explicitly allow for uncertainties scenario techniques can be used or ecological risks can be made object of the investigation.

Further aspects resulted from the questionnaire (FBE 2002) that has been carried out for this survey and from the discussions at the workshop in Salzau (WS 2002). The interviewed persons assume that the analysis of simple linear effect chains can not be sufficient for the consideration of the predominating complex systems and phenomena.

Ecosystem research makes crucial contributions to networked thinking and acting (FBE 2002):

- by dealing with the examination and modeling even of systems that react non-linear,
- by being interested in not only the instantaneous, but also the indirect and chronic consequences of environmental changes,
- by acknowledging the fact that distant effects can be more important than the effects in the closer surrounding areas,
- by integrating even complex (multiple) reaction mechanisms, that lead to characteristics as f.i. self organization, emergence or hierarchy and
- by examining ecological systems from the perspective of stability, instability, catastrophe and reversibility.

On the basis of these approaches, ecosystem research does not only consist of an additive roundup of single natural sciences (physics, chemistry and biology), but its knowledge is exceeding them. When inter– and transdisciplinarity[14] succeeds, ecosystem research delivers a sufficient broad ("holistic") spectrum of the environment as a basis for an integrative environmental evaluation.

The majority of persons that were interviewed in the context of this survey, saw that ecosystem research principally promoted interdisciplinary ways of thinking. According to their opinion, interdisciplinarity does not have to be restricted to an integration of different disciplines within the natural sciences, it can and it should also include engineering, social sciences and humanities.

Another aspect named in the questionnaire is that ecosystem research contributes to replace the physico-chemical paradigm that pictures the ecosystem primarily as a "chemical factory". A new approach would – according to the interviewees' opinion – stress the information processing aspect with regard to the interactions occurring in ecosystems.

As an interdisciplinary concept that examines complex interrelationships, ecosystem research has helped to bring more system theoretic, thermodynamic and synergetic approaches into ecology. At the same time, impulses from ecosystem research have been able to use for progress in system theory. In this connection, the use of simulation models plays an increasingly important role. For these models a lot of procedures have been developed out of the area of ecosystem research that are nowadays taken as a matter of course in a lot of ecological investigations.

In the context of the interviews four more criteria have been named on whose basis the influence that ecosystem research has had on parts of the scientific system can be identified (FBE 2002):

- **Enhancement of the object of investigation:**

The focus of ecosystem research is set on the interactions of the environmental compartments of a ecosystem. Due to a scale spanning network of relationships the objects of investigation are arranged on different benchmark levels. Thereby even landscapes and global problem areas have become object of (integrated) considerations and intense examinations on the basis of the ecosystem concept.

Moreover, man has been more often included as a "controlling measure" into the examinations. This enhancement of the object of investigation has been promoted especially by the MAB program.

- **Enhancing the research approaches:**

Following the enhancement of the object of investigation was the enhancement of the research approaches. While ecosystem research developed, it has – according to the interviewed scientists - become obvious that measuring and modeling have to be paralleled (spatially, temporally, and with regard to the different ecosystem components). As concerns previously applied questions, it has become increasingly noticeable that ecosystem research

[14] "Transdisciplinarity" broadens the interdisciplinary cooperative work by including non-scientific groups into environmental research, some of these are f.i. potential research users (FRÄNZLE & DASCHKEIT 1997) in KAISER 2002: 119). "Applied research" on the contrary means an approach that addresses oneself to the non-scientific environment but that does not include the respective groups into its work (DEFILIA et al. 1996 in KAISER et al. 2002: 119 und DASCHKEIT 1998).

can only lead to success when combining expert knowledge both from natural sciences and from practice (“local knowledge“).

- **Completion of the central objective of scientific research:**

Ecosystem research does not solely stem from scientific interests. Rather a lot of questions from ecosystem research are defined by societal necessities. Therefore one crucial objective of ecosystem research is not only to promote the understanding of the interrelations between environmental compartments as well as between function, structure and use of ecosystems, but also to provide for concrete contributions towards a sustainable – in Central Europe that means a regularly “multifunctional“ – use of ecosystems. The great chance of ecosystem research lies within the demand to examine complex practical questions in a broad and well organized way.

- **Impulses for the organization of research:**

Even the organization of research has gained new and important impulses from the shift of stress within the natural sciences. From the tasks of ecosystem research inevitably results the need for cooperation between the different fields of science. This is the reason why a lot of ecosystem research projects entailed the founding of research communities. The administrative “rootage“ has also changed in some aspects: the ecosystem research project on the Schleswig-Holstein Wadden Sea f.i. has been coordinated by the responsible public authorities. This has certainly helped to align scientific activities with practice (see even “materials“ 10, chapter 10.2.1).

4.2 Contribution of ecosystem research to the paradigm shift in environmental politics

4.2.1 Prosperities of ecosystem research

Ecosystem concepts are becoming increasingly fundamental even to environmental politics and environmental management. Sectoral (department-oriented) views are more often replaced by department spanning approaches. The orientation on a more integrative view and treatment of environmental problems has been promoted. The growing awareness of the high complexity and interrelatedness of environmental problems has had the effect that solutions for these problems have no longer been searched and discussed for within a narrow sectoral and spatial field. It has rather become obvious that a lot of problems only are solvable in a successful way when integrative approaches are put into use that consider ecological, economic and social aspects in equal measure. Moreover, the awareness about the value of ecosystem goods and accomplishments for the socio-economic system and the knowledge about the dangers when losing these “ecosystem services“, influences to an increasing extent the discussion. As concerns the spatial dimension of environmental problems, ecosystem research has contributed to alert political decision makers to the importance and the consequences of global environmental problems (FBE 2002).

The above named tendencies are connected with a more goal-oriented approach, which leads to an abandonance of the load capacity paradigm and to a disposition towards a transparent, participative strategy focusing on a quality objective (see table 4).

Tab. 4a: Conceptional areas of conflict between analytic and synthesizing research approaches within environmental sciences (in reference to STABA et al. 2001)

A lot of research approaches within ecosystem research are based on analytic concepts (represented in the left column). It is attempted to integrate these reductionist strategies and perceptions by the use of holistic methods (right column).

Analytic Focal Points	Integrative Focal Points
short-term orientation	long-term orientation
single scale analysis	multiple, hierarchic methodology
reduction of complexity	inclusion of complexity
reductionist methodology (analysis)	holistic methodology (synthesis)
reversibility and mechanistic aspects	irreversibility and systems aspects
linearity	non-linearity
periodic processes	recursive processes
continuous development	integration of bifurcations
homoeostasis and stability	steady state and development
equilibrium orientation	assumption of a disequilibrium
closed systems	open systems
effect chains	effect networks
importance of causal relationships	relative unimportance of causal relationships
assumption of predictability	assumption of unpredictability
deterministic basic concepts	probabilistic basic concepts

Tab. 4b: Conceptional areas of conflict with concern to the development of strategies for environmental management (in reference to STABA et al. 2001)

Parallel to the advancement of ecosystem research, environmental politics developed towards a stronger orientation on the idea of sustainability, as concerns the environmental practice. Therefore, in a lot of cases the descriptions in the right column characterize the strategies for the application of ecosystem research.

Sectoral Focal Points	Integrative Focal Points
environmental politics restricted to resorts	resort spanning environmental politics
consideration of single environmental sectors	consideration of ecosystems
disciplinary structure	inter- and transdisciplinary structure
single problems	sustainable development
consideration of single elements	elemental and systematic effect structures
reparative orientation	management orientation
orientation on emissions and critical values	orientation on quality and targets
load capacity	relieve, development ability
carrying capacity limits	quality and management objectives
ecology – economy are antipoles	ecology – economy cooperate with each other
neglect of social aspects	integration of social aspects
central control approach	participation and transparency

The interrelatedness of tendencies in environmental sciences and in environmental politics makes the growing influences of ecosystem research on environmental politics visible. One important trend is f.i. that the formulation of integrated ecosystem protection concepts becomes more common. The object of ecosystem protection is, according to ELLENBERG (1973), the interrelationships between biocenose and biotope out of a viewpoint, that is defined by the observer. Special about the ecosystem approach is the importance of the interrelations, i.e. the ecological processes and interactions that connect its structural parts with each other. Examples for these processes are the procedures within the water-, energy- and element-budget, the informative interplays between the system elements and the inter-element-budget, the informative interplays between the system elements and the interactions between these groups. Ecosystem protection thus is founded on the linking of structures and processes and aims at the conservation of the dynamics, adaptive abilities and organization of the system as a whole. On the basis of this, the integration of nature conservation oriented species protection with an abiotic influenced environment protection or the conservation of resources is aspired. As ecosystem research deals with the dynamic and non-linear processes, it has given important impulses for environmental politics and environmental management in such a way, that environmental development nowadays is understood more as a dynamic process that can hardly be controlled by using “hard“ goals and single measures (FBE 2002).

The following discussion of new legal regulations illustrates this development. An important instrument corresponding with the new understanding of the environment – influenced by ecosystem research - is the so-called ecological environmental observation. With the amending law of the Federal Nature Conservation Law from spring 2001, ecological environmental observation has been legally defined as a joint task of federation and states. Even on the European level, ecological environmental observation gains in importance. The SUP guiding principle from summer 2001 f.i. binds all member states to monitor environmental effects by realizing plans and programs, in order to “detect unexpected negative effects at an early stage and to be able to find suitable remedies“ (Art. 10 sect.1 SUP guiding principle). According to § 12 Sect. 2 of the Federal Nature Conservation Law the “purpose of ecological environmental observation [...] is to determine, to analyze and to evaluate the <u>state of the nature budget</u> [highlighted by the authors], its changes, the consequences of these changes, the impacts on the nature budget and the effects of environmental conservation measures on the state of the nature budget.“ The following quotation shows how close these tasks are connected with the presented ecosystem protection concepts. In the explanatory statements of the Federal Nature Conservation Law´s amendment (contributor draft version (Referentenentwurf), explanatory stance on § 24[15]) the following statement is made: “Only comprehensive, <u>integrated ecosystem protection</u> [highlighted by the authors] that includes interactions, effect chains interactive structures, element and energy flows, well-accommodates for the whole nature budget and is the precondition for the maintenance of crucial ecological processes and the life preserving systems [...].“

The following text of law originates from the first paragraphs of the same source:

“In responsibility for future generations [...] nature and landscape are to be protected, to be cultivated and – as far as necessary – to be restored in such a way that

1. the performance and functioning ability of the nature budget,
2. the ability for regeneration and for sustainable use of natural assets,
3. flora and fauna including their habitat and
4. the diversity, characteristics and beauty as well as recreational value of nature and landscape

are secured in perpetuity.“

In the amendment´s 10th paragraph the key-terms of this draft version are explained. For the problem, that is discussed in this paragraph, it firstly is of special relevance to analyze the

[15] http://www.bmu.de

term “nature budget“. In the legal sense, it relates to “its components soil, water, air, climate, animals and plants as well as the interactions [highlighted by the authors] between them.“ This definition can very well be understood as an adapted version of ELLENBERG`s definition of the ecosystem (see chapter 4.1). The nature budget – as first-order subject of protection – can only be explained as a wholeness if the elements and relations of the ecosystem are seen, analyzed and treated as interactive structure. The protection of the nature budget therefore includes the protection of the elements, relations and the organization of ecosystems, i.e. the protection of an ecosystem. The German Council of Environmental Advisors makes a similar categorization (SRU 1985): “A nature budget is the complex interactive and interrelated structure that links all living creatures with their abiotic environment and with each other.“ In this example it is also possible to equate the two definitions: The term “nature budget“ implies an ecosystem view on the environment.

Besides the named, precise comprehensible influences of ecosystem research on national legislature, the results and the knowledge from ecosystem research have also been reflected on national and international fields of politics and management, that are summarized in the following (FBE 2002).

Besides the categorical promotion of the understanding of environmental problems in public, ecosystem research has practically contributed to an establishment of modern, dynamics- and process-oriented strategies for nature conservation.

Due to these strategies f.i. large biological reserves have been installed, that have - at least in some areas - the primary goal to protect the natural processual dynamics. Also the needed scientific basics for installing protection and management measures have been provided by ecosystem research. Among these are f.i. findings on the spread of pollutants and on thresholds of disturbance, which have led to the implementation of the principle of precaution and to concrete (national and international) activities f.i. in the area of air pollution control (f.i. the UN/ECE Convention on Long-Range Transboundary Air Pollution in 1979, Gothenburg Protocol in 1999), but also in the area of soil and water protection.

The awareness about the necessity of systemic views that has grown out of ecosystem research, is acknowledged to have a major influence on the conception and adoption of different international legal regulations and agreements. The system approach is f.i. reflected on in the EU Water Framework Directive and in the Convention on Biodiversity.

4.2.2 Discussion

Although ecosystem research has influenced political and administrative definitions, strategies and decisions, the dominant opinion is that ecosystem research has a more implicit, theoretical and indirect impact and that it leads to “collective“ effects, f.i. the acceptance of certain ideas and objectives. As examples, the idea of sustainability, the strengthening of the awareness on the necessity of department spanning and system approaches in environmental conservation as well as the growing willingness to see the possible consequences of the environmental use are named. The potentials of ecosystem research that lead to practical changes in governmental and administrative actions, have not yet been fully tapped (FBE 2002).

During a long period of time, the legislator has implicitly acted for the ideas of ecosystem research - at least in some aspects, (as f.i. the law on the environmental assessment or included in states’ laws), and this approach can also more often be found in current bills. But on the other hand it has to be noted, that the terminology connected with ecosystem research so far has remained within a diffuse area of undefined juridical terms or empty formulas within natural sciences, because there is a lack of fully developed imaginations for a concretion of objectives and terms. The consequence was that under the umbrella of “holistic“ demands largely sectoral, media isolating approaches have been carried out in research and in practice.

The cause for the problems of implementation can be seen in the fact that in a lot of cases the boundaries between the different departments and thus the sectoral separation of responsibilities have not yet been overcome in politics and administration. This led to an insufficient reception of scientific results. But the causes for the slowness with which ecosystemic knowledge is incorporated into the political or administrative practice, can also be found in the operative approaches of ecosystem research itself (FBE 2002). Ecosystem research has - apart from a few contributions - so far not succeeded in giving broad and universally valid answers to urging management problems. That there temporarily has been put too much emphasis on process based (very theoretic) prediction models, while “empirical“ procedures and perceptions have not sufficiently been taken into consideration, might have had negative effects on the research outcome (ibid.). The concentration on just a few applied problem types (land use in agricultural areas, forest damage) has also reduced the possibilities for a broad impact. Moreover, the scientific system is alleged to be conservative in a way that prevents a flexible response to problems and demands from within politics and administration (ibid.).

Torn between programmatic demands and the reality´s practical problems, it is important to revive and to stimulate the discussion on a possible realization of high-ranking legal demands. Ecosystem protection concepts can support the efforts for implementation by serving as connecting, communicative levels between the (necessary) sectoral operative approaches. With regard to this, the following phenomena need to be more considered, especially in sustainable development strategies:

- indirect effects, effect chains and effect networks: a lot of results from ecosystem research show that the effects of indirect impacts (f.i. the consequences of acid deposition on plant crops of forest ecosystems via the the soil´s nutrient balance) are much more effective than the consequences of direct impacts (f.i. the direct phytotoxity of acid deposition). The changes within important ecosystem parameters are non-linear, media spanning and networked with each other in a complex way, so that a risk analysis is only able to produce correct statements, if the diverse and far-reaching effect chains are taken into consideration;
- chronic effects: in a lot of cases the effects of interferences or furnishing appear only after a long period of time, because the ecosystems´ buffering capacities last for a certain period to sustain a meta-stable state, (f.i. pH-buffering systems from forest soils). If the limits for the central components’ capacity load are exceeded, disastrous changes can occur in a very fast paste (f.i. root toxicity caused by aluminium due to a sufficient long term of acidification of soil);
- spatially displaced effects: Sometimes strains do little damage to the directly affected ecosystem but all the more harm to neighboring systems. An intensive use of liquid manure for cultivation (slurry management) changes relatively little in the concerned acre but it can due to emissions, f.i. ammonia-emission, cause plant damage in neighboring for-

ests, it can cause eutrophications in communicating waterbodies (f.i. surface transport of nutrients) or contaminations of the groundwater (f.i. eluviation of nitrate);

- ecological processes and relationships: In conventional nature conservation oriented environmental management the reflection on ecosystem processes has so far been missed out. Only in recent times, questions about the relevance of processes for biodiversity and about the influence of diversity on the procedures in the ecosystem are posed. These two factors cannot be regarded isolated from each other. On the one hand the organisms function as “processor“ of ecological processes. On the other hand the processes within the water-, matter- and energy-budgets preset important properties of the habitat conditions that affect the existence of the organisms. This does also apply for the flow of information to ecological systems that influences the existence and the allocation of ecological structures (f.i. with regard to the genetic flow of information by pollination or the dispersion of propagules). In this context, the linking of structure and process as a research and management leading strategy is of special importance;
- ecological complexity and self-organization: Ecosystem research has shown that it is principally possible and reasonable to describe and to analyze the complexity of ecological systems as an important property. Firstly, the reduction to subsystems can be overcome methodologically, and secondly results from this step the development of new properties that only have an impact on the level of the ecosystem. These emergent phenomena that allow for important statements about the state of the ecosystem, apply to self-organized processes, which conservation and development should become an important component of sustainable landscape management strategies.

4.3 Contribution of ecosystem research to the formulation of goals for environmental politics

Goals for environmental politics can be made available for discussion or to be decided upon by very different organizations and institutions in very different degrees of legal bindingness. These degrees reach from concrete demands that are included into the environmental international law by international treaties, over binding - but in a lot of cases hardly concretized – definitions on nature conservation models, to results from discussions that are brought into the debate on national critical values in the preliminary stages. About the systematization of environmental goal systems see f.i. ARL (1987), FÜRST & KIEMSTEDT (1990), SCHOLLES (1990), FÜRST et al. (1992a und b), PUSTER (1992), ANL (1994), UBA (1994, 2000a), DREIER (1995), SRU (1996), FINCK et al. (1997), REGIERUNGSPRÄSIDIUM FREIBURG (1997), ARSU (1998), BECHMANN et al. (1998) and KIESLICH & NEUMEYER (2000).

Ecosystem research is said to have exerted a determining influence – even if mostly indirect – on the formulation of models and laws. Principally it is assumed that ecosystem research has - due to prove from natural sciences - supported the implementation of justiciable reference points and critical values (FBE 2002). The knowledge gained in ecosystem research also has made a notable contribution to the acknowledgement of system approaches as a principal paradigm for the solution of environmental problems. Ecosystem research has influenced the discussion about reference points and critical values so that no longer the single critical value, but rather the function of the whole system to be conserved has come to the fore when it comes to the formulation of goals and models (ibid.).

That the knowledge, gained by ecosystem research, had a strong impact on the amendment of the Federal Nature Conservation law, has been shown in chapter 4.2.1. Ecosystem viewpoints are also reflected upon in the Ecosystem Approach of the Convention on Biodiversity (see chapter 4.7.1) and in the integrated ecosystem approach on catchment areas in the EU Water Framework Directive (FBE 2002, WS 2002). Of central importance in the EU Water Framework Directive is, that not administrative devices, but rivers' catchment areas as functional entities of the landscape water budget serve as the respective spatial level of integration. The fact, that ecological aspects has been attached much more importance to, is also to be noted. Especially within the area of air pollution control and climate protection ecosystem research is said to have influenced, at least indirectly, the adoption of international conventions and resolutions (FBE 2002). In this context, the most important examples are:

- the Montreal Protocol,
- the Convention on the Reduction of Greenhousegas Emissions,
- the Kyoto-Protocol,
- the Geneva Convention on Air Pollution Control,
- the EU Air Quality Framework Directive and its sub-guidelines (acceptance of critical level values and stronger consolidation of the precautionary principle, AOT40 values),
- the Convention on Biodiversity (ecosystem approach),
- the Convention on the Alps (media- and sector spanning goals) and
- the resolution of the ministerial process for forest protection (MCPFE).

Meanwhile, ecosystem approaches have been included into the German Planning Law in various ways. This applies to the different planning instruments of the Nature Conservation Law as well as to landscape planning, about which statements will be made in detail in chapter 4.4.1. Apart from this, in the last years more and more impulses for ecosystem planning instruments have come from the European Union that have been implemented in Germany or that are going to be put into practice in the future. The project related environmental assessment (Umweltverträglichkeitsprüfung - UVPG, 1985) can serve as an example. As an integral part of the environmental assessment, the sector spanning effect evaluation can be ascribed to central ideas in ecosystem research (WS 2002, see also chapter 4.4.1). Noteworthy are also the strategic environmental audit (EU SUP guideline[16]) as well as the new Immission Control Legislation (GlmSchG Amendment following the so- called IVU guideline[17] (for details, see chapter 4.4.1).

In summary, it can be stated that especially the European legislation and as a consequence also the national legislations of the member states more and more ecosystem and thus protected property exceeding concepts are taken as their basis, and that they are searching for approaches to solutions that are taking the whole system and its possible problem shifting as well as long term perspectives and developments into consideration.

Even if the evidence for a direct influence of ecosystem research or even a single research project on the formulation of models, laws, guidelines, enactments etc in a lot of cases is hard to prove, a direct relationship suggests itself in the following examples:

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[16] Guideline 2001/42/EG of the European Parliament and Council on the examination of environmental effects of certain plans and programs, from June 27 2001 (ABl. EG Nr. L 197/30)

[17] Guideline 96/61/EG of the Council on the integrated prevention and reduction of environmental pollution, from September 24th 1996 (ABl. EG Nr. L 257/26)

- The results of ecosystem forest damage research have directly been reflected in the objective targets of environmental politics on the reduction of sulfur and nitrogen-emissions. They delivered application-oriented basic information about the interpretation of the Enactment on Combustion Plant Systems, the TA Air and about the obligated German and EU-wide equipping of automobiles with catalysts (FBE 2002, WS 2002, see also “materials“ 10, chapter 10.2.3).
- The approach to mass balance, which has been advanced by the ecosystem research, especially forest ecosystem research (WS 2002) has – even if in simplified form – been reflected in the Enactment on Fertilisation. The ecosystem idea of mass balance does also build the basis for the instruments, that were agreed on in the Kyoto Protocol on CO2-emissions, so that the protocol in spite of all its shortcomings principally is founded on knowledge from global atmospheric-biogeochemical process models;
- The approach to “bioaccumulation“ respectively “bioconcentration“ does also stem from ecosystem research and is of the same relevance as the approach to mass balance. It is f.i. used in order to determine critical values of pollutants (WS 2002). Juridical applications have been f.i. the Principles of Soil Protection, the Protection of Water Bodies and the Law on Chemical Products.
- Ecosystem research in the German wadden seas – especially in Schleswig-Holstein – has had an strong impact on the design respectively the amendments of the Law on the Nationalpark (WS 2002, see also “materials“ 10, chapter 10.2.1).
- Evaluation criteria, that have been developed by the ecosystem research program Schleswig-Holstein Wadden Sea have been included in the typing of coastal waters for the EU Water Framework Directive (FBE 2002).
- The FAM project (Munich/Scheyern Research Community Agricultural Ecosystems) had direct influence on the design of the Bavarian Program on Cultural Landscapes (KULAP, FBE 2002).

In spite of the existence of the above named examples, it has to be pointed to the fact, that the influence of the scientific research results on the adoption of especially international regulations and agreements is limited in such a way, as notedly these international negotiations are more subject to political compromise between the different parties, as it is the case in the national discussion about laws and target objectives. This implies, that societal opinions, ethic perceptions and economic interests often have a much stronger impact on the adoption of mainly international conventions as the results from ecosystem research are able to at short notice (FBE 2002).

Even if a such limited influence of ecosystem research on the legal finalization concerning the objectives of ecosystem protection in the broadest sense is seen critically, it is explicitly to be pointed out that it is due to the principal philosophy of science that empirical science – which ecosystem research is part of – is not able to be the direct cause for societal target objectives. This fully applies to the formulation of goals for environmental politics according to the results of ecosystem research. But this does not excuse ecosystem research from editing scientific results in such a way that the legitimate decision makers from the communal to the international level are able to use them for a responsible decision-making on future objectives.

4.4 Significance of ecosystem research to environmental planning[18]

4.4.1 Introduction to basic ideas

As ecosystem research has been developed in order to – among other goals – create a faculty spanning cooperation that was to exceed the borders between the different scientific fields, it appears only rational, that notably environmental planning with its faculty and sector spanning regulation tasks uses the results and the knowledge from ecosystem research for its purposes. The "ecologicalization" of spatial planning and the differentiation of environmental planning in the 1970s has been the consequence of increasing knowledge about ecological interactive coherences and the awareness that these should be taken into consideration in planning processes. At that time, ecosystems have gained more and more importance as spatial and systematic levels of integration. Element- and energy-, respectively, information flows in and between ecosystems have been acknowledged to be crucial for ecosystem interrelationships (WEILAND 1996, RUNGE 1998, JESSEL & TOBIAS 2002).

Ecosystem approaches have started to be included in planning especially when the capability and operativeness of the nature budget have been accepted as goals of the Federal Nature Conservation Law (see chapter 4.2.1) as well as a central topic of landscape planning and the disturbance regulation. Ecosystem approaches have gained special relevance by the acceptance of the conservation exceeding integrative testing approach by the UVP. The approach is implemented by the complementation of the protected property related concept of environment. This concept has been complemented by the idea of interactive effects (§ 2 para.1 sentence 2 UVPG[19]). This formulation traces back from the UVP guideline (85/337/EWG), that has introduced this ecosystem approach to environment in the environmental law in 1985 which had so far mainly been media respectively sector- oriented (BALLA & MÜLLER-PFANNENSTIEL 1997, 1998).

Landscape planning: "Landscape planning determines the capability of the nature budget by using different potentials or functions concerning homogenous ecological units or landscapes. It treats the interactive effects of soil, water, air, climate, plant and animal species. The effects of all existent and planned uses of this interactive structure as well as the reactions on the uses are shown. Thus landscape planning is media and sector spanning." (BMU 1993 in WEILAND 1996: 120)

Environmental assessment (UVP): According to § 2 (1) UVPG, environmental assessment comprises the "detection, description and evaluation of the effects that a project has on 1. humans, animals and plants, water, air, climate and landscape, including the respective interactive effects 2. on culture and other goods". According to Nr. 0.6.2.1 UVPVwV, this demand has to be seen within the context of an effective environmental precaution due to the legal environmental demands, exceeding the single evaluation of UVP protected properties. Demanded is "the implementation of a media spanning evaluation, considering the respective interactive effects."

Strategic environmental assessment (SUP): Goal of the SUP guideline is, according to Art. 1, to "secure high level of environment protection in the context of a promotion of a sustainable development" by granting a protective property exceeding environmental inspection. According to Annex I, Nr. f SUP guideline, the inspection is to deal with "probably profound effects on the envi-

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[18] The superordinate concept "environmental planning" does in this survey refer to all procedures that serve the main goal to include environmental matters – however important they may be – into systematic societal decision-making processes. Planning as f.i. land use planning, land use regulation, regional planning and urban land use planning as well as mainly spatially related public planning and parts of admission procedures whose primary goal is environmental conservation as f.i. landscape planning, air pollution control plans, noise reduction plans, waste water disposal plans, water management plans and environmental compatibility examinations as a dependent planning instrument for the preparation of decisions (see WEILAND 1996). JESSEL & TOBIAS (2002) use the synonymic term "ecologically oriented planning".

[19] UVPG February 12th 1990 in the version from December 27th 1993, BGBl. I, p. 2378

ronment“ that are to be detected within the scope of an environmental report, “including secondary, cumulative, synergetic, short-, middle-, long-term, permanent and non-permanent positive and negative effects“, “including the effects on aspects as biological diversity, the population, human health, fauna, flora, soil, water, air, climate factors, goods, the cultural heritage with architecturally valuable buildings and archaeological treasures, landscape and the interactions between the named factors“.

IVU guideline: The principals of the IVU guideline that serves the integrated prevention and reduction of environmental pollution caused by industrial plants, have been included into the Federal Immission Protection Law in 2001. According to § 1 of this law with relation to admission procedures for immission protection “the integrated prevention and reduction of damaging environmental effects caused by emissions in the air, water and soil including waste management is to be taken into consideration, in order to achieve a high level of protection for the environment in the whole“.

Moreover, along with the discussion on the model of sustainable development (WCED 1987) and the increasing relevance it has for environmental planning, ecosystem ways of thinking have gained more significance within planning. Central demands concerning methods or contents linked with the implementation of the idea of sustainability can only be managed by using ecosystem approaches (WEILAND 1996, JESSEL & TOBIAS 2002). Among these demands are:

- the development of objective targets respectively targets of environmental quality;

  “Objectives for environmental quality, critical values and standards can only be set within the scope of a systemic view on the ecological, economic and socio-cultural interdependencies“ (SRU 1994, Tz. 130).

- the determination of carrying capacities of ecosystems;

  For the determination of carrying capacities, the SRU has recommended the advancement of the Critical Level- and the Critical Load Concept (critical rates of concentration and of input). These critical measures can only be defined on the basis of ecosystem knowledge (SRU 1994, Tz. 183-184).

- the protective property exceeding analysis and prognosis of possible environmental effects and risks (see chapter 4.4.2)

  Within environmental planning effect analyses and prognoses cannot be restricted to single protective properties, because indirect environmental effects would be neglected. This is why in practice it is attempted to determine and to forecast indirect effects by examining effect chains or networks and by using scenario methods of prognosis (f.i. JESSEL 2000; BALLA & MÜLLER-PFANNENSTIEL 2002). For planning the determination of clear cause-effect relationships is crucial. Especially the complexity of ecological interdependencies leads to the fact that the application of complex models for prognosis seldom produces clear results and that the error-rate of the results increases (f.i. JESSEL 2000).

- the generation of environmental or ecological balances.

  The environmental and ecological balances, i.e. the analysis of regional, operational or product related surface balances, element - and energy flows, that have since quite a long time been discussed, are relevant for the controlling of the resource consumption and the distribution of ecological loads. Approaches to balances are principally founded on a system view of the environment (WEILAND 1996).

The systems view, which has been opened by ecosystem research, has in the area of planning contributed to the fact that

- systems viewed plans gain more importance than single-problem related plans,
- even systems that are spatially wide-stretched are analyzed and included into planning concepts (FBE 2002).

Ecosystem research has given and does give answers to questions that cannot and could not be solved in the planning routine, and it supports the planning activities with regard to methods and techniques (FBE 2002). The - due to contents and methods - close relationship between ecosystem research and planning or practical implementation, in general has been reflected in many research projects. These reflections have been positive in such a way, that the research results have had a direct influence on the decisions within planning and politics in the researched regions. This success cannot only be reserved for the projects that have been declared to be "application-oriented" but also for a lot of research projects investigating principle questions that have – against the expectations at the beginning of the project – delivered knowledge relevant to practice. An example is f.i. the Solling project (WS 2002).

Ecosystem research projects have, among others, provided for concrete contributions for the following fields within planning:

- for the design and planning of biological reserves;

  The establishing of the Berchtesgaden Nationalpark has principally been carried out on the basis of considerable basic data from the MAB 6 research using a GIS which has been established within the scope of ecosystem research, as well (WS 2002). The data were used to make maps for the taking of an inventory for an evaluation of the natural resources and their use and for the decision about the different zones of national park and biosphere reserve.

  From the ecosystem research on the Schleswig-Holstein Wadden Sea stemmed ecological and especially ornithological information, that has been of great importance for the building and changing of guided tours as well as for socio-economic studies on the future use of the Wadden Sea by fishery and tourism (WS 2002, see "materials" 10, chapter 10.2.1).

  Within the scope of ecosystem research on the Lower Saxony Wadden Sea, broad analyses about the uses and strains of the national park area have been carried out, using aerial view interpretations and biotope classifications. Among other results, the basis for a blue mussel management, for the design of a porpoise protection zone, for the foreland management and for the alleviation of conflicts between visitors and breeding birds has been laid (WS 2002).

- for a harmonized classification of ecosystems according to natural sciences and for a sustainable management of ecosystems as well as the solving of land use conflicts (development planning);

  Modeling results from the WET I3 project have f.i. been included in the revision of the masterplan for the Venice Lagoon. Ecosystem research in the Everglades has provided for important contributions to the management of the water budget in this area, and forest ecosystem research has given essential evidences for the realization of plans and for the concipation of managemental interferences in forest ecosystems, f.i. for the carrying out of compensation liming or the rebuilding of forest especially into more nature-oriented forms of forest (see also "materials" 19, chapter 10.2.3). The Schleswig-Holstein ecosystem research on the Wadden Sea has - in coordination with the Ministry of Agriculture and the Nationalpark Bureau - led to an elaboration of a blue mussel fishery program, a visitor steering concept as well as a design of foreland management(FBE 2002, see also "materials" 10, chapter 10.2.1).

  The Schleswig-Holstein Research Peatland Program always set the focus on the development of an applicable system spanning evaluation system.

- for the evaluation of environmental effects

  With concern to the instruments for the procedures on the estimation of environmental effects (UVP, Interference regulation, FFH assessment) the modeling approach on cause-effect hypotheses has been used in order to reproduce environmental effects/derogations (f.i. SCHÖNTHALER et al. 2003). For the reproduction of ecosystem relationships effect chains and networks are used for the effect evaluation (MÜLLER 1995, BALLA & MÜLLER-PFANNENSTIEL 2002). These build on the systematic picturing of heteropolar effect chains that have for the first time been used within the context of an expert´s report on environmental compatibility of the BAB A 4 (KIEMSTEDT et al. 1980a und 1980b, 1982). The objective was an "ecological, i.e. comprehensive and systems perspective" *that "should also include procedures and chain reactions in natural ecosystems and parts of systems" (KIEMSTEDT et al. 1980a, 1980b).*

4.4.2 Significance of ecosystem research for the advancement and application of planning methods

Within the scope of ecosystem research projects, methodological instruments for the description and evaluation of ecosystems and their uses as well as a prognosis for changes have been developed, stimulated and/or improved. These instruments are f.i.:

- the ecological effect analysis;

  The procedures of the ecological effect analysis, that are in their basic form applied to landscape conservation plans, landscape planning and environmental assessment at current, have been developed within the scope of the MAB 11 project "Lower-Main Study" (also known as "sensitivity model", UVF 1980). The goal of the German MAB 11 project has been to contribute to the prevention of negative interactive effects between economic activities and the natural resources in the region of Frankfurt/Lower Main by suitable land use planning. For the development of a socio-economically and ecologically founded development plan quantifiable system elements have been assorted to each other in matrices. The "System-Dynamic-Model" that has come to exist on the basis of these matrices, has been developed on a computer-based regenerative simulation model for the prognosis of development alternatives for different regions. The model was to permit planners to "understand the anthroposphere as a biocybernetic system of which decision support can be won, that helps to increase the survivability of the regarded system" (DEUTSCHES NATIONALKOMITEE MAB 1978, in WEILAND 1996: 117). Complex and computerbased ecological effect analyses have not become widely accepted in planning, as the necessary effort often is too high and does not stand in a suitable relation to the evidence that can be used in planning. Within the scope of planning, rather single "cause-effect-concerned relationships" are used and individually founded as a basis for the deduction of relevant environmental effects.

- The development of procedures for risk evaluation;

  The ecological risk analysis (BIERHALS et al. 1974, BACHFISCHER 1978) has firstly been developed from strictly formalized system technical evaluation processes as f.i. the cost benefit analysis for land use planning and then has become one of the most important methodological parts of environmental assessment (RUNGE 1999). The ecological risk analysis combines the protected properties´ sensitivity of the nature budget with the derogation intensity of existing or planned uses, respectively projects, within the area of planning, from which an "ecological risk" can be derived in a more generalized form. This approach is based on a relatively simple structure and ordinal scalings, in order to be able to consider especially the fragmentary state of information about interdependencies between landscape ecological systems and procedures as well as the problem of not directly measurable "soft" ecological data, that are due to logical reasons not to be combined with each other by arithmetic operations. In the WAVES project (SBE 2002), possibilities for multithematic interrogations have been created, that relate to risk aspects on a long-term basis of sustainable development, as well.

- the concept on the potentials of homogeneous ecological units;

  The term "partial potentials of homogeneous ecological units" has, emerging from Neef´s "regional economic potential" (NEEF 1966 in SCHREIBER 1985: 10) been developed by HAASE (1976 in ibid., HAASE 1978). Part of the natural potential is the biotic potential yield, the water- ,disposal-, the biotic regulation-, the raw material-, settlement-, and the recreation potential. The concept of natural potential has – even though many times modificated – quickly been included into consideration in various plans, without references to the original paper (ZEPP 1994). Advancement has also resulted from the work of MANNSFELD 1979 and 1983 (in SCHREIBER 1985: 10), BIERHALS 1978 (in WEILAND 1996: 120), BACHFISCHER et al. 1977 and SCHEMEL 1978 (for both see ZEPP 1994: 106). A broad collection of evaluation processes for single "landscape budget potentials and functions" has been presented by MARKS et al. (1989). Concept and terminology of natural potentials are, in spite of a widely spread use of the idea, not undisputable (f.i. ECKEBRECHT 1996).

- model based scenario techniques, that can be used for planning in connection with GIS on different measuring levels;

Within the scope of the Lake Bornhöved District ecosystem research, to some extent supported by WASMOD/STOMOD, scenarios for the use of landscape have been worked out and analyzed under the aspects of ecosystem effects. The scenarios deal with anticyclical trends within the development of agriculture that are relevant to politics (promotion of "peasant" agriculture versus "worldmarket scenario",MEYER 2000), effects of measures by environmental politics (nitrogen taxes, DIBBERN 2000) or the global climate change (HÖRMANN 1995, HERBST & HÖRMANN 1998). Furthermore, the conceptional basis for a model-based, discoursive development of models and indicators for a sustainable landscape management, building on scenario techniques has been developed (BARKMANN 2001, 2002; vgl. WIEGLEB 1997).

The MAB 6 research has debated scenario techniques in the following partial programs and elaborated development scenarios as case studies for specific problems (LORCH et al. 1995):

- *Swiss MAB 6 research: scenario "Development of Tourism in Grindelwald", scenario "Development of Tourism in Pays-d'Enhaut, land use scenarios Davos";*
- *German MAB 6 research: scenarios on alternative plans within the scope of the Olympic Wintergames 1992 (GERMAN NATIONALCOMITTEE MAB 1986), scenarios on alternative traffic concepts also directed towards possible wintergames (KERNER et al. 1991), scenarios about the effects of air purification on progress and extent of forest dieback (ibid.), scenarios on mountain farming in the Berchtesgaden Alpspark (KERNER & SPANDAU 1990).*

At the Ecology-Center the applicability of the developed models has been examined using a landscape plan for the Belau township. In this connection the recommendations base on scenarios of a differentiated degree of land use especially considering economic consequences.

- the discussion about hierarchies of objectives, meaning the systematic deduction of models, environmental quality goals (UQZ), environmental quality standards (UQZ) and environmental objectives for action (WS 2002);

For the 1990s, four new research directions have been established for the MAB programs in completion of the former scope of duties (HEINZ 1988). Part of these programs were f.i. the elaboration of evaluation reference, i.e. the formulation of environmental quality goals. In the Berchtesgaden MAB 6 project, it has been possible to relate to this new scope of duties during its term of implementation. As further components of the methodology, techniques that enable the comprehensible deduction ov UQZ, UST and "ecological marginal rates" have been developed. Besides these theoretical considerations, the implementation of UQZ and UST in the examined area has become a central topic, using a case study on "water" as an example (DEUTSCHES NATIONALKOMITEE MAB 1983, KERNER et al. 1991, SPANDAU et al. 1990). Within the Swiss MAB 6 research, especially the use of the simulation model Pays-d'Enhaut has stimulated a regional discussion about target objectives.

This discussion had direct effects on the planning of the national park as well as on the preparations for the elaboration of a conceptional framework for the Berchtesgaden biosphere reserve. In Berchtesgaden, target systems have been developed on the basis of the MAB 6 philosophy (SCHÖNTHALER et al. 1994, D'OLEIRE-OLTMANNS 1997).

In the third phase of the Lake Bornhöved District ecosystem research project, a focal point of work has been the debate on procedures for the elaboration of target systems, that would to be scientifically correct and could use the results from ecosystem research optimally (PZÖ 1996). As in the Kiel Cooperation of Ecosystem Research, which works on interdisciplinary projects about "Macro Indicators of Environmental Quality" a strategy of procedural rationality and legitimacy for the development of models has been used (STABA et al. 2002, BARKMANN 2001, 2002).

- the development and use of indicators for qualification and quantification of ecosystem functions (FBE 2002, see chapter 4.5.2);
- the development of geostatistical procedures that can be used for a spatial generalization of data (FBE 2002).

The development and the handling of the named instruments has influenced planning in such a way that the ecosystem way of thinking has been adapted to effect structures – and networks by the planners (WS 2002) and the methods have to some extent started to be used in the planning process. The comprehensible deduction of planning statements on the basis of target systems f.i. has become methodological standard in environmental planning. Within the field of indicators, comparable developments have been observed. More problematic in application are especially model based procedures f.i. for the development of scenarios. In part, this is founded in the still insufficient practical mellowness of models (see chapter 4.4.3).

4.4.3 Significance of ecosystem research for the use of technical utilities in environmental planning

An important result from ecosystem research has been the advancement of technical utilities for the generation, preparation and keeping of data. Environmental planning profits from these results

- by the area-wide introduction of GIS and the competent technical use of these systems (f.i. cutting techniques, WS 2002): GIS are suitable instruments for the creation of a unified level of integration, processing even very heterogeneous objects of information (HOSENFELD 1999: 143). Apart from that, they offer – in comparison to conventional planning instruments – the advantage of a flexible cartography, a quick adaptation of analysis-, evaluation-, and planning results to new evidence, a relatively inexpensive documentation of intermediary results, and an improvement of the persuasiveness, using more effective presentations (ZÖLITZ-MÖLLER 1999: 188);

  Within the scope of MAB 6 research in Berchtesgaden f.i. a broad GIS has been built up and along with the research activities fed with data. This GIS has been serviced and advanced by the national park administration even after the research project had been completed in 1994 and has been the basis for the activities concerning the establishment of the national park plan that had started in 1995 (BAYERISCHES STAATSMINISTERIUM FÜR LANDESENTWICKLUNG UND UMWELTFRAGEN 2001).

- by applying improved methods and techniques to the preparation and use of spatially related data from mapping as well as the generation of new data, that have in part been costly to collect, f.i. from aerial view or satellite based mappings (FBE 2002);
- by principally improving the data administration and exploration (FBE 2002) as well as
- by using modeling techniques, especially GIS model coupling.

The last point is especially important, as a lot of nowadays statuatory tasks in planning can only be coped with in a reasonable way when using GIS and models.

In planning, models can be used in very various ways:

- as models for concepts or thoughts, capable to demonstrate the most important subsystems and processes of an ecosystem as well as the qualitative relationships between the objects;

  Such a model for a concept is f.i. the so-called "Messerli-Paradigm" (MESSERLI & MESSERLI 1979), that had been developed within the frame of the MAB 6 research drafting the coactions and interactions of socio-economic and ecological processes within a man-environment-system. The Messerli-Paradigm has had a strong impact on the planners' mindsets (WS 2002).

- as models based on rules (decision support systems) that have expert knowledge on specific problem fields on a structured accessible basis of knowledge in store (HEINRICH 1999: 112) and

- mathematical models, that quantify the relationships between single objects and measures. The most different types of process – or event based simulation models are belonging to this group of models,
- GIS-models: the representation of spatial realities in a geographic information system is a model. The integration of GIS and simulation, respectively rule based models, is an intense research field at current (LAUSCH 2003).

It is regarded as undisputable that models can be increasingly used as practicable instruments even in planning.

> *Especially mechanical, process-oriented models are often the only utility that enables us to make statements - quantitative as well as scenaric and prognostic - and to transfer empirical knowledge on different temporal and spatial levels. In a lot of cases, statements can only be made when such transformations have taken place, that beyond the pure research results are relevant for political and planning decisions..*

It is also undisputable, that ecological modeling has reached a very high professionality in some study fields. But there still is a large discrepancy between the variety of available ecological models and their use in planning practice (HEINRICH 1999: 115).

The potential of models is far from being bailed out, which has manifold reasons:

- the absence of available data for the parametrization of models (f.i. GOODCHILD et al. 1996, ZÖLITZ-MÖLLER 1994)[20],

  This applies especially to highly parametrized computer models that sometimes restrict their results to paradigmatically used algorithms, assume vast and escapist proportions and that are often overestimated in comparison with empirics and experiment (FBE 2002). But even with concern to comparatively simple models, problems of parametrization have consistently been articulated. MEYER et al. (1999) have, on the basis of the simple, USLE (Universal Soil Loss Equation, WISCHMEIER & SMITH 1965) respectively ABAG (General Soil Loss Equation, SCHWERTMANN et al. 1987) founded, soil loss model, proven, that there is a great discrepancy between the data required for the parametrization of the single ABAG-factors and the available surface data. Especially the needed temporal and spatial processing of data can in most cases not be secured. MEYER et al. (1999) do not conclude that it has to be abstained from the use of models, but rather that a differentiated evaluation of modeling results in dependence of inadequacies and simplifications is needed for the preparation of parameters.

- the partially inexplicit information on the actual capacity/ significance of models,

  Models are viewed with distrust by the applicators, when there is a lack of clear statements on the prognostic quality of the modeling results or when the reliability of these statements is criticized to be too low[21].

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[20] In comparison with the situation in the United States it has to be pointed out, that in the United States there principally is free access to all data that has been collected and prepared by the federal authorities. In Germany on the other hand, important – basically existent – data f.i. on weather and climate, on soil consistency or on land use are not freely accessible or not accessible at all.

[21] On the part of the users, all the more demands are made on the models' quality of prognosis, the more the political, administrative or planning decisions that build on the modeling results, interfere with civil rights or property rights. If the modeling, that has been carried out according to acknowledged scientific measures, forecasts the most severe disturbances in the man-environment relationship, these model statements can - in regard to the environmental and due to resource precaution - justify resolute actions even if the quality of prognosis cannot be assessed. The reason for this is, that a governmental right for regulation on the basis of the precautionary principle is established even if the "potential for concern" can hardly be founded on arguments (BENDER et al. 1995). Strategies for a handling of the various environmental risks, about which model statements of unequal quality are available, have been pointed out by the Scientific Committee of the Federal Government on Global Environmental Changes (WBGU 199). Within the German ecosystem research, respective strategies for risk precaution have been developed on the part of the "acceptors", that have explicitly emanated from a modeling ability that is -

- the preparation of models that are normally little user-friendly, i.e. a lot of the models developed in ecosystem research are relevant to practice and planning but they are actually not capable for application (WS 2002); in most cases there is a lack of user interfaces or handbooks that allow for a use by other persons than the developer,
- the missing overview on the variety of models available on the part of the planners, due to a lack of a consistent registration and documentation of models (ERNST et al. 1997),
- the absence of educated staff corresponding to the use of models, that are able to use the models effectively in the planning offices.

From the view of the planners it is to be pointed out that – especially in regard to the high methodological demands of UVP – there are mathematical simulation models available for many fields of work that could also be used within UVP (f.i. groundwaterflow models, models on the dispersion of noise and harmful substances, models on the population dynamics of the single animal species, models on the element budget). The problems with these models in regard to their application for a prognosis of complex effects of ecosystem projects are, that sometimes only narrow limited ranges of effect are taken into consideration and that in some cases too high demands are put on the data material. The attempts to produce great faculty spanning UVP simulation models have so far always been failures (MUNN 1983 in RUNGE 1998: 175).

4.4.4 Discussion

In spite of the positive examples of the research results‘ successful transformation to environmental planning, there still is a strong need for development at the interface research - planning (NEEF 1967, DURWEN et al. 1980, RASSMUS et al. 2001, ZÖLITZ-MÖLLER 1994). Thus, the legal requirements named in chapter 4.4.1 to root the ecosystem approach in landscape planning and the environmental compatibility test has – also due to a lack of scientific knowledge – until now not been fulfilled in a satisfactory manner. Besides the reasons, that will be named in the following, the absence of a broad operationalizing of the terms "nature budget“ and "interactions“ is responsible for the insufficiencies (KLEYER et al. 1992, ZEPP 1994, WEILAND 1996).

Ecosystem research and planning work in relatively strictly defined general framework (see figure 3). Ecosystem research projects are always pressed to investigate the ecosystem’s complexity within a limit of time and costs. As simplifications of the scientific matter often are regarded as unprofessional, a strict selection of the objects of investigation has to be made.

because of increasing environmental strains – insufficient in regard to long-term prognoses on the man-environment relationship (MÜLLER 1998, KUTSCH et al. 2001, BARKMANN et al. 2001; see also chapter 4.7.3).

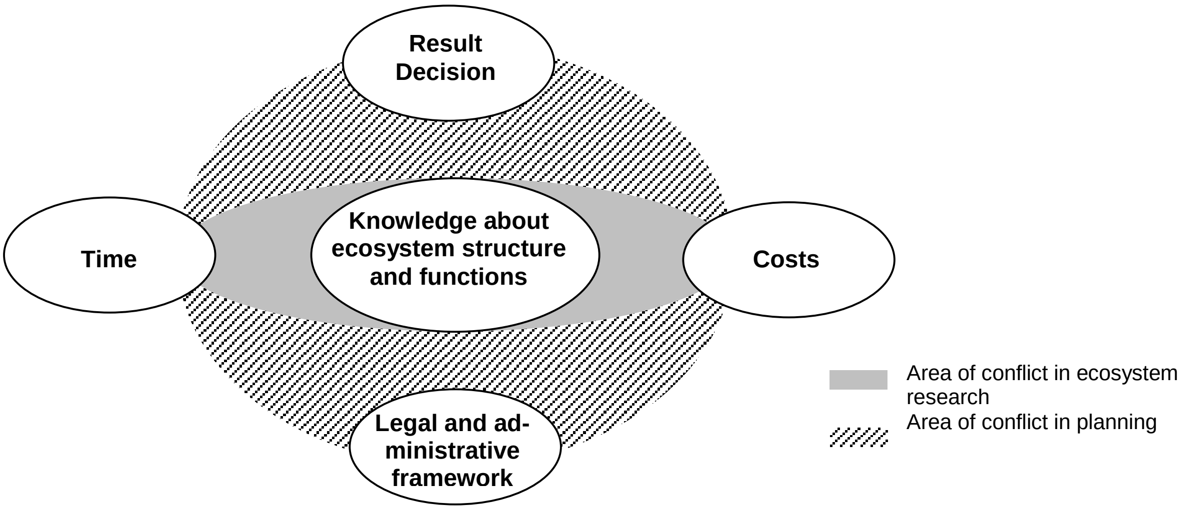

Fig. 3: Area of conflict in comparison with ecosystem research and planning

Planners work in a far more complex stress field, they are constricted to

- pressure of time:

  Due to practical problems or as a consequence of political conditions a counterproductive pressure of time arises for the planners, that does not permit a broad triage and adequate consideration of the research results and their implementation within the planning process (ZÖLITZ-MÖLLER 1994);

- financial bottle-necks (see f.i. BALLA & MÜLLER-PFANNENSTIEL 2002);
- a comparatively fixed legal and administrative setting:

  Planners are bound to guidelines from laws and enactments, which has the effect that the demand of ecosystem knowledge and utilities primarily aims at standardized, approved, juridically sustainable knowledge. When using the - in fact methodologically demanding - UVP in practice, this often leads to a retraction to the sectoral criteria that are subject to rules of the specific field of work, and which from the ecosystem view are not sufficient. (f.i. critical values, ZÖLITZ-MÖLLER 1994). Beyond this, juridical deficits have been asserted, especially to landscape planning (KLEYER et al. 1992). This means, that the demands to planning formulated by politics and judicature offer a poor incentive for the respective transfer of knowledge and technology from research to planning.

  In a lot of cases, the still very strong sectoral orientation of the authorities' structures defines narrow limits for the use of ecosystem approaches in planning (ZÖLITZ-MÖLLER 1994);

- a strong coercion to orient oneself strictly on results and decisions:

  Planning has to generate concrete, realizable results, the generation process of these results has to be comprehensible and understandable. As planners are more often demanded to work public-oriented, the methodological standards often are simplificated. The use of demanding methods is, even if more suitable to the treated issue, often refused, because it could not be put across to clients and to the public.

In a lot of cases, this narrow framework complicates a consistent use of existent knowledge on ecosystem structures and its functioning for the decision-making of the planners. As the research results are not available in a directly receivable, compressed and understandable form, these problems become even more effective[22]. Such a transformation is in most cases no longer part of the research project. In addition, simplifications of coherences found to be complex are not regarded as career advantage in a scientific environment, and thus, the research work is not honored according to effort and accomplishments (ZÖLITZ-MÖLLER 1994: 14). This deficit in transformation is especially hard, as ecosystem research normally produces a plentitude of data, that is firstly difficult to overview and secondly only can be used in part (FBE 2002).

Further causes for an insufficient consideration of ecosystem knowledge in planning processes can be found in the fact that supply (on the part of research) and demand (on the part of planning) are not adjusted stringently to each other (ZÖLITZ-MÖLLER 1994). Results are f.i. the following:

Supply	⇔	**Demand**
Knowledge on ”individuals in ecosystems“		Demand for transferable results

Ecosystem research delivers knowledge for the description and explanation of the ecosystem individuals‘ functioning instead of delivering information on types of ecosystems. According to ZÖLITZ-MÖLLER (1994) this can be viewed as a capitulation to the variety of the own object of investigation. As recommendations from planning have to be area-wide and more roughly scaled, planning is - in order to overcome scale limits - demanded to develop suitable techniques for the generalization of research results and their transformation to areas, that have been examined less intensely or that have not been examined at all. Apart from that, the demands from the users pointing to the legal security of planning statements have made it even more difficult to carry out the generalizations and transformations of data and results. On the part of the researchers, though, it has often been called attention to the single case while neglecting the generalizability of the results (ibid.). Against the background of this, a suggestion has been to carry out research less intense but in more areas (WS 2002).

Supply		Demand
Contributions to explanations of and solutions for few exclusive issues		Demand for contributions to explanations of and solutions for a preferably broad spectrum of planning issues

Ecosystem research inevitably concentrates on few exclusive issues as f.i. land use in agricultural areas or the phenomenon forest damage. Planning has to concentrate on a much more broad spectrum of issues. This is why the influence of ecosystem research has been limited so far, at least as concerns practical contributions of the contents.

Ecosystem research usually is not related to interferences. Compared to the frequent consideration of important influences of land use or superior diffuse element depositions, changes in ecosystems due to efficiency coefficients as they are characteristic for UVP binding types of projects (f.i. carving effects, surface loss, punctual emissions) have within the scope of largely designed ecosystem research projects been much neglected. SRU (1994: 268) f.i. points to the “urgent need for research on effect analysis“ as f.i. is the case with road related environmental effects (BALLA & MÜLLER-PFANNENSTIEL 2002).

For the determination of research issues relevant to planning a better communication between research and planning would be desirable.

Against this background, the current initiative of the German Federal Environmental Agency can be regarded as positive. In view of the practical constraints following from

[22] In this context, KAISER et al. 2002 use the term “connector-quality“, meaning the ability to use the results, that are oriented towards fundamentals and towards application, from research for applications.

Supply	⇔	**Demand**

the EU-SUP guideline (guideline on strategic environmental examination) the Federal Environmental Agency has commissioned the research assignment to develop monitoring mechanisms for environmental effects of plans and programs (FBE 2002)

Emphasis on the systems‘ heterogeneity	Demand for procedures for overcoming scale limits

The (increasing) discovery of heterogeneities in natural systems is an inevitable consequence of an intensely practiced ecosystem research. This easily leads to an excessive representation of heterogeneities while the handling of these heterogeneities in practice, the degree of dependency on scales and aggregation strategies are issues, that are less thought about and worked at (ZÖLITZ-MÖLLER 1994).

Development of innovative procedures and techniques	Request for a provision with methods applicable to practice

A lot of procedures and methods that have been developed in ecosystem research are even with concern to contents too demanding for a use in planning (u.a. ZÖLITZ-MÖLLER 1994).

This applies f.i. to approaches from population ecology as well as meta population theory as a basis for analyses on population dangers and the concept of the minimum viable population. In this connection simplistic (technological) “rule-of-thumbs“ would be more target-oriented. The statements would be formulated less clear but would lead to practically applicable evaluations of magnitudes, f.i. with concern to ordinal assessments (FBE 2002).

Planning is an interdisciplinary field of work. Planning decisions are normally based on a compromise between knowledge from the natural sciences about system reactions, legal demands, social desires as well as economically and politically led considerations. A comparable demanding interdisciplinarity has always been claimed and is still claimed on the part of ecosystem research, but it has until now only been accomplished in few cases. There is especially a lack of a consistent integration of social and political sciences. The orientation on natural sciences, that has so far been very strong, contributes only little to planning decisions.

Additionally,

- even in ecosystem research, because of a too frivolous dealing with the term “application relevant“, the production of actually application relevant results has rather been left to chance than prepared target oriented and strategically (ZÖLITZ-MÖLLER 1994: 14), and
- in spite of a consideration of well-founded scientific evidence in planning processes, this evidence, following societal and political considerations, is not necessarily reflected in planning results (ibid.).

4.5 Contribution of ecosystem research to environmental observation/ environmental monitoring and indicator derivation

4.5.1 Ecosystem research and environmental observation

The close relationship between ecosystem research and ecosystem observation has for the first time explicitly and extensively been pointed out in the advisory opinion of the German Council of Environmental Advisors in 1981.

As the council has extensively described in the environmental advisory opinion in 1987 (SRU 1988, paragraph 1.1.1), “environment“ is a complex system that can only insufficiently be influ-

enced and designed when using the conventional sectoral instruments; these often lead to a shift of an environmental problem from one environmental medium to another. Environmental observation therefore has to be planned comprehensively [...]. (SRU 1991, para. no. 68).

The crucial awareness from ecosystem research, that environment as a complex system can only be comprehended, evaluated and influenced by using interdisciplinary approaches, directly led to the demand for an integrated sector spanning environmental observation. For environmental monitoring as it has been so far – related to single environmental media, sectoral monitoring – is overemployed in regard to the demand for effect statements and trend prognoses.

In his advisory opinion, the council has explicitly called attention to different ecosystem research projects from which integrated approaches could be deduced for environmental observation.

Named in SRU 1991 (para. no. 70) are f.i..:
- *the Solling project (ELLENBERG et al. 1986),*
- *the landscape ecological model examination Ingolstadt (BACHHUBER et al. 1983),*
- *the establishment of the Environmental Speciment Bank (LEWIS 1985 and 1987),*
- *the ecosystem research projects Berchtesgaden, Wadden Sea, Lake Bornhöved District".*

Research and environmental observation (according to the definition in table 5) are a reasonable completion of each other (FBE 2002) in such a way that,

- ecosystem research supports the development of environmental observation programs: it promotes the selection of suitable variables and their orientation within the ecosystem effect network, it provides for contributions to an improved practice in observation and to an interpretation of the observation results;
- environmental observation is used for the long-term testing of ecological models (interdepending effects between the components of an ecosystem) and ecosystem theories;
- from environmental observation, a need for research can be derived: environmental observation discovers trends or even short, unexpected changes; these cannot always be explained on the basis of existing knowledge.

Tab. 5: Attempt of a conceptional classification of research and environmental observation (SCHÖNTHALER 2002)

Research	**Environmental observation**
Ecological research or ecosystem research serves the **clarification** and quantification of **ecological coherences** and the decoding of cause-effect relationships between the system's components. Research activity is normally based on **hypotheses** that are to be validated or to be vitiated. Ecological research can **also** extend over **short periods of investigation**. The **selection of methods** is usually **innovative**, meaning that beyond application and securing of methods that are already introduced, an essential part of research is the development of new methods.	Environmental observation can be regarded as a part of research. In contrary to research, it is carried out at a **long-term** level. Environmental observation is in regard to the problems treated and the selection of methods based on results from (ecosystem) research, i.e. it registers the **qualitative and quantitative development** of relationships between parts of the system, it attempts to interpret these developments and to detect which consequences are connected with them. Against the background of long-term periods of investigation, environmental observation has specific demands to the selection of **observation methods**. These ought to: • be already tested in practice, • be easily standardized, • be affordable on a long-term basis and • be sparing and reproducable, i.e. the objects of observation should preferably not be influenced by repeated samplings.

When ecosystem research and environmental observation are closely connected, the implementation of results from ecosystem research into practice and the transformation of innovative approaches to routine applications can be resolved more easily.

Beyond the conceptional and methodological orientation of environmental observation ecosystem research (SRU 1991, para. no. 69), the council recommended – on the basis of the above named reasons - even a spatial approximation of ecosystem research and integrated environmental observation.

> *"For pragmatic reasons, the council recommends to start with those areas that enable to build on ecosystem research or to connect environmental observation and ecosystem research". (SRU 1991, para. no. 87)*

> *"Long-term ecosystem research should be concentrated on the areas of ecological environmental observation." (SRU 1991, para.no. 89).*

The council's 1991 advisory opinion has – supported by two decisions of the German Conference of Environment Ministers from 1991 and 1992 – activated manifold activities on the political level. Firstly, the aim was to improve the state of information on environmental observation programs of federation and states that already have been installed (especially UBA 1998, CONDAT 1998, SCHRÖDER et al. 1999, UBA 1999, KLITZING 2000). Secondly methodological support was to be provided in order to improve the coordination and concentration of environmental observation activities (KNETSCH & MATTERN 1998), and to implement the high conceptional demands of the SRU to describe the environment based on a system view and to create the preconditions for an early detection of environmental changes (f.i. SCHÖNTHALER et al. 1997, AKNU 1999, SCHÖNTHALER et al. 2003).

The fixation of ecological environmental observation as a legal commission came to pass as amendment of the Federal Nature Conservation Law and its paragraph 12. In chapter 4.2.1 it has already been pointed out that the text of the law as well as the newly formulated explanatory statements imply a direct linking of environmental observation and ecosystem research.

4.5.1.1 Impulses for structure, contents and methods of environmental observation programs

The impulses of ecosystem research for structure, contents and methods of an ecosystem designed environmental observation can be described as follows:

- Ecosystem research has provided important stimulations for interdisciplinary cooperation, which is a precondition for the implementation of an integrated sector spanning environmental observation. The cooperation of the different public authorities that has been realized in several research projects, prepared - in coordination between these authorities - the elaboration and implementation of integrating concepts for environmental observation (FBE 2002).

  The measuring approach that has been developed in the Göttingen Forest Ecosystem Research has been included into the EU monitoring program (level II). Currently at more than 800 European sites measurements on deposition have been carried out according to this methodical pattern. A significant contribution to the concept of a nationwide determination of the chemical state of forestal soils (BZE) can also be ascribed to the Göttingen Forest Ecosystem Research (see also "materials" 10, chapter 10.3.2).

  The collaboration between the Ecology Centre at the University of Kiel and the Schleswig-Holstein State Office for Nature and Environment implementing the research project Lake Bornhöved District turned into a close cooperation of these and other institutions building up the "Schleswig-

Holstein Integrated Environmental Observation“ and the state-wide Information System on Nature and Environment NUIS (ibid., f.i. WINDHORST et al. 2001, BARKMANN 2003).

The cooperation within research on the wadden sea have been the precondition for the establishment of the Trilateral Monitoring and Assessment Program (TMAP) (f.i. CWSS & TMAG 1997).

Important suggestions for the establishment of a state spanning monitoring of the northern tree line regions have come from the HIBECO project (FBE 2002).

- Ecosystem research has given essential stimulation for the selection of parameters that are to be recorded by means of a long-term oriented environmental observation. The discussion on this issue is closely linked with the determination of suitable indicators for the indexing of changes within structures and functions of ecosystems (ibid.).

The projects, that have been carried out by SCHÖNTHALER et al. 1997 and 2003 on assignment of the Federal Environmental Agency treating the pilot implementation of ecosystem environmental observation in the biosphere reserve Rhön have led to the formulation of a so-called “core data set on ecosystem environmental observation“. It contains a set of parameters that is (sorted by priorities) important for the description of structures and functions of ecosystems. The selection of parameters is based on a list of variables derived from MAB 6 research in Berchtesgaden, and model sizes, that have been used for modeling in the Lake Bornhöved District (WASMOD/ STOMOD).

The parameters of the Trilateral Monitoring and Assessment Program (TMAP) have been selected on the basis of results from ecosystem research on the wadden seas, although the complexity of the finally implemented “common package of TMAP“ has resulted from an observation program‘s limitation that has been desirable from an ecosystem perspective. The limitation has been decided on due to strictly pragmatic considerations.

Within the frame of the BMBF-sponsored research project “Development of an indicator system for the state of the environment in the Federal Republic of Germany, including a practice test for selected indicators and related areas“, suggestions for indicators applicable in practice have been developed with regard to an ecosystem oriented environmental observation. The superior project assignment was to complete the economic book keeping on which the environmental economic total accounting of the Federal Statistical Office, and to see the economic statistics in the necessary broader connection of the environmental situation. For the development of an indicator system, that could be operationalized and implementable the results of the German ecosystem research were to be comprised. The indicator system, that has been worked out, includes indicators for the description of functionality and of the physical structure of landscapes and ecosystems as well as for the description of material strains and accumulations in ecosystems (RADERMACHER et al. 1998, see also STABA et al. 2002).

- Methodological acquisitions from ecosystem research can be used for the evaluation of data from routinely carried out environmental observation (FBE 2002).

Some of these relevant methodological innovations are f.i. (ibid.):

- *the advancement of procedures for statistical evaluation (as f.i. the creation of multivariate statistics) and the time series analysis (using new, non-linear methods as f.i. z.B. RQA, SSA etc.);*
- *the advancement of balancing (f.i. the bioelement budget for complete forest ecosystems and canopy budget models for the total deposition, that are nowadays used within the frame of the level II program);*
- *the advancement of procedures for a spatial generalization of data collected punctually or on small areas (as f.i. geostatistical procedures (Kriging – approaches) or the KGG – and TIN – approach of the MAB 6 project in Berchtesgaden);*
- *the determination of landscape functions and natural potentials (see SCHREIBER 1985) on different scales;*
- *the development of simulation models and scenario techniques, that first of all help reduce the efforts for the collection of empirical data in routine operations and that are secondly able to deliver scenaric statements on possible future developments of ecosystems (FBE 2002);*
- *the development of procedures that help combine modelled and empirically collected data (f.i. the “nested“ measuring strategy, that is combined with model simulations, ibid.);*

- *the development of procedures that enable the comparison of empirical data' s spatial patterns and of computerbased simulation models or*
- *the advancement of methods for an efficient data collection (ibid.).*

Furthermore it is noteworthy that (FBE 2002):

- relevant indications about the sensitivity of specific ecosystem types and their reactions to environmental changes can be derived from ecosystem research, and thus, should be taken into consideration of the environmental observation;
- an improved selection of suitable measuring points and measuring frequencies become possible on the basis of ecosystem research results,
- the results from research projects point to a suitable temporal-spatial resolution of measurements in long-term oriented environmental observation programs. Only on the basis of a system understanding improved by ecosystem research (f.i. the limitation of measurements to measuring periods, in which a reaction to changed environmental parameters actually can occur) can be decided about these indications.

Especially the area of evaluation methods still has a very large potential for the utilization of methodological instruments from ecosystem research for environmental observation, as universities and administrations principally differ from each other in their general routine and the know-how available.

It is not always possible to establish the demanding evaluation procedures from ecosystem research for the every day use in the administrational institutions of environmental observation. This does also apply for complex simulation models that require very much effort for the parametrization.

SCHÖNTHALER et al. (2003) have, within the scope of a pilot implementation of ecosystem environmental observation, using the example of the state spanning biosphere reserve Rhön, derivated a selection of suitable methods for an (integrated) data evaluation from environmental observation. It has shown that both, simple and more complex evaluation methods, have found a reasonable application within ecosystem environmental observation. The pilot use of the water budget and material flow model WASMOD (that has been developed and advanced within the context of the Lake Bornhöved District research), in a Bavarian part of the biosphere reserve has shown, that models can accomplish the following results for ecosystem environmental observation (ibid.):

- *Certain models can, when connected with a GIS combine punctually collected data with data that has been collected planarly, so that an area-wide representation of the dynamic processes can be achieved. This enables the description of not only single sites, but larger areas with regard to their state of environment.*
- *Certain parameter measurements can only be accomplished with great effort. Model calculations provide further evaluations with data that is too elaborate to collect or that cannot be collected in the every day practice.*
- *Ecosystem models link medially or sectorally collected data of different information levels with each other.*
- *Simulation models enable the discussion about scenarios and thus serve the objective of an anticipatory environmental observation.*

4.5.1.2 Contribution of ecosystem research to technical innovations within the every day practice of environmental observation

Ecosystem research has made a large contribution to the development and improvement of measuring and process related techniques. Thus it helps overcome technical problems within environmental observation (FBE 2002).

Examples for ecosystem research projects, that have achieved significant results with regard to improvements of measuring techniques are f.i.:

Forest ecosystem research at the BITÖK: Research programs have led to recommendations on which measuring instruments f.i. in the area of soil hydrology and soil chemistry should no longer be used (these results have only informally been discussed in experimentally working groups, they have not been published, FBE 2002).

Ecosystem research at Lake Bornhöved: Measuring and sampling techniques founded on regional statistics have been developed for soil uptake and environmental chemistry (FBE 2002).

FAM/Scheyern: Improvements in measuring techniques have been accomplished especially within the measuring of surface drain and soil erosion, collection of soil hydrological parameters, area-wide differentiated recording of biomass upgrowth and harvest, demarcation of soil units by means of remote sensing. The establishment of the measuring system has been carried out under the precondition that the measurements and observations do not oppose the continuation of agricultural use (FBE 2002).

MAB 6 research in Berchtesgaden: Procedures for a conceptionally new, hierarchically constructed, data collection, - exploration, - organization, - and administration, adapted to the specific site, have been developed and tested (FBE 2002).

New sampling strategies for chemical examinations and benthos studies and an in-situ dyeing method for benthos examinations have been derived from the ecosystem research on the wadden seas (DITTMANN et al. 1998 in KAISER et al. 2002: 125). Furthermore, GIS and remote sensing methods have been used for the first time in the terrestrial-marine transitional area in order to planarly register structures as f.i. seaweed – and blue mussel stocks as well as sediment types (KOHLUS 1997, ROY et al. 1997 as well as MILLAT 1996 in ibid.).

A lot of techniques, that are used in ecosystem research, have not been concipated for the everyday practice. They are often prototypes that have been constructed with great ingenuity and accurateness and that are not ready yet for a serial production. The techniques and methods are sometimes so differentiated that it takes a high technical expertise and great care to secure a high data quality. But for the realization of a long-term oriented environmental observation program, adequate technical capacities granting a similarly high data quality cannot always be made available (FBE 2002).

Apart from this, even in the technical area the preparation and passing on of the necessary information from research to the everyday business is a problem. A lot of "meta knowledge" from ecosystem research is not documented by the researchers, thus it cannot be passed on to the institutions responsible for environmental observation (ibid.). In a lot of cases, the prevalent method of the authorities responsible for environmental observation is the personal advancement of the technical instruments. In these cases, it cannot always be reproduced how much profit has been gained from research results. For the magisterial practice, in some cases own experiments have proven to be more practicable than the time-consuming study of literature and concept studies in order to take up the necessary experience from ecosystem research (PEICHL 2002, oral interview).

At the Bavarian State Office for Environmental Conservation, excessive experiments with different types of deposition collectors have been carried out. It has been aimed at the development of a collector that secures a stabile sampling quality, even when infrequently emptied, (meaning that it *prevents chemical transformation processes in the holding basin as much as possible), a demand that is of little importance when more researchers are present at the research site.*

The development of technical instruments mostly served the instantaneous solving of specific problems in ecosystem research. This aspect has been far more relevant than the demands of the routine measuring and observation practice (FBE 2002).

An exception is f.i. the ICP Forest. Within the scope of this project, important preparations for the establishment of a Europe-wide level II program have been made. Input from ecosystem research has especially been related to the Europe-wide consistent installation of weather stations and the harmonized measuring of deposition in forests (FBE 2002).

Another example for the successful handing over of routine capable measuring techniques from ecosystem research to environmental observation is the “Ferry Box“, a fully automatized sensor system, that has been developed in the Netherlands, installed on the Hamburg-Harwich ferry, and that is continuously providing for data on the quality of the North Sea water (SWERTZ et al. 1999).

4.5.1.3 Discussion

In a lot of cases, ecosystem research projects led to the conception and implementation of environmental observation programs (FBE 2002).

The forest ecosystem research projects within the context of the ICP led to Forestal Environmental Monitoring (level I und II).

The ecosystem research projects on the wadden sea led to the Trilateral Monitoring and Assessment Program (TMAP), that has been carried out in the whole wadden sea area since 1994.

From the Schleswig-Holstein WET project, especially from the accompanying research, the Peatland Program, suggestions for a reduced monitoring program have resulted, parts of which already have been accepted by the responsible governmental State Offices for the Environment.

Measurements within the Lake Bornhöved District ecosystem research have in part been taken on by the Environmental Speciment Bank. The measurements on deposition led to a deposition measurement program of the Schleswig-Holstein industrial inspectorate in Itzehoe.

As concerns the Lake Constance project (SFB 248 of the Lake Constance element budget), subsequent measurements have already been institutionalized and have become statuatory.

Research within the context of the HIBECO project are to lead to a new monitoring activity, called “TREBIOREMA” (Treelines as indicators of climate change, biodiversity and resource management).

The LTER program (Long-term ecological research and monitoring, f.i. in Loch Vale Watershed, Rocky Mountain National Park, Colorado, USA) has already in the beginning been concipated for a transformation into a long-term environmental observation program.

MAB research in Berchtesgaden and the studies of SCHÖNTHALER et al. (2003) that build on this project, currently stimulate a new organization of environmental observation within the Nationalpark Berchtesgaden.

The FAM-Project/Scheyern is planned to transform its research results to environmental observation programs. Precise steps concerning these plans have not been taken so far.

Such a transformation of ecosystem research to a long-term environmental observation program has many cases not yet carried out. The following reasons can be made responsible for this (FBE 2002):

- reasons in connection with finances and budget:

  Ecosystem research programs or projects are much better equipped than the environmental observation programs. They are designed for short-term or long-term duration and designed for detailed measurements that are necessary for the solving of demanding and differentiated research problems. The transformation of research measurements into a practicable and affordable measuring program for environmental observation mostly requires major conversions of the measuring instruments, in some cases a changed measuring design as well as the setup of a data evaluation applicable for the routine business. Thus, besides the long-term financial securing of measurements within the frame of environmental observation, finances are a relevant problem already in the "phase of transformation". Research at university does not have the financial means (and they are not entitled) to transfer the results to the institutions, that are responsible for environmental observation or to prepare them accordingly. Such a procedure ought to be promoted separately. Furthermore, it has to be pointed out, that it takes a relative large amount of time to build up an environmental observation program. Research projects that have a duration of three to five years can, due to a lack of time not set the course for an establishment of an environmental research program.

- organizational reasons:

  Besides financial reasons, in a lot of cases organizational arguments oppose the transformation of ecosystem research results to environmental observation. For, normally such a "transformation" implies a change within magisterial responsibilities. This does not only apply to the integration of a new observation assignment into the magisterial structure – a demand that often exceeds its personnel capacities. It can also require to adjust the existing observation programs to the new demands as a consequence of a changed state of science (FBE 2002). The authorities often dispute changes of long-term oriented (sectoral) environmental observation programs, while the resistance is mostly excused with the disruption of longtime statistical series (SCHÖNTHALER et al. 2003).

  Changed magisterial responsibilities can also lead to the consequence, that feedback from environmental observation to research is insufficient. This means, research is only granted restricted access to data from environmental observation, so that the possibilities for data reviews and for an adjustment of scientific hypotheses are limited (FBE 2002).

- technical and methodological reasons (see chapter 4.5.1.2);
- other reasons:

  An intense and effective connection between ecosystem research and environmental observation can only be realized if it becomes a declared intention on the part of the political institutions to build up the necessary structures and to keep financial and personnel means available (FBE 2002).

But also the researchers and the staff responsible for environmental observation need to approach each other. A lot of researchers still find environmental observation to be an uninteresting field of work, so that there is a lack of creative ideas for environmental observation. The routine business of environmental observation often leads to a lack of understanding and readiness to open up the results of ecosystem research to their own work area and to articulate clear demands to research (ibid.).

4.5.2 Contribution of ecosystem research to the indicator discussion

Especially since the Rio conference in 1992, broadly accepted methods and approaches are looked for in order to describe the environmental situation and their changes quantitatively and qualitatively and to be able to review the performance of environmental and development goals. Chapter 40 of Agenda 21, which has been signed by the community of states at the Rio conference, asks for a development and application of parameters or evaluation criteria that ought to be used for a review of national and international developing processes, focusing on their applicability for a sustainable development. At the latest in 1993 at the beginning of OECD’s treatment of catalogues on parameters and evaluation criteria, the term “indicator“ has been used.

Indicators are measured, calculated or derived parameters that are - as components of indicator systems and in a representative manner - used for the description or evaluation of an issue or a complex system (indicandum), (f.i. SRU 1998, UBA 2000b).

Indicators have to fulfill both scientific and functional, user related and practical demands (see table 6). There hardly is an ideal type of indicator that fulfills all of these demands. The aggregation of information concerning political consulting services or public communication normally means a simplification of coherences and thus implies a lower quality of the criterion “adequate representation“. From a scientific view this criterion is of great importance and would require rather extensive indicator systems that embraces the complexity of the respective coherences (SRU 1998).

Tab. 6: Demands to indicators of sustainability (Preparation and completion by OPSCHOOR & REIJNDERS 1991, UK DEPARTMENT OF THE ENVIRONMENT 1996, WALZ et al. 1996, PIORR 1998, SRU 1998, LÜDEKE & REUSSWIG 1999[23])

Scientific demands	• Representativeness and adequacy in relation to the respective ecological, economic and social coherences • Transparency • Reproductivity of results • Aggregation traceability • Traceability of the criteria for selection • Data quality, transparency on the uncertainty of data
Functional demands	• Sensitivity to changes over time • Suitability for the tracing of trends • Early-warning function • International compatibility • Sensitivity to economic, ecological and social interactions
Demands from the user’s view	• Target orientation • Adequate aggregation of information due to addressees • Political controllability • Comprehensibility for politics and publicity • Societal minimum consensus on the suitability of an indicator for the representation of coherences and on the context of interpretation
Practical Demands	• Availability of data • Possibility of regular updating • Reasonable effort for data acquisition

The use of indicators is motivated by the experience that the complexity of the interactions between societal and ecological processes overextends the information systems that are usually used. Against this background it is - for political consulting services and for the publicity - attempted to come to a systematic reduction of complexity and to an approximate representation of reality. This aim is to be achieved by selecting few significant and representative parameters from a multiplicity of single data.

While the selection of suitable parameters for qualified environmental observation is strongly influenced by the results from ecosystem research (see chapter 4.5.1.1), the determination of significant indicators for political consulting services and public relations – especially with

[23] see: http://www.itas.fzk.de/deu/tadn/tadn002/coen00a.htm

regard to the multiple and in part contrary demands to indicators – is the result from a strictly selective process[24], for which also normative criteria are relevant (STEINER 2001; cf. "Model oriented indicator development": SRU 1996). The contribution of ecosystem research to the development of indicator systems thus cannot always be detected unambiguously. Exceptions are indicators that result from a strong data aggregation respectively indicators. Key indicators or headline indicators and aggregated indicators[25] are examples for this kind of indicator, for their selection or calculation professional aspects are most important (knowledge on the special significance of certain factors of the ecosystem as well as correctness and traceability of aggregation procedures).

For the environmental total accountings (UGR) within the scope of the IN∆ECO[2] project ("Macro Indicators of the state of the environment") commissioned by the BMBF and in cooperation with the Federal Statistical Office, highly aggregated indicators on the state of the environment have been developed on the basis of models from natural sciences, statistical aggregation procedures and societal decision processes (STABA et al. 2002).

Along with the LTER research on the Rocky Mountains, the development of aggregated indicators has been pushed forward (FBE 2002).

The knowledge from ecosystem research has also had a strong impact on the formulation of so-called functionality indicators.

The deduction and calculation of "functionality indicators" for ecosystems and landscapes has been intensified in the research project "Macro Indicators on the state of the environment" that has been named previously (STABA et al. 2002). On the basis of ecosystem theories, a set of eight functionality indicators has been selected that relate to the indicandum "provision for long-dated dangers within the man-environment relationship". As indicands measured or calculated values for emergent ecosystem properties have been used, that are significant for the ecosystem's ability for self organization (BARKMANN et al. 2001a und 2001b, BAUMANN 2001, STABA et al. 2002). Using ecological thermodynamics, high-quality energy (exergy) that has been taken in by the system, and energy that cannot be disposed and that has been emitted (entropy), is identified as characteristic parameters. The indicators "biodiversity" and "abiotic heterogenity" have been derived from the issue of organization/complexity. As material basis of system development, the storage capacity as well as the loss of nutrients are indexed. Finally, the biotic use of water and the metabolic efficiency are selected as representatives of ecophysiological measure for efficiency.

As a result of the questionnaire the following ecosystem research projects have been pointed out due to their relevant contributions to the indicator discussion:

Within the context of ecosystem research in the Everglades, specifically indicators with regard to hydrology and water quality have been identified.

The German forest ecosystem research has worked out indicators on the matter export by leaching.

Within the ICP, indicators for sustainable forestry have been developed.

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[24] Therefore it has to be remarked that the use of indicators never can replace a qualified environmental observation, that usually also uses a lot of parameters.

[25] **Key indicators or headline indicators** are indicators that have been selected from several alternatives as representative and as key function for a certain issue. The indicator "life expectancy" can be used as suitable key indicator for the more complex indicandum "human health". Key indicators do not always have to be aggregated indicators, but they have, due to their high explanatory power, deliberately been emphasized (STABA et al. 2002).
(Highly) aggregated indicators are indicators that are factually and/or spatially highly aggregated and thus characterize a complex indicandum. They are aggregated from a multitude of single data and are an alternative to the key indicators that are not or only little aggregated (f.i. the sum of green house gases, measured in CO_2-equivalents), (STABA et al. 2002).
For the characterization of the green house problem it is f.i. possible to build an aggregated indicator by aggregating the emissions of different green house gases on the basis of their global warming potentials. CO_2-emissions can be equally selected as key indicator, because they currently are the preponderant part of the green house emissions.

The treeline as a complex indicator for climate changes has been intensely discussed within IBP and NSSE.

Moreover, it is referred to the discussion on agricultural indicators that has also been strongly influenced by ecosystem research..

4.6 Impulses from ecosystem research for environmental education and public relations

Environmental education and public relations occur on several levels, that will be treated in the following two subchapters. Chapter 4.6.1 deals with the “classical“ environmental education and public relations, which are designed for perception. Beyond this, German ecosystem research does – via the participating universities - make a major contribution to the ”academic“ environmental education (see chapter 4.6.2). The education of system oriented subjects in environmental sciences serves both the education and recruiting of new academic staff for ecosystem research and neighbouring disciplines and the teaching of suitable ecosystem knowledge to students, that are going to hold responsible positions in environmental practice and politics.

4.6.1 Environmental education and public relations

Education, as it is assigned to ecosystem research, can relate to motivational factors of environmental awareness or to cognitive aspects. In particular the contribution, that ecosystem research makes to stimulate the awareness of environmental problems in public, has to be pointed out. Ecosystem research is able to show in which way man depends from the benefits and offers of his natural environment, respectively, which ecological conditions are relevant for the capability of the nature budget (FBE 2002). Even if a strengthened environmental awareness of the population only is one precondition for environmentally conscious actions and efficient environmental politics, it is an eminently necessary condition.

Ecosystem research ought not to trust in the public and in political decision-makers when it comes to the acknowledgement of system environmental research at the levels of ecosystems and ecosystem complexes as important societal support. For this reason, public relations are needed. It is in the own interest of ecosystem research to strengthen its societal and political acceptance and relevance for all target groups using a preferably transparent presentation and a consistent flow of information on its results. It is going to depend on public relations, if financial means are going to be made available in the future (ibid.).

Ecosystem research is a suitable field of study and training for the promotion of a system way of thinking – i.e., to think in categories of relationships, interactive effects and reactions[26] – because ecosystem research and the understanding of it principally demands a combination of entirely different abilities and skills. This does not only refer to the promotion of students and scientists, but also to the forming of these abilities on all levels of society (ibid.).

If it has not been possible to realize the connection between ecosystem research, environmental education and public relations in the past, this has been the result of (among others) the following aspects (ibid.)

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[26] Almost all conceptions on environmental education or on education in promotion of sustainable development include the formulation of respective goals (f.i. DEHANN & HARRENBERG 1999, REIßMANN 2001).

- In spite of the complexity of global environmental problems, the importance of environmental issues in public has decreased in the previous years, which is reflected in a decreasing political interest in environmental issues, too. Moreover, the readiness for the reception of environmental problems and the demand for sustainable solutions – more than any other topic – depends on the political framework. This makes it more complicated to ensure a continuous education and public relations. It can be taken as a matter of fact that, apart from this, public relations - that over a period of several years have been carried out inadequately and not very differentiated, often reducing scientific statements to the prognosis of possible catastrophes - have done much damage to the reputation of environmental research and the acceptance of scientifically founded recommendations.

- There generally is a lack of personnel and financial resources for a qualified education and PR, as these are not explicitly budgeted in research programs.

  In the case of the ecosystem research on the Schleswig-Holstein Wadden sea, press relations, training and presentations had to be financed from own resources of the Nationalpark Schleswig-Holstein Wadden Sea.

- The researchers usually lack commitment to PR and educational work, as well as advanced training. They are generally confronted with the problem to accomplish demanding research and simultaneously to prepare the results in a way that they can be understood by the general public. For the latter, there usually are no additional resources available, and so far these tasks have offered little reward.

In spite of the named difficulties there are multiple positive examples for successful public relations and education to be named. The dominating forms of public relations and educational work are among others (f.i. FBE 2002):

- the production of brochures and their distribution to public authorities, teachers' s training seminars etc (f.i. German research projects on the wadden sea);

- internet presentations (as f.i. for the ICP or the BITÖK; in the third phase of Lake Bornhöved District ecosystem research the subject area "Communication and Public Relations" has been established. The very successful media related public relations led to a cooperation with the Environmental Ministry of Schleswig-Holstein for the installation of the so called "InfoNet-Umwelt" – an environmental information network – which has become the state's official internet presentation of environmental information);

- presentations and discussions in newspapers, radio and television (as f.i. within the context of the LTER at the Rocky Mountains, the Göttingen/Solling forest ecosystem research and the ecosystem research on the wadden sea, KAISER et al. 2002: 160);

- organization of guided tours on the research grounds: the target group is not primarily researchers, but also staff from public authorities (f.i. the Schleswig-Holstein WET projects), schools (f.i. the project on Lake Constance / SFB 248 of the DFG on the material budget of Lake Constance) and relevant users (f.i. FAM);

- information and training for multipliers (f.i. within ecosystem research on the wadden sea the project's goals and contents have been discussed with the wadden sea tourist guides on location, KAISER et al. 2002: 160);

- installation of nature trails (f.i. at the Hohe Tauern Nationalpark) presentation of glaciological research results at the University of Innsbruck and expositions (f.i. “Wadden Sea and More“ within the scope of the Lower Saxony Wadden Sea ecosystem research, KAISER et al. 2002: 161);
- organization of discussion forums with political actors (within the FAM project such discussion forums have taken place f.i. in cooperation with the National Farmer’s Union as well as with local and state politicians);
- organization of scientific conferences, workshops and seminars (f.i. accompanying the IBP as well as the NSSE and HIBECO; within the Schleswig-Holstein WET project seminars have been held at the Academy for Environment, that have been well attended);
- organization of open-days (within this context, the FAM project has welcomed about 30.000 visitors so far);
- elaboration of subject units for students and for teacher’s training seminars (within the FAM project, about 1.600 students and approximately 100 teachers have participated during one summer term, within the project of the University of Jena “Biodiversity and ecosystem functions of farmed grasslands“ films have been produced for the use in schools; the Kiel Ecology Center cooperates with the Schleswig-Holstein BLK 21 program on education for a sustainable development concerning the issue of evaluation and indicators).

In most of the above named projects, public relations and education is restricted to single, temporally limited actions, though, and there is no long-term oriented strategy for education and information. As outstanding German exceptions can be named the FAM project and the MAB 6 research in Berchtesgaden. Within the frame of these programs, it was able to realize educational and PUBLIC RELATIONS activities on a larger scale, including in part independently acting groups that were responsible for specific tasks. Theoretical impulses have come from the Lake Bornhöved District ecosystem research project: within the context of the interdisciplinary and transdisciplinary research, target group analyses have been made and didactic considerations on the selection of issues and on the presentation of the results have been undertaken.

Another positive example at international level is the ecosystem research on the Everglades. Parallel to research from the South Florida Water Management, educational programs on a use of water that is environmentally acceptable have been carried out with the media reporting on these programs (ibid.).

The conditions for effective educational and public relations activities currently are as fortunate as ever, because of the IT methods that are available today (FBE 2002). Especially with concern to the visualization of complex system reactions, IT can – as a combination of real observational data and simulation experiments – provide for valuable support.

> *The Environmental Atlas on the Wadden Sea, that has come out in two volumes, is a positive example for the use of IT methods and the popular scientific presentation of complex project issues (FBE 2002, KAISER et al. 2002: 161).*

In spite of all the technical “seductions“, environment related educational and PUBLIC RELATIONS activities are only successful if the “direct, sensual experience“ (FBE 2002) as well as the insight into societal and individual possibilities for action are acknowledged to be of the same relevance than the cognitive aspects. Empirical results from research on environmental education point to the fact that unilaterally scientifically oriented educational measures can lead to an undesirable “objectivistic“ narrowing of the engagement in environmental systems (cf. BÖGEHOLZ 2001). Especially for this rather “sensual“ educational work, ecosystem research is demanded to search for suitable coalitions with other scientific disciplines.

4.6.2 Academic environmental education

The crucial preconditions for a successful academic environmental education are above all (FBE 2002):

- the promotion of the cooperation between the different disciplines of natural sciences,
- the strengthening of the relevance of systems analysis and environmental informatics,
- the organization of the cooperation between ecological-scientific disciplines on the one hand and of economical and societal disciplines on the other hand,
- the preparation of real case studies as starting-points for a transdisciplinary linking of ecosystem research and teachings, and
- the training of ecological evaluation and assessment skills.

With concern to all the above named aspects, direct coherences between ecosystem research and educational work exist. On the one hand, ecosystem research can stimulate the work at the universities and set a good example. On the other hand, it profits from personnel that is educated accordingly.

There is a consensus on the fact, that the cooperation between different scientific disciplines will be continued to be promoted (FBE 2002). While the cooperation in multi- and interdisciplinary research communities within or between universities is said to be far developed and well functioning, there are still great deficits within teaching. A possible starting-point for the promotion of cooperative work between different scientific disciplines within teaching could be (ibid.):

- subject spanning courses, possibly at subject spanning institutions (“centers“),
- the overcoming of traditional subject structures and the introduction of a real subject “environmental sciences“ within which the disciplines geography, geology, biology, zoology, botany etc. would be brought together,
- the stimulation of the teaching staff’s integrative abilities,
- a stronger concentration of financial support on projects that promote this integration (consistent, “performance related apportionment of funds“).

Furthermore, an important precondition is seen in an improved professional qualification, especially with concern to the “tough“ natural sciences (especially physics and chemistry) and mathematics. Currently, universities suffer from a lack of students, that are sufficiently high-performing and motivated to get involved in integrative projects and to campaign for a more integrative teaching. Thus, academic schooling remains a (sectoral) basic education in a lot of cases; in the beginning, there are relatively low standards, so that there are only few opportunities to advance to a level of more integrative approaches (FBE 2002).

Systems analysis and environmental informatics have, throughout the survey, been said to be of great importance for the academic education. While knowledge about systems analysis is crucial for a university career - f.i. for the work on theoretical approaches - profound knowledge in environmental informatics – i.e. GIS techniques, statistical evaluation programs and basic programming skills – is an important precondition for the graduates that need to assert themselves on the job market outside universities. But education within the area of systems analysis and environmental informatics is still neglected, especially outside scientific faculties. Reasons for this are, among others, the too low qualification of the students in mathematics. A consequence is, that university education often is exposed to a multitude of very high demands that cannot be fulfilled. In a lot of cases, the more demanding courses can only be carried out in small groups. Generally, the students are very motivated, though. (FBE 2002).

The promotion of cooperation between ecological-scientific as well as economic-social disciplines within academic education is also seen as desirable. It is a great challenge, though, as comparable research cooperation has not been implemented continuously satisfactory (FBE 2002). Starting-points for an improvement of the situation are especially

- the realization of joint projects and seminars by working on concrete, application-oriented questions,
- the organization of subject spanning conferences and colloquiums (even exceeding single universities, in Germany f.i. promoted by DFG, DBU and DAAD).

Principally, it has been regarded as motivating for the students – parallel to a well-funded scientific education - to work on real case studies (f.i. within landscape planning)

> *An internationally very appreciated example of a respective case study based course, focusing on an interdisciplinary environmental science, is the Section for Environment and Social sciences at the Zurich ETH (SCHOLZ & TIETJE 2002).*

The training of ecological evaluation and assessment skills has been regarded as another component of a successful academic environmental education (FBE 2002). But the normative basics of assessment and decisions on the part of the environmental sciences or politics, the techniques of assessment procedures, that are reasonable due to objectives and resources, as well as the basics of decision theory have hardly been part of the teachings so far. For, sufficiently reflective working within the application-oriented fields of ecosystem research, lacking clear legal foundations, basic training in evaluation and assessment is essential. Instead, teaching is almost exclusively targeted to the mediation of knowledge and expertise within the methodological-technical area. Also for the researchers, that are concentrating on basic research, respective skills are useful. These skills enable them to assess the effects of their own statements in coherences that are similar to application.

By setting the focal point of education on the area of evaluation and assessment skills, it is intended to show how the descriptive discipline ecology manages to handle normative problems scientifically correctly. The main target direction normally is going to be the generation and preparation of ecosystem knowledge for societal decision-making processes, in such a way that it is traceable, without false conclusions and oriented on the decision-makers‘ demands for information (cf. BARKMANN 2002). If knowledge is to be brought into target orientation and assessment processes with concern to nature conservation and environmental politics, expertise on relevant legal norms is needed. There are, in fact, courses, f.i. on decision theory, scheduled at many universities, but there is a lack of approaches that use the specific strengths of ecosystem research. Among other explanations for this development, the change concerning the understanding of planning, can be named. Expert planning is more and more avoided, instead there is a tendency to turn to a cooperative, participative planning as well as to strengthen the informal planning instruments in comparison with the formal planning instruments (FBE 2002).

4.7 Impulses for “ecosystem management“

The previous chapters have discussed the influences of ecosystem research on environmental politics and planning. In the following, superior guiding principles for ecosystem management are to be outlined. The presented approaches and guiding principles have in common, that their development has been significantly influenced by ecosystem research results. Furthermore, the approaches are closely linked with the debate on sustainability.

4.7.1 The ecosystem approach of the Convention on Biodiversity

The “ecosystem approach“ developed from the SBSTTA Paris recommendations (Subsidiary Body on Scientific Technical and Technological Advice, 1995) on the promotion of holistic approaches for the protection and sustainable use of biodiversity, and it became the basic framework for the implementation of the Convention on Biodiversity (CBD). Pathbreaking results have been achieved in the following years on the IUCN’s international workshops in London (Sibthrop 1996) and in Malawi (hosted by the governments of Malawi and the Netherlands as well as the CGD office in 1998). On the occasion of the 5th Conference of the Parties (COP) 2000 that has taken place in Nairobi, the ecosystem approach has officially been decided upon (the V/6 decision). Central directives for the implementation of the CBD can be taken from the ecosystem approach that is based on the 12 so-called Malawi Principles.[27]

Important features of the CBD ecosystem approach have been influenced by ecosystem research. Thus, an adjusted management is demanded, that embraces the complexity and dynamics of ecosystems and, moreover, takes the incompleteness of our knowledge on ecosystems and their functioning into consideration (KORN 2002, see “materials“ 8). Within the discussion on the Malawi Principles, the following general directives on protection and sustainable use of biodiversity have been worked out, that can directly be connected with the ecosystem way of thinking (OESCHGER 2000):

- A key component of the ecosystem approach comprises the conservation of ecosystem structures and functions (5th principle). Ecosystems have to be managed with regard to their functionability (6th principle).
  The ecosystem approach aims at a conservation of biological diversity as a critical component of ecosystem protection from excessive disturbances. The maintenance of ecosystem functions and the conservation of ecological integrity are aspired. Ecosystems are temporally and spatially dynamic, but their resilience is limited. These limits have to be defined in order to be able to create human use in a sustainable manner.

- Ecosystem managers are to pay attention to the (actual and potential) effects that their activities have on neighboring and other ecosystem (3rd principle). The ecosystems that we define mentally, are no closed systems. They overlap, intertwine and interact with each other. The approach requires a broad perspective and the awareness that complexity and functioning of a certain ecosystem are strongly influenced by neighboring systems.

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[27] http://www.biodiv-chm.de/Info-Texte/%D6ko-Ansatz.html

- Ecosystem management has to act on the assumption, that changes cannot be stopped from occuring (9th principle).
  The ecosystem approach acknowledges, that social and cultural factors influence the use of resources over time, and that they change. Ecosystems have always several potential possibilities for development, that cannot be clearly defined. Management therefore has to be flexible and adaptable.
- The ecosystem approach has to attune management to the respective spatial-temporal scales.
  A clear identification of the suitable spatial and temporal is vital for the success of the ecosystem approach. Governmental organs, NGO's and local communities have to co-operate profitably when determining the different working levels of ecosystem management. In addition to the ecological, economic, social and political aspects of the respective management areas, the framework of international politics and extern environmental influences has to be considered duly.
- As a result of the ecosystem processes' overlapping temporal magnitudes (due to often delayed reactions), the targets of ecosystem management should be set on a long-term basis (8th principle).
  Ecosystems are characterized by a multitude of temporally overlapping processes. In addition, reactions occur with temporal delay, f.i. due to the gradual exhaustion of the buffering capacities. These patterns of reactions are in conflict with the human tendency to attach more importance to short-term profits and immediate values than to future values.

The debate on the ecosystem approach that in the beginning has been very theoretical, soon led to the awareness, that there is a need for practical examples in order to concretize and to design the concept (Trondheim 1999, Pathfinder Workshops in South Africa, South America and South East Asia in 2000, MALTBY: "moving the ecosystem approach from principles to practice").

OESCHGER (2000) has carried out a case study for the implementation of the CBD ecosystem approach to the ecosystem research on the wadden sea. The result of the study was, that an implementation of all 12 principles basically had taken place (see summary of the results, "materials" 11). The study has also given prove to the fact, that a close cooperation between research and management is possible.

4.7.2 The guiding principle "ecosystem health"

Another guiding principle for ecosystem management, that fundamentally builds on results from ecosystem research, is the concept of "ecosystem health". It has been developed during the course of the debate on sustainability in the USA. NORTON (1993) names the following basics of the concept:

1. Nature is less an arrangement of objects, than a structure of processes, that dynamically conserve all ecosystem properties with which ecosystems develop and age. The ecosystem dynamics has to be a crucial criterion for the evaluation of the ecosystem state.
2. All processes are linked with all processes. Indirect connections are more frequent than direct. For concepts on environmental indication it has to be noted, that interactions within ecosystems are of significant relevance.

3. Ecosystem processes occur at different scales. Thus, for an evaluation of the ecosystem state, coacting different spatial-temporal hierarchic stages have to be assumed to exist (cf. MÜLLER 1992).
4. Ecosystem processes are creative. The ecosystem energy flows allow for a self-organized development. A crucial characteristic of living systems is their ability for self-organization. Thus, for indicator problems it is important to comprehend the respective system state's potential for self-organization.
5. Ecosystems are differing due to their sensitivity and resilience. Not only the different capabilities of their single parts, but also their coacting with regard to resilience should be taken into consideration on a system level, when measures for an environmental management are conceptualized.

Based on these fundamentals, different approaches for a definition of the “ecosystem health” concept exist. HASKELL et al. (1993) find an ecosystem to be “healthy”, “if it is stabile and sustainable, if it is active and keeps its organization and autonomy and if it is resilient to stress.” ULANOWICZ (1993) on the other hand describes a “healthy” ecosystem as follows: ”An ecosystem can be characterized as healthy if its trajectory is insensitive towards climax and that it reacts resiliently to influences that would throw back the system to an earlier stage of succession.” COSTANZA (1993) pictures “ecosystem health“ as “property, that consists of the components vigor, organization and resilience.” According to KAY (1993), “ecosystem health“ is “the ability of ecosystems to sustain their optimal state at regular environmental conditions.“

Thus, “health“ can be defined and evaluated from different points of view. A healthy system can be understood as dynamic system, that diverges only little from its dynamic equilibrium. “Health” can also be seen from the perspective of structure conservation as a measure for stability and resilience, or it is defined as absence of illness.

The guiding principle of “ecosystem health“ is intensely debated among scientists. But a concept, that can be operationalized, is still missing.

4.7.3 The guiding principle “ecological integrity“

The “integrity” (“ecosystem/ecological integrity“) of ecological systems is actively disputed on the international level, while the German debate on environment and nature conservation hardly notices that. Meanwhile, references can be found in almost all international documents, that deal with the description and with the objectives of biological environmental conservation (see Brundtland report, Rio-Declaration and Agenda 21, cf. BARKMANN et al. 2001a).

The origins of the term can be dated back to the 1940s. Aldo Leopold, precursor of the US-American ecologically oriented nature conservation movement, understood “integrity” in a very common way as “intactness” of ecological systems, that are of crucial relevance for the stability of the “biotic community”. Taking an organism view on ecological systems, Leopold equated their “functional integrity” with their “health” (LEOPOLD 1991 in BARKMANN et al. 2001a: 97). The term “integrity” was established once more by being adopted into the completion of the “Clean Water Acts”, that have been part of the US-American legislation in 1972 (serving the protection of “biological integrity” of US-American waterbodies). This was not a practicable definition, either. Starting in 1980, ecologically specified suggestions for the operationalization of biological integrity have been presented. Thus, KARR & DUDLEY (1981) define ecological integrity as "the ability of an ecological system, to build and sustain a balanced, integrated and adjustable community of organisms as well as an organization that is natural and regionally typical." Subsequently, this term is more and more often included in further national and international regulations on ecosystem protection (BARKMANN et al. 2001a). But yet today there is no consensus on the definition of the term (see also KAY 1993 and WOODLEY et al. 1993). In addition to an approach, that builds on the structural properties of ecological systems, several authors are favoring a linking of the integrity term with the "ecosystem's ability for self-organization".

Thus, the "Kiel interpretation" of ecological integrity stresses – with regard to risks of environmental use, that are not known or not explicable[28] yet and within the framework of sustainable landscape management - the necessity, to strengthen those properties of ecosystems, that make them most resistant to unknown dangers:

"Ecological integrity is a guiding principle for precaution of unspecific ecological dangers within the context of sustainable development. It has the objective to permanently sustain the nature budget's capability as a natural basis for life by protecting those ecosystem processes and structures, that build the preconditions for the self-organizing ability of ecosystems" (BARKMANN et al. 2001a: 99). For the operationalization of the integrity concept, eight indicators have been suggested, that can be used for a quantification of the self-organizing ability, assumed the respective data are available, (cf. functionality indicators, chapter 4.5.2).

4.8 Summarizing evaluation

As ecosystem research has developed, Knowledge on the ecology of systems, populations and organisms has extended. Today, knowledge on f.i. the systems' reactions to risen SO^4 concentrations or increased nitrogen input is widely spread. At last, a great amount of data on the most different ecosystems in the whole world has been produced over many years (WS 2002), even if the basic decoding of ecosystem structures, functions and processes have not been able to succeed in each single case. A lot of complex approaches from ecosystem research are still waiting for a more intense and systematic evaluation, and especially from a habitat spanning interpretation, interesting results can be expected.

In a critical debate and evaluation of the ecosystem research on the wadden sea, KAISER et al. (2002) have reasoned, that such a decoding could not be realized in a comprehensive way for the wadden sea. In fact, the initially broad objective has been narrowed to the research on "researchable problems" (REISE 1997 in KAISER et al. 2002: 125).

The use of ecosystems (both their products and the technologies for their management) has, along with the increasing knowledge on ecosystems, fundamentally changed in a lot of areas. Ecosystem research was able to acquire and to proliferate knowledge on the economic and social consequences, that are connected with changes in ecosystems (f.i. changes of systems' productivity or damage to human health, WS 2002).

Ecosystem research has led to a large enhancement of the methodological standards within research, as well. Especially the consideration of human activities for the formulation of research problems have – on the basis of scientific-ecosystem facts - brought new demands and perceptions (WS 2002).

[28] The term implies, that neither specific causes nor specifically endangered elements can be identified.

Basically, ecosystem approach has influenced ecological and environment related fundamental research and research in such a way, that it has led to a combination of bio- and geosciences within the area of research. Since then, ecology (and especially systems ecology) has not only been understood as a part of biology, but as a holistic science, within which the different disciplines come into a productive competition and are able to achieve synergistic results. Interdisciplinarity has been realized in ecosystem research, but a more consequent integration of the level of awareness within social sciences and engineering, i.e. an even more consequent implementation of the interdisciplinarity concept is desired. Besides experiments, models have made an important contribution to the promotion of communication between the participating disciplines (WS 2002).

System theoretic approaches of applied ecosystem research have the basic disadvantage that they start from a purely descriptive theory of the behavior and the control of systems. A reflection on the normative problems of applied ecosystem research – including a reflection on a scientifically suitable concept of applied ecosystem research itself – therefore cannot be derived from theory (cf. BARKMANN 2002). In application, problems often result from an insufficiently clarified normative basis of ecosystem recommendations for applications. But there are necessarily starting points for a fruitful system theoretic treatment of these problems. The target value f.i. could be set on the basis of methods that are committed to participative and discourse-oriented approaches of a deliberative democracy. On this foundation, a broadened basis for discussion, for the interdisciplinary cooperation with humanities and a transdisciplinary cooperation with citizens on location will be established.

The realization of large research projects have essentially been justified by the excess of benefits that – in comparison with the discipline designed research - can be derived from ecosystem research due to the intense communication between the single disciplines (KAISER et al. 2002 has accepted the term “special benefits“ of ecosystem research). It is difficult, though, to provide evidence for the actual production of this excess of benefits by the completed projects. Possible evaluation criteria have been debated at length by KAISER et al. (2002: 122 ff.). DASCHKEIT (1998 in KAISER et al. 2002: 124) has recorded, that an evaluation of interdisciplinary research only is possible for each specific project and that the evaluation criteria cannot be generalized. Furthermore, it has been pointed out, that such an evaluation only is possible, if the excess of benefits or the “special benefits“ and the project specific evaluation criteria have been agreed on in the beginning of the project. This has not taken place, nor in those ecosystem research projects that endeavored a critical reflection of their organization and their structure, e.g. the Solling project, the Berchtesgaden MAB 6 research and the Ecosystem Research on the Wadden Sea (f.i. ibid.: 169).

> *The interviews that had been carried out for the completion of ecosystem research on the wadden sea within the context of a critical reflection led to the result that the scientific results of the joint projects have from almost all participants been judged to be more extensive than those from the single projects. This positive evaluation has been founded on the synergistic effects between the single projects and on the interdisciplinary answering of superior questions. However, for a quantification of this success, suitable criteria are lacking (KAISER et al. 2002: 124).*

Ecosystem research claims to make contributions to a sustainable use of the ecosystems. Especially the younger German (application related) projects – as f.i. forest ecosystem research and research on the wadden sea – have succeeded in deducting statements directly relevant to practice and have provided precises recommendations for management from ecosystem research. The contributions of ecosystem research on the wadden sea have been detailed described by KAISER et al. (2002: 127 ff.) But in a lot of other projects, it has not been possible to compress the research results within the context of a comprehensive project synthesis to statements relevant to management.

The experience from the completed projects have shown that a direct use of the research results for politics, planning and management only can be guaranteed when the users - in the sense of transdisciplinarity (see chapter 4.1.) – become already during the project's execution involved with decisions on project objectives, intensifications of certain issues, methods etc. Thus, the users should not only be understood as acceptors of the research output, but their knowledge and experience within ecosystem management should be regarded as relevant input measures for research. In the past, communication problems between researchers and users often have led to a loss of empiric knowledge, that had been gained from experiences in ecosystem management (WS 2002).

5 CONCLUSIONS

5.1 Recommendations for future ecosystem research

For a forward-looking continuation of ecosystem research and for an opening up of the financial resources (see chapter 5.2), it will be necessary to develop perspectives, that are structurally and conceptionally attractive. Both, within the questionnaire and within the scope of the workshop (especially working group D, see “materials“ 8.4), these perspectives have been debated. In the following, these perspectives have compendiously been reproduced. These descriptions do not consider the advancements in ecosystem research due to the development in information techniques.

5.1.1 Recommendations for the future contents of ecosystem research

Basically, both researchers and users want a closer, interactive communication. Research activities should much more integrate the empiric knowledge from the users of landscape. This does imply a stronger orientation of ecosystem research on application-oriented issues, but it does not at all reject fundamental research. Only if it is possible to continue working on basic issues without being pressured to consider the direct possibilities for application, theoretical, so far unsolved problems can be worked at, that could open up important perspectives for application in the remote future (WS 2002).

5.1.1.1 Development of instruments and methods

With concern to the development of (application relevant and practicable) instruments, especially the following research problems should gain importance (WS 2002):

- How can the results from single case studies be transferred to other areas and to other levels of perspective? For which scale levels are we able to develop and use which kind of models? (WS 2002)

  Therefore, suitable methods for the overcoming of scale related connections between ecosystem structures and functions are needed (WS 2002). If the respective methods and instruments would be made available, especially planning and political decisions for regions with low data availability would be facilitated or founded (FBE 2002).

- How can the prognostic significance of ecosystem research be improved? (WS 2002)

  Intensified knowledge within the area of dynamic systems theory should be acquired and practicable scenario techniques should be developed.

- How can communication between different research disciplines as well between researchers and users be improved? (WS 2002)

  For this purpose, the development of integrative models as a platform for communication should be promoted.

- Which measures are suitable for a preferably simple description of ecosystem structures and functions ? (WS 2002)

  There is a need for further debates with concern to the development of relevant (also aggregated) environmental indicators.

In this connection, models are of great importance. A focus on model development should be put on the development of models that are easy to handle. Demands for the development of models would be f.i. (FBE 2002):

- the development and validation of modeling systems on different scale levels and for different problems in the area of application or of research;
- the improvement of models‘ sensitivity analysis and documentation;
- the systematic testing of existing models with regard to their forecast and accuracy field : this applies basically to all model classes, but especially for complex models that are to represent a larger number of processes; the consequences of fuzziness at the process parametrization and the environmental conditions have to be more considered and they have to be more visible;
- the creation of linking between existing (sectoral) models, f.i. in order to enable a system adequate representation of matter transport and transformation;
- the improvement of the conditions for a representation of the ecosystem's dynamic properties.

As concerns the methodology, a more experimental orientation of ecosystem research, i.e. the carrying out of “in situ“ experiments in the ecosystems has been recommended. It is hoped to derive more secure prognoses thereof (WSE 2002).

5.1.1.2 Thematic emphasis

With regard to relevant research issues and problems, the need for intensification is especially seen for the examination of:

- the relevance of (genetic) biodiversity for the long-term functioning of ecosystems (yet there are multiple questions to be clarified within the context of redundancies of ecosystems; this does especially apply to the question, to what extent the functionally related species or species groups mutually can replace each other, without that fundamental changes in functions take place) (WS 2002);
- the analysis of the generation and prognosis of extreme events that are not exclusively exogenous dependent (among others, the question, to what extent an improved assessment of risks and consequences, on the basis of a more systematic analysis of historical events, could be reached WS 2002);
- global changes with regard to the ecosystems and to the extent of regulatory functions that the ecosystems take over for the global system (f.i. the clarification of the question, which function vegetation and soils have for the global C and N cycle, to what extent they contribute to the permanent binding of climate relevant gases and which effects have to be expected for the ecosystems and – due to the climate changes and the climate extremes, WS 2002);
- interactions (among others: element and energy exchange) of different ecosystems (especially urban ecosystems and densely populated areas should be taken into the visual focus of research, KLEYER et al. 1992, WS 2002);
- limits of ecosystem use and capability (in this connection the scientifically comprehensible and normatively reflected formulation of objectives and standards for environmental

quality should be promoted; this would also include the advancement of workings on Critical Loads and Critical Levels, FBE 2002,WS 2002);

- the shifting, transformation, accumulation and deposition of substances in environmental media (as concerns Germany, a tighter connection between ecosystem research and the Environmental Speciment Bank is desired, FBE 2002);
- the risks of using new technologies (f.i. within food production, especially important is to describe the effects of the use of genetically changed organisms, but also of changes in land use, WS 2002) and for a specification of the terms “risk“ and “danger“ (FBE 2002).

A lot of the above named instruments (as f.i. the improvement of scenario techniques or techniques for the overcoming of scale jump, see chapter 5.1.1.1) and focal thematic research points (as f.i. the definition of environmental qualities and load limits) would also meet the planners’ demands for practicable methods and procedures and for a stronger connection between ecosystem research and legal, normative allegations at all levels.

Considering the demands for a stronger connection between ecological research and social sciences (see chapter 5.1.2), the following problems are to be investigated by a future ecosystem research (WS 2002):

- How highly esteemed are material ecosystem goods (f.i. fresh water from clean ground water) and ecosystem services (f.i. flood protection) by the society?
- How can communication between different groups of actors, that are influencing ecosystem structures and processes, be strengthened?
- Which ecosystem relevance do politics and programs have?
- How can the availability of decision relevant information for the societal decision making process – and thus the quality of the decision – be improved?

5.1.2 Recommendations for spatial focal points within future ecosystem research

Principally, the inclusion of further ecosystem types into ecosystem research is desired, in order to achieve a higher representativeness of the research results. While there is a multitude of surveys on ecosystems in the moderate climate zone, large deficits in knowledge and research are seen with concern to the ecosystems‘ functions in development countries or in newly industrializing countries, above all in the tropics and subtropics. In these regions, there is a blatant disproportion between the knowledge about ecosystems and the serious problems that come about with the changes in land use. This demand is especially important against the background of a stronger concentration of research to problems in connection with global changes of the biosphere (FBE 2002, see chapter 5.1.1.2).

Furthermore, it is recommended - besides the examination of single ecosystems - to pay more attention to ecosystem complexes respectively landscapes (FBE 2002).

In order to broaden knowledge on the differentiated behavior of the different ecosystems, a possibility would be, to concentrate more on the research regions than on issues (WS 2002). In this connection it would be interesting – especially from the perspective of the planners and decision-makers – to be able to dispose of a comprehensive set of freely accessible, preferably digitally available cartographies with spatially assigned, ecologically relevant data files (FBE 2002).

5.1.3 Recommendations for the future organization of ecosystem research

Organization and strategic plans for ecosystem research have been critically reflected upon in the completed projects. However, some of the results of this critique are only put into writing in publications and final reports.

> *As an exemplary exception the broad project reflection of the ecosystem research on the wadden sea has been pointed out by KAISER et al. 2002. This self-criticism is in part based on interviews, that have been carried out with members of the project direction, with project managers of subprojects, with arrangers of partial syntheses and associates working at the two participating National Park authorities in Tönning and in Wilhelmshaven..*

In a lot of cases, the main critique refers to the fact, that interdisciplinarity has not been realized to a sufficient degree (FBE 2002). Organizational and structural problems have mostly been made accountable for this deficit.

The dissatisfactory transformation of research results to application is another point of critique. Besides the demand for a stronger content-related orientation of the research workings on application relevant issues (see chapter 5.1.1), there are organizational and structural reasons why the potential of contributions from ecosystem research for the solving of tasks within planning and politics cannot be regarded as exhausted (FBE 2002).

Therefore, the following recommendations for the future organization of ecosystem research put an emphasis on the goal to create convenient preconditions for the realization of interdisciplinary working approaches (as an improvement within the science system). Apart from this, possibilities and chances for a stronger internationalization and network building have been expressed. With regard to the recommendations on the organization of different project phases within a joint project, it is referred to the detailed descriptions of KAISER et al. (2002).

5.1.3.1 Structural preconditions for a successful interdisciplinarity

The structural advancement of interdisciplinary research approaches still is an urgent need. Due to the demands to ecosystem research, the necessary conditions for advancement are that interdisciplinarity is not just understood as a coalition within natural sciences, but as a further opening of ecosystem research towards social sciences (DASCHKEIT 1998, WS 2002).

Preconditions for successful interdisciplinarity in ecosystem research are[29]:

- project management has to become more professional and more streamlined, as the moderation and communication efforts for the implementation of integrative ecosystem research projects have been underestimated in the past [30]: Project management – f.i. a steering committee[31] - has to succeed in focusing the single working groups more to the joint project objective, to understand the scientific approaches that have been developed

[29] For further reading it is referred to f.i. the workings of BALSINGER et al. 1996, FRÄNZLE & DASCHKEIT 1997, DASCHKEIT & SCHRÖDER 1998 as well as JAEGER & SCHERINGER 1998 (all cited in KAISER et al. 2002 : 116).

[30] KERNER et al. 1991 estimate the effort for coordination and information exchange to about 10% of the working capacity. DATSCHKEIT (1998 in KAISER et al. 2002 : 155) estimates the effort for interdisciplinary working steps to 20% of the entire working time that is reserved for the project.

[31] KAISER et al. (2002) recommend a steering committee of at least five members : two scientists, one colleague for PR, one for the organizational cooperation and one responsible for office work.

by the different working groups, their efforts and their statements and to integrate them into the context of the joint project. For this purpose, the project direction should possess competencies in the different disciplines without working highly specialized itself. The project direction ought to be trained specifically for these tasks, i.e. the profession "project manager for interdisciplinary environmental research" should be established. Eventually, a joint project poses the same demands to competency than a business that has to coordinate different working groups in order to make them work for the common business objective. A good project coordination ought to be reflected in the creation of synthesis reports that have been designed commensurate to integration (FBE 2002, WS 2002);

- project management/the steering committee needs broader and more precise competencies (among others, KAISER et al. 2002): Project management should view itself as a service provider for the project and (in project applications, as well) should have accurately described tasks and competencies, for which the respective project resources will be secured. For this purpose, there should be a central administration for financial resources and for the administration of jobs within the project. Project management ought to see itself as the organizer of the whole project, that brings the different parts of the project into line, and it should be respected by the participants in this function. It should be possible for the management to sanction disciplinary attempts of participants to "outly" the joint project, and it should also be able to repel influences from the financial backers that are contrary to the project's objective (FBE 2002);
- the creation of attractive positions in ecosystem research: If employees that are talented and dedicated to their job are wished to be won for ecosystem research, and if interdisciplinarity and team spirit is to be strengthened in ecosystem research, the acknowledgement of single and group efforts has to be more balanced. This implies an adequate acknowledgement of integrative and interdisciplinary efforts that have been achieved for the team and for the common project goal. Efforts have to enable progress in career (FBE 2002, WS 2002);
- the creation of suitable preconditions for the employment of project experienced staff in ecosystem research projects: at the moment, an optimization of structures and strategies especially at German universities is restrained. As a consequence of the changed University Framework Act, it is feared, that it will hardly be possible to hire project experienced staff for a goal-oriented and professional management or for a consistent and competent project processing. Due to the fact that occupation is limited to a maximum of 12 years, universities lose these personnel resources (FBE 2002);
- a consequent broadening of interdisciplinarity exceeding the natural sciences, i.e. the search for specific cooperation, also with social sciences, economics and humanities, and an increased consideration of social and economic components, which determine the development of ecosystems (FBE 2002);
- a clear and concerted project presentation (within application and reporting procedures as well as within educational work and PUBLIC RELATIONS): This could be supported by f.i. the establishment of coordinating working groups or committees (FBE 2002).

Problems with interdisciplinarity are also ascribed to the fact , that it is a very demanding goal, especially in large projects, to time the multiple single projects in such a way, that a mutual stimulation is possible (KAISER et al. 2002). For this purpose, a very differentiated estimation of the time need would be required for each subproject (a simultaneous start of all projects usually is not reasonable, due to the different time need for the development of methods, instruments and models) as well as a close coordination of the projects and the building up of a GIS and the integrative models.

Firstly the creation of concrete integrative elements is considered to be an efficient support of the interdisciplinary work. This can imply f.i. (FBE 2002, KAISER et al. 2002):

- joint basic hypotheses and questions on the conceptual orientation of the different project contributions (f.i. HABER 2002);
- jointly used working resources, methods and strategies as well as a joint data structure and compatibility that has been determined at the beginning and that enables an integrative combination of data from the different working groups, joint spatial relations, concerted measuring campaigns and/or joint strategies of data evaluation, f.i. in the form of special evaluation projects. Their most stringent expression can be the build-up of hierarchically structured modeling systems. Within complex projects, modeling systems can often be the only efficient tool for an integration of knowledge, ideas and data and for the finding of a joint communicative medium. Models cannot be developed without the combination of expert knowledge from different disciplines. They support the sector spanning evaluation of measuring data and the creation of a synoptic project result[32];

  Positive experiences with the use of models as integrative tools have been made in the following research projects (KAISER et al. 2002):

  Within the Solling project, "word models" (graphic representations and textual overviews) have been developed by representatives of the different disciplines for the analysis of complex coherences, so that cross connections could be found and it could be worked towards a synthesis (ELLENBERG et al. 1986).

  The concept model, that has been worked out in the frame of the MAB 6 project also had an important integrative function, even if at that point of time the originally aspired mathematical ecosystem model had not been developed yet (KERNER et al. 1991).

  Within the Lake Bornhöved District ecosystem research project, it was managed to combine the different models on the water, element and energy budget, that had been developed in the first project phase, to one workable overall model (WASMOD/STOMOD).

  A comparable integrative function had the models that had been used by BITÖK and FAM (GOLLAN & HEINDL 1997 as well as HANTSCHEL et al. 1997 in KAISER et al. 2002: 127).

  GIS have proven to be an effective integrative tool within the Berchtegaden MAB 6 research. GIS included the so-called "real land use types" with the accompanying "property files" (KERNER et al. 1991, HABER 2002). On the other hand, GIS had not been able to share out their integrative effect in such a high degree, because it had started to be built up only at the end of the project (KAISER et al. 2002: 152, 168, 172).

- joint results in the form of a high class project synthesis report and joint publications of the project participants from different working groups.

On the other hand, a good and intense communication between the researchers substantially serves the goal of interdisciplinarity. This can be promoted by (FBE 2002):

[32] KAISER et al. (2002) points to the fact that models can only be effective tools for integration, if the modeler is not isolated from the other project workers and if the workers become actively included into the modeling activities, if necessary, by training them accordingly. Their participation should never be restricted to the delivering of data for the model validation.

- a joint placement of the project participants, f.i. at a project center or an institute, (as has been the case with BITÖK or the Kiel Ecology Center, see also KAISER et al. 2002),
- the consequent use of intra- and internet as information platforms between the working groups,
- the regular publication of a newsletter for a continuous updating of the project participants' state of information on problems and progresses of the other working groups and
- communication on a regular basis (department spanning dialogue on the object of examination, joint workshops or conferences for conceptual and technical consultations).

Technology, especially information technology offer great chances for ecosystem research. In order to be able to tap the full potential for ecosystem research, a stronger integration of information sciences into the research activities is needed (WS 2002).

5.1.3.2 Organizational and structural preconditions for an effective knowledge transfer from ecosystem research to application

Besides that ecosystem research concerning application relevant issues needs to orient itself more on the contents, also organizational and structural reforms are needed for a knowledge exchange between researchers and applicators. In this connection, ZÖLITZ-MÖLLER (1994) names the term "common market", where supply and demand can adjust themselves to each other (see chapter 4.4.4)[33]. That such an exchange is left to the chance – relying on personal contacts, as it is practiced at the moment - cannot be regarded a future-oriented solution.

For the building up of such a "common market", the following organizational and structural suggestions are made:

- A more consequent research orientation on application can be achieved by integrating the potential users of the research results into the project conception and implementation (WS 2002), i.e. the promotion of transdisciplinarity:

  The integration of the potential users should be carried out already during the project's conception phase. Part of this phase ought to be a consequently conducted discussion about target groups, that enables researchers and users to present their ideas about the contents of the project and about its process and thus to influence the project design (ibid.).

  As a positive example of such an early combination of the researchers' and the users' interests the ecosystem research on the Wadden Sea can be named (especially the Schleswig-Holstein Wadden Sea). Within the scope of this research project, a good cooperation between research centres and national park has been achieved, that has had extremely positive effects on the application of the research results (see also "materials" 10, chapter 10.2.1).

  For a goal-oriented cooperation during the project duration several forms of organization can be thought of. They reach from a contractual safeguarding of an institutional cooperation to the offer of interactive scenarios on the internet, with the users helping to shape their conditions and evaluating their results (FBE 2002).

  The ongoing cooperation of the Kiel Ecology Centre with the Schleswig-Holstein State Office for Nature and Environment is an example for such an institutional cooperation. Thus, the administra-

[33] A similar formulation is used by FRÄNZLE & DASCHKEIT (1997 in KAISER et al. 2002: 134) : "Science is a discipline which services are bargained for as for as a good or as for other services on the markets."

tion is enabled to bring their research problems actively into the research centre's task schedule and the research centre, that has – among other functions – the role of the service provider for the administration, thus receives specific research assignments and is enabled to help design demanding conceptual tasks within the administration.

- The transformation of research results to application can be facilitated by the creation of conceptional bridges (WS 2002):

  "Conceptional bridges" that help transfer the research results into an applicable form are needed in order to make the research results usable for application. Examples for such a kind of bridges can be (WS 2002):

  - indicators that can facilitate the analysis and evaluation of environmental changes and the mediation of results in a synthesized form, both in planning and in the areas of environmental observation and environmental reporting,
  - practicable planning methods as f.i. effect models, landscape potential analyses and methods for the description and evaluation of interactive effects,
  - measuring procedures, that can be used in the every day business of environmental observation,
  - or finally also a consequently persecuted systematic archive data back-up which secures the accessibility of data from research for the users.

  As an example for such a systematic data back-up, the Central Archive for Empirical Social Research of the Cologne Society for Social Research, that had been established in 1987 at the University of Cologne, can be named. The central archive files primary information (data questionnaires, results from empirical studies etc) with the aim to make them accessible for an interested public and for further processing[34].

- Facilitation of knowledge transfer by means of a commonly understandable synthesis (FBE 2002):

  Independently from the creation of the above named "conceptual bridges", a commonly understandable synthesis of research results should be seen as a consolidated part of the research instructions and calculations. This synthesis should not depend on which person subgroup is most capable of carrying out such "transferring activities" (HINRICHS 1994 in KAISER et al. 2002: 135, WS 2002)[35]. Such a project synthesis finally serves the aim to discipline all research participants for the joint achievement of the project result (FBE 2002).

  If the implementation of the synthesis is not taken care of during the phase of application, there is the risk for a neglect of this implementation due to a lack of time and resources. Thus, in the case of the Solling project a synthesis succeeded to be carried out only 13 years after the project's finishing. The FAM, on the other hand, is a positive example for a synthesis preparation as a consolidated part of the project, which has been considered already during the planning of a large joint project (KAISER et al. 2002: 141). In this connection, it has also to be referred to the comprehensive synthesis process within the ecosystem research project on the wadden sea (STOCK et al. 1996, ZENTRUM FÜR FLACHMEER, KÜSTEN- UND MEERES- UMWELTFORSCHUNG E. V. & FORSCHUNGSZENTRUM TERRAMARE 2001, KAISER et al. 2002).

  In spite of the demanded relation to application, it should be made possible to present the scientific results and recommendations independently from political, societal and eco-

[34] http://www.ifdo.org/org-archives/archivs/de_za.htm

[35] KAISER et al. (2002 : 137 ff. and 176 ff.) have – based on experiences from a project synthesis for the ecosystem research on the wadden sea - formulated differentiated recommendations for the implementation of a (preferably "parallel persecuted") synthesis. These recommendations also include thoughts about a capable person subgroup and its acquired qualification.

nomic interests and thus, to preserve the independence of science (KAISER et al. 2002). Besides an overall synthesis, especially in projects with a long duration, partial syntheses as interim results could bring out applicable supplies for the user.

Moreover, the creation of a platform (f.i. a magazine) that is explicitly devoted to an exchange between ecosystem researchers and users, would be beneficial (ibid.).

5.1.3.3 Internationalization and network building

The development of ecosystem research out of the various political, societal/cultural and natural frame conditions varied between the different countries. From this variety a lot of suggestions, both due to contents and due to methods and strategies, could be exchanged. Against the background of this, a strengthening of international contacts would be desirable (FBE 2002).

Until now, German ecosystem research centers – also in consequence of the financial conditions – have acted independently from each other. For future research, an increased network building would be preferable. This could f.i. be operationalized by a German participation at the ILTER program (WS 2002). An effective, research organizing instrument for a more efficient use of financial resources for ecosystem research – these resources are limited in Germany – can be found in the consistent use of technical and scientific installations on research areas connected with the “research platform strategy” as aspired by LTER and ILTER. Since decades, ecosystem research in Hubbart Brook has set an example for this (cf. also GOLLEY 1993).

Within the course of the synopsis project it became obvious that there is a strong interest in a cooperation within the frame of the ILTER on the part of the German research institutions. Thus, as an indirect result of the present project, strong efforts for an establishment of a national network are currently made.

5.2 Recommendations for a future evaluation of ecosystem research projects

An evaluation of the several completed ecosystem research project has not been task of this R+D project. Among others, DASCHKEIT et al. (1998 in KAISER et al. 2002: 124) have pointed to the fact, that such an evaluation only is possible within the frame of the specific project on the basis of beforehand determined evaluation criteria. So far, in none of the ecosystem research projects in Germany, such a systematic self-reflection has taken place.

A catalogue of criteria, suitable for the evaluation of future interdisciplinary research projects, has been published by HÄBERLI & GROSSENBACHER (1999 in Kaiser et al. 2002: 169) on the basis of experiences in Switzerland. This catalogue could enable a – at least relatively – standardized evaluation and, if so, also a comparison of the different projects.

5.3 Recommendations for the promotion practice

The future of ecosystem research is closely linked with the provision of financial resources. In this context it will be decisive, if ecosystem research succeeds in diversifying their financing (FBE 2002). On the part of research, a more stringent orientation on application as well as an increased endeavoring for the production of applicable results, that react to demands on the part of planning, environmental observation, politics etc, could be the key component for the opening up of new financing sources.

So far, German promotion practice has been characterized by a distinct separation between basic and application-oriented research. The experience (f.i. within the Berchtesgaden MAB 6 research and the ecosystem research on the wadden sea) has shown that both research branches necessarily complete each other in a reasonable way and thus, ought to be much more linked with each other by a respective financing (f.i. KERNER et al. 1991, KAISER et al. 2000: 145). Against this background f.i. a more intense cooperation of promoting institutions, as f.i. DFG, UBA or BfN would be desirable (FBE 2002, WS 2002).

In the past, the financial conception of many ecosystem research projects, had made no or insufficient financial arrangements for services that have proven to be extremely important. For the calculation of future projects considering the demand for interdisciplinarity, orientation on application and acceptance by the public and the experiences from the past, an emphasis should be put on financial means for the following work modules respectively services (FBE 2002):

- for a competent and consequent coordination of the single working groups within trans- or interdisciplinary research projects,
- for professional educational work and public relations accompanying the research projects,
- for the preparation of research results for practical applications,
- wherever applicable, for a critical reflection of the researchers due to the performances carried out within the scope of the project.

Apart from that, a future promotion practice should to an increasing extent consider that ecosystems on the one hand are a temporally and spatially dynamic system, so that a prediction of research results is possible only in a very limited degree (WS 2002). On the other hand, interdisciplinary projects with a lot of participants remain – even with a good project planning and controlling - unpredictable, which sometimes leads to a restructuring of organization and conception during the project’s duration. This requires a higher flexibility for adjustments of the projects‘ direction (FBE 2002).

With concern to the project durations, researchers and users have different demands. Thus, ecosystem research needs – from the researchers‘ point of view continuously reliable, available financial means for a further development, especially in regard to its integrative, and thus complex and demanding assignment. Especially the interdisciplinary exchange of experiences needs time and can seldom be realized due to the ever decreasing time of project duration. Contrary to this demand, the users want more compact projects that do not take much time, so that answers to prevailing practical problems and questions can be delivered more quickly. Thus, the following strategies seem possible and reasonable (FBE 2002):

- the continuous integration of users into research work, so that even in long-term oriented projects the project’s direction can be changed short termed towards more recent problems,
- a regular transmission of intermediate results that are relevant to practice.

CONCLUSION:

Altogether, it has become clear, that a lot of impulses, that are beneficial to the scientific system and the environmental practice, have emanated from ecosystem research in the past. The effects of these impulses are often indirect and hard to quantify. But there is a multitude of positive examples to be derived from the present report.

It has also become obvious, that still very much effort has to be put into many working fields, in order to improve the incorporation of ecosystem research results into practice, and that a great potential still is awaiting its concrete implementation. Reflecting on this survey's problem – the application and applicability of ecosystem concepts and results – it can thus be recorded, that the constructive opportunities have not at all been tapped and that further initiatives could and should lead to interesting, useful and efficient results.

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ZÖLITZ-MÖLLER R. 1999: Umweltinformationssysteme, Modelle und GIS für Planung und Verwaltung? Kritische Thesen zum aktuellen Stand der Dinge. In: BLASCHKE T. (ed.): Umweltmonitoring und Umweltmodellierung – GIS und Fernerkundung als Werkzeuge einer nachhaltigen Entwicklung. H. Wichmann-Verlag, Heidelberg: 183-189.

APPENDIX 1: EXAMPLES OF THE PROJECT DATA BANK

Bily Kriz, Beskidy Mountains

Staat: Czech Republic
Institution: ILE Academy of Sciences
Finanzierung: European Union
Beginn: 1988, Dauer: 0 Jahre
Anlass:
Methoden: Tower Measurement (112m): air temperature; annual fine roots production; annual leaf litter production; bole respiration; bole temperature; canopy height; carbon dioxide concentration ; carbon dioxide flux density; CO2 storage in canopy air layer; diffuse radiation; global radiation; latent heat; leaf area index; leaf area index density; leaf dark respiration; leaf nitrogen concentration ; leaf nitrogen pool ; leaf stomatal conductance; light interception; litter leaf C/N; momentum; net radiation; pH; photosynthetic max capacity; photosynthetic photon flux density; precipitation; pressure; reflected radiation; relative humidity; retention curve field capacity; sensible heat; snow depth; soil bulk density; soil profile description ; soil temperature; soil water content; species composition; species phenology; specific leaf weight; standing leafbiomass ; stem area index; throughfall ; total soil carbon; total soil nitrogen; tree transpiration; trees age; trees density; water vapour; Water vapour concentration; Wind direction; Wind horizontal speed; wood biomass; wood increment;
Gebiet: 60 kms SSE from OSTRAVA, Rechtswert: 18° 32'28" E, Hochwert: 49° 30'17" N
Systemtyp: Wald
Schwerpunkte:
LeiterIn: Dalibor Janous
Institution: ILE Academy of Sciences
Dokumentation:
Kommunikation:
Entwicklung:
Kontaktperson: Dalibor Janous
Adresse: ILE Academy of Sciences, Porici 3 b, 603 00 Brno, Czech Republic
Internet: http://www.bgc-jena.mpg.de/public/carboeur/sites/index_ind.html, **E-mail:** ejanous@brno.cas.cz
Literatur: None
Anmerkungen: Coniferous Forest (planted) age 20 years Participant in Carboeuroflux

Kennung: KW69, **Literaturliste des Projekts**

Comprehensive Evaluation of Carbon Dioxide Budget for the Deciduous Broadleaved Forest in Cool-Temperate zone of Northern Japan, etc.

Staat: Japan

Institution: Environment Conservation Laboratory, Hokkaido Research Center, Forestry and Forest Products Research institute 7

Finanzierung:

Beginn: 1999, Dauer: 0 Jahre

Anlass:

Methoden: Tower Measurement (41m): Micrometeorological Measures, Eddy Correlation, Heat Balance meas., Scintillation method height (31.8 m) Sensible heat flux and Momentum,Photosynthesis, Respiration, Soil moisture (tensio-meter methods), continuous Litter fall/sample traps , Biomass (Tree Diameter and Tree height per year), high resolution diameter measurement (per month);Hydrology research, crown surface photography (once a week)

Gebiet: Hitsujigaoka Experimental Forest, Sapporo, Rechtswert: 141o23' E, Hochwert: 42°59' N

Systemtyp: Wald

Schwerpunkte: 1) Measurements of Carbon Dioxide Flux Above Forest and its Components 2) Comparison of Carbon Dioxide Flux Measurement among Several Methods 3) Quantifying the Exchange of Heat and Water between Forests and Atmosphere 4) Measurements on Nutrient-Cycling Processes within Forest Ecosystems 5) Analysis on the Interaction between Forest Ecosystem Dynamics and Micro-meteorology 6) Measurements of the exchange of Acidic Materials between Forests and Atmosphere

LeiterIn:

Institution: Environment Conservation Laboratory, Hokkaido Research Center, Forestry and Forest Products Research institute 7

Dokumentation:

Kommunikation:

Entwicklung:

Kontaktperson: Yuichiro Nakai

Adresse: Environment Conservation Laboratory, Hokkaido Research Center, Forestry and Forest Products Research institute 7, Hitsujigaoka,Toyohira-ku Sapporo, 062-8516, Japan phone:+81-11-851-4131 Fax:+81-11-851-4167

Internet: http://www-cger.nies.go.jp/~moni/flux/asia_flux/index.html, **E-mail:** nakaiyui@ffpri-hkd.affrc.go.jp

Literatur: None

Anmerkungen: Deciduous Broadleaved forests, Participant in Asiaflux

Kennung: KW7, **Literaturliste des Projekts**

Elastizität des Ökosystems Wattenmeer (ELAWAT)

Staat: D

Institution: ZENTRUM FÜR FLACHMEER-, KÜSTEN-UND MEERESUMWELTFORSCHUNG E.V. FORSCHUNGSZENTRUM TERRAMARE, Wilhelmshaven

Finanzierung: Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie

Beginn: 1993, Dauer: 4 Jahre

Anlass: 4. Rahmenprogramm der Europäischen Kommission "COST - European Cooperation in the field of Scientific and Technical Research"

Methoden: Feldstudien, Modellierung

Gebiet: Rückseitenwatt der Insel Spiekeroog (Niedersächsisches Wattenmeer), Rechtswert: 7,5° O, Hochwert: 53,6° N

Systemtyp: Aquatisch

Schwerpunkte: Analyse von Prozessen, die dem Wattenmeer eine Reaktion auf Störungen ermöglichen (11 Teilprojekte)

LeiterIn: Dr. Liebezeit (geschäftsführender Leiter des Forschungszentrums TERRAMARE)

Institution: ZENTRUM FÜR FLACHMEER-, KÜSTEN-UND MEERESUMWELTFORSCHUNG E.V. FORSCHUNGSZENTRUM TERRAMARE, Wilhelmshaven

Dokumentation: ELAWAT95 (1995): Ökosystemforschung Niedersächsisches Wattenmeer/ELAWAT (1995). Erster Zwischenbericht. - Forschungszentrum Terramare e.V., Wilhelmshaven ELAWAT96 (1996): Ökosystemforschung Niedersächsisches Wattenmeer/ELAWAT. Zweiter Zwischenbericht. - Forschungszentrum Terramare e.V., Wilhelmshaven

Kommunikation: Der Datenaustausch zwischen den Teilprojekten erfolgte über eine dBASE-Struktur.

Entwicklung:

Kontaktperson: None

Adresse: ZENTRUM FÜR FLACHMEER-, KÜSTEN-UND MEERESUMWELTFORSCHUNG E.V. FORSCHUNGSZENTRUM TERRAMARE Schleusenstraße 1 26382 Wilhelmshaven Tel. +49 4421 / 944 0 Fax +49 4421 / 944 199

Internet: http://www.terramare.de/index01.htm, **E-mail:** Gerd.Liebezeit@terramare.de

Literatur: None

Anmerkungen:

Kennung: G27, **Literaturliste des Projekts**

Forschungsverbund Agrarökosysteme München (FAM)

Staat: Deutschland

Institution: Technische Universität München-Weihenstephan, GSF-Forschungszentrum für Umwelt und Gesundheit, Fachgebiet Naturschutz der Universität Marburg

Finanzierung: BMBF, Eigenmittel der Institute, Bayern (Ministerium für Unterricht und Kultus, Wissenschaft und Kunst) hat die Pacht- und Bewirtschaftungskosten für das Versuchsgut Scheyern für 15 Jahre übernommen.

Beginn: 1990, Dauer: 0 Jahre

Anlass: Probleme einer intensiv genutzten Agrarlandschaft

Methoden: - Steuerung durch Vorgaben/Eingriffe der Landnutzungssysteme an den Standorten (Integrierte und ökologische Acker-, Gründlandwirtschaft und Sukzessionen) - Prozesse werden gemessen und modelliert, um die Auswirkungen durch die steuernden Eingriffe der Landnutzungssysteme auf N-, C-, Wasser-, Feststoff-, Wirtschafts- und Organismenbilanzen zu erfassen. Freilandmessungen, ergänzende Versuche auf Parzellen, Überprüfung von Feldanalysen im Labor, Studium wichtiger Vorgänge im Boden und in der Pflanze an Modellökosystemen (Bodensäulen), Untersuchung der chemischen und physikalischen Zusammensetzung des Bodens, Erfassung der Pflanzen- und Tierarten und Beobachtung ihrer Entwicklung (v.a. Ausbreitungsverhalten, Nahrungsnetze). - Bewertung (ökonomisch und ökologisch) der auf der Prozeßebene verursachten Auswirkungen. Erarbeiten von Planungsgrundlagen, -instrumenten (Indikatoren) und Dokumentation.

Gebiet: Klostergut Scheyern, 40 km nördlich von München , Rechtswert: 11,5°O, Hochwert: 48,5°N

Systemtyp: Agrar

Schwerpunkte: Untersuchung der ökologischen Folgen von zwei unterschiedlichen Bewirtschaftungssystemen in einem Landschaftsausschnitt. Dabei sollen Wege der Landbewirtschaftung aufgezeigt werden, die wirtschaftliche Landnutzung mit der Erhaltung und Wiederherstellung der natürlichen Lebensgrundlagen unserer Agrarlandschaft zu vereinen.

LeiterIn: Prof. Dr. J. C. Munch

Institution: Technische Universität München-Weihenstephan, GSF-Forschungszentrum für Umwelt und Gesundheit, Fachgebiet Naturschutz der Universität Marburg

Dokumentation: Pressmitteilungen, gsf-Zeitschrift mensch+umwelt, FAM-Berichte, Jahresberichte

Kommunikation: eingebunden ins MAB

Entwicklung:

Kontaktperson: PD Dr. Peter Schröder

Adresse: FAM-Sekretariat GSF-Forschungszentrum für Umwelt und Gesundheit GmbH Ingolstädter Landstraße 1 85764 Neuherberg

Internet: http://fam.weihenstephan.de/, **E-mail:** peter.schroeder@gsf.de

Literatur:

Anmerkungen: None

Kennung: A3, **Literaturliste des Projekts**

Klimatologie und Deposition von Luftschadstoffen im Fichtelgebirge

Staat: Deutschland
Institution: BITÖK Universität Bayreuth
Finanzierung: Bundesministerium für Bildung und Forschung (BMBF)
Beginn: 2001, Dauer: 4 Jahre
Anlass:
Methoden: Messungen an zwei stationären und mehreren mobilen Klimastationen; Erfassung von klimatologischen, mikrometeorologischen und atmosphärischen Parametern; Erfassung von meteorologischen Größen wie Strahlungsbilanz und Turbulenz für die Bestimmung der Flüsse von Wasserdampf und Kohlendioxid; Depositionsmodell; Einzelstudien u.a. zur Erfassung der Deposition von Wasser und dessen Inhaltsstoffen durch Nebel, zur Analyse der vertikalen Verteilung des Ozons und der Aerosolpartikel sowie zur Untersuchung der sekundären Bildung von Aerosolpartikeln bzw. des Partikelwachstums über dem Waldbestand als Folge der Emissionen von reaktiven gasförmigen organischen Verbindungen aus Bäumen und deren Reaktion mit atmosphärischem Ozon.
Gebiet: BITÖK-Untersuchungsstandorte im Fichtelgebirge, Rechtswert: , Hochwert:
Systemtyp: Gebirge
Schwerpunkte: Verständnis der gasförmigen und partikulären Deposition von Nähr- und Schadstoffen aus der Atmosphäre in das Ökosystem (Prozessverständnis und Quantifizierung der Flüsse). Konzentrationen von Gasen und Partikeln in der Luft und deren Flüsse zur Vegetation.
LeiterIn: Dr. Otto Klemm
Institution: BITÖK Universität Bayreuth
Dokumentation:
Kommunikation:
Entwicklung:
Kontaktperson: None
Adresse: Universität Bayreuth, BITÖK, Klimatologie, D-95440 Bayreuth
Internet: http://www.bitoek.uni-bayreuth.de/Forschung/Projekte/000910/DE.html, **E-mail:** Otto.Klemm@bitoek.uni-bayreuth.de
Literatur: None
Anmerkungen: Nachfolgeprojekt von „Klimatologie und Luftverschmutzung im Fichtelgebirge“, 1998 - 2000

Kennung: BP24, **Literaturliste des Projekts**

Niwot Ridge (Colorado) Long-Term Ecological Research

Staat: USA

Institution: Institute of Arctic and Alpine Research, University of Colorado at Boulder, University of Colorado at Denver, University of Denver, Colorado State University, United States Forest Service, Institute of Computational Earth System Science, National Center for Atmospheric Research, National Atmospheric Deposition Program, U.S. Man and the Biosphere Program

Finanzierung:

Beginn: 0, Dauer: 0 Jahre

Anlass: LTER Long Term Ecological Research

Methoden: Routine monitoring /measurements including meteorology/climatology (air temperature, precipitation, solar radiation...), hydrology (stream discharge, snowpack ablation...) and biogeochemistry (atmospheric deposition, surface water quality...) as well as other research on meteorology/climatology (lake-ice clearance and freeze-up...), biogeochemistry (atmospheric N loading, wood, litter and chemical decomposition...) and biology (plant species composition, aboveground phytomass...). Research activity in the area of GIS, remote sensing and modelling.

Gebiet: Niwot Ridge/Green Lakes Valley, Colorado, Rechtswert: 40,1 W, Hochwert: 105,6 N

Systemtyp: Gebirge

Schwerpunkte: The impact of climate change on Colorado tundra ecosystems, with focus on the effects of altered snowpack and rainfall regimes. Patterns and controls of nutrient cycling; trace gas dynamics, plant primary productivity and species composition, geomorphology, and paleoecology

LeiterIn: Nel Caine

Institution: Institute of Arctic and Alpine Research, University of Colorado at Boulder, University of Colorado at Denver, University of Denver, Colorado State University, United States Forest Service, Institute of Computational Earth System Science, National Center for Atmospheric Research, National Atmospheric Deposition Program, U.S. Man and the Biosphere Program

Dokumentation: homepage, reports, workshops

Kommunikation:

Entwicklung:

Kontaktperson: None

Adresse: University of Colorado INSTAAR Campus Box 450 Boulder, CO, 80309-0450 USA

Internet: http://sql.lternet.edu ; http://culter.colorado.edu:1030/Niwot/Niwot_Ridge_LTER_research.html,
E-mail: cainen@culter.colorado.edu

Literatur: Bowman, WD, Seastedt, TR (Editors) 2001: Structure and Function of an Alpine Ecosystem – Niwot ridge, Colorado. Unibversity of Colorado, Boulder

Anmerkungen: None

Ökosystemforschung im Bereich der Bornhöveder Seenkette

Staat: Deutschland

Institution: 13 Institute der Universitäten Kiel und Hamburg, des MPI Limnologie Plön, der FAL Braunschweig, der Gewerbeaufsicht Itzehoe, des Deutschen Wetterdienstes Quickborn und des Fraunhofer-Instituts Garmisch-Partenkirchen

Finanzierung: BMFT

Beginn: 1988, Dauer: 12 Jahre

Anlass: Ellenberg, Fränzle & Müller (1987): "Ökosystemforschung im Hinblick auf Umweltpolitik und Entwicklungsplanung", Rastorf-Projekt (1982-86), Studie zur Auswahl von Hauptforschungsräumen für die bundesdeutsche Ökosystemforschung (1985-87), Vorhaben 'Umweltbeobachtung' (1987-91)

Methoden: Messung, theoretischen Ökologie, Modellierung, Ökologischen Informationssystem, Integration, Integrative Auswertung (Ökosystemverständnis, Umsetzung, Anwendung)

Gebiet: Bornhöveder Seenkette , Rechtswert: 10,1°O, Hochwert: 54,1°N

Systemtyp: Agrar

Schwerpunkte: Das Konzept des Projektes beruht auf einer ganzheitlichen Betrachtungsweise von Ökosystemen. Themenbereiche sind: Ökosystemtheorie, Informationssystem, Modellbildung, Biozönotische, Stoffliche, Energetische und Interökosystemare Interaktionen, Nachhaltiges Landschaftsmanagement, Mensch-Umwelt-Beziehungen,Umweltbewertung- und planung, Wissenstransfer und Öffentlichkeitsarbeit

LeiterIn: Prof. O. Fränzle, Prof. H.-P. Blume, Prof. B. Heydemann, Prof. L. Kappen, Prof. W. Nellen, Prof. P. Widmoser, Prof. H. Roweck, Prof. P. Widmoser, Prof K. Dierßen, Prof. R. Horn, Prof. O. Wassermann, ...

Institution: 13 Institute der Universitäten Kiel und Hamburg, des MPI Limnologie Plön, der FAL Braunschweig, der Gewerbeaufsicht Itzehoe, des Deutschen Wetterdienstes Quickborn und des Fraunhofer-Instituts Garmisch-Partenkirchen

Dokumentation: Interne Berichte, EcoSys-Bände

Kommunikation: Es wurden vielfältige nationale und internationale Kooperationsvorhaben initiiert. Hierzu zählen z.B. die Beteiligung am "Störvorhaben" des BMBF, die Teilnahme am TEMPUS-Programm der EU", die Zusammenarbeit mit Landeseinrichtungen, z.B. in der Begleitforschung von Naturschutzmaßnahmen, die Kooperation mit kommunalen Einrichtungen bei der Erstellung von Landschaftsplänen und der Durchführung von Umweltverträglichkeitsprüfungen, die internationale Einbindung in die Monitoringprogramme "Level II" zum Waldschadensmonitoring und GEMS (UNESCO) sowie die Anerkennung als

Pilotvorhaben im UNESCO Programm MAB für mehrere Schwerpunktbereiche. Darüber hinaus ist die Beteiligung an den MAB-Programmen "Ökosystemare Umweltbeobachtung" und "Biosphärenreservats-Begleitforschung" etabliert worden. Schließlich hat das PZÖ eine Reihe von Symposien, Tagungen und international besuchten Workshops durchgeführt, die sich vor allem auf Bereiche der Theoretischen Ökologie, der ökologischen Modellbildung und auf das Thema "Sustainability" bezogen. Der zunehmenden Globalisierung der relevantenFragestellungen wird auf europäischer Ebene durch die Bemühungen, ein Netzwerk zur Hochschulkooperation im Rahmen eines zu entwickelnden europäischen Studienganges "Environmental Systems Analysis and Modelling" zu erstellen, nachgekommen. Ergänzt wird dieser Ansatz durch erste Schritte zur Etablierung eines internationalen Zentrums für ökologische Modellbildung (ICEM), dessen Koordination im Aufgabenkatalog des ÖZK festgeschrieben wurde.

Entwicklung:

Kontaktperson: Felix Müller

Adresse: Ökologie-Zentrum Kiel, Christian-Albrechts-Universität, Schauenburger Str. 112, 24118 Kiel

Internet: http://www.pz-oekosys.uni-kiel.de/ , **E-mail:** felix@ecology.uni-kiel.de

Literatur:

Anmerkungen: None

Kennung: A1, **Literaturliste des Projekts**

Ökosystemforschung Schleswig-Holsteinisches Wattenmeer FKZ: 108 02 085/01 = Teil A FKZ: 03F0006 A,B,C,D = Teil B Sylter Wattenmeerraum Austauschprozesse = SWAP FKZ: 03F0138A = Synthese

Staat: Deutschland

Institution: Teil A: Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer, Tönning (Federführung) Teil B: Wattenmeerstation Sylt (Federführung)

Finanzierung: Teil A: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit; Umweltbundesamt; Ministerium für Natur und Umwelt des Landes Schleswig-Holstein Teil B: Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie; Projektträger BEO; Ministerium für Natur und Umwelt des Landes Schleswig-Holstein

Beginn: 1989, Dauer: 7 Jahre

Anlass: Unkenntnis der Ökosystemzusammenhänge, der ökosystemaren Wirkungen von Nutzungen, etc.

Methoden: s. Synthesebericht der ÖSF (Stock et al. 1996), SWAP-Projektsysnthese (Reise et al. und Umweltatlas Wattenmeer S.-H. (NPA/UBA 1998)

Gebiet: Wattenmeer in Schleswig-Holstein, Rechtswert: , Hochwert:

Systemtyp: Aquatisch

Schwerpunkte: Verständnis der FUnktionsweise Natur-Mensch im Wattenmeer, Lösung bzw. Entschärfung von Umweltproblemen und Nutzungskonflikten, Erarbeitung von Schutzkonzepten und Monitoringstrategien

LeiterIn:

Institution: Teil A: Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer, Tönning (Federführung) Teil B: Wattenmeerstation Sylt (Federführung)

Dokumentation:

Kommunikation: Christian-Albrechts-Universität Kiel, Institut für Meereskunde an der Universität zu Kiel, Universität Hamburg, Biologische Anstalt Helgoland, Wattenmeerstation Sylt, GKSS-Forschungszentrum Geesthacht, Umweltstiftung WWF-Deutschland, Wattenmeerstelle, Deutsches Wirtschaftswissenschaftl. Institut für Fremdenverkehr an der UNiversität München, Institut für Frischwasser- und Abwasserbiologie, Hamburg, Landesamt für Wasserhaushalt und Küsten, Kiel, Universität Kopenhagen, Universität Odense, Ernst-Moritz-Arndt-Universität Greifswald, Fraunhofer-Institut für Atmosphärische Umweltforschung, Garmisch-Patenkirchen

Entwicklung:

Kontaktperson: None

Adresse:

Internet: **, E-mail:**

Literatur: None

Anmerkungen: None

Kennung: J36, **Literaturliste des Projekts**

Projekt Hof Ritzerau

Staat: Deutschland

Institution: Ökologie-Zentrum Kiel, Christian-Albrechts-Universität zu Kiel Institut für Pflanzenern. und Bodenkunde Inst. f. Pflanzenbau und Zuechtung Inst. f. Wasserw und Landsch-Oekologie

Finanzierung: Fielmann

Beginn: 2001, Dauer: 15 Jahre

Anlass:

Methoden:

Gebiet: Gut Ritzerau Schleswig-Holstein , Rechtswert: 10,5°O, Hochwert: 53,7°N

Systemtyp: Agrar

Schwerpunkte: Umstellung auf ökologischen Landbau

LeiterIn: Prof. Dr. H. Roweck

Institution: Ökologie-Zentrum Kiel, Christian-Albrechts-Universität zu Kiel Institut für Pflanzenern. und Bodenkunde Inst. f. Pflanzenbau und Zuechtung Inst. f. Wasserw und Landsch-Oekologie

Dokumentation:

Kommunikation:

Entwicklung:

Kontaktperson: Carsten Höhler

Adresse: Schauenburger Str. 113, 24118 Kiel

Internet: http://www.ecology.uni-kiel.de/ritzerau/ , **E-mail:** carstenh@ecology.uni-kiel.de

Literatur:

Anmerkungen:

Kennung: A2, **Literaturliste des Projekts**

Sodankylä - FMI-Arctic research centre

Staat: Finland
Institution: Sahaajankatu 20 E
Finanzierung: European Union
Beginn: 0, Dauer: 0 Jahre
Anlass:
Methoden: Tower measurement (48 m): air temperature; annual leaf litter production; atmosphere stability parameter; canopy radiative temperature; canopy height; carbon dioxide concentration; carbon dioxide flux density; CO2 storage in canopy air layer; diffuse radiation; global radiation; heat storage in canopy air layer; latent heat; latent heat in canopy air layer; leaf area density; leaf area index; leaf dark respiration; leaf nitrogen concentration; leaf nitrogen pool; leaf stomatal conductance; litter leaf C/N; momentum; net radiation; pH; photosynthetic max capacity; photosynthetic photon flux density; precipitation; pressure; reflected radiation; relative humidity; soil heat flux density; sensible heat; snow depth; soil bulk density; soil heat flux density; soil property: depth, texture, structure, horizon, etc; soil temperature; soil water content; species composition; specific leaf weight; standing leafbiomass; stem area index; trees age; trees density; total soil carbon; total soil nitrogen; Water vapour concentration; Wind direction; Wind horizontal speed; wood biomass;
Gebiet: Lappland; Sodankylä, Rechtswert: 26° 39' E, Hochwert: 67°22' N
Systemtyp: Wald
Schwerpunkte:
LeiterIn: Tuomas Laurila
Institution: Sahaajankatu 20 E
Dokumentation:
Kommunikation:
Entwicklung:
Kontaktperson: Tuomas Laurila
Adresse: Sahaajankatu 20 E, FIN-00810 Helsinki, Finland
Internet: http://www.bgc-jena.mpg.de/public/carboeur/sites/index_ind.html; www.fmi.fi,
E-mail: tuomas.laurila@fmi.fi
Literatur: None
Anmerkungen: North boreal coniferous forest; Age: unevenaged 50-80 years; Part of CARBOEUROFLUX (An investigation on Carbon and Energy exchanges of terrestrial ecosystems in Europe); [colocated facility: Close to the facilities of FMI-Arctic research centre]

Kennung: KW74, **Literaturliste des Projekts**

UFZ-Umweltforschungszentrums Leipzig-Halle GmbH

Staat: Deutschland
Institution: UFZ-Umweltforschungszentrum Leipzig-Halle GmbH
Finanzierung: 90 % BMBF, 5% Sachsen, 5% Sachsen-Anhalt
Beginn: 1992, Dauer: 0 Jahre
Anlass: stark belastete Landschaft des Mitteldeutschen Raumes
Methoden: Die landschaftsorientierte, naturwissenschaftliche Forschung wird eng mit Sozialwwissenschaften der ökologischen Ökonomie und dem Umweltrecht verbunden. Anwendunsorientierte, interdisziplinäre Forschung ist Bestandteil von Verbundprojekten, an denen die Sektionen des UFZ mit ihrer Grundlagenforschung beteiligt sind.
Gebiet: Raum Halle-Leipzig, Rechtswert: 12°W, Hochwert: 51,5°N
Systemtyp: Agrar
Schwerpunkte: Sanierung und Gestaltung der stark belasteten Landschaften Mittel- und Ostdeutschlands, Biodiversität, genetische Vielfalt und Habitat, Umweltbiotechnologie, Gentechnologie, Forschung zur Definition und Umsetzbarkeit von Umweltqualitätszielen
LeiterIn: Prof. Dr. Peter Fritz
Institution: UFZ-Umweltforschungszentrum Leipzig-Halle GmbH
Dokumentation: Messebeteiligungen, Jahresbericht, Imagebroschüre, Magazin Lebensräume, Broschüren, Faltblätter, UFZ-Berichte, UFZ-Diskussionspapiere
Kommunikation: Forschungskontakte zu Nord- und Südamerika, Osteuropa, südliches Afrika
Entwicklung:
Kontaktperson: Prof. Dr. Peter Fritz
Adresse: Standort Leipzig, Permoserstraße 15, 04318 Leipzig
Internet: http://www.ufz.de/, **E-mail:** gf@gf.ufz.de
Literatur: None
Anmerkungen: None

Kennung: A9, **Literaturliste des Projekts**

US LTER (Long Term Ecological Research) Network

Staat: USA

Institution: Institute of Arctic and Alpine Research, University of Colorado; University of Alabama; Colorado State University; Texas Tech University; Montana State University; Desert Research Institute; Dartmouth College; U.S. Geological Survey, Water Resources Division, Portland State University; and University of Illinois at Chicago

Finanzierung: US Science Foundation

Beginn: 1992, Dauer: 10 Jahre

Anlass: US LTER-Site

Methoden:

Gebiet: McMurdo Station, Antarktis , Rechtswert: 165,0° E, Hochwert: 78,0° S

Systemtyp: Polar

Schwerpunkte: Mikrobielle Ökosystemdynamik in ariden Böden, ephemerische Flüsse, geschlossene Beckenseen; Ressourcen- und Umweltkontrollen im terrestrischen, in Flüssen und Ökosystemen; Materialtransporte zwischen aquatischen und terrestrischen Ökosystemen; Ökosystemreaktionen auf größere hydrologische Ströme verursacht durch Klimaerwärmung

LeiterIn: William Berry Lyons

Institution: Institute of Arctic and Alpine Research, University of Colorado; University of Alabama; Colorado State University; Texas Tech University; Montana State University; Desert Research Institute; Dartmouth College; U.S. Geological Survey, Water Resources Division, Portland State University; and University of Illinois at Chicago

Dokumentation:

Kommunikation:

Entwicklung: noch in Betrieb

Kontaktperson: None

Adresse: Ohio State University, 1090 Carmack Rd, Scott Hall Columbus, OH 43210-1002 USA

Internet: http://huey.Colorado.EDU/LTER/, **E-mail:** lyons.142@osu.edu

Literatur: John C. Priscu (Ed.) (19##) :Ecosystem Dynamics in a Polar Desert: The McMurdo Dry Valleys, Antarctica. Washington D.C..W.B. Lyons (Ed.) (19##) : Ecosystem Processes in Antarctic Ice-free Landscapes. Rotterdam.

Anmerkungen: None

Kennung: B3, **Literaturliste des Projekts**

Weidelandschaft Eidertal

Staat: Deutschland
Institution: Ökologiezentrum
Finanzierung: BMBF
Beginn: 1999, Dauer: 4 Jahre
Anlass: Gefährdung von Offenlandschaften
Methoden: -Vegetationsökologie:Vegetationskartierung vor und nach Beweidung -Tierökologie:Habitateignungsanalyse im Rahmen der Veränderung des Gesamtgebietes sowie auf der Beobachtung der tatsächlichen Habitatnutzung. Hinzu kommen punktgenaue Aufnahmen einzelner Zeigerarten. Parallel dazu wird eine Habitateignungsschätzung auf Basis vegetationsstruktureller Merkmale sowie vorhandener Habitatmodelle durchgeführt.
Gebiet: Eidertal, wenige Kilometer südlich von Kiel, Rechtswert: ~10°E, Hochwert: ~54°N
Systemtyp: Feuchtgebiete
Schwerpunkte: Auswirkungen extensiver Beweidungssysteme auf Biozönosen und sozio-ökonomische Analyse des Managements von Offenland-Ökosystemen
LeiterIn: Prof.Dr.Roweck
Institution: Ökologiezentrum
Dokumentation:
Kommunikation:
Entwicklung:
Kontaktperson: None
Adresse: Ökologiezentrum Schauenburger Str. 112 24118 Kiel
Internet: http://www.ecology.uni-kiel.de/ageider, **E-mail:** kai-j@ecology.uni-kiel.de
Literatur: None
Anmerkungen: None

Kennung: J9, **Literaturliste des Projekts**

Weiherbach-Projekt - Prognosemodell für die Gewässerbelastung durch Stofftransport aus kleinen Einzugsgebieten

Staat: Deutschland

Institution: mehrere Institute der Universität Karlsruhe, die Staatliche Landwirtschaftliche Untersuchungs- und Forschungsanstalt (LUFA) Augustenberg in Karlsruhe sowie je ein Institut der Universität Heidelberg, der Technischen Universität Cottbus und der Universität Bayreuth

Finanzierung: BMBF

Beginn: 1989, Dauer: 0 Jahre

Anlass:

Methoden:

Gebiet: Weiherbach im Kraichgau, Rechtswert: , Hochwert:

Systemtyp: Agrar

Schwerpunkte: Ziel des Verbundvorhabens ist die Erstellung eines prognosefähigen numerischen Simulationsmodells für den Transport von Wasser und dessen Inhaltsstoffen in und aus kleinen, hauptsächlich landwirtschaftlich genutzten Wassereinzugsgebieten. Die Prozesse auf der Geländeoberfläche, in den Oberflächengewässern, in der ungesättigten Bodenzone und der Zufluß aus dem Grundwasser sollen flächendetailliert und möglichst weitgehend deterministisch nachgebildet werden. Zu den untersuchten Stoffen gehören Feststoffe (aus Erosionen), Nitrat, Phosphat und Pflanzenschutzmittel. Untersuchungen und Modellentwicklung werden für das Einzugsgebiet des Weiherbaches im Kraichgau.

LeiterIn: Prof.Dr. Ing. Dr. Ing. E.h. Erich J. Plate

Institution: mehrere Institute der Universität Karlsruhe, die Staatliche Landwirtschaftliche Untersuchungs- und Forschungsanstalt (LUFA) Augustenberg in Karlsruhe sowie je ein Institut der Universität Heidelberg, der Technischen Universität Cottbus und der Universität Bayreuth

Dokumentation: mehrere Internetseiten:
http://www.geo.uni-bayreuth.de/bodenphysik/projekte/weiherbach.html
http://www.uni-karlsruhe.de/~fzu/Projects/UniProjects/project.42.de.html
http://pweb.uunet.de/werner.ma/publikationen/kgr-mw10.htm

Kommunikation:

Entwicklung:

Kontaktperson: Markus Casper

Adresse: Institut für Hydrologie und Wasserwirtschaft Universität Karlsruhe Kaiserstr.12 D-76128 Karlsruhe

Internet: http://www.uni-karlsruhe.de/~wei/, **E-mail:** markus.casper@bau-verm.uni-karlsruhe.de

Literatur: None

Anmerkungen: None

Kennung: n8, **Literaturliste des Projekts**

Yatir

Staat: Israel

Institution: Weizmann Instiute of Science

Finanzierung: European Union

Beginn: 2000, Dauer: 0 Jahre

Anlass:

Methoden: Tower measurement (14 m): air temperature; atmosphere stability parameter; canopy height; carbon dioxide concentration; carbon dioxide flux density; latent heat; leaf area index; litter leaf C/N; momentum; net radiation; photosynthetic max capacity; photosynthetic photon flux density; precipitation; pressure; relative humidity; soil heat flux density; sensible heat; soil heat flux density; soil temperature; soil water content; stemflow; throughfall; trees age; trees density; tree transpiration; Water vapour concentration; Wind direction; Wind horizontal speed; wood increment

Gebiet: North Negev; , Rechtswert: 35°00' E, Hochwert: 31°20' N

Systemtyp: Wald

Schwerpunkte:

LeiterIn: Dan Yakir

Institution: Weizmann Instiute of Science

Dokumentation:

Kommunikation:

Entwicklung:

Kontaktperson: Dan Yakir

Adresse: Weizmann Instiute of Science; PO Box 26; 76100 Rehovot / Israel

Internet: http://www.bgc-jena.mpg.de/public/carboeur/sites/index_ind.html; http://www.weizmann.ac.il/ESER/Yakir/Yatir.htm, **E-mail:** ciyakir@wisemail.weizmann.ac.il; Eyal.Rotenberg@weizmann.ac.il

Literatur: None

Anmerkungen: semi arid coniferous forest; (Plantation, Kyoto 3.3); Age: 35 (oldest part); Part of CARBOEUROFLUX (An investigation on Carbon and Energy exchanges of terrestrial ecosystems in Europe)

Kennung: KW82, **Literaturliste des Projekts**

Zentrum für Agrarlandschafts- und Landnutzungsforschung (ZALF) e.V.

Staat: Deutschland

Institution: ZALF

Finanzierung: BMVEL, MLUR

Beginn: 1992, Dauer: 0 Jahre

Anlass:

Methoden: Die Grundlagenforschung ist anwendungsbezogen, d.h. die Untersuchungen orientieren sich an akuten Problemen und münden in Werkzeugen zur Entscheidungshilfe. Die Größen des Natur- und Landschaftshaushaltes werden beachtet und ökonomische, gesellschaftliche und politische Faktoren einbezogen. Die vorrangig disziplinär ausgerichteten Institute werden im interdisziplinären Forschungsverbund "Nachhaltige Landschaftsentwicklung - Nordmitteleuropa 2020" gebündelt. Weitere interdisziplinäre Arbeit findet u.a. über institutsübergreifende Forschergruppen statt.

Gebiet: Nordost-Brandenburgs (Nördliche Uckermark, Südliche Uckermark, Barnim-Lebus), Niedermoorgebiet des Rhinluchs, Rechtswert: 13,5°W, Hochwert: 53°N

Systemtyp: Agrar

Schwerpunkte: Analyse, Beurteilung und Prognose von Prozessen und ihrer Wechselwirkungen in vorwiegend agrarisch genutzten Landschaften des Nordostdeutschen Tieflands.

LeiterIn: Prof. Dr. Hubert Wiggering

Institution: ZALF

Dokumentation: ZALF-Berichte, ZALF-CDs, ZALF-Jahresberichte, ZALF-Bibliothek-Recherche im Internet

Kommunikation: Forschungsarbeiten werden in enger Abstimmung und Kooperation mit auf vergleichbaren Forschungsgebieten tätigen Institutionen des In- und Auslands realisiert.

Entwicklung:

Kontaktperson: Prof. Dr. Hubert Wiggering

Adresse: ZALF, Inst. für Landnutzungssysteme und Landschaftsökologie Eberswalder Str. 84, 15374 Müncheberg

Internet: http://www.zalf.de/, **E-mail:** wiggering@zalf.de

Literatur: None

Anmerkungen: siehe auch Kennung A4

Kennung: A7, **Literaturliste des Projekts**

ANNEX 2: QUESTIONNAIRES

Overview:

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2.1 General Information Sheet

1. General Details

1.1 Please provide the following personal details:

Name, Surname and Title: Institution (Name and Address): E-mail address:

1.2 Are you, or were you, active...

☐ in ecosystem research or adjacent research areas?

☐ in environmental politics and/or planning?

☐ on the interface of both fields?

☐ in education and training?

1.3 Please briefly explain your expertise in reference to ecosystem/environmental research (e.g. project leader, coordinator etc)

1.4 Please name the ecosystem research projects in which you are/were active

In the framework of the project, we have begun to create a data base, in which we put together searchable information pertaining to complete and current ecosystem research projects. The data base will be further supplemented – with the support of your entries – in the next few weeks.

Should the project, in which you are or were active, already be included in the data base (see list in the files 'Data_Base_Projects.rtf' or 'Data_Base_Projects.pdf' or see www.ecology.uni-kiel.de:8080/synopse), please refer to the corresponding reference number and notify us of supplements or corrections. If your project is not already in the list, please complete the form on the next page

Reference number of the ecosystem research project in the project data bank:

Description of the research organisation and the research project (Use as much space as necessary, and copy the table, if you are able to give comments about more than one project.	
1	Title of the research project and/or research program

2	Managing and participant institutions (e.g. universities, non-universities)
3	Project leader: (Name, address, e-mail)
4	Project structure, project organisation (includes participation institutions)
5	Duration of the research project
6	Research area (investigated landscapes and ecosystem types)
7	Incorporation of project in a research association or a superior research program
8	Funding of the research projects, contractor
9	Main focus and objectives
10	Motivation for the project
11	Applied methods, techniques and work practice (e.g. integrated concepts and methods, particularly out-standing method development)
12	Reference to summarising literature
13	Type of document and publication of the research results
14	Internet address with more in depth information pertaining to project content and structure:

2. Specific questions

Please select one of the following questionnaires, according to the details entered above in point 1.2

If you are/were active in ecosystem research or adjacent research areas
⇨ Form 1 (File „Fragebogen1.rtf“ or „Fragebogen1a.pdf“)

If you are/were active in environmental politics, management or planning
⇨ Form 2 (File „Fragebogen2.rtf“ or „Fragebogen2a.pdf“)

If you are on the interface of both areas, or are active in education and training
⇨ Form 3 File „Fragebogen3.rtf“ or „Fragebogen3a.pdf“)

If you wish to complete the questionnaire digitally, please select the appropriate file/files with the suffix „rtf“ (rich text format).

If you wish to complete the questionnaire on paper, please select the appropriate file/files with the suffix „pdf“ (the pdf file can be printed without problem using the program Acrobat Reader).

In some cases yes/no answers are required, please cross the corresponding box (digital or on paper)

[X] No

[ ] Yes

In other cases, we give you the choice of different answers to cross. These are multiple chose questions; you may cross more than one answer.

2.2 Questionnaire 1

Please complete if you are/were active in the area of ecosystem research.

1 Significance of ecosystem research in the scientific system

1.1 In your opinion, which contribution has ecosystem research delivered to the change in approach and interpretation in the **environmental and system sciences** (e.g. considering chain reactions and reaction nets, or linearity of processes to non-linearity)?

1.2 Is there such a contribution from 'your' ecosystem research project/s?

☐ no

☐ yes

If yes, wherein does this exist?

2 Contribution of ecosystem research to the organisation of environmental policy and to the formulation of environmental politicy objectives

2.1 In your opinion, which contribution has ecosystem research delivered to the change in approach and interpretation in **environmental politics and environmental management** (e.g. restricted department strategies or single problem focus or interdisciplinary focus on sustainable development)?

2.2 Can you in general recognise a relevant influence of results from ecosystem research on the formulation of (specific) politicy **objectives** (e.g. on enacting conventions, such as the biodiversity convention)?

☐ no

☐ yes

If yes, which ones?

2.3 According to your knowledge and with emphasis on 'your' project/s, were or will be results produced used for the formulation and specification of **environmental objectives** (environmental quality targets, environmental standards and best practice guidelines)?

☐ no

☐ yes

If yes, which ones?

2.4 At the beginning of the project or during the project, were there targeted ideas for later application of the research results **in the framework of environmental policy**? Was the project planned with a specific application in mind, e.g., the revision of environmental standards for the emission of pollutants?

☐ no

☐ yes

When yes, what was planned?

2.5 At which **scale** (e.g. national, regional etc.) do you see the most important influences of ecosystem research on environmental policy?

2.6 Were there **surprising applications**, which according to the original research concept were not anticipated or which stood out as they exceeded expectations (e.g., applications of non-planned technical innovations)?

☐ no

☐ yes

If yes, which ones?

3 Significance of ecosystem research for environmental planning

3.1 Can you, in principle, recognise a relevant **influence** of the results of ecosystem research on **environmental planning** (e.g. on the development of planning methods, or the use of particular techniques in planning, such as scenario techniques or the use of geographical information systems)?

☐ no

☐ yes

If yes, which ones?

3.2 Do you know of **specific applications** of research results produced in 'your' project/s in environmental planning?

☐ no

☐ yes

And if yes, which of the following applies?

☐ The use of basic data produced within the research project for the research area and for the planning area (e.g. adoption of research results for the description and analysis of the research area)

☐ Use of methodological tools (e.g. investigation strategies, evaluation procedures, superimposition of information layers)

☐ Use of more advanced technology (e.g. GIS techniques, techniques in the area of remote sensing, computer models)

☐ Other

If possible, provide more detail of the applications examples:

3.3 At the beginning of the project or during the project, were there targeted ideas for later application of the research results **in environmental planning** (e.g. for management problems concerned with the expansion of a protected area)?

☐ no

☐ yes

If yes, which ones?

3.4 At which **scales** (e.g. national, regional, etc) do you see the most important influences of ecosystem research on environmental planning? Were there, e.g., influences on the demarcation of protected areas?

3.5 Do the current **applications** of research results in planning correspond to your ideas or the ideas of other research participants?

☐ no

☐ yes

If no, why not?

3.6 Were there **surprising applications** in planning, which according to the original research concept were not anticipated (e.g. applications of technical innovations)?

☐ no

☐ yes

If yes, which ones?

4 Contribution of ecosystem research to environmental monitoring and surveillance

4.1 How do you value the significance of a close **link**
(a) conceptionally and
(b) practically
between ecosystem research, environmental monitoring and environmental surveillance?

4.2 Have specific **technical innovations** resulted from 'your' project/s that are used or could find a use in routine environmental monitoring during data <u>collection</u> (e.g. applied measuring and process techniques)?

☐ no

☐ yes

If yes, which ones?

4.3 Have specific **conceptional and methodological innovations** resulted from 'your' project/s that are used or could find a use in routine environmental monitoring in data analysis/synthesis (e.g. correlation analysis, scenario technique)

☐ no

☐ yes

If yes, which ones?

4.4 Has/have 'your' project/s produced **ideas of a more strategic and structural nature** that lead to the initiation or reformulation of environmental monitoring programs?

☐ No

☐ yes, of a strategic and structural nature (e.g. with respect to the question, how different institutions that measure and evaluate environmental monitoring data can intensively cooperate)

☐ yes, by nature of content (e.g. with respect to the question, which topics and environmental problems should be the focus in future environmental monitoring)

Can you give more precise detail to these ideas?

4.5 Does/do 'your' project/s lead (directly) to an **environmental monitoring program** or is this planned (e.g., with reduced sampling costs compared to a research program)?

☐ no

☐ yes

Can you provide details of the monitoring program (title, objective and spatial reference)?

4.6 Which **problems** do you see that hamper the **'transfer'** from a **research program to a regular environmental monitoring program**?

5 Contribution of ecosystem research to environmental training, public relations and environmental reporting

5.1 Are you of the opinion that ecosystem research should be closely **linked** with environmental training,especially at universities, and with 'pro-environment' public relations efforts?

☐ no

☐ yes

Please explain your view.

5.2 Do you think that this link existed in the past to a satisfactory level?

☐ no

☐ yes

If no, where do you think the problem may lie?

5.3 Do you know of **positive examples** (as well from ‘your’ ecosystem research project/s) **of such links** of ecosystem research with environmental training and public relations)? Were there or are there e.g. open discussion forums, are there/was there guided tours of field plots, are there accompanying publications in local media?

☐ no

☐ yes

If yes, can you name these?

5.4 Did ‘your’, or does ‘your’ ecosystem research project produce **ideas for environmental reporting**? Are these conceptions of a strategic and structural nature or of a methodological nature?

☐ No

☐ yes, of a strategic and structural nature (e.g. in reference to the questions, which target groups are addressed by which reporting styles, or who reports or from which data)

☐ yes, methodological and by nature of content (e.g. in reference to the question, which topics and environmental problems will be dealt with or how cause–effect relationships in environmental systems can me made transparent in the report)

Can you further detail these ideas?

5.5 Has ecosystem research, according to your opinion, delivered significant **contributions to the indicator discussion** (e.g. choice of predictive indicators, or to the formulation of aggregated indicators)?

☐ no ☐ Yes

Can you name ecosystem research projects that have significantly enriched the indicator discussion?

6 Critical reflection of ecosystem research projects

Your statements in this section will be carefully evaluated and only passed on in an anonymous form.

6.1 Does your/do ‘your’ project/s critically reflect its **organisational structure and strategic approach** (e.g. was discussed whether the organisational structure was suitable in order to achieve a synthesis of project results)?

☐ no

☐ yes

If no, can you name reasons?

If yes, which critique was given, where is it published, and which recommendations were made?

6.2 In the project/s was or is a **synthesis of project results** produced/being produced? Were or are summarising synthesis reports published?

☐ no

☐ yes

If no, can you name reasons here?

If yes, please cite the synthesis report:

6.3 Which are the most important specific results of 'your' ecosystem research project that – in the context of environmental science – have stimulated the field or effected important progress (name e.g. in point form what you consider to be the 10 most important results)?[1]

6.4 At the end of the project/s, were **further research needs** described, or – if the project is not finished yet – is it evident that this will happen?

☐ no

☐ yes

If no, can you name reasons?

6.5 From your own experience, how do you judge the **problem of interdisciplinary research**? Was interdisciplinary work in 'your' project/s practiced?

☐ no

☐ yes

If yes, which forms of organisation and communication have in your opinion been particularly successful?

If no, what was to blame for the lack in interdisciplinarism?

6.6 Do you see **model development** (development of concept and computer models) as a substantial task of ecosystem research?

☐ no

☐ yes

[1] We understand that such a brief portrayal of the scientific essence of 'your' project/s must remain unsatisfactory, and does not allow any kind of evaluation. However, we would like to include the significant results of your research in the final report.

If yes, which significance has model development in your opinion?

If no, please give reasons

6.7 What do you consider, in brief, to be the greatest **advantages and disadvantages of ecosystem research** and its greatest problems?

7 What do you hope for from ecosystem research in the future?

☐ a stronger orientation at current environmental problems

☐ a stronger detachment from current environmental politics discussions

☐ in principle a closer exchange between ecosystem research and application as well as a stronger orientation of ecosystem research to applied topics.

☐ a greater emphasis on the extraction of suitable methods and instruments (e.g. easy to use models, easily understood indicators producible from available data)

☐ greater independence from the demands of management and planning offices, and environmental politics

Have you other suggestions or ideas for ecosystem research in the future?

- In respect to organisation:
- In terms of content (among others, topical main points, developments of methods and technical tools):

If you favour a closer exchange between ecosystem research and application: Do you have ideas, how this can be organised?

8 Other

At this point we would be pleased to hear ideas and criticisms about our approach in this project:

Many thanks for your cooperation and assistance.

2.3 Questionnaire 2

Please complete, if you are/were active in the areas of environmental politics, management or planning (among others, representatives of planning offices and environmental administration, including institutions, which are active in the area of environmental monitoring and environmental reporting)

1 Contribution of ecosystem research to the organisation of environmental policy and to the formulation of environmental politicy objectives

1.1 In your opinion, which contribution has ecosystem research delivered to the change in approach and interpretation in **environmental politics and environmental management** (e.g. restricted department strategies or single problem focus or interdisciplinary focus on sustainable development)?

1.2 Can you in general recognise a relevant influence of results from ecosystem research on the formulation of (specific) politicy **objectives** (e.g. on enacting conventions, such as the biodiversity convention)?

☐ no

☐ yes

If yes, which ones?

1.3 At which **scale** (e.g. national, regional etc.) do you see the most important influences of ecosystem research on environmental policy?

2 Significance of ecosystem research for environmental planning

2.1 Can you, in principle, recognise a relevant **influence** of the results of ecosystem research on **environmental planning** (e.g. on the development of planning methods, or the use of particular techniques in planning, such as scenario techniques or the use of geographical information systems)?

☐ no

☐ yes

If yes, which areas of application of ecosystem research results do you judge as particularly significant.

Please use a scale of 1 (very significant) to 5 (not significant)

☐ The use of basic data produced within the research project for the research area and for the planning area (e.g. adoption of research results for the description and analysis of the research area)

☐ Use of methodological tools (e.g. investigation strategies, evaluation procedures, superimposition of information layers)

☐ Use of more advanced technology (e.g. GIS techniques, techniques in the area of remote sensing, computer models)

☐ Other

Where possible, please give reasons for your rating.

2.2 In your opinion, are the results from ecosystem research so prepared, that you as a planner are able to work further with them? Or is there a relevant **"transformation problem**", which makes it difficult to use the know-how from ecosystem research to your concrete planning needs?

☐ no, there is no transformation problem ☐ yes, there is a transformation problem

Please provide some details for your judgement.

2.3 Are there particular ecosystem research projects, which have in your opinion delivered an **outstanding contribution to methodological and technical advancement in environmental planning** and which have particularly enriched your work?

☐ no

☐ yes

If yes, which projects and through which results do the projects particularly stand out.

2.4 Would you in principle wish for a greater applicability of ecosystem research?

☐ no

☐ yes

If yes, in which areas do you wish to have useful methodological, technical or informative contributions from ecosystem research?

3 Contribution of ecosystem research to environmental monitoring and surveillance

3.1 How do you value the significance of a close **link**
(c) conceptionally and
(d) practically
between ecosystem research, environmental monitoring and environmental surveillance?

3.2 Which contributions appear to you to be of particular significance?

Please use a scale of 1 (very significant) to 5 (not significant)

☐ Specific **technical innovations** that are used or could find a use in routine environmental monitoring during data <u>collection</u> (e.g. applied measuring and process techniques)?

☐ Specific **conceptional and methodological innovations** that are used or could find a use in routine environmental monitoring in data analysis/synthesis (e.g. correlation analysis, scenario technique)

☐ **Suggestions of a structural and strategic nature** (e.g. in respect to the question, how different measuring and data processing institutions can co-operate more intensively in environmental monitoring.

☐ **Suggestions by nature of content** (e.g. in respect to the question, which topics and environmental problems should be focal points in environmental monitoring in the future)

☐ Other

Where possible, please give reasons for your rating:

3.3 Would a close (also spatial) link between ecosystem research and environmental monitoring be in your opinion desirable?

close spatial link	☐ no	close content/methodological link ☐ no
	☐ yes	☐ yes

If yes, in which areas do you wish methodological, technical or topical stimuli?

3.4 Which **problems** do you see that hamper the **'transfer'** from a **research program to a regular environmental monitoring program**?

4 Contribution of ecosystem research to environmental training, public relations and environmental reporting

4.1 Are you of the opinion that ecosystem research should be closely **linked** with environmental training, especially at universities, and with 'pro-environment' public relations efforts?

☐ no

☐ yes

Please explain your view.

4.2 Do you think that this link existed in the past to a satisfactory level?

☐ no

☐ yes

If no, where do you think the problem may lie?

4.3 Do you know of **positive examples** (as well from 'your' ecosystem research project/s) **of such links** of ecosystem research with environmental training and public relations)? Were there or are there e.g. open discussion forums, are there/was there guided tours of field plots, are there accompanying publications in local media?

☐ no

☐ yes

If yes, can you name these?

4.4 Do you know of ecosystem research projects, from which significant ideas for environmental reporting arose? If so, of which nature are the ideas?

☐ No

☐ yes, of a strategic and structural nature (e.g. in reference to the questions, which target groups are addressed by which reporting styles, or who reports or from which data)

☐ yes, methodological and by nature of content (e.g. in reference to the question, which topics and environmental problems will be dealt with or how cause–effect relationships in environmental systems can me made transparent in the report)

Can you further specify these ideas and name ecosystem projects which are in your opinion relevant?

4.5 Has ecosystem research, according to your opinion, delivered significant **contributions to the indicator discussion** (e.g. choice of predictive indicators, or to the formulation of aggregated indicators)?

☐ no

☐ yes

Can you name ecosystem research projects that have significantly enriched the indicator discussion?

In which areas do you work with indicators?

5 Critical reflection of ecosystem research projects

Your statements in this section will be carefully evaluated and only passed on in an anonymous form.

5.1 Do you believe that the **organizational structure and the strategic approach** of ecosystem research projects as well as the selection of the main research objectives were satisfactorily reflected in the past and the present?

☐ no

☐ yes

If no, in regard to which aspects would you desire specifically strong reflections? In your opinion, what is the most important critique?

In your opinion what are the reasons for unsatisfactory self-reflection?

Do you have an idea of the reasons behind the points you regard as problematic?

5.2 How do you judge the **problematic of interdisciplinary work** in ecosystem research based on your personal experience in the area? Do you personally practice a form of interdisciplinary work?

☐ no

☐ yes

If yes, which forms of organisation and communication have in your opinion been particularly successful?

If no, what causes the lack of interdisciplinarism in your opinion?

5.3 Do you see **model development** (development of concept and computer models) as a substantial task of ecosystem research?

☐ no

☐ yes

If yes, which significance has model development in your opinion?

If no, please give reasons

5.4 What do you consider, in brief, to be the greatest **advantages and disadvantages of ecosystem research** and its greatest problems?

6 What do you hope for from ecosystem research in the future?

☐ nothing, as from my previous experience I cannot expect any concrete support for my work

☐ in principle a closer exchange between ecosystem research and application as well as a stronger orientation of ecosystem research to applied topics

☐ a stronger orientation at current environmental problems

☐ a stronger detachment from current environmental politics discussions

☐ a greater emphasis on the extraction of suitable methods and instruments (e.g. easy to use models, easily understood indicators producible from available data)

☐ an improved and generally more understandable synthesis of research results.

Have you other suggestions or ideas for ecosystem research in the future?

- In respect to organisation:
- In terms of content (among others, topical main points, developments of methods and technical tools):

Which ideas do you have on the organisation of a close, institutionally supported exchange between ecosystem research and application?

7 Other

At this point we would be pleased to hear ideas and criticisms about our approach in this project:

Many thanks for your cooperation and assistance.

2.4 Questionnaires 3

Please complete if you are/were active in the interface between ecosystem research and environmental politics, management and planning or in education and training.

1 Significance of ecosystem research in the scientific system

1.1 In your opinion, which contribution has ecosystem research delivered to the change in approach and interpretation in the **environmental and system sciences** (e.g. considering chain reactions and reaction nets, or linearity of processes to non-linearity)?

2 Contribution of ecosystem research to the organisation of environmental policy and to the formulation of environmental politicy objectives

2.1 In your opinion, which contribution has ecosystem research delivered to the change in approach and interpretation in **environmental politics and environmental management** (e.g. restricted department strategies or single problem focus or interdisciplinary focus on sustainable development)?

2.2 Can you in general recognise a relevant influence of results from ecosystem research on the formulation of (specific) politicy **objectives** (e.g. on enacting conventions, such as the biodiversity convention)?

☐ no

☐ yes

If yes, which ones?

2.3 At which **scale** (e.g. national, regional etc.) do you see the most important influences of ecosystem research on environmental policy?

3 Significance of ecosystem research for environmental planning

3.1 Can you, in principle, recognise a relevant **influence** of the results of ecosystem research on **environmental planning** (e.g. on the development of planning methods, or the use of particular techniques in planning, such as scenario techniques or the use of geographical information systems)?

☐ no

☐ yes

If yes, which ones?

If yes, which areas of application of ecosystem research results do you judge as particularly significant. Please use a scale of 1 (very significant) to 5 (not significant)

☐ The use of basic data produced within the research project for the research area and for the planning area (e.g. adoption of research results for the description and analysis of the research area)

☐ Use of methodological tools (e.g. investigation strategies, evaluation procedures, superimposition of information layers)

☐ Use of more advanced technology (e.g. GIS techniques, techniques in the area of remote sensing, computer models)

☐ Other

Where possible, please give reasons for your rating

3.2 In your opinion, are the results from ecosystem research so prepared, that you as a planner are able to work further with them? Or is there a relevant **“transformation problem**”, which makes it difficult to use the know-how from ecosystem research to your concrete planning needs?

☐ no, there is no transformation problem ☐ yes, there is a transformation problem

Please provide some details for your judgement.

3.3 Are there particular ecosystem research projects, which have in your opinion delivered an **outstanding contribution to methodological and technical advancement in environmental planning** and which have particularly enriched your work?

☐ no

☐ yes

If yes, which projects and through which results do the projects particularly stand out.

3.4 Would you in principle wish for a greater applicability of ecosystem research?

☐ no

☐ yes

If yes, in which areas do you wish to have useful methodological, technical or informative contributions from ecosystem research?

4 Contribution of ecosystem research to environmental monitoring and surveillance

4.1 How do you value the significance of a close **link**

(e) conceptionally and
(f) practically
between ecosystem research, environmental monitoring and environmental surveillance?

4.2 Which contributions appear to you to be of particular significance?

Please use a scale of 1 (very significant) to 5 (not significant)

☐ Specific **technical innovations** that are used or could find a use in routine environmental monitoring during data collection (e.g. applied measuring and process techniques)?

☐ Specific **conceptional and methodological innovations** that are used or could find a use in routine environmental monitoring in data analysis/synthesis (e.g. correlation analysis, scenario technique)

☐ **Suggestions of a structural and strategic nature** (e.g. in respect to the question, how different measuring and data processing institutions can co-operate more intensively in environmental monitoring.

☐ **Suggestions by nature of content** (e.g. in respect to the question, which topics and environmental problems should be focal points in environmental monitoring in the future)

☐ Other

Where possible, please give reasons for your rating:

4.3 Would a close (also spatial) link between ecosystem research and environmental monitoring be in your opinion desirable?

close spatial link	☐ no	close content/methodological link	☐ no
	☐ yes		☐ yes

If yes, in which areas do you wish methodological, technical or topical stimuli?

4.4 Which **problems** do you see that hamper the **'transfer'** from a **research program to a regular environmental monitoring program**?

5 Contribution of ecosystem research to environmental training, public relations and environmental reporting

5.1 Are you of the opinion that ecosystem research should be closely **linked** with environmental training, especially at universities, and with 'pro-environment' public relations efforts?

☐ no

☐ yes

Please explain your view:

5.2 Do you think that this link existed in the past to a satisfactory level?

☐ no

☐ yes

If no, where do you think the problem may lie?

5.3 Do you know of **positive examples** (as well from 'your' ecosystem research project/s) **of such links** of ecosystem research with environmental training and public relations)? Were there or are there e.g. open discussion forums, are there/was there guided tours of field plots, are there accompanying publications in local media?

☐ no

☐ yes

If yes, can you name these?

5.4 Do you know of ecosystem research projects, from which **significant ideas** for environmental reporting arose? If so, of which nature are the ideas?

☐ No

☐ yes, of a strategic and structural nature (e.g. in reference to the questions, which target groups are addressed by which reporting styles, or who reports or from which data)

☐ yes, methodological and by nature of content (e.g. in reference to the question, which topics and environmental problems will be dealt with or how cause–effect relationships in environmental systems can me made transparent in the report)

Can you further specify these ideas and name ecosystem projects which are in your opinion relevant?

5.5 Has ecosystem research, according to your opinion, delivered significant **contributions to the indicator discussion** (e.g. choice of predictive indicators, or to the formulation of aggregated indicators)?

☐ no

☐ yes

Can you name ecosystem research projects that have significantly enriched the indicator discussion?

6 Links between ecosystem research and training/education

6.1 In your opinion, how could the **cooperation between differing natural sciences** be best supported in tertiary/university education?

6.2 In your opinion, which significance have system analysis and environmental informatics for academic education as far as the competencies for interdisciplinary work are concerned?

6.3 How should cooperation between **ecological scientific disciplines** on the one hand, and **economic and social science disciplines** on the other hand be organised in education?

6.4 Do you see an innovative potential for academic education by working on **real case** studies with stake holder participation (transdisciplinarity'),e.g. regarding case studies in nature and landscape planning?

6.5 Do you see a deficit in the training of competences for **ecological evaluations and assessments** (e.g. normative fundaments for environmental assessments, decision theory, processes for the definition of environmental objectives)?

7 Critical reflection of ecosystem research projects

Your statements in this section will be carefully evaluated and only passed on in an anonymous form.

7.1 Do you believe that the **organisational structure and the strategic approach** of ecosystem research projects as well as the selection of the main research objectives were satisfactorily reflected in the past and the present?

☐ no

☐ yes

If no, in regard to which aspects would you desire specifically strong reflections? In your opinion, what is the most important critique?

In your opinion what are the reasons for unsatisfactory self-reflection?

Do you have an idea of the reasons behind the points you regard as problematic?

7.2 How do you judge the **problematic of interdisciplinary work** in ecosystem research based on your personal experience in the area? Do you personally practice a form of interdisciplinary work?

☐ no

☐ yes

If yes, which forms of organisation and communication have in your opinion been particularly successful?

If no, what causes the lack of interdisciplinarism in your opinion?

7.3 Do you see **model development** (development of concept and computer models) as a substantial task of ecosystem research?

☐ no

☐ yes

If yes, which significance has model development in your opinion?

If no, please give reasons

7.4 What do you consider, in brief, to be the greatest **advantages and disadvantages of ecosystem research** and its greatest problems?

8 What do you hope for from ecosystem research in the future?

☐ nothing, as from my previous experience I cannot expect any concrete support for my work

☐ in principle a closer exchange between ecosystem research and application as well as a stronger orientation of ecosystem research to applied topics

☐ a stronger orientation at current environmental problems

☐ a stronger detachment from current environmental politics discussions

☐ a greater emphasis on the extraction of suitable methods and instruments (e.g. easy to use models, easily understood indicators producible from available data)

☐ an improved and generally more understandable synthesis of research results.

Have you other suggestions or ideas for ecosystem research in the future?

- In respect to organisation:
- In terms of content (among others, topical main points, developments of methods and technical tools):

Which ideas do you have on the organisation of a close, institutionally supported exchange between ecosystem research and application?

9 Other

At this point we would be pleased to hear ideas and criticisms about our approach in this project:

Many thanks for your cooperation and assistance.

APPENDIX 3: ADDRESSEES OF THE QUESTIONNAIRES

In alphabetical order

Name	Institution
Aber, Prof. John	Yale University, Joint Appointment Department of Natural Resources, Forest Ecosystem Analysis, US
Ågren, Göran	Swedish University of Agricultural Sciences, Dept. of Ecology and Environmental Research, Uppsala, Sweden
Alexy, Prof. Dr. Robert	Universität Kiel, Juristisches Seminar, Kiel, Germany
DeAngelis, Prof. Dr. Donald L.	University of Miami, U.S. Geological Survey, Biological Resources Division, Department of Biology, Corla Gables, US
Baron, Ph.D. Jill S.	U.S. Geologica.Survey, Nagural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado, US
Bastian, Dr. habil Olaf	Sächsischen Akademie der Wissenschaften zu Leipzig, AG Naturhaushalt und Gebietscharakter, Dresden, Germany
Bechmann, Prof. Dr. Armin	Synök-Institut, Basinghausen, Germany
Beese, Prof. Dr. Friedrich	Universität Göttingen, Institut für Bodenkunde und Waldernährung, Göttingen, Germany
Beierkuhnlein, Prof. Dr. Carl	Universität Rostock, Fachbereich Landeskultur und Umweltschutz, Landschaftsökologie und Standortkunde, Rostock, Germany
Bendoricchio, Prof. Dr. Giuseppe	University of Padova, Dept. Chemical Processes of Eng., Padova, Italy
Binder, MinR Dr. Norbert	BMBF 422 Globale Umweltaspekte, Friedens- und Konfliktforschung, Bonn, Germany
Blume, Prof. Dr. H.-P.	Ökologie-Zentrum der Christian-Albrechts-Universität, Kiel, Germany
Bork, Prof. Dr. Hans-Rudolf	Ökologie-Zentrum der Christian-Albrechts-Universität, Kiel, Germany
Bornhoeft, Dr. Dirk	Ministerium für Umwelt, Natur und Forsten des Landes Schleswig-Holstein (MUNF), Kiel, Germany
Bossel, Prof. i.R. Dr. Hartmut	Gesamthochschule Kassel, Lehrstuhl für Umweltsystemwissenschaften
Breckling, PD Dr. Broder	Universität Bremen, Zentrum für Umweltforschung und Umwelttechnologie (UFT), Bremen, Germany
Bredemeier, PD Dr. Michael	Universität Göttingen, Forschungszentrum Waldökosysteme, Göttingen, Germany
Bridgewater, Dr. Peter	UNESCO, Division of Ecological Sciences, Secretary of the MAB Programme, Paris, France
Buchmann, PD Dr. Nina	Max-Planck-Institut für Biogeochemie, Jena, Germany
Carpenter; Steve	University of Wisconsin, Centre of Limnology, US
Cernuska, Prof. Dr. Alexander	Universität Innsbruck, Institut für Botanik, Abteilung: Ökologie, Innsbruck, Österreich
Chapin III, Prof. Dr. Stuart F.	University of Alaska-Fairbanks, Department of Biology and Wildlife, Institute of Arctic Biology, US
Christensen, Prof. Dr. Torben R.	Lund University, Centre for Geobiosphere Studies, Department of Physical Geography & Ecosystem Analysis, Lund, Sweden
Colijn, Prof. Dr. Franciscus	Forschungs- und Technologiezentrum Westküste, Hafentörn, Büsum, Germany
Costanza, Prof. Dr. Robert	University of Maryland, Dept. of Zoology, US
Davies, Prof. Dr. Huw C.	ETH Zürich, Atmospheric and Climate Science ETH, Zürich, Schweiz
DBU	Deutsche Bundesstiftung Umwelt, Osnabrück, Germany
Debeljak, Marko	University of Ljubljana, Biotechnical Faculty: Department of Forestry, Ljubljana, Slovenia
Dittmann, Dr. Sabine	Zentrum für Flachmeer-, Küsten- und Meeresumweltforschung e.v., Forschungszentrum terramare, Wilhelmshaven, Germany

Name	Institution
Drösler, Matthias	Universität Bayreuth, Department of Plant Ecology, Bayreuth, Germany
Ehleringer, Prof. Dr. James R.	University of Utah, Department of Biology, Salt Lake City, US
Elbaz-Poulichet, Françoise	Université Montpellier II, UMR Hydrosciences "Géochimie", Montpellier Frankreich
Fagre, Dr. Daniel	U.S. Geological Survey, Reston, US
Farke, Dr. Hubert	Biosphärenreservat Nationalpark, Niedersächsisches Wattenmeer, Wilhelmshaven, Germany
Filser, Prof. Dr. Juliane	Universität Bremen, Zentrum für Umweltforschung und Umwelttechnologie (UFT), Bremen, Germany
Fränzle, Prof. Dr. Otto	Universität Kiel, Geographisches Institut, Kiel, Germany
Frankignoulle, Michel	Mécanique des Fluides Géophysiques, Unité d'Océanographie Chimique, Sart Tilman, Belgien
Franz, Helmut	Nationalparkverwaltung Berchtesgaden, Berchtesgaden, Germany
Fritz, Prof. Dr. Peter	Umweltforschungszentrum (UFZ) Leipzig-Halle, Department of Ecological Modelling, Leipzig, Germany
Fuentes Hutfilter, Ursula	Geschäftsstelle WBGU, Berlin, Germany
Gaedke, Prof. Dr. Ursula	Universität Potsdam, Institut für Biochemie und Biologie, Potsdam, Germany
Gätje, Dr. Christiane	Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer, Tönning, Germany
Galagan, Dr. Alexander	Center of Ecological Monitoring of Ukraine, Ukraine
Gerold, Prof. Dr. Gerhard	Universität Göttingen, Geographisches Institut, Abteilung Landschaftsökologie, Göttingen, Germany
GLORIA-Europe	Universität Wien, GLORIA-Europe, Austria
Gollan, Dr. Thomas	Universität Bayreuth, BITÖK, Wissenschaftliches Sekretariat, Bayreuth, Germany
Golley, Dr. Frank US	University of Georgia, Institute of Ecology, US
Gosz, James	University of New Mexico, Department of Biology, Albuquerque, US
Gravenhorst, Prof. Dr. Gode	Universität Göttingen, Institut für Bioklimatologie, Göttingen, Germany
Grimm, Dr. Volker	Umweltforschungszentrum (UFZ) Leipzig-Halle, Department of Ecological Modelling, Leipzig, Germany
Grossmann, Wolf Dieter	GKSS-Forschungszentrum Geesthacht GmbH, Geesthacht, Germany
Haaren, Prof. Dr. Christina von	Universität Hannover, Institut für Landschaftspflege und Naturschutz, Hannover, Germany
Haber, Prof. Dr. Dr. hc Wolfgang	Technische Universität München-Weihenstephan, Lehrstuhl für Landschaftsökologie, Freising, Germany
Hall, Dr. Forrest G.	University of Maryland, Baltimore County, US
Hauhs, Prof. Dr. Michael	Universität Bayreuth, BITÖK, Ecological Modelling, Bayreuth, Germany
Haussmann, Thomas	Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft (BMVEL), Bonn, Germany
Heal, Dr. O.W.	The Granary-Allerwash-Newbrough-Hexham, Northumberland, UK
Heinrich	Ökologie-Zentrum der Christian-Albrechts-Universität, Kiel, Germany
Helming, Dr. Katharina	Zentrum für Agrarlandschafts- und Landnutzungsforschung (ZALF) e.V., Müncheberg, Germany
Hobbie, Dr. John	The Ecosystems Center, Marine Biological Laboratory, Massachusetts, US
Hoffman-Kroll, Dr. Regina	Statistische Bundesamt, Wiesbaden, Germany
Höpner, Prof. Dr. Thomas	Carl von Ossietzky Universität, Institut für Chemie und Biologie des Meeres, Oldenburg, Germany
Holling C.S.	University of Florida, US
Hoppenstedt, Adrian	Planungsgruppe Oekologie + Umwelt GmbH, Hannover, Germany
Huntley, Prof. Dr. Brian	Environmental Research Centre, University of Durham, UK

Name	Institution
Jensen, Dr. Kai	Ökologie-Zentrum der Christian-Albrechts-Universität, Kiel, Germany
Jessel, Prof. Dr. Beate	Universität Potsdam, Institut für Geoökologie, Lehrstuhl für Landschaftspla-nung, Potsdam, Germany
Jong, Mr. Folkert de	The Common Wadden Sea Secretariat (CWSS), Wilhelmshaven, Germany
Jørgensen, Prof. Dr. Sven Erik	Royal Danish School of Pharmacy, Institute A (Environmental Chemistry), Copenhagen, Denmark
Junk, Prof. Wolfgang Johannes	Max-Planck-Institut für Limnologie, Arbeitsgruppe Tropenökologie, Plön, Germany
Kainz, Max	Technische Universität München-Weihenstephan, FAM-Versuchsstation Klostergut Scheyern, Germany
Kappen, Prof. Dr. Ludger	Universität Kiel, Institut für Botanik, Kiel, Germany
Kay, James	University of Waterloo, Environment and Resources Studies, Ontario, US
Kellermann, Dr. Adolf	Nationalpark und Biosphärenreservat Schleswig-Holsteinisches Watten-meer, Tönning, Germany
Koch, Dr. Herr	Planung + Umwelt, Planungsbüro Dr. Koch, Stuttgart, Germany
Korn, Horst	Bundesamt für Naturschutz, Insel Vilm, Germany
Köppel,. Prof. Dr. Johann	Technische Universität Berlin, Institut für Landschaftsentwicklung, Berlin, Germany
Körner, Prof. Dr. Christian	Universität Basel, Botanisches Institut, Basel, Swizerland
Koptsik, Dr. Galina bzw. Kopsik, Serguei V.	Moscow State University, Soil Science Faculty, Moscow, Russia
Lancelot, Dr. Christiane	Université Libre de Bruxelles, Microbiologie des Milieux, Bruxelles, Belgium
Lenz, Prof. Dr. Roman	Fachhochschule Nürtingen, Institut für Angewandte Forschung Fachbereich Landschaftsarchitektur, Umwelt- und Stadtplanung, Nürtingen, Germany
Leser, Prof. Dr. Hartmut	Geographisches Institut, Bernoullianum, Basel, Swizerland
Li, Bai-Lian	University of California, Department of Botany and Plant Sciences, River-side, US
Likens, Gene	Institute of Ecosystem Studies, Millbrook, US
Loope, Dr. Lloyd	U.S. Geological Survey, Haleakala Field Station, Makawao, US
Loose, Dr. Carsten	Geschäftsstelle WBGU, Berlin, Germany
Loreau, Prof. Dr. Michel	Pierre et Marie Curie University, Laboratoire d'Ecologie, Paris, France
Lyons, W. Berry	The Ohio State University, Byrd Polar Research Center, US
Macaulay, Craig	CSIRO Marine Research, Australia
Mander, Prof. Dr. Ülo	University of Tartu, Institute of Geography, Estonia
Marques, Prof. Dr. João Carlos	University of Coimbra, IMAR – Institute of Marine Research, Department of Zoology, Faculty of Science and Technology, Portugal
Matzner, Prof. Dr. Egbert	Universität Bayreuth, Lehrstuhl für Bodenökologie, BITÖK, Bayreuth, Ger-many
Mengel, Dr. Andreas	Büro für Naturschutz, Umweltplanung und Regionalentwicklung, Obertshau-sen, Germany
Messerli, Prof. Dr. Paul	Universität Bern, Abteilung Kulturgeographie, Geographisches Institut, Bern, Swizerland
Mitsch, William J.	Ohio State University, US
Mooney, Harold	Stanford University, US
Mose, Prof. Dr. Ingo	Hochschule Vechta, Institut für Umweltwissenschaften, Vechta, Germany
Munch, Prof. Dr. Jean Charles	GSF – Forschungszentrum für Umwelt und Gesundheit GmbH, Neuherberg, Germany
Mühle, Prof. Dr. Heidrun	Umweltforschungszentrum (UFZ) Leipzig-Halle, Projektbereich Naturnahe Landschaften und ländliche Räume (NLLR), Leipzig, Germany

Name	Institution
Müller, Prof. Dr. Paul	Universität Trier, Biogeographie, Trier, Germany
Münzenberg, Dr. Annette	Deutsche Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen, Germany
Nauber, Dr. Jochen	Bundesamt für Naturschutz, Bonn, Germany
Neumann, Frank	IPU-Ingenieurbüro für Planung und Umwelt, Erfurt, Germany
Nielsen, Prof. Dr. Søren Nors	Royal Danish School of Pharmacy, Institut for Analytisk & Farmaceutisk Kemi, Kopenhagen, Denmark
Odum, Prof. Dr. Eugene	University of Georgia, Athens, US
d'Oleire-Oltmanns, Dr. Werner	Zukunft Biosphäre GmbH, Bischofswiesen, Germany
O'Neill, Prof. Dr. Jim	National Laboratory, Oakridge, US
Pampura, Dr. Tatiana	Institute of Physicochemical and Biological Problems in Soil Science RAS, Pushchino, Moscow region, Russia
Patrick, Simon	Environmental Change Research Center, London, UK
Patten, Prof. Duncan T.	Montana State University, US
Patten, Dr. Bernie C.	University of Georgia, Dept. of Zoology and Institute for Ecology, Athens, US
Petschel-Held, Dr. Gerhard	Potsdam-Institut für Klimafolgen-forschung, Potsdam, Germany
Pfadenhauer, Prof. Dr. Jörg	Technische Universität München-Weihenstephan, Lehrstuhl für Vegetati-onsökologie, Freising, Germany
Picket, Prof. Steward TA	Institute of Ecosystem Studies, Millbrook, New York, US
Pirkl, Anton	Landschaftsbüro, Landshut, Germany
Plachter, Prof. Dr. Harald	Philipps Universität Marburg, Fachgebiet Naturschutz, Marburg, Germany
Plän, Dr. Thomas	Institut für Biodiversität, Regensburg, Germany
Printz, Andreas	Technische Universität München-Weihenstephan, Department für Ökologie, Lehrstuhl für Landschaftsökologie, Freising, Germany
Putten, Dr. Wim H. van der	Netherlands Institute of Ecology, Netherlands
Pykh, Prof. Yuri A.	Center for International Environmental Cooperation, St. Petersburg, Russia
Rammert, Dr. Uwe	Landesamt für Natur und Umwelt des Landes Schleswig-Holstein, Stabsstel-le Integrierter Umweltschutz, Flintbek, Germany
Rapport, Prof. Dr. David J.	University of Guelph, School of Rural Planning and Development, Canada
Rasch, Dr. Morten	Danish Polar Center, Copenhagen, Denmark
Regier, Prof. Dr. Henry	University o Toronto, Department of Zoology, Canada
Reise, Prof. Dr. Karsten	Biologische Anstalt Helgoland, in der Stiftung Alfred-Wegener-Institut für Polar- und Meeresforschung, Germany
Riedel, Berthold	Landschaftsbüro, Landshut, Germany
Robertson, Phil	Michigan State University, Center for Microbial Ecology, KBS, Robertson Dept. of Crop and Soil Sciences Biogeochemistry, US
Roweck, Prof. Dr. Hartmut	Ökologie-Zentrum der Christian-Albrechts-Universität, Kiel, Germany
Ruthsatz, Prof. Dr. Barbara	Universität Trier, FB VI Geobotanik, Trier, Germany
Saint-Paul, Prof. Dr. Ulrich	Zentrum für Marine Tropenökologie (ZMT), Bremen, Germany
Schäfer, Prof. Dr. Matthias	Universität Göttingen, Institut für Zoologie und Anthropologie, Göttingen, Germany
Schanze, Jochen	Institut für ökologische Raumentwicklung, Dresden, Germany
Scherer, Dr. Bernd	Nationalpark und Biosphärenreservat Schleswig-Holsteinisches Watten-meer, Tönning, Germany
Scherer-Lorenzen, Dr. Michael	Max Planck Institut für Biogeochemie, Jena, Germany
Schindler, David W.	University of Alberta, Department of Biological Sciences, Edmonton, Can-ada
Schlesinger, William H.	Duke University, Department of Botany, US
Semenov, Mr. Serguei M.	Institute of Global Climate and Ecologie, Moscow, Russia
Schönwitz, Roswitha	Deutsche Forschungsgemeinschaft (DFG), Bonn, Germany

Name	Institution
Schröder, PD Dr. Peter	GSF – Forschungszentrum für Umwelt und Gesundheit, Neuherberg, Germany
Sukopp, Prof. Dr. Herbert	Technische Universität Berlin, Institut für Ökologie und Biologie, Berlin, Germany
Schütze, Dr.	Forschungszentrum Jülich GmbH, Projektträger Biologie, Energie, Ökologie (BEO), Jülich, Germany
Schulz, MinR Helmut	BMBF, Referat integrierter Umweltschutz in der Wirtschaft, Bonn, Germany
Schulze, Prof. Dr. Ernst Detlef	Max-Planck-Institut für Biogeochemie, Jena, Germany
Simenstad, Charles	University of Washington, School of Aquatic and Fishery Sciences, Wetland Ecosystem Team, Seattle, Washington, US
Sommer, Prof. Dr. Ulrich	Institut für Meereskunde (IFM), Kiel, Germany
Spandau, Dr. Lutz	Allianz Stiftung für Umwelt, München, Germany
Sündermann, Prof. Dr. Jürgen	Institut für Meereskunde, Hamburg, Germany
Svirezhev, Yuri	Potsdam-Institut für Klimafolgenforschung, Potsdam, Germany
Tenhunen, Prof. Dr. John	Universität Bayreuth, Lehrstuhl für Pflanzenökologie, Bayreuth, Germany
Theurer, Ralf	Landschaftsbüro, Landshut, Germany
Thompson, Dr Julian	University College London, Department of Geography, London, UK
Tilman, Prof. Dr. David	University of Michigan, Dept. of Ecology, Evolution and Behavior, US
Tobias, Prof. Dr. Kai	Technische Universität Kaiserslautern, Fachbereich ARUBI, Fachgebiet Ökologische Planung, UVP, Kaiserslautern, Germany
Trepel, Dr. Michael	Ökologie-Zentrum der Christian-Albrechts-Universität, Kiel, Germany
Trepl, Prof. Dr. Ludwig	Technische Universität München-Weihenstephan, Lehrstuhl für Landschaftsökologie, Freising, Germany
Turner, Prof. Dr. Monica	University of Wisconsin-Madison, Department of Zoology, US
Ulrich, Prof. Dr. Bernhard	Universität Göttingen, Forschungszentrum Waldökosysteme, Göttingen, Germany
Venslauskas, Prof. Dr. Minaugas	Universität Kaunas, Kaunas, Lithuania
Vitousek, Peter M.	Stanford University, Department of Biological Sciences, US
Vogel, Dr. Michael	Nationalparkverwaltung Berchtesgaden, Berchtesgaden, Germany
Walker, Brian	CSIRO Sustainable Ecosystems, Canberra, Australia
Wiedey. Dr.Gustav	Universität Göttingen, Forschungszentrum Waldökosysteme, Göttingen, Germany
Wielgolaski, Prof. Dr. Franz-Emil	University of Oslo, Department of biology, Norway
Wiens, Prof. Dr. John A.	Colorado State University, Department of Biology & Graduate Degree Program in Ecology, Fort Collins, US
Wiggering, Prof. Dr. Hubert	Zentrum für Agrarlandschaft und Landnutzungsforschung (ZALF), Müncheberg, Germany
Windhorst, Dr. Wilhelm	Ökologie-Zentrum der Christian-Albrechts-Universität, Kiel, Germany
Wissel, Prof. Dr. Christian	Umweltforschungszentrum (UFZ) Leipzig-Halle, Sektion Ökosystemanalyse, Leipzig, Germany
Wookey, Dr. Philip Andrew	University Department of Earth Sciences Villavägen, Uppsala, Sweden
Wolff, Dr. Barbara	Bundesforschungsanstalt für Forst- und Holzwirtschaft, Institut für Forstökologie und Walderfassung, Eberswalde, Germany
Zauke, Dr. Gerd	Carl von Ossietzky Universität Oldenburg, Institut für Chemie und Biologie des Meeres (ICBM), Oldenburg, Germany

APPENDIX 4: ANALYSIS OF THE QUESTIONNAIRES

only available in german

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Die zu den einzelnen Fragen der Fragebögen eingegangenen Antworten wurden zusammengestellt und systematisiert. Die Ergebnisse sind im Folgenden – hier von den Projektnehmern unkommentiert – wiedergegeben. Sie spiegeln nicht in jedem Falle die Meinung der Projektnehmer wieder.

Die Gliederung der Darstellungen orientiert sich eng an der Gliederung der Fragebögen. Ergaben sich differenzierte Aussagen von Seiten der einzelnen befragten Gruppen (Forscher, Anwender/Planer, in der Lehre Tätiger), so ist darauf an entsprechender Stelle hingewiesen.

4.1 Beitrag der Ökosystemforschung zu Veränderungen von Betrachtungsweisen und Interpretationen in den Umwelt- und Systemwissenschaften

- **Veränderungen und Erweiterungen im Denken:**

Sowohl von den in der Ökosystemforschung Tätigen als auch den an der Schnittstelle von Ökosystemforschung und Umweltpolitik, -verwaltung oder -planung und mit der Ausbildung und Lehre Beschäftigten wird anerkannt, dass die Ökosystemforschung zu einer Veränderung und Erweiterung des Denkens beigetragen hat.

Die Ökosystemforschung ist aus der Erkenntnis heraus motiviert, dass die Analyse einfacher linearer Wirkungsketten für die Betrachtung komplexer (und individuell reagierender) Systeme und Phänomene nicht ausreichend sein kann. Die Ökosystemforschung trägt nach Meinung der antwortenden Wissenschaftler entscheidend zum vernetzten Denken und Handeln bei, indem sie

- sich der Untersuchung und Modellierung auch nicht-linear reagierender Systeme widmet,
- sich neben den unmittelbaren auch für die indirekten und chronischen Konsequenzen von Umweltveränderungen interessiert,
- anerkennt, dass Fernwirkungen oft bedeutsamer als Nahwirkungen sein können,
- auch komplexe (multiple) Rückkoppelungsmechanismen, die zu Charakteristika wie Selbstorganisation, Emergenz und Hierarchie führen, in ihre Betrachtungen mit einbezieht und
- ökologische Systeme unter den Gesichtspunkten von Stabilität, Instabilität, Katastrophe und Reversibilität untersucht.

Mit diesen Ansätzen besteht die Ökosystemforschung nicht nur in einer (additiven) Zusammenschau der verschiedenen Naturwissenschaften (wie Physik, Chemie und Biologie), sondern reicht in ihrer Erkenntnis über diese hinaus. Bei gelungener Inter- und Transdisziplinarität bringt es die Ökosystemforschung zu einer holistischen Umwelterfassung als Grundlage einer integrativen Umweltbewertung.

Ökosystemforschung hat nach Ansicht der meisten Befragten grundsätzlich interdisziplinäre Denk- und Betrachtungsweisen gefördert, wobei die Interdisziplinarität dabei keineswegs auf die Integration unterschiedlicher naturwissenschaftlicher Diszipinen beschränkt bleibt, sondern ebenso auch sozio-ökonomische Disziplinen einbeziehen kann. Das Denken im Zusammenhang Mensch-Umweltsystem ist durch die Ökosystemforschung gefördert worden. Ob das veränderte Ziel- und Anforderungsprofil tatsächlich zu einem neuen Wissenschaftsverständnis führt, ist jedoch nicht unumstritten.

Als ein weiterer Aspekt wird genannt, dass die Ökosystemforschung dazu beiträgt, das „physiko-chemische” Paradigma abzulösen, in dem ein Ökosystem primär als „chemische Fabrik“

betrachtet wird. Das neue Paradigma hingegen betont die Informationsverarbeitung bezüglich der in den Ökosystemen ablaufenden Interaktionen.

Von Praktikern wird jedoch kritisiert, dass diese Änderung der Betrachtungsweisen hin zur Berücksichtigung immer komplexerer Zusammenhänge zu einem Anspruch geführt hat, der von den praktisch nutzbaren Ergebnissen der Ökosystemforschung keineswegs immer hat eingelöst werden können. Dies bezieht sich beispielsweise auf den Anspruch Wirkungsnetze anstelle von Wirkungsketten zu betrachten – ein Anspruch, der z.B. im Hinblick auf die Wechselwirkungen in der UVP bislang noch nicht eingelöst worden ist.

- **Erweiterung des Untersuchungsgegenstandes:**

Im Mittelpunkt der Ökosystemforschung stehen die Umweltkompartimente und Elemente eines Ökosystems in ihrem Zusammenwirken. Dementsprechend sind die Forschungsobjekte der Ökosystemforschung auch auf unterschiedlichen Maßstabsebenen angeordnet. Auch Landschaften werden zum Gegenstand (integrierter) Betrachtungen und intensiver Untersuchungen.

Der Mensch wird als „steuernde Größe“ in die Untersuchungen mit einbezogen. Diese Erweiterung des Forschungsgegenstandes wurde insbesondere vom MAB-Programm gefördert.

- **Erweiterung der Untersuchungsansätze:**

Mit der Erweiterung des Untersuchungsgegenstandes ging eine Erweiterung der Untersuchungsansätze einher. Im Verlauf der Ökosystemforschung ist nach Aussage der befragten Wissenschaftler deutlich geworden, dass Messung und Modellbildung parallel (räumlich, zeitlich und unter Einbeziehung unterschiedlicher Ökosystemkomponenten) eingesetzt werden müssen. Im Hinblick auf eher angewandte Fragestellungen ist zunehmend deutlich geworden, dass Ökosystemforschung nur in der Kombination von naturwissenschaftlichem und praktischem Expertenwissen zum Erfolg führen kann.

- **Veränderung der zentralen Zielsetzung der wissenschaftlichen Forschung:**

Die Ökosystemforschung entspringt nicht mehr allein wissenschaftlichen Interessen. Vielmehr werden die Fragestellungen der Ökosystemforschung aus gesellschaftlichen Notwendigkeiten heraus definiert. Ein wesentliches Ziel der Ökosystemforschung besteht nicht nur darin, das Verständnis von den Zusammenhängen zwischen Umweltkompartimenten sowie zwischen Funktion, Struktur und Nutzung von Ökosystemen zu fördern, sondern ebenso konkrete Beiträge zu einer nachhaltigen (und multiplen) Nutzung von Ökosystemen zu liefern. Die große Chance der Ökosystemforschung liegt nach Einschätzung einiger Befragter darin, angewandte Fragestellungen breit und gut organisiert zu untersuchen.

- **Impulse für die Organisation der Forschung:**

Die – gegenüber der klassischen naturwissenschaftlichen Forschung - veränderte Zielsetzung der Ökosystemforschung hat auch für die Organisation der Forschung neue und wichtige Impulse gegeben. Aus der Aufgabenstellung der Ökosystemforschung ergibt sich zwangsläufig ein Zwang zur Kooperation verschiedener Fachdisziplinen. So ging mit vielen Ökosystemforschungsvorhaben die Gründung von Forschungsverbünden einher. Z.T. hat sich auch die administrative „Ansiedlung“ der Forschung verändert; im Falle der Ökosystemforschung Schleswig-Holsteinisches Wattenmeer lag die Koordination beispielsweise bei den zuständigen Behörden. Auch dies hat zu einer stärkeren Praxisorientierung der wissenschaftlichen Aktivitäten beigetragen.

4.2 Beitrag der Ökosystemforschung zur Ausrichtung der Umweltpolitik und zur Formulierung umweltpolitischer Ziele

4.2.1 Beitrag der Ökosystemforschung zu Veränderungen von Betrachtungsweisen und Interpretationen in der Umweltpolitik und im Umweltmanagement

- **Beiträge zur Veränderung von Betrachtungsweisen:**

Die Ökosystemforschung hat nach Meinung der befragten Wissenschaftler und Praktiker einen Teilbeitrag zur Überwindung allein sektoraler (ressortgeprägter) Sichtweisen in der Umweltpolitik und –verwaltung geliefert und eine Hinwendung zu einer stärker integrativen Betrachtung und Behandlung von Umweltproblemen gefördert. Die verstärkte Wahrnehmung der hohen Komplexität und Vernetztheit von Umweltproblemen hat bewirkt, dass Lösungen für diese Probleme nicht mehr nur im engen sektoralen und räumlichen Umfeld gesucht und diskutiert werden. Vielmehr ist deutlich geworden, dass sich viele Probleme nur mit integrativen Initiativen erfolgreich lösen lassen. Außerdem prägen zunehmend die Erkenntnis zur Bedeutung und zum Wert ökosystemarer Güter und Leistungen für das sozio-ökonomische System und das Wissen um die Gefährdung durch den Verlust dieser „Ecosystem Services" die politische Diskussion. Die Ökosystemforschung prägt in diesem Sinne die Zusammenführung ökologischer, ökonomischer und sozialer Argumente im Rahmen der Nachhaltigkeitsdebatte.

Indem sich die Ökosystemforschung den dynamischen und nicht-linearen Prozessen in Ökosystemen angenommen hat, hat sie insofern wichtige Impulse für die Umweltpolitik und das Umweltmanagement gegeben, als Umweltentwicklung heute stärker als dynamischer Prozess verstanden wird, der sich mit „harten" Zielen nur bedingt steuern lässt.

Die Ökosystemforschung hat darüber hinaus die Bedeutung und Tragweite globaler Umweltprobleme nach Meinung der Befragten stärker in das Bewusstsein politischer Enscheidungsträger gerückt.

- Konkrete Beiträge zum Ökosystemschutz:

Neben der grundsätzlichen Förderung des Verständnisses von Umweltproblemen in der Öffentlichkeit hat die Ökosystemforschung konkret zur Herausbildung moderner Naturschutzstrategien beigetragen. Diese führten z.B. zur Einrichtung von Großschutzgebieten, in denen zumindest in Teilgebieten der Schutz natürlicher Prozessdynamiken im Vordergrund steht.

Von der Ökosystemforschung wurden auch notwendige wissenschaftliche Grundlagen zur Konzipierung von Schutz- und Managementmaßnahmen geliefert. Hierzu gehören beispielsweise Erkenntnisse zur Schadstoffausbreitung und zu Schadschwellen, die zur Implementierung des Vorsorgeprinzips und zu konkreten (nationalen und internationalen) Aktivitäten u.a. in den Bereichen Luftreinhaltung (wie z.B. UN/ECE Convention on Long-Range Transboundary Air Pollution (1979), Götheborg-Protokoll (1999)) sowie Boden- und Gewässerschutz geführt haben.

Dem aus der Ökosystemforschung erwachsenen Bewusstsein zur Notwendigkeit systemarer Betrachtungen wird außerdem ein relevanter Einfluss auf die Konzeption und Verabschiedung verschiedener internationaler rechtlicher Bestimmungen und Vereinbarungen zugewiesen. So schlägt sich der systemare Ansatz beispielsweise in der EU-Wasserrahmenrichtlinie und der Biodiversitätskonvention („ecosystem approach") nieder.

Insbesondere dann, wenn die Ökosystemforschungsvorhaben explizit zur Entwicklung eines dem System angepassten Managements ins Leben gerufen worden sind, lassen sich konkrete Beiträge für umweltpolitische Management-Entscheidungen benennen. So hat beispielsweise die Wattenmeerökosystemforschung in Schleswig-Holstein konkret zur Novellierung des Nationalparkgesetzes, zur Konzeption des TMAP, zur Ausarbeitung des Schleswig-Holsteinischen Miesmuschelfischereiprogramms, des Besucherlenkungskonzeptes sowie zur Ausgestaltung des Vorlandmanagements in Abstimmung zwischen dem Landwirtschaftsministerium und dem Nationalparkamt geführt.

Grundsätzlich äußern sich jedoch die Forscher selbst und insbesondere die in der Verwaltung Tätigen zum konkreten Einfluss der Ökosystemforschung auf Politik und Verwaltungshandeln eher zurückhaltend. Das heißt, ein diesbezüglicher Einfluss kann der Ökosystemforschung zwar unterstellt werden, aber nur in wenigen Fällen ist er konkret nachweisbar.

Die Ursache für Umsetzungsprobleme wird auch auf Seiten der Umweltpolitik/-verwaltung gesehen. So konnten in der Politik- und Verwaltungspraxis vielmals die Ressortgrenzen und die damit verbundene sektorale Trennung der Zuständigkeiten nicht überwunden werden.

Die Gründe für die ungenügende Einflussnahme der Ökosystemforschung auf Politik und Verwaltung werden keineswegs allein in der fehlenden Rezeption der wissenschaftlichen Erkenntnisse gesehen, sondern werden z.T. auch auf die Ökosystemforschung selbst zurückgeführt. So sei es der Ökosystemforschung bislang - von Teilbeiträgen abgesehen – nicht gelungen, umfassende und allgemeingültige Antworten auf drängende Managementfragen zu geben. Nachteilig mag sich hier ausgewirkt haben, dass in der Ökosystemforschung zeitweilig zu stark auf (theorielastige) prozessbasierte Vorhersagemodelle gesetzt wurde, während „empirische“ Verfahren und Erkenntnisse für das Umweltmanagement – beispielsweise für das Management von Waldökosystemen – nicht ausreichend beachtet wurden. Die Konzentration auf wenige angewandte Problemtypen (Landnutzung im ländlichen Raum, Waldschäden) verringerte ebenfalls eine breite Einflussnahme.

Außerdem wird auch dem Wissenschaftssystem ein gewisser Konservatismus unterstellt, der ein flexibles Eingehen auf die Fragestellungen und Anforderungen von Politik und Verwaltung verhindert.

Insgesamt dominiert die Auffassung, dass

- der Einfluss der Ökosystemforschung eher implizit, theoretisch und indirekt erfolgt und zu „kollektiven“ Effekten, z.B. zur Akzeptanz bestimmter Ideen und Zielsetzungen führt. Hierzu gehören u.a. die Verbreitung des Nachhaltigkeitsgedankens, die Stärkung des Bewusstseins um die Notwendigkeit ressortübergreifender und systemarer Ansätze im Umweltschutz sowie die wachsende Erkenntnisbereitschaft über die möglichen Konsequenzen von Umweltnutzungen,
- die Potenziale der Ökosystemforschung für Veränderungen des Politik- und Verwaltungshandelns noch lange nicht ausgeschöpft sind.

4.2.2 Einfluss der Ökosystemforschung auf die Formulierung (konkreter) politischer Leitbilder oder Ziele

Von der Mehrzahl der Befragten wird ein – wenn auch indirekter - Einfluss der Ergebnisse der Ökosystemforschung auf die Formulierung von Leitbildern und Gesetzen gesehen. Das heißt, grundsätzlich wird davon ausgegangen, dass die Ökosystemforschung die naturwissenschaftlich begründete Umsetzung justiziabler Richt- und Grenzwerte unterstützt. Ferner soll der systemare Ansatz der Ökosystemforschung die Diskussion um Grenz- und Richtwerte dahingehend beeinflussen, dass zunehmend weniger der einzelne Grenzwert als vielmehr die Funktion des Gesamtsystem bei der Formulierung von Zielen und Leitbildern in den Vordergrund tritt.

Auch wenn sich direkte Einflüsse der Ökosystemforschung – insbesondere einzelner Ökosystemforschungsvorhaben - nur schwer nachweisen lassen, wird davon ausgegangen, dass u.a. die im Folgenden genannten nationalen Gesetze und internationalen Konventionen von den Ergebnissen der Ökosystemforschung zumindest beeinflusst worden sind. Grundsätzlich scheint eine relevante Einflussnahme insbesondere für die Bereiche Luftreinhaltung und Klimaschutz stattgefunden zu haben:

- Montreal Protokoll,
- Konvention zur Reduzierung der Treibhausgasemissionen,
- Kyoto-Protokoll,
- Genfer Luftreinhaltekonvention,
- Biodiversitätskonvention,
- Alpenkonvention,
- Resolution des Ministeriellen Prozesses zum Schutz der Wälder (MCPFE),
- Wasserrahmenrichtlinie.

Außerdem wird davon ausgegangen, dass auch die Leitbilddiskussion für EUROPARC, die Diskussion um Critical Loads und der Helsinki-Prozess auf Ergebnissen der Ökosystemforschung aufbauen.

Speziell für Deutschland werden die Novelle des Bundesnaturschutzgesetzes (u.a. im Hinblick auf die „gute fachliche Praxis“), die TA Luft sowie die relevanten Gesetzeswerke im Bereich des Boden- und Gewässerschutzes und das Chemikaliengesetz erwähnt. Darüber hinaus sollen die Resultate der Ökosystemforschung die Weiterentwicklung von DIN-Normen z.B. in der Bodenanalytik geprägt haben.

Beispiele, in denen von einem bestimmten Ökosystemforschungsvorhaben nachweislich ein konkreter Einfluss auf die Formulierung eines Gesetzes, einer Richtlinie oder auch eines (politischen) Programms ausgegangen ist, bzw. eine solche Einflussnahme von Beginn an indiziert war, können nur wenige genannt werden. Zu erwähnen sind in diesem Zusammenhang insbesondere die in der Ökosystemforschung Schleswig-Holsteinisches Wattenmeer entwickelten Bewertungskriterien, die in die Typisierung der Küstengewässer für die EU-Wasserrahmenrichtlinie eingegangen sind, sowie die Auswirkungen des FAM-Projektes (Forschungsverbund Agrarökosysteme München/Scheyern) auf die Ausgestaltung des bayerischen Kulturlandschaftsprogramms (KULAP).

Einschränkend wird darauf hingewiesen, dass der Einfluss der wissenschaftlichen Ergebnisse der Forschung auf die Verabschiedung internationaler Regelungen und Vereinbarungen insofern als stark limitiert gelten muss, als gerade bei diesen internationalen Verhandlungen politischen Kompromissen zwischen den Verhandlungspartnern eine noch größere Rolle zukommt, als dies bei der Diskussion um nationale Gesetze und Zielfestsetzungen der Falle ist. Das bedeutet, gesellschaftliche Meinungen, ethische Vorstellungen und wirtschaftliche Interessen prägen i.d.R. die Verabschiedung internationalen Konventionen mitunter deutlich stärker, als dies Erkenntnisse der Ökosystemforschung vermögen.

4.2.3 Maßstabsebene, auf der die wichtigsten Einflüsse der Ökosystemforschung auf die Umweltpolitik stattfinden

Es ist keine allgemeingültige Aussage bezüglich der Frage möglich, für welche Maßstabsebene der größte Einfluss der Ökosystemforschung auf die Umweltpolitik angenommen werden kann. Der jeweilige Einfluss hängt wesentlich von der Problemstellung des einzelnen Forschungsvorhabens ab. So widmen sich manche Vorhaben gezielt klar regional begrenzten Problemen (z.B. der Versauerung durch Bergbau), andere - insbesondere im Bereich der Klimaforschung – thematisieren globale Umweltveränderungen. Letztere lassen dann auch Handlungsempfehlungen für die internationale/globale Maßstabsebene erwarten.

Grundsätzlich dominiert jedoch unter den Befragten die Einschätzung, dass konkrete Einflüsse der Ökosystemforschung auf die politische Meinungsbildung und Entscheidung insbesondere auf der regionalen und lokalen Ebene zu finden sind. Dies liegt im Wesentlichen darin begründet, dass Ökosystemforschungsprojekte zumeist exemplarische Einzelfälle bearbeiten, aus denen dann - vorausgesetzt es werden oder wurden hinreichend anwendungsorientierte Fragestellungen aufgegriffen – die konkretesten Handlungshinweise für die regionale und lokale Ebene abgeleitet werden können. Ein klares Beispiel ist hier u.a. die Ökosystemforschung Schleswig-Holsteinischen Wattenmeer, die konkreten Einfluss auf die Formulierung des Nationalparkgesetzes genommen hat. Für die nationale oder gar internationale Ebene ist dagegen davon auszugehen, dass die Ergebnisse der Ökosystemforschung eher indirekt über eine Erweiterung des allgemeinen Bewusstseins über die systemaren und globalen Zusammenhänge Einfluss auf politische Entscheidungen nehmen.

4.3 Bedeutung der Ökosystemforschung für die Umweltplanung

4.3.1 Einfluss der Ökosystemforschung auf die Umweltplanung

Übereinstimmend geht eine deutliche Mehrzahl der Befragten von einem relevanten Einfluss der Ökosystemforschung auf die Umweltplanung aus.

Die systemare Perspektive, welche die Ökosystemforschung eröffnet hat, hat in der Planung dazu geführt, dass

- systemische Betrachtungen gegenüber einzelproblem-zentrierten Planungen an Bedeutung gewinnen und
- Systeme auch mit großer räumlicher Ausdehnung analysiert und beplant werden.

Die Ökosystemforschung gibt (Teil-)Antworten auf Fragen, die im planerischen Tagesgeschäft nicht zu bewältigen sind und unterstützt die planerische Tätigkeit in methodischer und technischer Hinsicht. Konkret nennen die befragten Planer und Verwaltungspraktiker insbesondere die folgenden Beiträge für die Umweltplanung:

- Verfügbarmachung von Grundlagendaten für die Untersuchungsgebiete der Ökosystemforschung und damit auch für die Planungsgebiete,
- (Weiter-)Entwicklung methodischer Instrumente (z.B. Untersuchungsstrategien, Bewertungsvorgänge, Überlagerungen von Informationsschichten); hierzu gehören u.a.:
    - ❖ modellgestützte Szenariotechniken, die in Verbindung mit GIS auf verschiedenen Maßstabsebenen für die Planung eingesetzt werden können (hier haben u.a. die Ökosystemforschung in der Bornhöveder Seenkette, die MAB 6-Forschung in Berch-

tesgaden und der Schweiz sowie die Ökosystemforschung in den Everglades wichtige Beiträge geliefert),

- ❖ die Entwicklung und Nutzung von Indikatoren zur Qualifizierung und Quantifizierung von Ökosystemfunktionen (hierzu gibt es beispielsweise herausragende Beispiele aus der Waldökosystemforschung),
- ❖ die Entwicklung von Verfahren der Risikobewertung (im WAVES-Projekt wurden mit dem WAVES-MOSDEL Möglichkeiten zu multithematischen Nachhaltigkeits- und Risikenabfragen mit hoher räumlicher Auflösung trotz schlechter Datenlage geschaffen) und
- ❖ die Entwicklung geostatistischer Verfahren.

- (Weiter-)Entwicklung technischer Instrumentarien; dies sind insbesondere:
  - ❖ Umweltanwendungen von GIS und Verschneidungstechniken,
  - ❖ verbesserte Methoden und Techniken zur Aufbereitung und Nutzung von raumbezogenen Daten aus Kartierungen und die Erzeugung neuer, z.T. aufwändig zu erhebender Daten (z.B. aus luftbild- oder satellitenbildgestützten Kartierungen) sowie
  - ❖ eine grundsätzliche Verbesserung der Datenverwaltung und –exploration,

Grundsätzlich hat die Ökosystemforschung die Akzeptanz von vielfältig einsetzbaren Modellen für den Einsatz in der Umweltplanung erhöht.

Bezüglich der Frage, welchen der o.g. Beiträge ein besonderes Gewicht zukommt, gehen die Meinungen der Befragten auseinander. Es ergibt sich kein klares Bild, ob die Bedeutung der inhaltlichen, methodischen oder der technischen Beiträge überwiegt.

Diese allgemeine Evaluierung der Ökosystemforschung für die Umweltplanung darf jedoch – insbesondere nach Ansicht der Experten aus dem Bereich der Umweltplanung – nicht darüber hinwegtäuschen, dass

- die Ökosystemforschung zumeist eine Datenfülle erzeugt, die nur in Ausschnitten von der Umweltplanung tatsächlich genutzt werden kann;
- die möglichen Beiträge der Ökosystemforschung für die Planung nur ungenügend kommuniziert werden, d.h. es an „Übersetzern“ fehlt, welche die Ergebnisse zusammenfassend und bewertend für die Anwender transformieren können. Eine solche Transformation ist i.d.R. nicht mehr Bestandteil des Forschungsvorhabens und wird in Wissenschaftlerkreisen auch nicht dem Aufwand und der Leistung gemäß honoriert. Die Beiträge der Ökosystemforschung bleiben infolgedessen zu abstrakt und zu wenig umsetzungsorientiert;
- viele der in der Ökosystemforschung entwickelten methodischen und technischen Instrumente für die Planungspraxis nur bedingt einsetzbar sind, da im Rahmen der Forschung häufig deutlich umfangreichere Zeit- und Mittelkapazitäten zur Verfügung stehen, als dies für die Umweltplanung der Fall ist;
- viele der in der Ökosystemforschung entwickelten Verfahren und Methoden für den Einsatz in der Planung auch inhaltlich zu anspruchsvoll sind. Dies gilt z.B. für populationsökologische Ansätze wie die Metapopulationstheorie sowie die darauf aufbauende Populationsgefährdungsanalyse und das Konzept der Minimum viable Population. Hier wären vereinfachende (technologische) „Faustregeln“ zu entwickeln, die dann zwar nicht mehr dieselbe Aussageschärfe bringen, aber noch Aussagen über Größenordnungen, z.B. in Form ordinaler Abschätzungen zulassen;

- die Ökosystemforschung aufgrund des geforderten Detailgrades der Bearbeitung zwangsläufig reduktionistisch und selektiv vorgehen muss, was bedeutet, dass
  - ❖ sich die Ergebnisse der Ökosystemforschung aus zwangsläufig exemplarisch ausgewählten Forschungsflächen nur unter Einschränkungen auf andere Räume und Systeme übertragen lassen und für eine solche Übertragung i.d.R. die von den Auftraggebern an die Planer geforderte Rechtssicherheit nicht garantiert werden kann,
  - ❖ ein naturwissenschaftlich integrierender Anspruch der Ökosystemforschung von den Anforderungen der Planung nach der Entwicklung einer konkreten planerischen Lösung unter Berücksichtigung aller relevanten ökologischen, ökonomischen und soziokulturellen Aspekte noch übertroffen wird.
- sich viele der aus der Ökosystemforschung kommenden und für die Lösung planerischer Aufgaben übernommenen Methoden und Verfahren im Ergebnis nicht adäquat widerspiegeln, da die aus der Forschung resultierenden naturschutzfachlichen Empfehlungen vielfach im Abwägungsprozess zugunsten anderer Interessen untergehen oder nur in (stark) modifizierter Form übernommen werden.

Diese sowohl für die Forschungsseite als auch die Planer unbefriedigende Situation wird auch auf die fehlende oder ungenügende Kommunikation zwischen Forschung und Planung zurückgeführt. So wurden/werden sowohl Forschungsthemen als auch Räume i.d.R. nicht nach dem tatsächlichen Bedarf aus planerischer Sicht ausgewählt, der sich aus den aktuellen oder absehbaren Planungsinstrumenten und den dazugehörigen Rechtsgrundlagen an sich gezielt ableiten ließe. Ansätze in diese Richtung gehen derzeit vom Umweltbundesamt in Deutschland aus, das in Anbetracht der durch die EU-SUP-Richtlinie (Richtlinie zur strategischen Umweltprüfung) entstandenen Sachzwänge die Entwicklung von Überwachungsmechanismen der Umweltwirkungen von Plänen und Programmen als Forschungsauftrag formuliert.

Des Weiteren besteht das grundsätzliche Problem, dass wissenschaftliche und planerische Leistungen mit sehr unterschiedlichen Maßstäben gemessen werden. Einem Wissenschaftler wird i.d.R. Detailgenauigkeit, Neuartigkeit der Methode und vollständige Nachvollziehbarkeit abverlangt, während für den Erfolg eines Planers die Vorlage einer pragmatischen planerischen Lösung entscheidend ist.

Trotz des oben diskutierten „Transformationsproblems“ können konkrete Positivbeispiele genannt werden, in denen eine Verwertung wissenschaftlicher Ergebnisse für planerische Prozesse und Entscheidungen erfolgreich stattgefunden hat. Dies betrifft u.a. Beiträge der Ökosystemforschung:

- zur Ausweisung und Planung von Schutzgebieten: So erfolgte die Erstellung des Nationalparkplans Berchtesgaden im Wesentlichen auf der Basis umfangreicher Grundlagendaten aus der MAB 6-Forschung und unter Nutzung eines ebenfalls im Rahmen der Ökosystemforschung etablierten GIS, und die Wattenmeerökosystemforschung hat entscheidenden Einfluss auf die Abgrenzung der marinen Schutzgebiete genommen;
- zum nachhaltigen Management von Ökosystemen und zur Lösung von Nutzungskonflikten: Modellierungsergebnisse aus dem WET I3-Projekt wurden beispielsweise in die Überarbeitung des Masterplans für die Lagune von Venedig einbezogen; die Ökosystemforschung in den Everglades hat wichtige Beiträge zum Management des Wasserhaushaltes in diesem Raum geliefert, und die Waldökosystemforschung hat wichtige Hinweise zur Realisierung von Planungen und zur Konzipierung von Managementeingrif-

fen in Waldökosysteme wie z.B. zur Durchführung von Kalkungen und zum Waldumbau insbesondere in Richtung naturnäherer Waldformen geliefert;
- zur einheitlichen naturwissenschaftlichen Bewertung/Klassifikation von Ökosystemen: So war die Entwicklung eines praxistauglichen systemübergreifenden Bewertungssystems von Beginn an Ziel der Forschungen zum Niedermoorprogramm Schleswig-Holsteins.

Die Anforderungen, die aus Sicht der Planer an die Ökosystemforschung zur Überwindung des diskutierten Transformationsproblems gestellt werden, lassen sich wie folgt zusammenfassen:

- eine grundsätzlich stärker umsetzungsorientierte Aufbereitung der Forschungsergebnisse,
- die Verfügbarmachung von in der Planungspraxis einsetzbaren Methoden und Verfahren (inkl. Modelle),
- eine stärkere Orientierung der Forschungsthemen und –räume an den Erfordernissen der nationalen Planungsinstrumente und den zugehörigen Rechtsgrundlagen auf allen Ebenen.

4.3.2 Maßstabsebene, auf der die wichtigsten Einflüsse der Ökosystemforschung auf die Umweltplanung stattfinden

Wie in Kap. 4.2.3. bereits dargestellt, lässt sich eine eindeutige Aussage bezüglich der Frage, für welche Maßstabsebene der größte Einfluss der Ökosystemforschung auf die Umweltplanung angenommen werden kann, nicht treffen. Grundsätzlich lassen sich inhaltliche sowie verfahrenstechnische und methodische Anregungen aus der Ökosystemforschung für alle planerischen Ebenen (in Deutschland von der Bauleitplanung bis zur Landesplanung) ableiten. Auch hier hängen die möglichen Beiträge der Ökosystemforschung erheblich von der im jeweiligen Vorhaben thematisierten Problemstellung ab.

4.4 Beitrag der Ökosystemforschung zur Umweltbeobachtung und Umweltüberwachung

4.4.1 Bedeutung der Verknüpfung zwischen Ökosystemforschung, Umweltbeobachtung und Umweltüberwachung

Eine enge Verknüpfung zwischen Ökosystemforschung, Umweltbeobachtung und Umweltüberwachung wird übereinstimmend als sehr bedeutend beurteilt. Definitionsgemäß wird die Umweltbeobachtung sogar z.T. als Arbeitsfeld der Ökosystemforschung betrachtet.

Sinnvolle Ergänzungen von Ökosystemforschung und Umweltbeobachtung werden in Fällen gesehen, in denen:

- die Ökosystemforschung die Konzipierung von Umweltbeobachtungsprogrammen unterstützt: Die Ökosystemforschung fördert die Auswahl geeigneter Variablen und deren Orientierung im ökosystemaren Gefüge, sie liefert Beiträge zu einer besseren Beobachtungspraxis und zur Interpretation der Beobachtungsergebnisse;
- die Umweltbeobachtung dazu eingesetzt wird, die ökologischen Modelle (Wirkungsbezüge zwischen den Komponenten eines Ökosystems) und Theorien der Ökosystemforschung langfristig zu testen;

- sich aus der Umweltbeobachtung Forschungsbedarf ableiten lässt: Umweltbeobachtung deckt Trends oder auch abrupte, unerwartete Veränderungen auf; diese werden sich nicht immer mit existierendem Wissen erklären lassen.

Bei einer engen Verknüpfung zwischen Ökosystemforschung und Umweltbeobachtung lassen sich die Erkenntnisse der Ökosystemforschung besser in die Praxis umsetzen und innovative Ansätze in Routineanwendungen überführen. Es wird jedoch darauf hingewiesen, dass hinsichtlich dieser Verknüpfung noch Defizite bestehen.

4.4.2 Beiträge aus der Ökosystemforschung für die Praxis der Umweltbeobachtung

- **Technische Neuerungen, die in der routinemäßigen Umweltbeobachtung bei der Datenerhebung Einsatz finden oder finden können**

Im Vergleich zu konzeptionellen, methodischen und inhaltlichen Beiträgen der Ökosystemforschung zur Umweltbeobachtung (s.u.) werden technische Beiträge wie die Entwicklung anwendungsbezogener Mess- und Verfahrenstechniken hinsichtlich ihrer Bedeutung als geringer eingestuft.

Beispielhaft werden folgende Ökosystemforschungsvorhaben genannt, die diesbezüglich Beiträge geliefert haben:

- Waldökosystemforschung, BITÖK: Aus den Forschungsarbeiten resultieren Empfehlungen dahingehend, welche Messgeräte z.B. im Bereich der Bodenhydrologie und Bodenchemie nicht mehr eingesetzt werden sollten (diese Ergebnisse wurden jedoch nur informell mit experimentell arbeitenden Gruppen diskutiert und nicht veröffentlicht).
- Ökosystemforschung in der Bornhöveder Seenkette: Für den Bereich der Bodenaufnahme und Umweltchemie wurden regional-statistisch begründete Mess- und Beprobungstechniken entwickelt.
- FAM/Scheyern: Messtechnische Verbesserungen wurden insbesondere in den Bereichen Messung von Oberflächenabfluss und Bodenerosion, Erhebung von bodenhydrologischen Parametern; flächendeckend differenzierte Erfassung von Biomasseaufwuchs und Erträgen; Abgrenzung von Bodeneinheiten mittels Fernerkundung erzielt. Der Aufbau des Messsystems erfolgte unter der Vorgabe, dass die Messungen und Beobachtungen der Fortführung der landwirtschaftlichen Nutzung nicht entgegen stehen.
- ICP Forest: Für das Level II-Programm wurden die Messtechniken im Wald (z.B. Aufbau von Wetterstationen, Durchführung von Depositionsmessungen) weiterentwickelt.
- MAB 6-Forschung in Berchtesgaden: Es wurden Verfahren einer konzeptionell neuen, hierarchisch aufgebauten, standörtlich angepassten Datenerhebung, -exploration, -sammlung, -organisation und –verwaltung entwickelt und erprobt.

Allgemein wird darauf hingewiesen, dass technische Neuerungen aus der Ökosystemforschung insbesondere in den Bereichen Qualitätssicherung und Vergleichbarkeit von Ergebnissen für die Umweltbeobachtung von großer Bedeutung sind.

- **Konzeptionelle und methodische Neuerungen, die in der routinemäßigen Umweltbeobachtung bei der Datenauswertung Einsatz finden oder finden können**

Der aus konzeptionellen und methodischen Neuerungen resultierende Beitrag der Ökosystemforschung für die Umweltbeobachtung wird durchweg als bedeutsam eingeschätzt.

Folgende methodische Neuerungen und Fortentwicklungen aus der Ökosystemforschung sind auch für die Umweltbeobachtung von Interesse:

- die Weiterentwicklung von Verfahren der statistischen Auswertung (wie z.B. Erstellung multivariater Statistiken) und der Zeitreihenanalyse (mit neuen nicht-linearen Methoden wie z.B. RQA, SSA etc.);
- die Weiterentwicklung von Bilanzierungsverfahren (z.B. Bioelement-Bilanzansatz für komplette Waldökosysteme und Kronenraum-Bilanzansatz für die Gesamtdeposition, die heute im Rahmen des Level II-Programms zum Einsatz gelangen);
- die Weiterentwicklung von Verfahren zur räumlichen Verallgemeinerung von punktuell oder kleinflächig erhobenen Daten (wie z.B. geostatistische Verfahren (Kriging-Ansätze) oder der KGG- und TIN-Ansatz des MAB 6-Projektes in Berchtesgaden);
- die Bestimmung von Landschaftsfunktionen und Naturraumpotenzialen in verschiedenen Maßstabsbereichen;
- die Entwicklung von Simulationsmodellen und Szenariotechniken, die zum einen den Aufwand der Erhebung empirischer Daten für den Routinebetrieb reduzieren helfen und zum anderen szenarische Aussagen zu den möglichen künftigen Entwicklungen der Ökosysteme liefern können;
- die Entwicklung von Verfahren zur Kombination modellierter und empirisch erhobener Daten (z.B. „genestete“ Messstrategie, die mit Modellsimulationen verknüpft ist;
- die Entwicklung von Verfahren zum Vergleich räumlicher Muster von empirischen Daten und von computergestützten Simulationsmodellen;
- die Weiterentwicklung von Methoden zur effizienten Sammlung von Daten.

- **Impulse strategischer und struktureller oder auch inhaltlicher Art für die Initiierung oder Neukonzipierung der Umweltbeobachtung**

Die aus der Ökosystemforschung resultierenden Impulse strategischer und struktureller Art oder auch inhaltlicher Art für die Initiierung oder Neukonzipierung der Umweltbeobachtung werden sowohl von den Forschern selbst als auch den im Anwenderbereich Tätigen überwiegend für bedeutsam bis sehr bedeutsam eingestuft.

So hat die Ökosystemforschung wichtige Anregungen für die interdisziplinäre Zusammenarbeit gegeben, die auch Voraussetzung für die Umsetzung einer integrierten Umweltbeobachtung ist. Die Erfahrungen und Ergebnisse der Ökosystemforschung unterstützen damit die Abwendung von einer sektoral angelegten und die Orientierung hin zu einer stärker ökosystemar ausgerichteten Umweltbeobachtung.

Vergleichbares gilt für die integrativen Leistungen der Ökosystemforschung im Bereich der Behördenkooperation, auch über staatliche Grenzen hinweg. So wurden im Rahmen des ICP/Deutschland enge Kooperationen zwischen Bundesländern und Nachbarstaaten sowie zwischen Forschern und Praktikern aufgebaut, die letztendlich die Voraussetzung für den Aufbau des im Routinebetrieb etablierten und zugleich fachlich anspruchsvollen Level II-Programms waren. Vergleichbares gilt für HIBECO, das wichtige Anregungen für den Aufbau eines länderübergreifenden Monitoring der nördlichen Baumgrenzregionen geliefert hat. Die

Ökosystemforschung in der Bornhöveder Seenkette hat eine intensiveren Zusammenarbeit der Umweltbehörden des Landes Schleswig-Holstein gefördert, die sich nun auch für die Bemühungen um den Aufbau einer landesweiten ökosystemaren Umweltbeobachtung auszahlt.

Impulse inhaltlicher Art betreffen insbesondere:

- die Auswahl der in einer langfristig angelegten Umweltbeobachtung zu erfassenden Parameter - diese Diskussion ist eng mit der Bestimmung geeigneter Indikatoren für die Indizierung von Veränderungen der Strukturen und Funktionen von Ökosystemen verknüpft, die in zahlreichen Ökosystemforschungsvorhaben intensiv geführt wird;
- die Fokussierung der Umweltbeobachtung auf bestimmte Ökosystemtypen, die besonders sensibel auf Umweltveränderungen reagieren;
- verbesserte Auswahl von (integrierten) Messpunkten und Messfrequenzen für die Umweltbeobachtung;
- die angemessene raum-zeitliche Auflösung der Messungen in langfristig angelegten Umweltbeobachtungsprogrammen, über die nur aufbauend auf einem durch die Ökosystemforschung verbesserten Systemverständnis fundiert entschieden werden kann (Begrenzung der Messungen auf Messperioden, in denen potenziell überhaupt mit einer Reaktion auf veränderte Umweltparameter gerechnet werden kann).

4.4.3 „Überführung“ von Forschungsprogrammen und –vorhaben in Umweltbeobachtungsprogramme

Auch wenn unmittelbare Verknüpfungen zwischen Ökosystemforschung und Umweltbeobachtung für sehr bedeutsam erachtet werden, stehen einer Realisierung zahlreiche Hemmnisse entgegen. Dass i.d.R. nur in wenigen Fällen eine „Überführung“ der Ökosystemforschung in ein langfristiges Umweltbeobachtungsprogramm stattfinden kann, hat nach Meinung der Befragten vor allem die folgenden Gründe:

- **Finanzielle und finanzhaushaltliche Gründe:**

Die Ökosystemforschungsprogramme bzw. –vorhaben sind finanziell deutlich besser ausgestattet als die Umweltbeobachtungsprogramme. Sie sind für eine kurzfristige Laufzeit konzipiert und sehen detaillierte Messungen vor, die zur Beantwortung der anspruchsvollen und differenzierten Forschungsfragen erforderlich sind. Die Überführung der im Rahmen der Forschung praktizierten Messungen in ein praktikables und finanzierbares Messprogramm für die Umweltbeobachtung erfordert zumeist eine umfangreiche Umrüstung der Messeinrichtungen, ggf. eine Änderung im Messdesign sowie den Aufbau einer für den Routinebetrieb einsetzbaren Datenauswertung. Neben der langfristigen finanziellen Absicherung der Messungen im Rahmen der Umweltbeobachtung stellt sich damit bereits in der „Überführungsphase“ das Problem der Finanzierung. Die universitäre Forschung hat nicht die Mittel (und nicht den Auftrag), die Ergebnisse an die für die Umweltbeobachtung zuständigen Institutionen weiterzuleiten oder sie entsprechend aufzubereiten. Ein solcher Schritt müsste gesondert von Dritten gefördert werden. Ferner wird darauf hingewiesen, dass der Aufbau eines Umweltbeobachtungsprogramms verhältnismäßig lange Zeit in Anspruch nimmt. Forschungsvorhaben mit Laufzeiten von drei bis fünf Jahren sind zumeist zu kurz, um parallel die wichtigsten Weichen für die Etablierung eines Umweltbeobachtungsprogramms zu stellen.

- **Organisatorische Gründe:**

Neben finanziellen Gründen können in vielen Fällen auch organisatorische Argumente der Überführung der Ökosystemforschung in die Umweltbeobachtung entgegenstehen. Denn in der Regel kommt es bei einer solchen „Überführung“ zu einem Wechsel der Behörden-Zuständigkeiten. Dabei geht es nicht nur darum, einen neuen Beobachtungsauftrag in die Behördenstruktur zu integrieren, was zumeist an die Grenzen der personellen Kapazitäten stößt. Es kann sich vielmehr auch die Aufgabe stellen, die bestehenden Beobachtungsprogramme an die neuen Anforderungen eines veränderten Stands der Wissenschaft anzupassen. In den Behörden gibt es jedoch oftmals erhebliche Widerstände gegenüber Änderungen von langfristig angelegten (sektoralen) Umweltbeobachtungsprogrammen, die sich zumeist in einer Unterbrechung langjähriger Datenreihen begründen.

Ferner können veränderte Behörden-Zuständigkeiten zur Konsequenz haben, dass auch die Rückkoppelung von der Umweltbeobachtung zur Forschung nicht mehr in ausreichendem Maße stattfindet. Das bedeutet, der Forschung werden nur begrenzte Zugriffsberechtigungen auf die Daten aus der Umweltbeobachtung eingestanden, so dass die Möglichkeiten zur Überprüfung und Anpassung wissenschaftlicher Hypothesen eingeschränkt sind.

- **Technische und methodische Gründe:**

Die Ökosystemforschung liefert in den Augen der befragten Praktikerinnen und Wissenschaftler grundsätzlich wichtige Beiträge zur Bewältigung technischer Aufgaben in der Umweltbeobachtung (s. Kap. 4.4.2). Dennoch kann es zu erheblichen Problemen kommen, wenn die in einem Ökosystemforschungsvorhaben zur Anwendung gelangenden und bewährten Messverfahren und –techniken auch im Rahmen eines Umweltbeobachtungsprogramms zum Einsatz gelangen sollen. Denn häufig sind diese so differenziert, dass sie einen hohen technischen Sachverstand und große Sorgfalt erfordern, um hohe Datenqualitäten sicherzustellen. Nicht immer können jedoch für die Realisierung eines langfristig angelegten Umweltbeobachtungsprogramms ausreichende technische Kapazitäten des messenden Personals zur Verfügung gestellt werden, um ähnlich hohe Datenqualitäten garantieren zu können.

Viele in der Ökosystemforschung eingesetzten Verfahren sind nicht für den Routinebetrieb konzipiert worden. Häufig handelt es sich um mit viel Einfallsreichtum und Sorgfalt hergestellte Prototypen, die für eine serienmäßige Produktion noch nicht ausgereift genug sind.

Vergleichbares gilt für die in der Ökosystemforschung eingesetzten Auswertungsverfahren. Universitäten und Verwaltung unterscheiden sich grundsätzlich in der allgemeinen technischen Routine und im verfügbaren Know-how. Nur in wenigen Fällen gelingt es, die anspruchsvollen Auswertungsverfahren der Ökosystemforschung auch in einer Verwaltung für den Routinebetrieb der Umweltbeobachtung zu etablieren. Als positives Gegenbeispiel werden die Niederlande erwähnt. Dort findet auch in den angewandt arbeitenden Institutionen eine hochwertige Datenauswertung bis hin zur Modellierung statt.

Außerdem stellt sich auch im technischen Bereich das Problem der Weitergabe und Aufbereitung der erforderlichen Informationen aus der Forschung für den fortlaufenden Routinebetrieb. Viel „Metawissen“ aus der Ökosystemforschung wird von den Forschern nicht dokumentiert und folglich nicht an die für die Umweltbeobachtung zuständigen Stellen weitergeleitet.

Auch wenn sich im technischen Bereich keine gravierenden Probleme für die Überführung der Ökosystemforschung in ein Umweltbeobachtungsprogramm stellen, können veränderte Rahmenbedingungen der Nutzung dafür verantwortlich sein, dass sich Methoden und Techniken aus der Ökosystemforschung für die Umweltbeobachtung an gleicher Stelle als nicht geeignet herauskristallisieren. So lassen sich i.d.R. während eines zeitlich eindeutig befristeten Ökosystemforschungsvorhabens die Nutzungen in den Forschungsräumen festlegen oder steuern; in einer langfristigen Umweltbeobachtung ist dies nicht möglich oder auch gar nicht erwünscht.

- **Sonstige Gründe:**

Übereinstimmend wird betont, dass sich eine intensive und effektive Verknüpfung von Ökosystemforschung und Umweltbeobachtung nur dann realisieren lassen wird, wenn der politische Wille vorhanden ist, die hierfür erforderlichen Strukturen aufzubauen sowie Finanz- und Personalmittel bereitzustellen.

Aber auch von Seiten der Forschenden und der für die Umweltbeobachtung Zuständigen wäre eine gegenseitige Annäherung erforderlich. Umweltbeobachtung wird von vielen Forschern noch immer für uninteressant erachtet, so dass es an kreativem Input für die Umweltbeobachtung fehlt. Und den im Routinebetrieb der Umweltbeobachtung Tätigen fehlt es mitunter an Verständnis und Bereitschaft, die Ergebnisse der Ökosystemforschung für ihren Aufgabenbereich zu erschließen und klare Anforderungen an die Forschung zu formulieren. Einen Ansatz zur beidseitigen Annäherung stellt die Indikatorendiskussion dar. Sie ist einerseits für die Forschung ein interessantes Aufgabenfeld. Andererseits bietet sie den Anwendern eine Orientierung bei der Fokussierung der Umweltbeobachtungsprogramme auf ein Set tatsächlich aussagekräftiger Beobachtungsgrößen.

Trotz aller genannten Schwierigkeiten gibt es konkrete Beispiele, in denen es gelungen ist, Ökosystemforschungsvorhaben in Umweltbeobachtungsprogramme zu überführen. Genannt wurden:

- Die Wattenmeerökosystemforschung mündete in das Trilateral Monitoring and Assessment Program (TMAP), das seit 1994 im gesamten Wattenmeer - wenn auch mit einem gegenüber der Forschung stark reduzierten Parameterset - durchgeführt wird.
- Aus dem WET-Projekt in Schleswig-Holstein, speziell aus der Begleitforschung zum Niedermoorprogramm resultierten Vorschläge für ein reduziertes Monitoringprogramm, das bereits zum Teil von dem zuständigen Staatlichen Umweltämtern übernommen wurde.
- Ökosystemforschung in der Bornhöveder Seenkette: Die Messungen wurden z.T. Bestandteil der Umweltprobenbank des Bundes, die Depositionsmessungen mündeten in das Depositionsmessprogramm des Gewerbeaufsichtsamtes Schleswig-Holstein in Itzehoe.
- Im Falle des Bodenseeprojektes (SFB 248 der DFG Stoffhaushalt des Bodensees) sind Folgemessungen bereits institutionalisiert und gesetzlich verankert.
- Die Forschungen im Rahmen des HIBECO-Projektes sollen in eine neue Monitoringaktivität unter dem Titel „TREBIOREMA" (Treelines as indicators of climate change, biodiversity and resource management) münden.
- Die Waldökosystemforschungen u.a. im Rahmen des ICP mündeten in das Forstliche Umweltmonitoring (Level I und II).

- Das LTER-Programm (Long-term ecological research and monitoring, z.B. in Loch Vale Watershed, Rocky Mountain National Park, Colorado, USA) war von Beginn an für die Überführung in ein langfristiges Umweltbeobachtungsprogramm konzipiert.

In weiteren derzeit noch laufenden Ökosystemforschungsvorhaben (so z.B. im FAM-Projekt/ Scheyern) ist eine Überführung der Forschungen in Umweltbeobachtungsprogramme geplant. Konkrete diesbezüglich Schritte wurden jedoch noch nicht eingeleitet.

4.5 Beitrag der Ökosystemforschung zur Umweltbildung, Öffentlichkeitsarbeit und Umweltberichterstattung

4.5.1 Bedeutung der Verknüpfung zwischen Ökosystemforschung, Umweltbildung und Öffentlichkeitsarbeit

Übereinstimmend wird von allen Befragten eine möglichst enge Verknüpfung zwischen Ökosystemforschung, Umweltbildung und Öffentlichkeitsarbeit für sehr erstrebenswert erachtet. Folgende Gründe werden für diese Einschätzung genannt:

- Erfüllung des Bildungsauftrags der Ökosystemforschung:

  Die Ökosystemforschung hat den Auftrag, das Problembewusstsein in der Öffentlichkeit hinsichtlich negativer aber auch positiver Trends der Umweltentwicklung zu schärfen. Sie soll deutlich machen, in welcher Weise der Mensch von den Leistungen und Angeboten seiner natürlichen Umwelt abhängt. Denn nur ein gestärktes Umweltbewusstsein der Bevölkerung schafft die Voraussetzungen für umweltbewusstes Handeln und eine effiziente Umweltpolitik. Dabei wird ausdrücklich betont, dass der Bildungsauftrag der Ökosystemforschung keineswegs allein darin besteht, eine „pro-Umwelt-Message“ zu transportieren, sondern die Zusammenhänge von gesellschaftlichen Problemen und Umweltproblemen kritisch und differenziert darzustellen.

- Akzeptanz der Ökosystemforschung in der Öffentlichkeit:

  Es muss im Eigeninteresse der Ökosystemforschung liegen, ihre gesellschaftliche und politische Akzeptanz und Relevanz für alle Zielgruppen über eine möglichst transparente Präsentation und einen kontinuierlichen Informationsfluss ihrer Ergebnisse zu stärken. Letztendlich wird davon abhängen, ob auch in Zukunft Gelder zur Förderung der Ökosystemforschung zur Verfügung gestellt werden. Die Präsentation sollte dabei sowohl die Darstellung der Ziele als auch der Produkte und der Anwendungsmöglichkeiten beinhalten.

- Ökosystemforschung als geeignetes Lernfeld:

  Ökosystemforschung ist geeignetes Lern- und Trainingsfeld für die Förderung systemaren Denkens, d.h. des Denkens in Zusammenhängen, Wechselwirkungen und Rückkoppelungen, denn Ökosystemforschung und deren Verständnis fordern grundsätzlich die Kombination ganz unterschiedlicher Fähigkeiten und Kenntnisse. Dabei geht es nicht allein um die Förderung von Studenten und Wissenschaftlern, sondern ebenso auch um die Herausbildung dieser Fähigkeiten in der gesamten Gesellschaft

Einschränkend wird von einem Befragten angemerkt, dass dem „direkten, sinnlichen Landschaftserleben“ sowie der Einsicht in gesellschaftliche und individuelle Handlungsmöglichkeiten eine so große Bedeutung zukommen, dass diese nicht durch verstärkte ökosystemare Bildung zurückgedrängt werden sollte.

Die Voraussetzungen für eine die Ökosystemforschung begleitende effektive Bildungs- und Öffentlichkeitsarbeit sind nach Meinung der befragten Fachleute heute aufgrund der zur Verfügung stehenden IT-Methoden so günstig wie noch nie. Die Ökosystemforschung sollte diese Möglichkeiten umfangreich nutzen. Der Umweltatlas Wattenmeer wird als positives deutsches Beispiel für die Nutzung dieser Methoden herausgestellt.

So wie Übereinstimmung dahingehend besteht, dass die Verknüpfung zwischen Ökosystemforschung, Umweltbildung und Öffentlichkeitsarbeit wünschenswert ist, sind sich die Befragten aber auch einig, dass diese Verknüpfung bislang nicht in ausreichendem Maße stattgefunden hat. Dies liegt im Wesentlichen daran, dass

- der Bedarf zur Vermittlung der Erkenntnisse der Ökosystemforschung bislang noch nicht so groß war, da zum einen die durch Umweltprobleme ausgelösten Krisen zumindest in den mittleren und nördlichen Breiten noch nicht drängend genug waren und zum anderen die für die Ökosystemforschung zur Verfügung gestellten Mittel noch üppiger zur Verfügung standen. Diese Situation ändert sich jedoch zunehmend, was zwangsläufig eine Förderung der Kommunikation zur Folge haben muss;
- trotz der Unübersehbarkeit globaler Umweltprobleme der Stellenwert von Umweltthemen in der Öffentlichkeit in den letzten Jahren gesunken ist, was sich auch in einem sinkenden politischen Interesse niederschlägt. Darüber hinaus ist die Rezeptionsbereitschaft für Umweltprobleme und die Nachfrage nach tragfähigen Lösungen wie kaum ein anderes Themenfeld vom aktuellen politischen Rahmen abhängig, was eine kontinuierlich angelegte Bildungs- und Öffentlichkeitsarbeit erschwert. Sicher hat darüber hinaus auch eine über Jahre hinweg unangemessene und wenig differenzierte Öffentlichkeitsarbeit, in der wissenschaftliche Aussagen häufig auf die Vorhersage möglicher Katastrophen reduziert wurden, dem Ansehen der Umweltforschung und der Akzeptanz wissenschaftlich begründeter Empfehlungen geschadet;
- es grundsätzlich an personellen und finanziellen Ressourcen für eine qualifizierte, die Forschung begleitende Bildungs- und Öffentlichkeitsarbeit mangelt, da diese bei der Projektantragstellung bzw. in den Forschungsprogrammen nicht explizit vorgesehen ist. So mussten beispielsweise im Falle der Ökosystemforschung im schleswig-holsteinischen Wattenmeer die Pressearbeit, Schulungen und Vorträge aus Eigenmitteln des Landesamtes für den Nationalpark Schleswig-Holstein finanziert werden;
- dass Ökosystemforschung komplexer und wissenschaftlich anspruchsvoller ist als beispielsweise die Vermittlung von klassischen Naturschutzgedanken;
- es mitunter auch an geeigneten inhaltlichen Anknüpfungspunkten für die Präsentation von Forschungsergebnissen fehlt, denn (noch) nicht aus jedem Ökosystemforschungsvorhaben resultieren tatsächlich anwendungsrelevante und vermittelbare Ergebnisse;
- es den Forschern häufig an Engagement (und Aus- bzw. Weiterbildung) im Bereich der Öffentlichkeits- und Bildungsarbeit fehlt. Die Forscher sehen sich grundsätzlich mit dem Problem konfrontiert, eine anspruchsvolle Forschung zu bewältigen und gleichzeitig die (Zwischen-) Ergebnisse in allgemeinverständlicher Form aufzubereiten. Für Letzteres werden i.d.R. keine zusätzlichen Mittel zur Verfügung gestellt. Ferner wird eingestanden, dass es zahlreichen Wissenschaftlern an Kommunikationsfähigkeiten sowie politischer, sozialer und medialer Kompetenz mangelt, um auch in der außeruniversitären Öffentlichkeit überzeugend auftreten zu können. Darüber hinaus wird ein Engagement von For-

schern in der Bildungs- und Öffentlichkeitsarbeit bislang nur wenig honoriert. So definiert sich der Erfolg eines Wissenschaftlers i.d.R. allein durch die von ihm erzielten Forschungsergebnisse, die sich in der Anzahl von Publikationen und einer erfolgreichen Dissertation etc. niederschlagen.

- das Arbeitsgebiet der Umweltbildung noch immer nicht genügend anerkannt ist und häufig auf die schulische Bildung eingeengt wird.

Trotz der genannten Schwierigkeiten können von den in der Ökosystemforschung Tätigen zahlreiche Positivbeispiele für erfolgreiche Aktionen in den Bereichen Bildungs- und Öffentlichkeitsarbeit genannt werden. Bei den Anwendern (Planer und Verwaltungsangehörigen) sind diese Beispiele jedoch nur wenig bekannt.

Zu den dominierenden Formen der Öffentlichkeits- und Bildungsarbeit gehören:

- die Erstellung von Broschüren und Verteilung derselben an Ämter, Lehrerfortbildungsseminare u.a. (z.B. deutsche Vorhaben der Wattenmeerforschung);
- Internetpräsentationen (wie z.B. für das ICP oder das BITÖK);
- Präsentationen und Diskussionen in Presse, Rundfunk und Fernsehen (wie u.a. im Rahmen des LTER in den Rocky Mountains oder der Waldökosystemforschung in Göttingen/Solling);
- Veranstaltung von Führungen auf den Forschungsflächen: Die Zielgruppe sind dabei nicht nur Forschende, sondern ebenso auch Angehörige aus der Verwaltung (z.B. WET-Projekte Schleswig-Holstein), Schulen (z.B. Bodenseeprojekt / SFB 248 der DFG Stoffhaushalt des Bodensees) und relevante Nutzergruppen (z.B. FAM);
- Einrichtung von Lehrpfaden (z.B. im Nationalpark Hohe Tauern zur Präsentation der Ergebnisse der glaziologischen Forschung an der Universität Innsbruck);
- Veranstaltung von Diskussionsforen mit Akteuren im politischen Raum (im Rahmen des FAM-Projektes wurden solche Diskussionsforen u.a. mit dem Bauernverband sowie Kommunal- und Landespolitikern abgehalten);
- Veranstaltung wissenschaftlicher Konferenzen, Workshops und Seminare (wie z.B. begleitend zum IBP sowie zu NSSE und HIBECO, im WET-Projekt Schleswig-Holstein wurden projektbegleitend gut besuchte Seminare in der Umweltakademie veranstaltet);
- Veranstaltung von Tagen der offenen Tür (das FAM-Projekt konnte in diesem Rahmen bisher ca. 30.000 Besucher empfangen);
- Ausarbeitung von Unterrichtseinheiten für Schüler und die Lehrerfortbildung (im FAM-Projekt wurden auf diese Weise in einem Sommerhalbjahr ca. 1.600 Schüler und ca. 100 Lehrer erreicht, im Vorhaben „Biodiversität und Ökosystemfunktionen in bewirtschafteten Grünländern“/Universität Jena wurden Filme für den Schulunterricht produziert).

Auch in den meisten der o.g. Projekte beschränkt sich die Bildungs- und Öffentlichkeitsarbeit jedoch auf einzelne, zeitlich begrenzte Aktionen, und es gibt keine längerfristig angelegte Bildungs- und Informationsstrategie. Herausragende Ausnahmen im deutschen Raum sind sicher das FAM-Projekt, die Ökosystemforschung in der Bornhöveder Seenkette und die MAB 6-Forschung in Berchtesgaden, im Rahmen derer auch in größerem Umfang, z.T. mit selbständig agierenden Gruppen mit spezifischen Zuständigkeiten Aktivitäten der Bildungs- und Öffentlichkeit unternommen werden konnten. Als weiteres positives Beispiel sei die Ökosystemforschung in den Everglades erwähnt. Hier werden parallel zur Forschung vom South Florida Water Management District auch von den Medien begleitete Bildungsprogramme zur umweltgerechten Wassernutzung durchgeführt.

4.5.2 Impulse aus der Ökosystemforschung für die Umweltberichterstattung

Die Ökosystemforschung liefert – nach Auskunft und Einschätzung der Befragten – Impulse sowohl strategischer und struktureller als auch methodischer und inhaltlicher Art für die Umweltberichterstattung. Konkrete Nennungen von Beiträgen beziehen sich aber nahezu ausschließlich auf die Erstellung von Projektberichten oder die Bereitstellung von Informationsmaterialien. Über konkrete Beiträge aus der Ökosystemforschung beispielsweise zu einer nationalen oder auch regionalen Berichterstattung werden keine Aussagen getroffen. Eine Ausnahme stellt die Diskussion um geeignete Indikatoren zur Abbildung struktureller und funktioneller Veränderungen von Ökosystemen dar, die im Rahmen zahlreicher Ökosystemforschungsvorhaben insbesondere in jüngster Zeit geführt wird (s. auch Kap. 4.5.3). Indikatoren sind insofern wichtige „Arbeitshilfen“ für die Umweltbericht-ertstattung, als mit ihrer Unterstützung auch komplexe Sachverhalte in vereinfachter Form und allgemeinverständlich vermittelt werden können.

Eher theoretische Impulse hat das Bornhöved-Projekt insofern geliefert, als im Rahmen der projektbegleitenden Inter- und Transdisziplinaritätsforschung Zielgruppenanalysen vorgenommen und didaktische Reflexionen zur Themenwahl und Präsentation der Ergebnisse angestellt worden sind.

4.5.3 Beiträge der Ökosystemforschung zur Indikatorendiskussion

Die Ökosystemforschung liefert - nach Mehrheit der Befragten - relevante Beiträge zur Indikatorendiskussion. Folgende konkrete Projekte werden aufgrund ihrer herausragenden Beiträge beispielhaft hervorgehoben:

- Im Rahmen der Ökosystemforschung in den Everglades wurden Indikatoren insbesondere zur Hydrologie und Wasserqualität identifiziert.
- Im Zuge des LTER in den Rocky Mountains wurde die Entwicklung aggregierter Indikatoren vorangetrieben.
- Die deutsche Waldökosystemforschung hat Indikatoren zum Stoffaustrag mit dem Sickerwasser erarbeitet.
- Für die umweltökonomischen Gesamtrechnungen (UGR) wurden im Rahmen des IN∆ECO^2-Projektes („Makroindikatoren des Umweltzustands“) im Auftrag des BMBF und in Kooperation mit dem Statistischen Bundesamt hochaggregierte Umweltzustandsindikatoren auf Basis naturwissenschaftlicher Modelle, statistischer Aggregationsverfahren und gesellschaftlicher Entscheidungsprozesse entwickelt.
- Im ICP wurden Indikatoren für nachhaltige Forstwirtschaft entwickelt.
- Im IBP und NSSE wurde u.a. die Baumgrenze als komplexer Indikator für klimatische Veränderungen intensiv diskutiert.

Darüber hinaus ist auch die Diskussion um Agrarumweltindikatoren stark von der Ökosystemforschung geprägt worden.

Im marinen Bereich hat sich das Indikatorenkonzept, insbesondere das Konzept aggregierter Indikatoren nicht bewährt. So arbeitet das TMAP allein mit Schlüsselarten, die explizit nicht als Indikatoren bezeichnet werden.

4.6 Verknüpfung von Ökosystemforschung und Lehre/Ausbildung

Hinweis: Der Fragebogen 3 wurde nur von Deutschen beantwortet, so dass die nachstehend zusammengefassten Aussagen nur eine Analyse der Situation in Deutschland beinhalten.

4.6.1 Förderung der Zusammenarbeit zwischen unterschiedlichen naturwissenschaftlichen Disziplinen in der Ausbildung (an Hochschulen)

Es besteht Einigkeit darüber, dass die Zusammenarbeit zwischen unterschiedlichen naturwissenschaftlichen Disziplinen an den Hochschulen weiter gefördert werden sollte. So gilt die Zusammenarbeit in multi- und interdisziplinären Forschungsverbünden innerhalb und zwischen Hochschulen i.d.R. als bereits sehr weit entwickelt und gut funktionsfähig, während in der Ausbildung noch immer große Defizite diesbezüglich konstatiert werden.

Als mögliche Ansatzpunkte für die Förderung der Zusammenarbeit zwischen unterschiedlichen naturwissenschaftlichen Disziplinen werden genannt:

- die Initiierung konkreter gemeinsamer Projekte, an denen Vertreter mehrerer naturwissenschaftlicher Disziplinen beteiligt sind,
- das Angebot fächerübergreifender Lehrveranstaltungen und die Integration in gemeinsamen Fachbereichen und Instituten,
- die Aufbrechung der alten Fächerstruktur und die Einführung eines echten Studienfaches „Umweltwissenschaften“, innerhalb dessen die Teildisziplinen Geographie, Geologie, Biologie, Zoologie, Botanik etc. zusammengeführt werden,
- die Förderung integrativer Fähigkeiten auch beim Lehrpersonal,
- eine stärkere Konzentration von Fördergeldern auf Projekte, die diese Integration fördern (konsequente „leistungsbezogene Mittelzuweisung“).

Als wichtige Voraussetzung gilt auch eine bessere schulische Vorbildung in den „harten“ Naturwissenschaften (Physik und Chemie) und in der Mathematik. Denn derzeit gibt es zu wenige Studierende, die hinreichend leistungsstark und motiviert sind, um sich in integrativen Projekten und für eine stärker integrative Ausbildung zu engagieren. Die Hochschulausbildung bleibt daher in vielen Fällen in einer (sektoralen) naturwissenschaftlichen Grundausbildung, beginnend auf einem relativ niedrigen Niveau, stecken und hat keine Möglichkeiten, auf das Niveau stärker integrativer Betrachtungen vorzustoßen.

4.6.2 Bedeutung der Systemanalyse und der Umweltinformatik für die akademische Ausbildung

Der Systemanalyse und der Umweltinformatik wird durchweg eine große Bedeutung für die akademische Ausbildung zugesprochen. Während Kenntnisse in der Systemanalyse insbesondere für eine Bewährung im akademischen Umfeld (zur Bearbeitung theoretischer Ansätze) entscheidend sind, sind profunde Kenntnisse der Umweltinformatik (d.h. von GIS-Techniken sowie von Statistik und Programmieren) heute eine wichtige Voraussetzung, damit sich die Absolventen auch auf dem eher praxisorientierten Arbeitsmarkt behaupten können. Kritisiert wird jedoch, dass die Ausbildung sowohl in den Bereichen Systemanalyse als auch Umweltinformatik insbesondere außerhalb der naturwissenschaftlichen Fakultäten an den Universitäten noch immer vernachlässigt wird. Gründe hierfür sind u.a. die häufig (zu) geringen Vorkenntnisse der Studierenden in der Mathematik. Dies macht eine adäquate Ausbildung i.d.R. sehr aufwändig, insbesondere personalintensiv. Häufig lassen sich entsprechende Lehrveranstaltungen nur in kleinen Gruppen durchführen. Die Nachfrage seitens der Studierenden ist aber grundsätzlich hoch.

4.6.3 Organisation der Zusammenarbeit zwischen ökologisch-naturwissenschaftlichen Disziplinen einerseits und wirtschafts- und gesellschaftswissenschaftlichen Disziplinen andererseits in der Ausbildung

Die Förderung der Zusammenarbeit zwischen ökologisch-naturwissenschaftlichen sowie wirtschafts- und gesellschaftswissenschaftlichen Disziplinen in der Ausbildung wird als erstrebenswert erachtet. Sie gilt aber als große Herausforderung, zumal eine vergleichbare Kooperation ja bisher nicht einmal im Forschungsbereich befriedigend realisiert werden konnte.

Außer der Förderung und Durchführung gemeinsamer Projekte und Seminare mit der Bearbeitung konkreter anwendungsbezogener Fragestellungen sowie der Veranstaltung fachübergreifender Tagungen und Kolloquien (auch über einzelne Hochschulen hinaus, z.B. in Deutschland gefördert durch die DFG, DBU und den DAAD), zu deren Bewältigung sowohl natur- als auch geisteswissenschaftliche Kompetenzen erforderlich sind, gibt es jedoch keine konkreten und weiterführenden Ideen der Befragten.

4.6.4 Bearbeitung realer Fallbeispiele als Ansatzpunkte für eine innovative („transdisziplinäre”) Verknüpfung von Ökosystemforschung und Lehre

Grundsätzlich wird die Bearbeitung realer Fallbeispiele (z.B. der Landschaftsplanung) an den Universitäten als motivierend für die Studierenden betrachtet. Es wird jedoch davor gewarnt, dass solche Projekte – insbesondere dann, wenn sie zusätzlich Ansätze der Partizipation von Betroffenen verfolgen – leicht unübersichtlich und in einem vernünftigen Zeitraum nicht mehr bewältigbar werden. Die hohe Attraktivität solcher Projekte sollte auch nicht dazu führen, dass sich die Studierenden vom Pflichtprogramm der Aneignung zwingend notwendiger Grundlagen in den meist unbeliebten, eher abstrakten Fächern entbinden können. Befürchtet würde in diesem Fall eine zu starke Verflachung der Ausbildung, bzw. eine extreme Spezialisierung der Studierenden.

4.6.5 Schulung einer „ökologischen Bewertungs- und Urteilskompetenz” an den Hochschulen

Von den Befragten wird ein eindeutiges Defizit in der Schulung „ökologischer Bewertungs- und Urteilskompetenz” (z.B. normativer Grundlagen, Entscheidungstheorien, Bewertungsverfahren) in der universitären Ausbildung gesehen, die noch immer im Wesentlichen auf die Vermittlung von Fachwissen und Wissen im methodisch-technischen Bereich ausgerichtet ist, nicht aber normative Fragen thematisiert.

Ein wesentlicher Inhalt eines solchen Ausbildungsschwerpunktes sollte darin bestehen, deutlich zu machen, wie die deskriptive Disziplin Ökologie mit normativen Fragestellungen in Verbindung gebracht werden kann, d.h. wie es gelingen kann, naturwissenschaftlich und gesellschaftlich basiertes Wissen nachvollziehbar mit naturschutz(umwelt-)fachlichen Zielfindungs- und Bewertungsverfahren und Rechtsnormen zu verknüpfen. Kritisiert wird, dass es an einigen Hochschulen zwar entsprechende Lehrangebote z.B. in der Entscheidungstheorie gibt, es aber grundsätzlich an neueren Ansätzen fehlt. Zurückgeführt wird Letzteres u.a. auf einen Wandel des Planungsverständnisses, der zu einer Abwendung von der Expertenplanung und Hinwendung zur kooperativen, partizipativen Planung sowie einer Stärkung der informellen gegenüber den formalen Planungsinstrumenten führt.

4.7 Kritische Reflexion von Ökosystemforschungsvorhaben

4.7.1 Kritische Reflexion der organisatorischen Struktur und strategischen Vorgehensweise in Ökosystemforschungsvorhaben

Die deutlich überwiegende Zahl der Befragten aus Forschungseinrichtungen postuliert, dass eine kritische Reflexion von organisatorischer Struktur und strategischer Vorgehensweise in den von ihnen durchgeführten Ökosystemforschungsvorhaben stattgefunden hat. Diese ist jedoch nur z.T. in Veröffentlichungen und Schlussberichten niedergelegt. Die in der Anwendungspraxis Tätigen beurteilen die Bereitschaft zur kritischen Selbstreflexion der Forschenden als noch zu wenig ausgeprägt.

Die Selbstkritik der Forschenden richtet sich u.a. auf die folgenden Punkte:

- Die Fokussierung der einzelnen Arbeitsgruppen auf das gemeinsame Projektziel ist zu schwach ausgeprägt.
- Es fehlt u.a. aus Finanz- und Personalgründen an einer konsequenten Koordination der verschiedenen Arbeitsgruppen über die gesamte Projektlaufzeit hinweg. Dies schlägt sich dann auch in der Abfassung der Schlussberichte nieder.
- Die Projektleitung verfügt aufgrund der (universitären) Strukturen über zu geringe Möglichkeiten, auf den Verlauf des Projektes und die Arbeit der einzelnen Arbeitsgruppen im Sinne einer strengen Koordination wirksamen Einfluss zu nehmen.
- Die Projektleitung war nicht dazu in der Lage, die von den einzelnen Arbeitsgruppen entwickelten wissenschaftlichen Ansätze, deren Bemühungen und Aussagen zu verstehen und in den Gesamtkontext des Vorhabens einzuordnen.

In der Gesamtschau spielt die Rolle der Projektleitung nach Ansicht der Experten eine herausragende Rolle bei der Bewältigung des inter- oder transdisziplinären Projektauftrags. Bezüglich der Leistungsfähigkeit der Projektleitung wiederholt sich dabei die Kritik, dass das Projektmanagement in den gegebenen Strukturen zu wenig professionell arbeiten kann. Letztendlich stellt ein Verbundforschungsvorhaben der Ökosystemforschung vergleichbare Kompetenzanforderungen wie eine Firma, in der verschiedene Arbeitsgruppen auf das gemeinsame Betriebsziel hin koordiniert werden müssen. Die Projektmanager sind jedoch auf die Übernahme einer solchen Tätigkeit oftmals nicht professionell vorbereitet.

Ferner wird auf die Grenzen einer Struktur- und Strategieoptimierung insbesondere an den Universitäten in Deutschland hingewiesen. Infolge der Veränderungen des Hochschulrahmengesetzes wird sich das Problem weiter verschärfen, projekterfahrenes Personal für ein zielgerichtetes und professionelles Management gewinnen zu können. Aufgrund der Befristung der Tätigkeit von Mitarbeitern des Mittelbaus auf maximal 12 Jahre geht dieses Personal den Universitäten verloren.

Die Kritik der „Außenstehenden“ an der Struktur und den Strategien in Ökosystemforschungsvorhaben betrifft zusammenfassend die folgenden Punkte:

- Interdisziplinarität wird in den Ökosystemforschungsvorhaben nicht ernst genug genommen. Vielfach wird sie nur als besonders attraktive Möglichkeit gesehen, zusätzliche Forschungsmittel zu erlangen, der Anspruch schlägt sich aber nicht in ausreichender Form in der Strukturierung des Projektes nieder. Vielfach dominiert noch immer eine Disziplin.

- In vielen Ökosystemforschungsvorhaben verselbständigen sich die Arbeitsgruppen zu schnell voneinander, da es an Kompetenzen für die Entwicklung gut funktionierender Kooperationskonzepte fehlt.
- Von Seiten der Projektleitung wird noch immer der Forschungsleistung der einzelnen Arbeitsgruppen größeres Gewicht beigemessen als den Leistungen, die von den Projektmitarbeitenden im Sinne der Interdisziplinarität mit Blick auf das übergeordnete Ziel des Projektes erbracht werden. Der Erfolgsdruck, dem die beteiligten Wissenschaftler unterworfen sind, wirkt angesichts dessen der Interdisziplinarität häufig sogar direkt entgegen. Es fehlt an Möglichkeiten insbesondere für jüngere Teilnehmer, sich mit interdisziplinären Erfolgen persönlich qualifizieren zu können.
- Es fehlt häufig an einer gemeinsamen, vorab festgelegten Datenstruktur und –kompatibilität, die Voraussetzung für die integrative Zusammenführung der Daten aus den einzelnen Arbeitsgruppen wäre.

Die genannten Kritikpunkte schlagen sich dementsprechend auch in der Qualität der Syntheseberichte nieder.

Eine kritische Selbstreflexion sollte in Zukunft insbesondere auf die Frage gerichtet sein, inwieweit es gelungen ist, mit den gewählten Forschungsansätzen und Strukturen Ergebnisse zu erzielen, die sich mit herkömmlichen, also sektoral oder nur linear orientierten Ansätzen nicht hätten erzielen lassen.

Grundsätzlich wird von Anwenderseite eine konsequentere Selbstreflexion der Forschenden bezüglich der in den Vorhaben erbrachten Leistungen gewünscht. Es wir eingeräumt, dass diese ggf. separat finanziell gefördert werden müsste.

4.7.2 Zur Problematik interdisziplinären Arbeitens

Wie aus Kap. 4.7.1 hervorgeht, kann in vielen Ökosystemforschungsvorhaben der hohe Anspruch an Interdisziplinarität nicht eingelöst werden. Hauptgründe hierfür liegen nach Meinung der Befragten in dem Umstand, dass sich aus einem konsequenten Bemühen um die Realisierung dieser Arbeitsform keine greifbaren (karrierewirksamen) Erfolge und Vorteile für die Projektbeteiligten ableiten lassen. Ferner fehlt es vielerorts an der prinzipiellen Bereitschaft, andere Herangehensweisen und Disziplinen zu akzeptieren und deren Leistungen für die Erzielung eines gemeinsam angestrebten Ergebnisses adäquat wertzuschätzen. Und letztendlich sollte natürlich auch nicht übersehen werden, dass für das Scheitern von Interdisziplinarität nicht allein der mangelnde Wille der Beteiligten oder ungeeignete Strukturen verantwortlich sind, sondern auch fachliche Divergenzen zwischen den einzelnen Fachrichtungen.

Folgende Anregungen für die Stärkung von Interdisziplinarität werden gegeben:

- **Verbesserung der organisatorischen Rahmenbedingungen:**

Zur gezielten Unterstützung interdisziplinärer Arbeitsweisen bedarf es in erster Linie eines straffen Managements, denn der Diskurs- und Moderationsaufwand für die Durchführung integrativer Ökosystemforschungsvorhaben ist in der Vergangenheit immer wieder unterschätzt worden. Dies spiegelt sich auch darin wieder, dass es in den Projekten häufig an entsprechenden Mitteln für die Finanzierung einer kompetenten Projektkoordination fehlt, bzw. diese Mittel bereits bei der Antragstellung in den Projektanträgen nicht als selbständige finanzierungswürdige Posten eingeplant werden dürfen.

Das Projektmanagement sollte sich als Dienstleister für das Projekt betrachten und exakt beschriebene Aufgaben und Kompetenzen haben. Hierzu sollte u.a. auch die zentrale Verwaltung der Finanzmittel und Stellen innerhalb des Vorhabens gehören. Das Projektmanagement sollte sich als Liniengeber für das Gesamtprojekt verstehen und von allen Projektbeteiligten mit diesem Auftrag auch respektiert sein. Ihm sollte es auf dieser Basis dann auch möglich sein, disziplinäre Abweichungs- und Ausreißerversuche der Projektbeteiligten zu sanktionieren und Einflussnahmen der Geldgeber, die der Zielsetzung der Interdisziplinarität widersprechen, abzuwehren.

Die Projektleitung sollte über Kompetenzen in vielen unterschiedlichen Disziplinen verfügen, ohne selbst (noch) hochspezialisiert zu arbeiten (auch wenn er/sie das in der Vergangenheit getan hat), und insbesondere mit umfangreichen diplomatischen Fähigkeiten ausgestattet sein.

Innerhalb des Projektes sollte sich eine Kombination aus fachorientierten Teilprojekten und fächerübergreifenden Arbeitsgruppen bewähren. Letztere sollten den Auftrag übernehmen, Querschnittsaufgaben innerhalb des Projektes wahrzunehmen. Sie könnten z.B. als Koordinationsausschüsse institutionalisiert werden, die sowohl organisatorische als auch inhaltliche Fragen bearbeiten. Die einzelnen Koordinationsausschüsse wiederum könnten von einem Leitungsgremium koordiniert werden.

Die Einrichtung koordinierender Arbeitsgruppen oder –ausschüsse ist unerlässlich insbesondere für die Organisation des Antrags- und Berichtswesens sowie für die Bildungs- und Öffentlichkeitsarbeit. Das Projekt sollte in jedem Falle nach außen geschlossen und abgestimmt präsentiert werden. Dabei kann eine gezielte Einbindung der einzelnen Arbeitsgruppen in die Gesamtdarstellung der Projektergebnisse insofern sinnvoll sein, als diese dann zur Darstellung auch von Ergebnissen anderer Arbeitsgruppen gezwungen werden, was den Interdisziplinaritätsgedanken unterstützen kann.

Gefördert würde Interdisziplinarität in jedem Falle auch durch eine gemeinsame Ansiedlung der Projektbeteiligten z.B. innerhalb eines Projektzentrums oder Instituts (z.B. wie im Falle des BITÖK oder des Ökologie-Zentrums in Kiel), wo sich die Wissenschaftler „über den Weg laufen“ und auf diesem Wege die Kommunikation und das Bewusstsein für das gemeinsam zu erreichende Ziel gefördert werden.

- **Verbesserung der Kommunikation:**

Eine Verbesserung der Kommunikation geht vielfach mit einer Verbesserung der o.g. organisatorischen Rahmenbedingungen einher. An dieser Stelle seien jedoch noch gezielt einige spezifische Anregungen diesbezüglich aufgelistet:

- konsequente Nutzung von Intra- und Internet als Informationsplattform zwischen den Arbeitsgruppen,
- regelmäßige Herausgabe eines Newsletters zur kontinuierlichen Aktualisierung des Informationsstandes der Projektbeteiligten über die Probleme und Fortschritte der anderen Arbeitsgruppen,
- regelmäßige Veranstaltung gemeinsamer Gesprächsrunden, sei es in Form fachübergreifender Gespräche am Untersuchungsobjekt, gemeinsamer Workshops oder Klausurtagungen für fachliche und technische Beratungen (empfohlen wird z.B. ein Mitarbeitertref-

fen mind. alle drei Monate, die jährliche Veranstaltung eines wissenschaftlichen Symposiums und alle drei Jahre eines internationalen Symposium),

- Schaffung möglichst vieler Gelegenheiten auch zum informellen Austausch (z.B. Kaffeetreffen), der insbesondere die Herausbildung einer Gruppenidentität und das gegenseitige Verständnis für disziplinspezifisch unterschiedliche Arbeitsansätze fördern kann.

Die Verbesserung der Kommunikation und Kommunikationsfähigkeit sollte bereits an den Hochschulen im Lehrbetrieb gefördert werden. Hierzu würde die Durchführung gemeinsamer Forschungsvorhaben, Seminare, Tagungen, Kolloquien und Lehrveranstaltungen beitragen.

- **Schaffung von Integrationselementen:**

Interdisziplinäres Arbeiten erfordert konkrete Integrationselemente, d.h. gemeinsame Ausgangspunkte, gemeinsame Arbeitsmittel und gemeinsame Ergebnisse. Das bedeutet, Interdisziplinarität bedarf von Anfang an des geplanten Zusammenwirkens aller Akteure. Dieses beginnt bei der Formulierung der Basishypothesen einer Untersuchung (in einem in sich schlüssigen Projektantrag oder Projektplan) und endet bei der integrativen Ergebnisdarstellung (in einem qualitativ hochwertigen Projektsynthesebericht und gemeinsamen Publikationen der Projektbeteiligten unterschiedlicher Arbeitsgruppen). Die Beteiligung der jeweiligen Einzeldisziplinen sollte sich nicht an deren fachlichem Selbstverständnis orientieren, sondern an dem von der einzelnen Disziplin zu leistenden konkreten Beitrag zur Erfüllung des Forschungsauftrags.

Förderlich sind ferner:

- gemeinsame Flächenbezüge,
- abgestimmte Messkampagnen,
- gemeinsame Datenhaltung, die Ausdruck der Bereitschaft der einzelnen Arbeitsgruppen zur Freigabe ihrer Daten ist und einen möglichst reibungslos funktionierenden Datentransfer zwischen den Arbeitsgruppen sicherstellt,
- gemeinsame Strategien der Datenauswertung z.B. in Form spezieller Auswertungsprojekte (ihren strengsten Ausdruck können sie im Aufbau hierarchisch strukturierter Modellsysteme finden, die sich ohne die Zusammenführung des Sachverstandes mehrerer Disziplinen nicht entwickeln lassen).

Neben allen formellen Integrationsebenen darf es auch nicht an inhaltlichen Brücken fehlen, die zur Zusammenarbeit der Einzeldisziplinen anregen. Ohne solche gemeinsamen inhaltlichen Ziele bleibt die beste Projektstruktur unwirksam.

Wesentlich erscheint bei allen Anregungen, dass es auch bei guter Vorstrukturierung von Projekten mit dem Ziel, Interdisziplinarität zu fördern, in vielen Fällen an deren Umsetzung fehlt, d.h. sich die Arbeitsgruppen nach Projektbewilligung wieder verselbständigen, um ihre eigenen Ziele zu verfolgen. In Anbetracht dessen erlangt eine sorgfältige Auswahl aller Projektbeteiligten ein hohes Gewicht. Diese müssen ernsthaft an Interdisziplinarität und integrativen Projektstrategien und –ergebnissen interessiert sein.

Dem stringenten und zügigen Abschluss der Synthesephase der Projekte muss ebenso wie der Anfangsphase besonderes Gewicht gegeben werden. Ansonsten drohen durch die institutionelle Lockerung der Forschungsvorhaben gegen oder nach Ende ihrer Laufzeit Effizienzeinbußen.

4.7.3 Bedeutung der Modellentwicklung und des Modelleinsatzes in der Ökosystemforschung

Der Modellentwicklung und dem Modelleinsatz wird in großer Übereinstimmung der Befragten eine herausragende Bedeutung für die und in der Ökosystemforschung zuerkannt.

- Modelle sind wichtige Integrationsinstrumente, d.h. sie sind innerhalb von komplexen Projekten häufig die einzigen effizienten Werkzeuge, Wissen, Ideen und Daten zu integrieren und eine gemeinsame Sprache zu finden. Modelle unterstützen in diesem Sinne insbesondere die fachübergreifende Auswertung von Messdaten und die Erzeugung eines synoptischen Projektergebnisses.
- Modelle sind zum Verständnis und zur Veranschaulichung komplexer systemarer Zusammenhänge unentbehrlich.
- Modelle (insbesondere mechanistische, prozess-orientierte Modelle) sind häufig das einziges Mittel,
  - quantitative,
  - szenarische oder auch prognostische Aussagen zu treffen und
  - gemessen Daten und daraus ableitbare Aussagen auf andere Zeit- und Raumebenen zu skalieren.

  Mit dieser Aussageleistung erlangen die Forschungsergebnisse Relevanz für die politische und planerische Entscheidungsfindung.
- Modelle können der Einsparung großer Mengen von Einzelmessungen dienen.
- Modelle eigenen sich sehr gut dazu, Wissenslücken aufzudecken. Sie sind häufig Quellen weiterführender Hypothesenbildungen.

Es wird aber auch davor gewarnt, Modelle als Allheilmittel zu betrachten und ihre Ergebnisse unkritisch zu übernehmen. Z.T. wird die Auffassung geäußert, dass modellgestützte Vorhersagen zur Entwicklung von Ökosystemen, die über die bisherigen Beobachtungen hinausführen, im Unterschied zu physikalisch/chemischen Systemen nicht möglich sind. Dies gilt insbesondere für szenarische und prognostische Aussagen. Es wird jedoch übereinstimmend das Potenzial gesehen, Entwicklungsoptionen aufzuzeigen und die Diskussion darüber anzuregen. Ferner wird betont, dass Modelle den Anspruch erheben müssen, verständlich und nachvollziehbar zu sein, da sonst insbesondere beim Einsatz der Modellergebnisse in der politischen oder planerischen Argumentation Misstrauen entsteht.

Von Anwenderseite wird kritisiert, dass die Modelle, die von der Ökosystemforschung hervorgebracht werden, häufig nicht wirklich handhabbar und praxistauglich sind und ohne konkreten Problembezug entwickelt und angewandt werden. Dies gilt in besonderem Maße für hoch parametrisierte Computermodelle, die sich mitunter schnell in schematisch angewandten Algorithmen erschöpfen, „monströse“ und realitätsferne Dimensionen annehmen und gegenüber Empirie und Experiment oftmals weit überschätzt werden. So gibt es beispielsweise für die UVP konkreten Bedarf nach Modellen zur Wirkungsprognose. Die bisher von der Ökosystemforschung bereitgestellten Modelle hätten sich für diesen Zweck jedoch nicht als einsatzfähig erwiesen.

4.7.4 Vor- und Nachteile der Ökosystemforschung und ihre größten Probleme

Aus den Äußerungen der Befragten lassen sich die folgenden Thesen zu **Vorteilen** und Chancen der Ökosystemforschung und ihrer Arbeitsweisen extrahieren:

- **Die Ökosystemforschung liefert aufgrund ihrer Forschungsansätze neue Erkenntnisse, die über die Einzelergebnisse sektoraler Forschungen hinausreichen.**

Die Ökosystemforschung löst sich von der sektoralen (und medial orientierten) Betrachtung von Einzelproblemen. Sie betrachtet vielmehr den Gesamtkontext des Systems bei gleichzeitiger Berücksichtigung zahlreicher anthropogener Veränderungsfaktoren. Damit lassen sich mitunter Quellen für die Entstehung von Problemen aufdecken, die sich mit der Betrachtung nur einzelner Einflussfaktoren so nicht erkennen ließen.

- **Trotz des mit der Ökosystemforschung verbundenen erheblichen Mittelaufwands ist Ökosystemforschung dennoch ökonomisch.**

Ökosystemforschung stellt mit ihrem Anspruch zwar erhebliche Anforderungen an die Bereitstellung von Finanz- und Personalmitteln. Dennoch ist sie letztendlich ökonomisch, da die Forschungsergebnisse von Einzeldisziplinen zusammengeführt werden und ihre Interpretationsmöglichkeiten dadurch erweitert werden.

- **Die Kooperation unterschiedlicher Fachdisziplinen zwingt zur Herausbildung einer verständlichen Sprache.**

Auch wenn sich noch immer erhebliche Probleme hinsichtlich der Vermittelbarkeit der Diskussionsinhalte und Ergebnisse der Ökosystemforschung stellen, zwingt die interdisziplinäre Kommunikation innerhalb von Ökosystemforschungsvorhaben doch zu einer Übersetzung der Fachsprache der einzelnen Disziplinen in eine allgemeinverständlichere Sprache. Dies ist auch förderlich für die Öffentlichkeitsarbeit.

- **Ein erklärter Anwendungsbezug und der Untersuchungsgegenstand der Ökosystemforschung motivieren.**

Ein erklärter Anspruch auf Anwendungsbezug vermag Forscher in besonderer Weise zu motivieren, und es kann als besonderes Erfolgserlebnis gewertet werden, wenn die Forschungsergebnisse Relevanz für politische und planerische Entscheidungen erzielen. Auch das Erkennen und Erklären komplexer Ursache-Wirkungsbeziehungen in Ökosystemen ist ein an sich attraktives Arbeitsfeld, das besondere Herausforderungen bietet.

Gerade für die Ökosystemforschung haben sich in den letzten Jahren mit der Entwicklung der Informationstechnologie bis dahin ungeahnte technische Möglichkeiten eröffnet, die ganz neue Arbeitsperspektiven eröffnen. Dies gilt in besondere Weise für den Bereich der Modellbildung.

Die angeführten **Nachteile** und fundamentalen Probleme der Ökosystemforschung und ihrer Arbeitsweisen lassen sich in den folgenden Thesen zusammenfassen:

- **Ökosystemforschung ist zu teuer.**

Die gegenüber der sektoralen Forschung erfolgte Erweiterung des Untersuchungsgegenstandes und der Untersuchungsansätze bringt es mit sich, dass der Kapital- und Personalaufwand der Ökosystemforschung vergleichsweise sehr hoch sind. Angesichts dieser Kosten ist es fraglich, ob sich die Ökosystemforschung angesichts schmaler werdender Haushaltskassen in Zukunft überhaupt noch finanzieren lässt.

- **Ökosystemforschung bietet nur wenige und riskante Karriereoptionen.**

Auf die Schwierigkeit, sich mit interdisziplinären Erfolgen im Wissenschaftsbetrieb zu behaupten, wurde bereits an mehreren Stellen hingewiesen. Hier seien noch einmal die ungünstigen Rahmenbedingungen zusammengefasst, mit denen sich in der Ökosystemforschung tätige Wissenschaftler konfrontiert fühlen:

- Die mit der interdisziplinären Zusammenarbeit manchmal erforderlichen Vereinfachungen und Verallgemeinerungen werden gelegentlich von Fachspezialisten angegriffen. Dies kann die fachliche Anerkennung der in der Ökosystemforschung tätigen Wissenschaftler negativ beeinflussen.
- Ein wesentliches Erfolgskriterium für Wissenschaftler ist die pro Zeiteinheit produzierte Anzahl möglichst hochrangiger Publikationen (durch die mit dem neuen Hochschulrahmengesetz vorgegebenen Befristungen für Nachwuchswissenschaftler in Deutschland hat sich dieser Druck nochmals erheblich verschärft). Das bedeutet, es kann im Grunde nur das erforscht werden, was sich rasch hochrangig publizieren lässt. Dies sind typischerweise detaillierte Einzelstudien im Labor, nicht aber komplexe ökosystemare Zusammenhänge und Feldstudien (mit vielen Einflussgrößen, langen Reaktionszeiten usw.). Ergebnisse solch komplexer Studien lassen sich häufig auch nur schwer publizieren, da sie für den Leser mühsam zu erfassen sind und sich oft keine generalisierenden Aussagen treffen lassen.
- Die Selektion im Wissenschaftsbetrieb setzt beim einzelnen Individuum an und berücksichtigt nicht in ausreichendem Maße die Leistung einer Gesamtgruppe bzw. die für das Fortkommen der Gesamtgruppe erbrachten Leistungen der einzelnen Gruppenmitglieder. So müssen zum Verständnis ökosystemarer Zusammenhänge teilweise Parameter bestimmt werden, die zwar schwer zu messen sind, die aber alleine noch keine wertgeschätzten Einzelergebnisse darstellen. Die damit befassten Wissenschaftler leisten damit einen oft essenziellen Beitrag für das Gesamtprojekt, werden aber individuell schlecht beurteilt.
- Das für das Gelingen von Ökosystemforschungsvorhaben erforderliche kompetente Projektmanagement wird auch von den Wissenschaftlern selbst nur wenige gewürdigt und unterstützt. Damit bieten sich auch für hochqualifizierte Manager nur sehr eingeschränkte Karriereoptionen in der Ökosystemforschung.

Die genannten Rahmenbedingungen haben zur Konsequenz, dass sich erfolgsorientierte und kompetente Wissenschaftler zunehmend aus der Ökosystemforschung zurückziehen bzw. sich gar nicht erst in diese Forschungsteams integrieren. Sie widmen sich eher reduktionistischen Studien, die unter den geltenden Regeln größere Aussichten auf Erfolg bieten. Um diesem Dilemma abzuhelfen, bedürfte es attraktiver Positionen in der Ökosystemforschung, auf denen langfristig im Team Ökosystemforschung betrieben werden kann, und eine ausgeglichenere Balance zwischen Einzel- und Gruppenselektion im Wissenschaftsbetrieb.

- **Die politische Steuerung der Ökosystemforschung ist relativ groß.**

Ökosystemforschung ist aufgrund ihres erklärten anwendungsorientierten Anspruchs sehr viel stärker politischer Lenkung unterworfen, als dies bei der grundlagenorientierten Forschung der Fall ist. Das bedeutet, die Geldgeber binden i.d.R. die Mittelfreigabe an ein bestimmtes erwartetes Ergebnis, das konkrete Beiträge zur Lösung eines Umweltproblems liefern soll. Ökosystemforschung ist jedoch gerade aufgrund des komplexen Untersuchungsgegenstandes ein besonders von Überraschungen geprägtes Arbeitsfeld, das erhebliche Flexibilität in der Wahl der Forschungsansätze und Methoden erfordert. Dieser Flexibilität kann häufig von Geldgeberseite nicht gefolgt werden mit der Konsequenz, dass daraus inadäquate Einschränkungen für die Entfaltung der Forschungstätigkeit resultieren.

- **Die Ökosystemforschung blockiert sich durch ihren hohen integrativen Anspruch selbst.**

Der integrative Anspruch der Ökosystemforschung bietet Chancen und Probleme. Zum einen erwächst daraus ein wohltuender Zwang zur interdisziplinären Arbeit und zur engen Kooperation zwischen den unterschiedlichen Fachdisziplinen. Zum anderen besteht aber auch das Risiko, dass die Ökosystemforschung aufgrund wechselseitiger Abhängigkeiten der einzelnen Fachdisziplinen in ihren Fortschritten behindert wird. Dies gilt insbesondere dann, wenn etablierte Disziplinen die Beantwortung komplexer Fragestellungen an das Vorliegen von Ergebnissen aus der detaillierten Untersuchung von Teilsystemen binden.

- **Die Ergebnisse der Ökosystemforschung lassen sich nur schwer vermitteln.**

Auch dieses Problem steht im engen Zusammenhang mit dem hohen integrativen Anspruch der Ökosystemforschung. Von Anwenderseite wird vielfach die Fundamentalkritik geäußert, die Ökosystemforschung wäre nicht fähig, leicht anwendbare Resultate zur Lösung von Umweltproblemen zu erzeugen, so wie das andere stärker reduktionistische Ansätze für Teilprobleme schaffen. In vielen Fällen lässt sich dieser Eindruck auf die nur schwere Vermittelbarkeit der komplexen Ergebnisse zurückführen.

4.7.5 Wünsche an die Ökosystemforschung der Zukunft

Die Zukunft der Ökosystemforschung ist eng an die Bereitstellung entsprechender Finanzmittel gebunden. Hier wird es entscheidend sein, ob es der Ökosystemforschung gelingt, auch eigenständig ihre Finanzierung zu sichern und zu diversifizieren. Die bisherigen Leistungen und Ergebnisse der Ökosystemforschung werden sich dabei einer strengen Prüfung unterwerfen müssen. Darüber hinaus wird es erforderlich sein, attraktive strukturelle und inhaltliche Perspektiven für die künftige Ökosystemforschung zu entwickeln.

Neben zwangsläufigen, mit der technischen Entwicklung (insbesondere im IT-Bereich) einhergehenden Weiterentwicklung der Ökosystemforschung gibt es folgende Anregungen und Ideen für die zukünftige Ausgestaltung der Ökosystemforschung:

- **Verbesserungen in organisatorischer Hinsicht:**

- Verbesserung des Projektmanagements: Die Projektleitung sollte gezielt auf ihre Aufgaben hin geschult werden, und es sollte am Aufbau eines Berufsbildes „Projektmanager für Ökosystemforschungsvorhaben“ gearbeitet werden;
- Schaffung attraktiver Positionen in der Ökosystemforschung: Soll engagiertes und talentiertes Personal für die Ökosystemforschung gewonnen werden, soll Interdisziplinarität ausgebaut und tatsächlich realisiert werden und soll der Teamgedanke in der Ökosystemforschung gestärkt werden, dann muss eine bessere Balance zwischen der Anerkennung von Einzel- und Gruppenleistungen gefunden werden. Das bedeutet, integrative Leistungen, die für das Team und das übergeordnete gemeinsame Ziel des Vorhabens erbracht werden, müssen adäquate Anerkennung finden und Karrierefortschritte ermöglichen.

- **Stärkung bzw. Ausweitung der Interdisziplinarität und Internationalität:**

- Ausweitung der Interdisziplinarität über die Naturwissenschaften hinaus, Suche gezielter Kooperation auch mit politik- und geisteswissenschaftlichen Disziplinen und stärkere Berücksichtigung der sozialen und wirtschaftlichen Komponenten, welche die Entwicklung der Ökosysteme bestimmen;
- engerer Austausch zwischen (interdisziplinär arbeitenden) Wissenschaftlern, Umweltpolitikern und Managern während aller Projektphasen;
- Verbesserung der Karrierechancen für Projektbeteiligte, die sich für die Realisierung von Interdisziplinarität einsetzen (s.o.);
- Ausweitung internationaler Kontakte: Ökosystemforschung entwickelt sich unter den unterschiedlichen politischen, gesellschaftlichen/kulturellen und naturgegebenen Rahmenbedingungen in den verschiedenen Staaten sehr unterschiedlich; aus dieser Vielfalt ließen sich zahlreiche Anregungen sowohl in inhaltlicher, methodischer als auch strategischer Sicht austauschen. Gerade für die Durchführung internationaler Projekte wäre jedoch eine gezielte Unterstützung der Kommunikation (u.a. zur Überwindung interkultureller Missverständnisse) erforderlich;
- Aufbau gut etablierter Forschungsnetzwerke (z.B. auf europäischer Ebene).

- **Stärkere institutionelle und finanzielle Unterstützung:**

- Umfangreichere und längerfristige finanzielle Unterstützung der Ökosystemforschung: Die Ökosystemforschung braucht aus Sicht der Forschenden zu ihrer weiteren Entfaltung insbesondere mit Blick auf ihren integrativen und damit komplexen und anspruchsvollen Auftrag mehr und insbesondere längerfristig zuverlässig fließende Finanzmittel. Gerade der interdisziplinäre Erfahrungsaustausch braucht Zeit und ist bei immer kürzer werdenden Projektlaufzeiten häufig nicht mehr realisierbar. Von den Geldgebern wird vor diesem Hintergrund mehr Mut zur Bewilligung auch langfristiger (und internationaler) Projekte gewünscht. Dieser Ansicht konträr werden von der Anwenderseite kürzere, schnellere und kompaktere Vorhaben gewünscht, damit schneller adäquate Antworten auf aktuelle Fragen- und Problemstellungen der Praxis zur Verfügung stehen. Lange Laufzeiten von Ökosystemforschungsvorhaben führen häufig dazu, dass die Forschung alsbald an den rechtlich wirklich wichtigen Herausforderungen vorbeigeht (so lagen beispielsweise die Forschungsergebnisse zu Waldschäden zu einem Zeitpunkt vor, als das Thema in der Öffentlichkeit bereits deutlich an Aktualität verloren hatte). Sinnvoll im Hinblick auf Langfristigkeit erscheint den Anwendern vielmehr:
  - ❖ die Ergänzung einzelner abgeschlossener Vorhaben um eine fortdauernde Umweltbeobachtung,
  - ❖ eine stärkere Anknüpfung neuer Vorhaben an in der Vergangenheit abgeschlossene Vorhaben, um eine gezielte Aktualisierung von deren Ergebnissen zu ermöglichen;
- höhere Flexibilität bei der Finanzmittelvergabe: Ökosystemforschungsvorhaben sind aufgrund ihres komplexen Forschungsauftrags und der zahlreichen am Vorhaben Beteiligten häufig auch bei guter Projektplanung und -steuerung „unberechenbar“ in ihrer Entwicklung. Dies zieht mitunter notwendiger Weise die organisatorische und inhaltliche Umstrukturierung während der Projektlaufzeit nach sich. Die Geldgeber sollten bezüglich solcher Umorientierungen und Umstrukturierungen eine höhere Flexibilität an den Tag legen, mehr Vertrauen in die Kompetenz der Forschenden setzen, der wissenschaftli-

chen Arbeit einen größeren Freiraum einräumen und damit eine zielgerichtet Weiterentwicklung der Vorhabens unterstützen;

- umfangreichere institutionelle Unterstützung der Ökosystemforschung: In Anbetracht der großen räumlichen Heterogenität und der unterschiedlichen anthropogenen Belastung der Ökosysteme (dies gilt in besonderem Maße für Deutschland) bedarf es der Einrichtung weiterer interfakultativer Kompetenzzentren mit entsprechender Ausstattung.

- **inhaltliche Perspektiven:**

Neben diesen eher organisatorischen und strategischen Verbesserungswünschen gibt es zahlreiche Anregungen und Wünsche für die weitere inhaltliche Ausgestaltung der Ökosystemforschung. Der Forschungsbedarf lässt sich dabei im Wesentlichen aus den Ergebnissen und Erfahrungen noch laufender oder bereits abgeschlossener Ökosystemforschungsvorhaben ableiten.

Im Grundsatz wünschen sich sowohl Forscher als auch Anwender einen engeren wechselseitigen Austausch, auch eine stärkere Einbindung von Landnutzern und ihren Wissenschaften und damit eine stärkere Orientierung der Ökosystemforschung an anwendungsbezogenen Themen. Zugleich wird aber von Forscherseite her betont, dass weiterhin die Freiheit bestehen sollte, auch ohne Anwendungsdruck von Außen grundlegende Themen zu bearbeiten, denn nur dann wird es möglich sein, auch bislang ungelöste theoretische Fragestellungen zu bearbeiten, die ggf. wichtige Perspektiven für eine Anwendung in fernerer Zukunft eröffnen.

Als wesentlich wird ferner die Initiierung und Bearbeitung von Projekten erachtet, die sich globalen Zusammenhängen widmen.

Die Frage nach einer stärkeren Orientierung oder Loslösung der Forschung an oder von der aktuellen umweltpolitischen Diskussion wird von Forschern und Anwendern unterschiedlich verstanden. Auf Forscherseite werden durch eine zu enge Fokussierung an den aktuellen Umweltproblemen offensichtlich eine zu starke Einengung der wissenschaftlichen Freiheiten und eine zu starke Kurzfristigkeit der Forschungsaufträge befürchtet, da die umweltpolitische und gesellschaftliche Gewichtung von Umweltproblemen einem schnellen Wandel unterworfen sein kann. Demgegenüber wünschen sich die Anwender eine grundsätzlich stärkere Orientierung der Forschung an diesen Themen, da diese selbstverständlich ihre jeweiligen Arbeitsaufträge stark prägen und sie sich zur Bewältigung derselben Beiträge aus der Ökosystemforschung wünschen.

Spezielle Wünsche für zukünftige inhaltliche Schwerpunkte betreffen:

- die Weiterentwicklung im Bereich der Indikatorenfindung insbesondere zur Indizierung von Ökosystemfunktionen (Welche einfach zu messenden Kenngrößen erlauben eine Ableitung von Ökosystemfunktionen? Auf welchen räumlichen und zeitlichen Skalen sind sie sinnvoll einzusetzen und mit welchen Fehlern sind sie behaftet?);
- die Fortentwicklung der Arbeiten im Bereich der Critical Loads und Critical Levels (so besteht bei der Quantifizierung von kritischen Belastungsraten für Waldökosysteme im Zusammenhang mit der Deposition von Luftschadstoffen nach wie vor Forschungsbedarf. Hier stellen sich Fragen wie: Welche konzeptionellen Ansätze (Steady State Massenbilanz, empirische Modelle, dynamische Modelle) sind geeignet? Welche Zielparameter sind sinnvoll und wie können diese regional berechnet werden?);

- die Rolle der Vegetation und insbesondere der Böden im globalen C- und N-Kreislauf; damit eng verknüpft sind besonders folgende Fragen: Wie lassen sich Senken im Ökosystem quantifizieren, manipulieren und prognostizieren? Welche Auswirkungen haben erhöhte CO_2-Gehalte der Atmosphäre auf Ökosystemfunktionen?);
- die Fortsetzung bzw. Intensivierung der Forschung im Bereich der Klimafolgenforschung (z.B. welche Auswirkungen haben sowohl schleichende Klimaveränderungen als auch Klimaextreme auf die Ökosysteme - auf die hydrologischen Bedingungen, die Vegetation und die Tierpopulationen? Welche Konsequenzen hat das Zusammenwirken von Klimawandel und stofflichen Veränderungen wie z.B. zunehmende N-Deposition für die Ökosysteme?);
- die Aufklärung der Bedeutung von Biodiversität für die Funktion von Ökosystemen (Wie verändern sich Artenzusammensetzungen, Strukturen und funktionelle Gruppen und welche Konsequenzen hat dies für die Ökosysteme? Wie reagieren Arten auf veränderte Flüsse und wie wiederum beeinflussen sie diese?);
- die Erweiterung der Kenntnisse im Hinblick auf eine nachhaltige Nutzung von agrarisch geprägten Regionen, intensiv beanspruchten Siedlungs- und Verkehrsräumen sowie tropischen Ökosystemen;
- die Vertiefung der Untersuchungen zur Desertifikationsproblematik;
- die Erzielung weiterführender Kenntnisse zu Verlagerung, Transformation, Akkumulation und Abbau von Stoffen in Umweltmedien (für Deutschland besteht der Wunsch nach einer stärkere Verknüpfung der Ökosystemforschung mit den Aufgaben der Umweltprobenbank).

Aus Anwendersicht sollte in Zukunft insbesondere eine engere Verknüpfung der Ökosystemforschung mit rechtsnormativen Vorgaben gesucht werden. Das bedeutet, die Ökosystemforschung sollte u.a. Beiträge liefern:

- zur Definition von Schutzgütern,
- zur Präzisierung des Risiko- und Gefahrenbegriffs,
- zur Bestimmung von Umweltzielen (Umweltqualitätszielen und –standards),
- zur Frage der Gewichtung von Umweltbelangen und -problemen,
- zur Lösung von Prognoseproblemen.

Ein sinnvolles Instrumentarium, das für die Anwender aus der Ökosystemforschung resultieren könnte, wären frei zugängliche Kartenwerke mit räumlich zugeordneten, ökologisch relevanten Datenbeständen.

Mit Blick auf die methodische Weiterentwicklung der Ökosystemforschung betont eine große Zahl der Befragten sowohl von Forscher- als auch Anwenderseite eine stärkere Betonung der Erarbeitung praxistauglicher Methoden und Instrumente. Ein Schwerpunkt wird dabei auf die Entwicklung zahlreicherer und leicht handhabbarer Modelle gelegt. So sollen insbesondere:

- Modellsysteme auf verschiedenen Skalenebenen entwickelt und validiert werden;
- die Sensitivitätsanalyse von Modellen verbessert werden;
- die vorhandenen Modelle systematisch auf ihren Vorhersage- und Genauigkeitsbereich getestet werden. Dies gilt im Grundsatz für alle Modellklassen, in besonderer Weise jedoch für komplexe Modelle, die eine größere Zahl von Prozessen abbilden sollen; die Konsequenzen der Unschärfen bei der Prozessparametrisierung und den Umweltbedin-

gungen müssen stärker als bisher bei Prognosen berücksichtigt und ausgewiesen werden;
- Verknüpfungen zwischen bestehenden (sektoralen) Modellen geschaffen werden (um z.B. eine systemadäquate Abbildung des Stofftransports und der -transformation zu ermöglichen);
- die Bedingungen für eine Abbildung der dynamischen Eigenschaften von Ökosystemen verbessert werden.

Daneben gibt es den Wunsch nach
- einer engeren Verknüpfung zwischen Labor- und Feldstudien von ökosystemaren Schlüsselprozessen und bei der Untersuchung wirkungsbezogener Schwellen;
- der Wahl strengerer statistischer Versuchsanordnungen, die dem statistischen Charakter der Umweltgesetzmäßigkeiten stärker entsprechen,
- die Weiterentwicklung von Visualisierungsmethoden (u.a. zur Abbildung dynamisierter Verfahren z.B. zur Darstellung von Wachstumsprozessen oder Jahreszeitenwechseln);
- der systematischen Nutzung von Satellitendaten,
- einer Erweiterung der technischen und methodischen Möglichkeiten für die Arbeit in Regionen mit geringer Datenverfügbarkeit (low data – high output) sowie
- einen breiteren Einsatz von nur wenig destruktiven Techniken für die integrierte Ökosystemforschung (womit auch eine Überführung der Ökosystemforschung in eine langfristige Umweltbeobachtung vorbereitet werden könnte).

- **Räumliche Ausweitung der Ökosystemforschung:**

Grundsätzlich wird die Einbeziehung weiterer Ökosystemtypen in die Ökosystemforschung gewünscht, um eine höhere Repräsentanz der Forschungsergebnisse erzielen zu können. Während über Ökosysteme der gemäßigten Zone inzwischen eine Vielzahl von Studien vorliegt, werden große Wissens- und Forschungsdefizite insbesondere hinsichtlich der Funktion von Ökosystemen in Entwicklungs- und Schwellenländern, insbesondere in den Tropen und Subtropen gesehen. In diesen Regionen herrscht ein - im Vergleich zur gemäßigten Zone - eklatantes Missverhältnis zwischen der Kenntnis über die Ökosysteme und den gravierenden Problemen, die mit Änderungen der Landnutzung einhergehen.

Ferner wird für die Ökosystemforschung der Zukunft neben der Bearbeitung einzelner Ökosystemtypen auch eine stärkere Beachtung von Ökosystemkomplexen bzw. Landschaften für wünschenswert erachtet.

- **Verbesserungen in der Außendarstellung und Kommunikation:**

Von Anwenderseite wird grundsätzlich eine bessere und allgemein verständlichere Synthese der Forschungsergebnisse für die Zukunft erwünscht. Nur so kann das oben mehrfach angesprochene Transformationsproblem einer Lösung näher gebracht werden. Es besteht Einigkeit darüber, dass zur Umsetzung dieses Anspruchs spezielle Gelder zur Verfügung gestellt werden müssen.

Zwischen Ökosystemforschern und Anwendern sollten gezielt Brücken geschlagen werden:

- Der Kontakt könnte in Kompetenzzentren institutionalisiert werden.
- Es könnte daran gedacht werden, gemeinsame praxisbezogene Projekte unter Beteiligung von Forschern und Anwendern zu initiieren.

- Von der Ökosystemforschung könnten im Internet interaktive Szenarien angeboten werden, deren Rahmenbedingungen die Anwender mitgestalten und deren Ergebnisse sie bewerten können.
- Die Ökosystemforschungseinrichtungen könnten vermehrt Kooperationsverträge mit staatlichen und kommunalen Einrichtungen oder Firmen abschließen und Dienstleistungen für diese anbieten (z.B. laufende Kooperation des Ökologie-Zentrums Kiel mit dem Landesamt für Natur und Umwelt in Schleswig-Holstein).
- Gründung einer Zeitschrift, die als Plattform explizit den Austausch zwischen Ökosystemforschern und Anwendern zum Gegenstand macht.

APPENDIX 5: PROGRAM OF THE WORKSHOP

Overview:

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5.2 Structure of the Working Groups 78

5.1 Program of the Workshops

Tuesday, October 22

09:00-13:00 Arrival at Kiel and Transfer to Salzau
13:00-14:00 Lunch
14:00-14:30 Welcome

Key Note Lectures 1: Introducing the Subject

14:30-15:00 P. Müller (Saarbrücken)& O. Fränzle (Kiel): 25 Years of Ecosystem Research in Germany – Expectations, Results and Developments
15:00-15:30 W. Haber (Freising-Weihenstephan): The Ecosystem – Power of a Metaphysical Construct
15:30-16:00 Discussion
16:00-16:30 Coffee Break

Key Note Lectures 2: Concepts and Results

16:30-17:00 S.E. Jørgensen (Kopenhagen): Linking Ecosystem Theory and Ecosystem Models with Holistic Environmental Management
17:00-17:30 C.Gätje (Tönning) & T. Höpner (Oldenburg): Ecosystem Research in the German Wadden Sea – Concepts, Results and Applications
17:30-18:00 F. Beese (Göttingen)& E. Matzner (Bayreuth): Forest Ecosystem Research in Germany – Concepts, Results and Applications
18:00-19:00 Discussion
19:30-20:00 Get Together
20:00-23:00 Dinner

Wednesday, October 23

07:30-08:30 Breakfast

Key Note Lectures 3: Consequences und Applications

08:30-08:50 H. Korn (Vilm): The Ecosystem Approach of the Convention on Biodiversity
08:50-09:10 G. Petschel-Held (Potsdam): The Millennium-Assessment as Bases of Integrated Ecosystem Monitoring
09:10-09:30 P. D. Hansen (Berlin): Ecosystem Health Assessment: Potentials and Limitations
09:30-10:00 Discussion and Working Group Preparation
10:00-12:30 Working Groups, 1st Session – Impulse Papers, Definition of Targets, Organisation
12:30-14:00 Lunch
14:00-16:00 Working Groups, 2nd Session – Posters, Statements, Discussions
16:00-16:30 Coffee Break
16:30-18:30 Working Groups, 3rd Session – Posters, Statements, Discussions

Key Note Lectures 4: International Experiences

19:00-19:30 H. Regier (Toronto, Canada): Ecosystem Fundamentals of Environments Protection – Ecological Integrity

19:30-20:00 J. Gosz (Albuquerque, USA): The International Long-Term Ecological Research Initiative

20:00-23:00 Salzau Buffet and Salzau Music with "Piffari"

Thursday, October 24

07:30-08:30 Breakfast

08:30-10:00 Parallel Sessions:

Working Groups, 4th Session – Preparing the Reports
Key Note Lectures 5: Applied Systems Ecology
H. Franz (Berchtesgaden): Alpine Ecosystem Research Integrating Ecological and Social Processes

10:00-10:30 Coffee Break

10:30-12:00 Plenum Session: Presenting the Results of the Working Groups

12:00-13:00 Final Discussion

13:00-15:00 Transfer to Kiel and Departure

5.2 Structure of the Working Groups

Working Group A: Conceptual, Methodological and Strategic Experience and Problems of Ecosystem Research

“Group coordinator“: J.C. Munch
“Rapporteur”: M. Hauhs
“Impulse paper”: J. Filser
“Group assistent”: M. Bredemeier

Working Group B: Ecosystem Research and Ecosystem Management – Models for Integrative Environmental Practice

“Group coordinator“: F. Beese
“Rapporteur”: H. Regier
“Impulse paper”: W. Windhorst
“Group assistent”: J. Barkmann

Working Group C: Experience and Problems of Ecosystem Approaches in Practice – Demands from Environmental Policy and Planning

“Group coordinator“: K. Dierssen
“Rapporteur”: T. Höpner
“Impulse paper”: B. Hain & K. Tobias
“Group assistent”: K. Schönthaler

Working Group D: Future of Ecosystem Research

“Group coordinator“: E. Matzner
“Rapporteur”: H. Wiggering
“Impulse paper”: F. Müller
“Group assistent”: F. Müller

MATERIALIEN 6: PARTICIPANTS OF THE WORKSHOP

Dr. Karl – Friedrich Albrecht
Fakultät Forst-, Geo- und Hydrowissenschaften
Institut für allg. Ökologie, TU Dresden
Postfach 11 17, 01735 Tharandt
Tel.: 035203 / 38 31 309
Fax: 035203 / 38 31 266
e-mail: albrecht@forst.tu-dresden.de

Stefan Balla
Bosch & Partner GmbH
Schaeferstr.18, 44623 Herne
Tel.: 02323 / 94629 11
Fax: 02323 / 94629 20
e-mail: s.balla@bosch-partnergmbh.de

Dr. Jan Barkmann
Universität Göttingen, Interdisziplinäres Zentrum
für Nachhaltige Entwicklung & Institut für Fachdidaktik - Didaktik der Biologie
Waldweg 26, 37073 Göttingen
Tel.: 0551 / 39 14015
Fax: 0551 / 39 9204
e-mail: jbarkma@gwdg.de

Dr. habil Olaf Bastian
Sächsische Akademie der Wissenschaften zu Leipzig
Neustädter Markt 19, 01097 Dresden
Tel.: 0351 / 81 416- 806
Fax: 0351 / 81 416- 820
e-mail: olaf.bastia@mailbox.tu.dresden.de

Prof. Dr. Friedrich Beese
Institut für Bodenkunde und Waldernährung
Büsgenweg 2, 37077 Göttingen
Tel.: 0551 / 39- 9765
Fax: 0551 / 39- 3310
e-mail: fbeese@gwdg.de

Prof. Dr. Giuseppe Bendoricchio
University of Padova – DPCI
Via Marzolo 9, 35100 Padova, Italy
Tel.: 0039 049 827 5526
Fax: 0039 049 827 5528
e-mail: gbndo@unipd.it

Dr. Uta Berger
Zentrum für Marine Tropenökologie
Fahrenheitstraße 6, 28359 Bremen
Tel.: 0421 / 238 0053
Fax: 0421 / 238 0030
e-mail: uberger@zmt.uni-bremen.de

Dr. Michael Bredemeier
Forschungszentrum Waldökosysteme der Universität Göttingen
Büsgenweg 1, 37077 Göttingen
Tel.: 0551 / 39 98 40
Fax: 0551 / 39 97 62
e-mail: mbredem@gwdg.de

Benjamin Burkhard
Ökologiezentrum Kiel der Universität Kiel
Schauenburgerstr 112, 24118 Kiel
Tel.: 0431 / 880 4313
Fax: 0431 / 880 4083
E-Mail: benjamin@ecology.uni-kiel.de

Karoline Caesar
Ökologie-Zentrum der Universität Kiel
Schauenburger Straße 112, 24118 Kiel
Tel.: 0431 / 880-3251
Fax: 0431 / 880 4083
e-mail: karoline@ecology.uni-kiel.de

Prof. Dr. Franciscus Colijn
GKSS Institut für Küstenforschung
Max Planck Straße 1, 21502 Geesthacht
Tel.: 04152 / 87 15 33
Fax: 04152 / 87 20 20
e-mail: coljin@gkss.de

Prof. Dr. Klaus Dierßen
Ökologie-Zentrum der Universität Kiel
Schauenburger Straße 112, 24118 Kiel
Tel.: 0431 / 880 4030
Fax: 0431 / 880 4083
e-mail: klausd@ecology.uni-kiel.de

Dr. Oliver Dilly
Ökologie-Zentrum der Universität Kiel
Schauenburger Straße 112, 24118 Kiel
Tel.: 0431 / 880 4030
Fax: 0431 / 880 4083
e-mail: oliver@ecology.uni-kiel.de

Peter Dornbusch
Biosphärenreservatsverwaltung
Kapenmühle Postfach 13 82, 06813 Dessau
Tel.: 034904 / 42 10
Fax: 034904 / 42 121
e-mail: bioresme@t-online.de

Matthias Drösler
Institut für Pflanzenökologie
Universität Bayreuth, 95440 Bayreuth
Tel.: 08161/3386
Fax: 08161/3386
e-mail: m.droesler@gmx.de

Prof. Dr. Gert E. Dudel
Fakultät Forst-, Geo- und Hydrowissenschaften
Institut für allg. Ökologie, TU Dresden
Pienner Straße 8, 01737 Tharandt
Tel.: 035203 / 383 13 91
Fax: 035203 / 383 13 99
e-mail: dudel@forst.tu-dresden.de

Dr. Hubert Farke
Nationalparkverwaltung Nieders. Wattenmeer
Virchowstr. 1, 26382 Wilhelmshaven
Tel.: 04421 / 91 12 81
Fax: 04421 / 91 12 80
e-mail: hubert.farke@br-we-whv.niedersachsen.de

Prof. Dr. Juliane Filser
UFT Ökologie, Universität Bremen
Leobener Str., 28359 Bremen
Tel.: 0421 / 218 3026
Fax: 0421 / 218 7654
e-mail: filser@uni-bremen.de

Prof. Dr. Otto Fränzle
Geographisches Institut der Universität Kiel
Olshausenstr. 40, 24118 Kiel
Tel.: 0431 / 880 2950
Fax: 0341 / 880 4658
e-mail: fraenzle@geographie-uni-kiel.de

Helmut Franz
Nationalpark Berchtesgaden
Doktorberg 6, 83471 Berchtesgaden
Tel.: 08652 / 96 86 153
Fax: 08652 / 96 86 140
e-mail: H.Franz@natiomalpark-berchtesgaden.de

Dr. Andreas von Gadow
Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit
Heinrich von Stephan-Str.1, 53048 Bonn
Tel.: 0228 / 305 2660
Fax: 0228 / 305 2695
e-mail: andreas.vonGadow@bmu.bund.de

Prof. Dr. James Gosz
Department of Biology
Address: University of New Mexico, Albuquerque, NM 87131, USA
e-mail: jgosz@lternet.edu

Dr. Christiane Gätje
Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer
Schloßgarten 1, 25832 Tönning
Tel.: 04861 / 616- 45
Fax: 04861 / 616- 69
e-mail: gaetje@nationalparkamt.de

Dr. Volker Grimm
UFZ Umweltforschungszentrum Leipzig-Halle, Sektion Ökosystemanalyse
Postfach 500 136, 04301 Leipzig
Tel.: 0341 / 235 2903
Fax: 0341 / 235 3500
e-mail: vogri@oesa.ufz.de

Prof. Dr. Dr. hc Wolfgang Haber
Lehrstuhl für Landschaftsökologie der TU München in Weihenstephan
Am Hochanger 6, 85350 Freising
Tel.: 08164 / 71 41 40
Fax: 08161 / 71 44 27
e-mail: wethaber@aol.com

Dr. Benno Hain
Umweltbundesamt
Bismarkplatz 1, 14191 Berlin
Tel.: 030 / 89 03 28 36
Fax: 030 / 89 03 21 30
e-mail: benno.hain@uba.de

Prof. Dr. Peter-Diedrich Hansen
TU Berlin
Kepplerstr.4-6, 10589 Berlin
Tel.: 030 / 31 42 14 63 oder 0171 / 53 90 474
Fax: 030 / 83 18 113
e-mail: pd.hansen@tu-berlin.de

Prof. Dr. Michael Hauhs
BITÖK, Ökologische Modellbildung, Universität Bayreuth
Dr.-Hans-Frisch-Str. 1-3, 95448 Bayreuth
Tel.: 0921 / 55 5650
Fax: 0921 / 55 5799
e-mail: michael.hauhs@biotek.uni-bayreuth.de

Prof. Dr. Thomas Höpner
ICBM, Universität Oldenburg
Schneideweg 101, 26127 Oldenburg
Tel.: 0441 / 30 17 78
Fax: 0441 / 30 46 903
e-mail: thomas.hoepner@icbm.de

Daniel Hoffmann
Institut für Biogeographie, Universität Trier
Auf der Haide 17, 24306 Niederkleveez
Tel.: 0431 / 68 31 08
Fax: 0431 / 64 75 966
e-mail: hoffmann@uni-trier.de

Dr. Regina Hoffmann-Kroll
Statistisches Bundesamt
Gustav-Stresemann-Ring 11, 65180 Wiesbaden
Tel.: 0611 / 75 26 76
Fax: 0611 / 75 39 71
e-mail: regina.hoffmann-kroll@destatis.de

Prof. Dr. Beate Jessel
Lehrstuhl für Landschaftsplanung, Universität Potsdam
Postfach 60 15 53, 14415 Potsdam
Tel.: 0331 / 977 2116
Fax: 0331 / 977 2068
e-mail: jessel@rz.uni-potsdam.de

Prof. Dr. Sven Erik Jørgensen
DHF, Env. Chemistry
University Park 2, 2100 Copenhagen, Danmark
Fax: 0045 35 30 60 13
e-mail: sej@dfh.dk

Folkert de Jong
CWSS
Virchowstraße 1, 26382 Wilhelmshaven
Tel.: 04421 91 08 13
Fax: 04421 91 08 30
e-mail: dejong@waddensea-secretariat.org

Dr. Galina Koptsik
Soil Science Faculty, Moscow State University
Vorob `evy Gory, Postal Code, City 119899, Moscow, Russia
Tel.: 70 9593 93573
Fax: 70 9593 91716
e-mail: koptsik@soil.msu.ru

Dr. Serguei Koptsik
Faculty of Physics, Moscow State University
Moscow 119892, Russia
Tel.: 70 9514 37141
Fax: 70 9593 95907
e-mail: koptsik@skop.phys.msu.su

Dr. habil Horst Korn
Bundesamt für Naturschutz
18581 Putbus
Tel.: 03831 / 86 130
Fax: 03831 / 86 150
e-mail: horst.korn@bfn.de

Prof. Dr. Egbert Matzner
BITÖK, Bodenökologie, Universität Bayreuth
Dr.-Hans-Frisch-Str.1-3, 95448 Bayreuth
Tel.: 0921 / 55- 5610
Fax: 0921 / 55- 5799
e-mail: egbert.matzner@bitoek.uni-bayreuth.de

Dr. Felix Müller
Ökologie-Zentrum der Universität Kiel
Schauenburger Straße 112, 24118 Kiel
Tel.: 0431 / 880 3251
Fax: 0431 / 880 4083
e-mail: felix@ecology.uni-kiel.de

Prof. Dr. Jean Charles Munch
GSF- Forschungszentrum Neuherberg, Inst. Für Bodenökologie
Ingolstätter Landstr. 1, 85758 Neuherberg
Tel.: 089 / 3187 4064
Fax: 089 / 3197 2800
e-mail: munch@gsf.de

Pascale Annette Nauke
Lehrstuhl Pflanzenphysiologie Universität Bayreuth
Universitätsstr. 30, 95440 Bayreuth
Tel.: 0921 / 55 26 38
Fax: 0921 / 55 26 42
e-mail: pascale.nauke@uni-bayreuth.de

Dr. Gerhard Petschel-Held
Potsdam-Institut für Klimafolgenforschung
Telegrafenberg A31, 14473 Potsdam
Tel.: 0331 / 28 82 513
Fax: 0331 / 28 82 648
e-mail: gerhard@pik-potsdam.de

Andreas Printz
TU München, Lehrstuhl für Landschaftsökologie
Am Hochanger 6, 85954 Freising
Tel.: 08161 / 71 3714
Fax: 08161 / 71 4427
e-mail: aprintz@web.de

Prof. Dr. Henry Regier
University of Toronto
10 Ernst Street, Elmira, Ontario, N3B 1K5, Canada
Tel.: 51 966 695552
Fax: 51 966 91569
e-mail: hregier@fes.uwaterloo.ca

Dr. Dietrich Rosenkranz
Umweltbundesamt
Bismarck Platz 1, 14193 Berlin
Tel.: 030 / 8930 2535
Fax: 030 / 8930 2965
e-mail: dietrich-rosenkranz@uba.de

Dr. Claus Schimming
Ökologie-Zentrum der Universität Kiel
Schauenburger Straße 112, 24118 Kiel
Tel.: 0431 / 880 4030
Fax: 0431 / 880 4083
e-mail: claus-s@ecology.uni-kiel.de

Konstanze Schönthaler
Bosch & Partner GmbH
Josephspitalstr. 7, 80331 München
Tel.: 089 / 235558-51, 08161/3386
Fax: 089 / 235558 40
e-mail: k.schoenthaler@bosch&partnergmbh.de

Prof. Dr. Winfried Schröder
Institut für Umweltwissenschaften
Hochschule Vechta
Postfach 1553, 49364 Vechta
Tel.: 04441 / 15 559
Fax: 04441 / 15 464
e-mail: wschroeder@iuw.uni-vechta.de

Prof. Dr. Kai Tobias
Universität Kaiserslautern
Postfach 3043, 67653 Kaiserslautern
Tel.: 0631 / 205- 2754
Fax: 0631 / 205- 3624
e-mail: tobias@rhrk.uni-kl.de

Gabriele Twistel
Umweltbundesamt
Bismarck Platz 1, 14193 Berlin
Tel.: 030 / 8930 2758
Fax: 030 / 8930 2965
e-mail: gabriele.twistel@uba.de

Prof. Dr. Mindaugas Venslauskas
Vytautas Magnus University (VDU)
str. Donelaicio 58, 3000 Kaunas, Lithauen
Tel.: 3707 451363
Fax: 3707 203858
e-mail: mive@gmf.vdu.lt

Prof. Dr. Hubert Wiggering
ZALF e.V. Müncheberg
Eberswalder Str. 84, 15374 Müncheberg
Tel.: 033432 / 82-200
Fax: 033432 / 82-223
e-mail: wiggering@zalf.de

Dr. Wilhelm Windhorst
Ökologie-Zentrum der Universität Kiel
Schauenburger Straße 112, 24118 Kiel
Tel.: 0431 / 880 4386
Fax: 0431 / 880 4083
e-mail: wilhelm@ecology.uni-kiel.de

Dr. Peter Zander
ZALF-SO
Eberswalder Str. 84, 15374 Müncheberg
Tel.: 033432 / 82 214
Fax: 033432 / 82 308
e-mail: PZander@zalf.de

Anne Zemmrich
Botanisches Institut der Ernst-Moritz-Arndt-Universität Greifswald
Grimmer Str. 88, 17487 Greifswald
Tel.: 03834 / 86 4190
Fax: 03834 / 86 4187
e-mail: zemmrich@uni-greifswald.de

Prof. Dr. Reinhard Zölitz-Möller
Geographisches Institut der Ernst-Moritz-Arndt-Universität Greifswald
F.-L.- Jahn-Str.16, 17489 Greifswald
Tel.: 03834 / 86 4500
Fax: 03834 / 86 4501
e-mail: Zoelitz@uni-greifswald.de

APPENDIX 7: WORKSHOP - THEORY PAPER

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7.1 Theses

Thesis 1: Demands on and financial limitations to ecosystem research

For five decades ecosystem research has included two demands:

(i) On a basic science level there is a search for comprehensive principles allowing to understand the interaction of organisms and their abiotic environment;

(ii) on an applied level, ecosystem research helps to improve the scientific potential to prognosticate changes of ecological systems, caused by either anthropogenic or non-anthropogenic factors.

Productive development of the discipline was always marked by intensive exchange between researchers active at both poles.

The motivation for ecosystem research is based on the understanding that the analysis of linear effect chains does not suffice for the analysis of complex (and individually reacting) systems and phenomena. Therefore, it is the major impetus of ecosystem research to develop integrative points of view for the analysis of ecosystems, and ultimately for the promotion of a more integrated and more consistent environmental policy. Therefore, ecosystem research

- investigates and models systems that react non-linearly,
- works not only on immediate effects of environmental changes but also on indirect, latent, and temporally and spatially decoupled effects
- acknowledges that distant effects can be more important than proximate effects,
- integrates complex (multiple) feedback mechanisms that lead to characteristics such as self organisation, emergence and hierarchy, and
- investigates systems under the aspects of stability, instability, catastrophe and irreversibility.

With these integrative demands, ecosystem research aims for the generation of knowledge that is not accessible by an additive synthesis of the co-operating natural and social sciences. Due to its interdisciplinary, cross-sectoral approach, ecosystem research tends to reconstitute its research objects in a more comprehensive way employing more comprehensive methodological approaches. This necessitates a rather high expenditure of both materials and staff for ecosystem research.

Thesis:

⇨ Ecosystem research has promoted integrative thinking in the analysis of the human-environment interaction.

⇨ Despite the immanently high expenditure, ecosystem research is still efficient and economical since the data collected in the projects can be used and interpreted to a far larger degree. Additionally, only integratively collected and analysed data allow the identification of areas where less comprehensive, sectorally oriented investigations is sufficient.

These 2: Relevance of applied ecosystem research

Besides the general promotion of the understanding of environmental problems in the public, ecosystem research has contributed significantly to the development of modern nature conservation strategies. These led, for example, to the establishment of nature reserve systems that aim at the protection of natural process dynamics. Further, ecosystem research provided scientific a basis for the planning of protection and management regimes. This includes, for example, insights on the dispersal of pollutants and on threshold values of pollutants. Implementing the precautionary principle, this research resulted in concrete (national and international) activities, such as the UN/ECE Convention on Long-Range Transboundary Air Pollution 1979, the Göteborg Protocol 1999, or the European Water Framework Guideline in the field of soil and water protection.

The impact of ecosystem research, however, is often rather implicit, theoretical and indirect. This means that the results of ecosystem research le(a)d to ‘collective‘ effects, e.g. to the acceptance of certain environmental ideas and objectives in society and politics. Amongst other, this includes the spreading of the idea of sustainability, the increased awareness of the necessity of cross-sectoral and systemic approaches to environmental protection and the growing willingness to discern possible effects of environmental resource use. So far, however, ecosystem research has not succeeded – apart from some contributions- to supply comprehensive and generally valid answers to many relevant management questions.

Reasons are on the one hand the failure of potential end users to access scientific findings, and the difficulty for scientists to find out on which socially accepted management goals they should base for their more applied research. On the other hand, a further reason is too strong a conservatism of the science system that prevents a flexible and focused knowledge production regarding social and political demands. Additionally, the characteristics of the environmental systems at stake plays a central role. Although there are basic principles for the functioning of ecosystems, the generalisation or even the transfer of findings from ecosystem research to other application areas usually is only possible with significant limitations. A failure to recognize these limitations may lead to management suggestions that do not stand fierce litigation, and therefore will hardly be implemented.

Thesis:

- ⇨ Most certainly, the potential of ecosystem research to instigate changes in politics, in administrative or in individual environmental action is not fully used.
- ⇨ A promising programme of applied ecosystem research works with alternative scenarios that are relevant for decision-making, employ regional feedbacks and are differentiated according to environmental system types.

These 3: Contributions of ecosystem research to planning practice

The more comprehensive perspective opened by ecosystem research has led to the fact that systemic and integrative considerations in planning gain importance compared to individual problem-centred plans. Also systems with a large spatial extension are analysed and planned. Ecosystem research gives (partial) answers to questions that cannot be solved in the daily planning routine. In this respect, it supports planning activities both methodologically and technically. Examples are the availability of basic data for the investigation areas of ecosystem research (and therefore also directly for some planning areas), or the (further) development of methodological tools (e.g., investigation strategies, evaluation processes) and technical instruments (e.g., environmental application of geographic information systems, use of remote sensing for land use mapping or availability of effective systems of data management and exploration).

These contributions of ecosystem research for environmental planning, however, cannot hide that

- ecosystem research usually produces a large amount of data that can only be used partially by environmental planning;
- many instruments developed in ecosystem research can only be applied to some extent because scientific research can frequently devote much larger resources to the analysis of an area than planning administrations can;
- many of the processes and methods developed in ecosystem research are too demanding for a practical planning implementation. E.g. quantitative analyses and evaluations can often not be produced – nor are they always necessary. Instead, methodologically more simple assessments are necessary for often sufficient semi-quantitative or qualitative results;
- the results of ecosystem research inevitably refer to exemplary research areas and can only be transferred with limitations to other areas and systems. For a such a transfer there is usually no legal security (as frequently asked for by the client).

A major problem is the fact that the information about possible contributions of ecosystem research to planning is only insufficient, i.e. there is a lack of 'translators' able to transform the results for the planning practitioner by summarising and evaluating them. Such a transformation is usually not part of the research project, and there is no adequate appreciation, of both, such an expenditure and achievement amongst the scientists. Consequently the contributions of ecosystem research remain abstract and are seldom oriented towards implementation.

Thesis:

⇨ In order to reach a better utilisation of results from ecosystem research for planning practice, research topics as well as methods and processes need to be better oriented to the demands from planning practice. These demands can be derived from actual or foreseeable planning tasks and theirs legal bases. Altogether a higher sensitivity is necessary towards applied planning questions on part of the ecosystem research community.

⇨ The results of ecosystem research must be made available for the user in a more easily accessible and applicable way. This requirement has also to be formulated more offensively from the research sponsors.

These 4: Ecosystem research between application orientation and political control

Close co-ordination is necessary, on the one hand, between ecosystem research and the planning disciplines but also between ecosystem research and politics/administration in order to make sure that ecosystem research can fulfil the manifold demands on an applicability. The present practice to award the funds for research and development projects does not yet correspond to these demands. The agencies that provide funding often expect results that provide concrete contributions for the solving of a particular environmental problem; a problem whose relevance was politically defined. Application oriented ecosystem research therefore is much more likely to become subject of political control than basis oriented research. This fact itself is not to be criticised here, instead, a different problem of the granting practice shall be stressed.

Due to its complex subject matter, ecosystem research is a discipline with many surprises. Therefore, it requires considerable flexibility regarding the choice of research approaches and methods. The sponsors, however, often cannot conform to the scientifically required flexibility, which leads to unacceptable – but avoidable – restrictions of the scientific work. Arguably, the situation worsened within the last years because of a dramatic imbalance in scientific funding that developed between application oriented and basis oriented ecosystem research. The large ecosystem research projects, financed by the Federal Department of Education and Research and by the Federal Department of the Environment were discontinued in Germany finishing most of the fundamental ecosystem research studies in Germany. This situation holds disadvantages not only for the German ecosystem research in general, but also for its application oriented part:

- Naturally, application oriented research relies on productive fundamental research.
- The extreme shortage of funds in the field of basis research leads to a situation in which rather fundamental research projects are increasingly conducted under the title of applied ecosystem research. If the respective projects are, furthermore, established by working units with main orientation towards natural sciences and empirics, the conditions for an applied success are rather unfavourable: many problems of applied ecosystem research inextricably include, for example, difficult – and also complex – socio-economic questions. Such a state of affairs harms the reputation of both research branches.

<u>Thesis:</u>

⇨ Only a stronger accentuation of research programmes into applied and fundamental ecosystem research makes sure that ecosystem research can achieve the expected and promised results.

These 5: Connection of integrated environmental research programmes, concepts and plans with environmental monitoring programmes

There is a close relationship between ecosystem research and environmental monitoring. Sometimes environmental monitoring is even considered a working field of ecosystem research. Ecosystem research and environmental monitoring complement each other in many respects, both in the subject and strategically:

Ecosystem research supports the conception of environmental monitoring programmes: It promotes the selection of suitable variables, and their orientation in the ecosystem structure. It makes contributions to a better monitoring practice, and to the interpretation of monitoring results. Ecosystem research, additionally, provides important ideas for inter-disciplinary and inter-administrative co-operation as a precondition for the implementation of integrated environmental monitoring. In this context, the experiences and results of ecosystem research support a new orientation away from sectoral monitoring towards a stronger ecosystem-oriented environmental monitoring across sectors and media.

Environmental monitoring can be used to test ecological models (effect-relations between the components of an ecosystem) and ecosystem theory on the long term. In addition, research needs can be identified by environmental monitoring because environmental monitoring reveals trends or even sudden, unexpected changes that cannot always be explained with existing knowledge.

A closer connection between ecosystem research and environmental monitoring would allow to better implement the findings of ecosystem research. Innovative approaches could be transferred into routine methods. Such a close linking should, amongst other, lie in a 'transfer' of research programmes into environmental monitoring programmes – but it often fails because of

- financial bottlenecks (e.g., a lack of funds for (i) the preparation of research results for environmental monitoring, and (ii) for the continuation of more sophisticated measuring campaigns);
- organisational obstacles, which mainly concern the change of bureaucratic competence (usually ecosystem research and environmental monitoring are subject to different administrative responsibilities), and
- a basic lack of interest of the scientists towards the field of environmental monitoring, which is complemented by an insufficient willingness of administrators of the environmental monitoring programmes to apply the results of ecosystem research and to formulate clear research priorities.

Thesis:

⇨ So far, there is a lack of political will to establish the structures necessary for an intensive and effective connection of ecosystem research and environmental monitoring, and to provide the necessary funds and personnel.

⇨ The development of methods, techniques and procedures of ecosystem research need a stronger co-ordination with the needs of routine environmental monitoring. This is valid, both, for data collection as well as data analysis and evaluation.

⇨ The processing of research results for respective integration into environmental monitoring must be part of research applications.

⇨ For a mutual convergence of those involved into research and in environmental monitoring, a discussion on suitable indicators would be useful. On the one hand it is an interesting research area, on the other it provides orientation for the users to focus monitoring on a set of actually convincing parameters.

These 6: Interface between ecosystem research and environmental education

Besides its research tasks, ecosystem research has also an educational task. It is to sharpen the public awareness of negative but also positive environmental trends. It shall make clear in which way humans depend on the performance of and services gained from the environmental systems. Only considering the combination of all environmental media allows an adequate understanding of the mutual dependence of biotic and abiotic resources. And only strengthened environmental awareness of the public creates the conditions for environmentally sensitive acting and efficient environmental policy.

In the field of environmental education, ecosystem research is a suitable field of training and learning to improve systemic thinking, i.e. the thinking in connections, interactions and feedback mechanisms. So far, the potential of this area has hardly been used: neither for the training of of students and scientist, but also for the development of environmental literacy in society at large.

Further, it must be the self-interest of ecosystem research to strengthen its social and political acceptance by a transparent and sustained presentation of the relevance of its results to all target groups.

The conditions for effective educational and public relations work seem to be very favourable due to the broad availability of information technology. Nevertheless it has not succeeded so far to convincingly communicate the specific achievements of ecosystem research to the public and to fulfil the educational tasks. Some possible reasons:

- There is/was a lack of personal and financial resources for qualified educational and public relations work accompanying the research because it is/was explicitly targeted neither in the project application nor in the research programmes.
- Lacking engagement and insufficient training of the scientists in this area result in a disregard of public relations and educational work. The scientists face the fundamental problem to deal with demanding research tasks, and to process ‘marketable’ interim-results understandable to the general public. For the latter, there is usually neither funding nor time available. Additionally, some scientists lack the necessary communicative, political, social and medial skills.

Thesis:

⇨ So far, insufficient value has been attached to educational and public relations work – in the research applications as well as during projects themselves. This means that ecosystem research is not able to effectively present its particular achievements in the public.

⇨ The appreciation of the engagement of scientists in educational and public relations work has not been sufficient so far.

These 7: Limits and options of interdisciplinary training and education in the universities

Whilst the co-operation in the fields of natural science in multi- and interdisciplinary research programmes seems to succeed within and between universities, the education in the universities still shows significant deficits. The connection of the knowledge of different natural science disciplines is hampered by an deficient school education in the ‘hard‘ natural sciences. In many cases, university education gets stuck on the level of a ‘sectoral‘ basic education in natural sciences. This reduces the opportunities to reach a level of more integrative consideration that is characteristic for ecosystem research.

There are approaches of an increased co-operation:

1. Initiation of common projects with participants of several disciplines.

2. Offers of seminars across subjects, perhaps organised by common university departments, institutes or research centres.
3. Breakdown of the old structure of subjects, and introduction of a real subject 'environmental sciences' which combines parts of geography, geology, biology, zoology and botany etc.
4. Improvement of the integrative abilities of the teaching staff.
5. Provision of funds within the universities for projects that improve interdisciplinary integration.

For the fulfilment of the demands of integrative ecosystem research, the education has to go beyond the preparation for an infra-scientific interdisciplinarity. The educational deficits become even more evident, however, if the demand for interdisciplinarity also comprises basics of humanities and the social sciences. A particularly serious deficit in questions of applied ecosystem research exists in the field of ecological 'evaluation and judgement competence' (e.g., normative bases of applied ecosystem research, evaluation methods, decision theories). Although there is a potential to work on trans-disciplinary, close-to-reality case-studies, its applicability is questioned mainly due to the expenditure of time. As particularly suitable appears the examination of systemising methods of decision-making in relation to complex systems if multiple target dimensions exist (e.g. model-based, scenario-based multi-criteria evaluation processes).

The introduction of the new M.S. courses planned in many German universities might offer the opportunity to improve the problematic educational situation in the field of interdisciplinary work. If the study courses are resolutely directed at the individual research projects of the students, the students would be able to acquire the necessary interdisciplinary competence outside restricting study rules and department limits. This would be possible after the 5th or 6th semester by (a) far-reaching renunciation of regulations on course requirements and/or subject combinations and (b) the installation of – usually inter-disciplinary – supervising committees as practised, e.g., in North America.

<u>Thesis:</u>

⇨ The – despite restrictive peripheral conditions – existing potentials of university education are not used sufficiently to promote interdisciplinary competence necessary for successful work in ecosystem research.

These 8: Impediments to interdisciplinary work

Ecosystem research can only fulfil the high integrative demands if interdisciplinary work succeeds. The experiences of finished projects show, however, that interdisciplinarity has not been taken seriously enough in many ecosystem research projects. Occasionally, no synthesis reports were produced; frequently the reports they did not fulfil the demands on a real synthesis.

Reasons for the failure of interdisciplinarity can be:

- lacking competence for the development of effective co-operation concepts as well as absence of a competent and assertive project co-ordination – and hence an insufficient acceptance of the co-ordination by the project participants. As a result, working groups may become independent too quickly, and their scientific approaches and results cannot be integrated seamlessly into the overall context of the project;

- insufficient appreciation of individual or co-operative interdisciplinary achievements by the scientific peers: The project management usually still appreciates scientific achievement of the individual working groups more than achievements produced from the project participants in the sense of interdisciplinarity with view to the overall project aim;
- lack of common integration elements in the scientific project. Examples are as mutually accepted initial hypotheses, or a compatible data structure defined in advance, which could serve as precondition for an integrative linking of the data from the individual working groups;
- insurmountable professional divergences between the individual scientific fields.

Although from time to time interdisciplinarity is a declared aim of a scientific project, it often is not a real request of the scientists. In this case, interdisciplinarity is seen primarily as an attractive slogan to attract additional funding, in reality, however, one discipline is dominating.

The amount of expenditure necessary for the design and management of integrative ecosystem research projects has frequently been underestimated in the past. In general, the project management plays a pivotal role in the dealing with the inter- or trans-disciplinary project tasks. In many cases, however, it lacked of assertiveness. Following the new Federal University Framework Act (Hochschulrahmengesetz) the problem will probably worsen as it gets more difficult to employ experienced staff for a well-directed and professional management. Due to the limitation of the employment of the non-professorial teaching staff to 12 years, this personnel will be lost for the universities.

Thesis:

⇨ Successful interdisciplinarity primarily requires effective and strong project management with comprehensive steering competence and sufficient financial resources as well as structures that make it possible for the project participants to derive tangible career-effective ascendancy and advantages from consistent efforts for interdisciplinary working results.

⇨ Interdisciplinary working requires concrete integration elements, i.e. common project aims and initial hypotheses as well as common working tools and investigation areas. Successful interdisciplinarity manifests itself in convincing, integrated synthesis reports.

These 9: Transfer of knowledge and technology from ecosystem research into planning practice with models

Complementing the abovementioned ‘internal‘ reasons for a limited knowledge transfer into planning practice, the possible transfer is also hampered by a lacking demand for the knowledge of ecosystem research.

Models belong to the most important instruments in ecosystem research. They also meet a large interest of planning practitioners. The models developed in ecosystem research, however, are frequently difficult to handle and not really suited for everyday application. This is particularly true for computer models, which sometimes use schematically applied algorithms, are overly data-intensive and often are overestimated compared to empirical knowledge and experiments.

As an example, environmental impact assessments have a significant need for models for effect prognoses. The models provided by ecosystem research so far, however, do hardly serve this objective. Nevertheless, there is also a structural problem of lacking or insufficient practical tools due to low legal requirements placed on the scientific complexity of the models. If the administrative courts accept 'modest' prognosis models, there is no real incentive to provide higher financial funds that are necessary for conducting more integrative effect assessment at the ecosystem level. Consequently, the economic incentive to realise the possible transfer of knowledge and technology is low even in the case when capable models are already applied as prototypes. Due to limited commercial prospects under these circumstances, the existing instruments of transfer of knowledge and technology hardly take effect, such as start-up promotion or promotion of innovations.

Thesis:

⇨ There is a need for practicable, computer-based instruments for the integration of ecosystem knowledge into the practice of planning and administration. Due to low legal requirements for cross-media analysis options of the models ('interactions'), the incentive is also low to realise the possible transfer of knowledge and technology.

These 10: Future of Ecosystem Research

This thesis is to be produced during the workshop as resulting hypothesis in co-operation of all participants.

7.2 Questions

Working Group A:

Conceptual, Methodological and Strategic Experience and Problems of Ecosystem Research

The subject of this group relates primarily to theses 1, 4, and 8.

Focus Questions:

1. What are the most important advances/results of ecosystem research regarding
   - ecological,
   - methodological,
   - organisational,
   - applied

   topics?
2. How did the ecosystem science approach affect ecological and environmental research – in the applied as well as in the fundamental domain, or regarding the general organisation of research? Were paradigm shifts initiated?
3. Which examples are suitable to demonstrate emergence, a phenomena that is regarded as an important focal point of several ecosystem approaches? Where, how, and when "is the sum more than its parts"? Which conclusions can be drawn for environmental research and management?
4. Which are the most significant research deficits that arose in the last 25 years of ecosystem research?

5. Which are the most important problems which became apparent in ecosystem research? With which strategies, methodologies or approaches can be solved these problems regarding
   - genuinely ecological problems?
   - methodological problems?
   - in organizational affairs?
   - public research funding?
   - problems of applied ecosystem research?
6. What does the working group recommend taking into consideration the experiences of ecosystem research with regard to
   - fundamental ecosystem research?
   - applied ecosystem research?
   - the organisation and management of science?
   - the practice of sponsoring and the orientation of the sponsoring institutions?
   - environmental management and politics?

Working Group B:

Ecosystem Research and Ecosystem Management – Models for Integrative Environmental Practice

The subject of this group relates primarily to theses 2 and 4.

Focus Questions:

7. In which form and intensity do the fundamentals and results of ecosystem research influence environmental politics?
8. Did the public perception of the environment and of environmental problems change due to ecosystem research results?
9. Did ecosystem research evoke strategic, intellectual and structural changes in environmental politics? Did it have consequences for the development of nature protection concepts?
10. Do the internationally common, integrative concepts of Ecological Integrity or Ecosystem Health correspond to the status of ecosystem research?
11. What does the working group recommend taking into consideration the experiences of ecosystem research with regard to
    - fundamental ecosystem research?
    - applied ecosystem research?
    - the organisation and management of science?
    - the practice of sponsoring and the orientation of the sponsoring institutions?
    - environmental management and politics?

Working Group C:

Experience and Problems of Ecosystem Approaches in Practice – Demands from Environmental Policy and Planning

The subject of this group relates primarily to theses 2, 3, 4, 5, and 9

Focus Questions:

12. Which demands have been/are expressed by practitioners to ecosystem research? Have these demands been fulfilled already or do relevant deficits remain?
13. Which demands have been/are expressed by ecosystem research to practitioners? Have these demands been fulfilled already or do relevant deficits remain?
14. Which specific examples can be named to demonstrate a successful transfer of knowledge and methods?
15. Did ecosystem research convey a positive impetus to
    - planning methods?
    - strategies in the environmental integrated monitoring?
    - the definition of indicators?
    - the application of models?
    - the solution of specific environmental problems?
16. What does the working group recommend taking into consideration the experiences of ecosystem research with regard to
    - fundamental ecosystem research?
    - applied ecosystem research?
    - the organisation and management of science?
    - the practice of sponsoring and the orientation of the sponsoring institutions?
    - environmental management and politics?

Working Group D:

Future of Ecosystem Research

The subjects of this working group relate to all abovementioned hypotheses.

Focus Questions:

17. Which demands must be fulfilled
    - on the part of the administrative co-ordinator of research programmes and
    - on the part of the single scientific workgroup?

    to carry out extensive research projects in the future?
18. Which important research issues need to be investigated in the field of
    - fundamental ecosystem research?
    - applied ecosystem research?
19. Which new research issues arose during the ecosystem research campaigns?
20. How can the applicability of ecosystem research be increased?
21. What does the working group recommend with regard to

- future fundamental ecosystem research?
- future applied ecosystem research?
- a forward-looking practice of sponsoring?

APPENDIX 8: WORKSHOP - ABSTRACTS OF THE KEY-NOTES

In order of the Program of the Workshop

Overview:

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8.1 O. Fränzle

The comprehensive Ecological Surveillance System for Germany, as conceived by Ellenberg, Fränzle and Müller (1978) to provide a scientific basis for environmental planning and politicy, consists of three interrelated components, namely an ecological monitoring network, comparative ecosystem research, and an environmental specimen bank. The scientific and practical aims of every component require the fulfillment of geostatistical requirements in order to permit an up-scale extrapolation of the primarily local or catchment-related results obtained; therefore, in the first instance a set of putative representative, study areas was determined by means of multivariate availabilty of interdisciplinary manpower, long-term research on agrarian, forest and high mountain ecosystems has concentrated on the Bornhöved Lake District., the Weichelian morainic landscapes northeast of Berlin, the Solling Mountains, the Fichtelgebirge, the Bavarian Tertiary Hills, and the Berchtesgaden Alps, while the Umweltforschungszentrum Halle-Leipzig has inquiries into complex urban-industrial systems and their agrarian environment for subject.

The general objectives of German ecosystem research comprise the analysis of the obove core areas with a view to defining and modelling structure, dynamics and stability or vulnerability conditions of interrelated terrestrial and aquatic systems in terms of site characteristics, biocoenotic diversity, natural and anthropogenic fluxes of energy and matter, productivity and land use patterns. In addition, and owing to the specific spatial and ecological setting of the different study areas, specific regional research objectives were defines, as the following examples may show. In the framework of Scheyern Project focus was on site effects on the variability of crop growth, while biogeochemistry of montane spruce forests on response to changing atmospheric deposition was a key issue of the Fichtelgebirge Project. Modelling site-dependent relationship between lakes and their drainage basin with focus on the role of land/water ecotones or testing the validity of spatial extrapolation procedures for simulation models by means of comparative site analyses and geographic information systems were of particular interest in the Bornhöved Project.

With regard to natural resource management, it ensues from these studies that the assessment of the impact of human activities on ecosystems requires close attention to the scale of assessment and the spatial relationship between ecosystems. Thus, the issues which resource management or, more specifically, inquiries into the vulnerability of ecological and related societal systems have to address are increasing both in terms of complexity and the breadth of temporal and spatial scale. It is at this juncture that ecosystem modelling and geographic information systems provide important contributions to resource policy and vulnerability analyses by means of multiple perturbation scenarios, development trend scenarios or sensitivity analyses for pertinent natural and socio-economic inventories. In rational combination these instruments allow planners and resource managers to ask questions about resources and human impact on ecosystems at spatial and temporal scales where extensive data collection is difficult, if not impossible. On the basis of such scenarios in near real-time it is possible to test static as well as dynamic hypotheses about resource uses and alternative fates, critical response potentials in relevant exposure units or the adaptive capacity of systems as a function of major entity characteristics like diversity, connectivity, technological development, and institutional endowment.

8.2 The Ecosystem – Power of a Metaphysical Construct

Prof. Dr. Dr. hc em. Wolfgang Haber, Lehrstuhl für Landschaftsökologie der TU München in Weihenstephan, Freising, Germany

In his book "In Search of Nature", Edward O. Wilson (1996) assigned the ecosystem to the "metaphysical constructs" which have proven more powerful and less vulnerable than ordinary theories. Ernst Mayr (1997), however, opined that the ecosystem concept – after its great Odum-owed popularity in the 1960s and 1970s – has lost its role of a dominant paradigm. In my view, this objection holds only for the purely physicalist approach to ecosystems, which was introduced by Tansley and worked out by Lindeman and Hutchinson in the early 1940s. Today's stronger emphasis on population properties, behavioural and life-history adaptations of organisms has shifted the attention of ecologists more to the biological features of the ecosystem, that is to its community aspect. This raises once more the question whether the ecosystem is "more" than a biotic community because it comprises non-living components. I consider this a futile question, because neither is an object in nature, both are "metaphysically constructed" units, but justifiable as such regarding their usefulness for organizing ecological research and their heuristic value not to be underestimated. Epistemological objections towards such views should not be underrated either, but they are not helpful if they only veil the paths leading into a better understanding of environmental complexity.

Another aim of my contribution is to explain why I strongly refuse regarding ecosystem or community ecology as an expression of "organicist thinking" or of adherence to "superorganism belief". No organism can exist without interacting with other organisms, be it in the form of symbiontic or antagonistic interactions. These constitute, when displaying a recurrent behaviour, an interrelationship network whose structure can be analyzed step by step without any organicist idea in mind, and which, if the steps are integrated, can of course be called a system. Ecosystem critics emphasizing species interactions as the "real thing" fail to notice that species are a category as problematic as the ecosystem. The current biodiversity debate with its overemphasis on species diversity will go astray if not combined with functional roles of populations, which can best be grasped by an ecosystem approach, even it is only a mental construct. The reproach of "holism" is out of place if ecologists abstain from ideological thinking which, however, is always a temptation.

Ecosystems render valuable services to society, as convincingly shown by Daily's book (1999). These services, however, are not based on clearly delimitable environmental objects, but on functional units of variable size and composition. Regarding ecosystem diversity and protection, we are faced with a big problem of implementation requiring enormous mental efforts which can take profit from the power of the ecosystem concept – if it is applied with epistemological insight and practical prudence.

8.3 Linking Ecosystem Theory and Ecosystem Models with Holistic Environmental Management.

S.E. Jørgensen, DFH, Environmental Chemistry, Denmark

Holistic environmental management requires a heavy use of models, as modeling is the best tool to provide an overview of a complex system. The development has furthermore been towards modeling more and more complex systems. For instance in lake and reservoir management: from lakes and reservoirs towards modeling the entire drainage area included all activities in the drainage area affecting lakes and reservoirs. The development from ecosystem models to landscape models and further on to region models can also be mentioned in this context. The holistic management can also be understood as the integration of all aspects of a problem for instance by development of social-economic-ecological models which however is in its infancy here in the beginning of the 21st century.

Better models have been developed lately by incorporation of more ecosystem theory into the ecological models. A clear example is the development of structurally dynamic models, where the goal function exergy has been used most frequently to cover the ecosystem property of growth. This development has resulted in models that yield at least in some cases a better calibration, validation and prognosis. A few examples will be presented to illustrate these results.

It is expected that the observed tendency towards more integrated models and a development of models with a higher content of ecosystem theory will continue in the coming years. It will most probably improve the quality of the model results and the applicability of the models in a holistic management approach.

8.4 Ecosystem Research Schleswig-Holstein, Wadden Sea - Concepts, Results and Applications

Dr. Christiane Gätje, National Park Office, Tönning, Germany

An ecosystem research project was carried out in the Schleswig-Holstein Wadden Sea from 1989 to 1994. On the one hand emphasis was placed on basic research in a selected area near the island of Sylt (SWAP – Sylt Wadden Sea Exchange Processes). On the other hand it was focussed on applied research, which covered the whole area of the national park, including mapping of ecological and socio-economic structures, an inventory of human utilization and impact, as well as an analysis of conflicts.

A synthesis phase of an additional two years followed which culminated in the publication of a synthesis report in 1996, that provided the foundation for a national park plan. In 1998, further results were published in an Environmental Atlas of the Wadden Sea and a Springer book (The Wadden Sea Ecosystem – exchange, transport and transformation of matter).

The complete process was coordinated and steered by a team of three scientists employed in the national park office. This structure allowed permanent feedback, iterative exchange of information and discussions between scientists and the administration of the national park – which was of decisive importance for the direct application of scientific research results already during the project and for the implementation of research-based concepts in administration work.

Schleswig-Holstein Wadden Sea ecosystem research provided essential contributions to

- a harmonized Trilateral Monitoring and Assessment Program (TMAP),
- the amendment of the Schleswig-Holstein Wadden Sea National Park Law in 1999, i.a. extension of outer borders and new zonation with a reference/zero use area on the basis of tidal basin approach, and a small cetacean protection area,
- the implementation of a mussel fishery program and a contract between the government and fishermen,
- the management of salt marshes,
- the installation of a socio-economic monitoring and
- the establishment of an efficient visitor guidance, information and management system including national park service staff

The ecosystem research project supported conservation decision-making processes and the results are of special value for long-term national park management.

8.5 Ecosystem Research in the Wadden Sea of Lower Saxonia (Germany) – Concepts and Results

Prof. Dr. Thomas Höpner, ICBM, Universität Oldenburg, Oldenburg, Germany

The project was carried out from 1990 to 1996. It consisted in two parts, a basic research programme on variability and stability focussed on the area south of the island of Spiekeroog (ELAWAT, Elasticity of the Wadden Sea Ecosystem), and an applied programme covering the whole area of the Lower Saxonian National Park. The first was funded by the German Federal Research Ministry (BMBF), the second by the Federal State Lower Saxonia and the Federal Environmental Administration (UBA).

After a synthesis phase of an additional two years the summarising ELAWAT report appeared in 1999: The Wadden Sea Ecosystem – Stability and Mechanisms (S. Dittmann ed.). An application-based final report followed in the same year (Gesamtsynthese, V. Knoke et al. eds.). Also in 1999 appeared the Umweltatlas Wattenmeer, Vol. 2 for the area between Ems and Elbe, (National Park Lower Saxonian Wadden Sea and Federal Environmental Administration eds.) covering graphical results of the Ecosystem Research.

The co-ordination was in the hands of three scientists, each one from the national park office, from the environmental administration of the state Lower Saxonia, and from Oldenburg university. A full-time steering group was established and localised with the National Park office in Wilhelmshaven. Regular meetings and common experimental field campaigns ensured the collaboration and the exchange with the National Park administration. The strong and regular co-ordination with the simultaneous Schleswig-Holstein project is worth mentioning.

The ecosystem research project contributed essentially to

- The transferability and further development of the “Applied Ecosystem Research” concept, developed for the high mountains ecosystem during the Berchtesgaden project,
- Flows of matter and budgets of production and consumption, anthropogenic sources such as fishery discard included,
- The meaning of geochemical and biological signs of eutrophication, the Black Spots and Black Areas and the recovery processes,
- The environmental quality objectives and the Trilateral Monitoring and Assessment Program (TMAP),
- A theoretical comprehension and a mathematical modeling,
- The subsequent research such as the DFG Research Group Wadden Sea (Oldenburg-Bremen) or the biotechnological production of seed mussels (Wilhelmshaven).

And, finally, it encouraged a global comparison of climatically different intertidal zones among which the Dutch/German/Danish one counts to the largest.

8.6 Forest ecosystem research in Germany – concepts, results and applications

F. Beese, Forest Ecosystems Research Center , University of Göttingen, Germany
E. Matzner, Bayreuth Institute of Terrestrial Ecosystem Research, University of Bayreuth, Germany

Forest ecosystems in Germany are managed to fulfil various functions: timber production, habitat for organisms, regulation of water and elemental cycling as well as recreation and education. The general goal for forest ecosystem research is to develop criteria and strategies of sustainable use and protection of these functions by investigating the relations between structure and functions in response to environmental changes and management practices. In more detail, major research subjects of German forest ecosystem research related to management effects were: comparisons of pure and mixed stands, influence of silvicultural practices and dynamics of regeneration. Among the effects of changing environmental conditions, acidic precipitation, N-saturation, C-sequestration, trace gas exchange and climatic controls of fluxes and processes were studied. The focus under the theme “structure – function relations” was given to stand age effects, phyllosphere organisms, soil fauna and microbiota and to microhabitates in soils. Furthermore measures for mitigation of impacts on forest ecosystems were investigated, namely liming and fertilization, as well as the quantification of critical loads.

The research approaches include monitoring of fluxes and structural properties in intensive study sites, regional assessments of gradients and patterns, experiments in the field to test hypotheses at the ecosystem scale, experiments in the laboratory for detailed process understanding and quantification, model application at different scales and regionalization using empirical indicators of ecosystem functioning.

The results are documented in numerous peer reviewed publications and demonstrate in summary that our knowledge on the function of forest ecosystems has increased tremendously over the last 20 years. Ther presentation will be focussed on some of the recent significant results in this area. The environmental conditions of forest ecosystems have changed strongly in the last decade: S, Ca, Mg and H^+-inputs have decreased while the input of N from the atmosphere remained chronically high and CO_2 concentrations are steadily increasing. The phyllosphere organisms influence the spatial and temporal patterns of C and N fluxes in throughfall. Reversibility of soil and water acidification is retarded by decreasing Ca and Mg inputs, release of sulfate from soil pools and by N deposition. Nitrate outputs with seepage and runoff can be estimated at the regional scale using N deposition data and C/N ratios of forest floors. Critical loads, especially those of N are still exceeded. The emission of N_2O from soils is triggered by the deposition of N. Earth worms and anoxic microhabitats seem to play a major role in N_2O emissions from soils as well as the soil compaction by heavy machines. The forest floor is the dominant sink of deposited N. The N sequestration goes along with C sequestration in the forest floor. Dissolved organic matter is an important component of the C and N biogeochemistry.

Models for regionalization of forest ecosystem functioning using GIS and remote sensing have been developed and successfully applied.

With respect to management practices, the effect of thinning, harvesting and rejuvenation on element turnover and the biodiversity of plants, animals and microorganisms have been investigated. To remediate strongly acidified forest soils the application of lime and compost is recommended.

The results of German forest ecosystem research have found applications in forestry (liming + fertilization, change of tree species, avoid clear cut), water management (predicting future water use from forested watersheds), emission control (reduce emissions of N and S to match critical loads, define critical loads, quantify C sinks in forest ecosystems). environmental control (implementation of EU wide monitoring programs LEVEL I and II) and in global climate models (parametrization of SVAT models for water and CO_2).

8.7 The ecosystem approach of the Convention on Biological Diversity

Horst Korn, Bundesamt für Naturschutz, Putbus/Rügen, Germany

The ecosystem approach of the Convention on Biological Diversity (CBD) is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Thus the application of the ecosystem approach will help to reach the balance of the three objectives of the convention: conservation, sustainable use, and the fair and equitable sharing of benefits arising out of the utilization of genetic resources.

An ecosystem approach is based on the application of appropriate scientific methodologies focused on all levels of biological organization. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.

The focus on structure, processes, functions and interactions is consistent with the definition of “ecosystem” provided in Article 2 of the CBD. “Ecosystem” means the dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. This definition does not specify any particular unit or scale. Indeed the scale of analysis and action should be determined by the problem being addressed. It could for example be a pond, a forest, a biome or the entire biosphere.

The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning. Management must be adaptive in order to be able to respond to uncertainties.

The ecosystem approach does not preclude other management and conservation approaches, such as biosphere reserves, protected areas, and single species conservation programmes, as well as other approaches carried out under existing national policy and legislative frameworks, but could, rather, integrate all these approaches and other methodologies to deal with complex situations. There is no single way to implement the ecosystem approach, as it depends on local, provincial, national, regional or global conditions. Indeed, there are many ways in which ecosystem approaches may be used as a framework for delivering the objectives of the Convention in practice.

8.8 Das Millennium Ecosystem Assessment – Forschungsergebnisse für Entscheidungsträger

Gerhard Petschel-Held, Potsdam-Institut füpr Klimafolgenforschung, Potsdam, Germany

Zu Beginn des 21.Jahrhunderts steht die Menschheit vor der Herausforderung, den Umgang mit ihrer natürlichen Umwelt, also auch mit den Ökosystemen neu zu gestalten und Ansätze für eine nachhaltige Nutzung und Erhaltung der Ökosysteme zu entwickeln. Zum Einen ist zu erwarten, dass der menschliche Bedarf an Ökosystemleistungen (s.u.) nicht zuletzt aufgrund des Bevölkerungswachstums weiterhin stark ansteigen wird, während wir andererseits in ihrer Größenordnung einmalige Veränderungen der Ökosysteme verursacht haben und weiter verursachen. Der Herausforderung, den gegenwärtigen Zustand der Ökosysteme weltweit zu analysieren, ihre Kapazität für den Menschen essentielle Leistungen jetzt und in der Zukunft zu erbringen abzuschätzen und Handlungsoptionen für ein besseres Management zu entwickeln, stellt sich das Millennium Ecosystem Assessment (MA).

Das MA fokussiert auf Ökosystemleistungen. Darunter sollen die Bedingungen und Prozesse verstanden werden, durch die, von Biodiversität unterstützt, Ökosysteme menschliches Leben ermöglichen und bereichern. Diese Leistungen werden klassifiziert in (1) die Bereitstellung von Gütern (Nahrung, Wasser, ...), (2) die Funktionalität erhaltenden Prozessen und Bedingungen (Biodiversität, Bestäubung, etc.) und (3) kulturelle Aspekte (Religion, Ästhetik, usw.). Darüber hinaus wird ein starker Bezug zu den Konsequenzen von Ökosystemveränderungen für das menschliche Wohlbefinden hergestellt. Als grundlegende Definition eines Ökosystems greift das Assessment auf die entsprechende Definition in der Biodiversitätskonvention zurück (s. den Beitrag von Horst Korn).

Bei einem „Assessment" handelt es sich nicht um ein originäres Forschungsprojekt. Vielmehr gilt es, den gegenwärtigen Stand des Wissens in einem gemeinsamen Prozess von Wissenschaftlern und Entscheidungsträgern auf zu arbeiten und Letzteren für eine verbesserte Entscheidungsfindung zugänglich zu machen. In diesem Sinne Nutzer des MA sind zum Einen die drei mit Ökosystemen befassten UN-Konventionen (CBD, CCD und Ramsar), zum Anderen aber Regierungen, der Privatsektor, lokale Gemeinschaften oder internationale Organisationen (UNEP, NGOs, usw.). Hierzu wurden vier Arbeitsgruppen gebildet, von den sich drei mit einem globalen Blickwinkel auf die gegenwärtigen Bedingungen und Trends (WG 2), auf die Entwicklung plausibler Zukünfte (WG 3) und die Ausarbeitung und Analyse von Handlungsoptionen (WG 4) konzentrieren. In der vierten Arbeitsgruppe (WG 1) werden zahlreiche lokale und regionale Assessments koordiniert und schließlich zu einer Synthese zusammengefasst. Dabei versucht jedes dieser sog. „sub-globalen" Assessments wiederum die drei grundlegenden Themenstellungen der globalen Gruppen aufzugreifen.

Konzeptionell wird das MA als ein sog. Integrated Assessment gestaltet, in dem zunächst die entscheidenden Triebkräfte analysiert werden. Darunter sind die essentiellen demographischen (Bevölkerungswachstum und -struktur), ökonomischen (Wachstum, Struktur, Handel, usw.), sozio-kulturell und politischen (Partizipation, Lebensstile, Institutionen usw.), aber auch bio-physikalischen (Klimawandel, Stickstoffeinträge, usw.) Trends und Entwicklungen zu verstehen. In einem zweiten Schritt gilt es die Auswirkungen dieser „Treiber" auf die Ökosystemstruktur und -leistungen zu analysieren, um schließlich die Rückkopplung auf menschliches Wohlbefinden (materielle Ausstattung, Gesundheit, Umweltsicherheit) abzuschätzen, was schließlich wiederum Auswirkungen auf die Triebkräfte besitzt.

8.9 Assessment of Ecosystem Health: potential and limitations of approaches

P.-D. Hansen, University of Technology, Faculty 7- Institute for Ecology - Department for Ecotoxicology, Berlin, Germany

Chronic sub lethal environmental effects monitoring approaches provide "signals" in frequencies and amplitudes to understand in advance the changes in the environment for the purpose of inland water, coastal zone or terrestrial management. To understand the complexity of the structure of populations and processes behind the health of populations, communities and ecosystems, we have to direct our efforts to promote rapid and cost-effective parameters of ecological health. One way of achieving that goal is to use biomarkers.

There are many definitions of biomarkers e.g.: “A biomarker is a xenobiotically –induced variation in cellular or biochemical components or processes, structures, or functions that is measurable in a biological system or sample” (National Research Council – NRC, Committee on biological markers, *Environmental Health Perspective*, 74, 3-9, 1987). The IPSC (International Programme on Chemical Safety of the WHO) has three classes of biomarkers identified: - biomarker of exposure; -biomarker of effect and biomarker of susceptibility.

How can this complex definition and the biomarker classes be handled by governmental regulations? How can this definition be useful in an operational way for governmental decision making in collaboration with industry and the governmental authorities? Very difficult! Environmental management and regulative requirements needs a number of tools for risk assessment and risk minimization and this can best achieved by standardized, highly sensitive, reaction-specific and a widely applicable suite of bioassays and biomarkers. But bioassay methods contribute only a limiting amount of knowledge to illustrate the environmental evaluation under the heading of precautionary measures. However, in the area of precautionary measures for the protection of aquatic life and to fulfil the regulations with regard to the risk to the environment, bioassays and biomarkers still provides a most important aid in the fulfilling of the legal requirements.

For the understanding of complexity the range of biotoxins, endocrine disrupting chemicals, heavy metals etc., biomarkers have been developed and approved. But all those biomarkers have to be checked for sensitivity against toxicants, reaction time, validity of data and practical handling under field conditions at waterways, sediments, estuaries or coastal areas as well as at the outlet of sewage plants. There are already biomarkers for environmental monitoring available, which facilitate integral monitoring of pollutants in surface water and waste water. These biomarkers achieve high sensitivities in a minimum of measuring time. New emerging effect related parameters are the genotoxic, immunotoxic and the endocrine potential of surface waters, effluents and drinking water. Measuring results, obtained from “biomarker multi-arrays”, form the basis for a reliable environmental diagnosis of the observed system. They are applied to the protection of drinking water and surface water, but also to monitor effluent streams of industrial plants, sewage plants and environmental stability.

Extended exposure of organisms to environmental genotoxins would result in several physiological disorders such as reproductive impairments and other related abnormalities. Therefore, the response measurements to reproductive toxicity is essential for assessing the effects of anthropogenic sources.

Biochemical responses in ecosystems due to environmental stress could provide us with signals of a potential damage. These responses, if perceived in early stages, in ecosystems, the eventual deteration can be prevented. On the other hand once ecosystem damage has occurred, the remedial action processes for their recovery could be expensive and pose certain logistical problems. Prevention of ecosystem deterioration is always better than curing the damaged one. Ideally , "early warning signals" in ecosystems using biomarkers would not only tell us the initial levels of damage, but these signals could provide answers to develop control strategies and precautionary measures.

Acute toxicity results in organism selection, genotoxicity results in mutagenicity and physiological impairments (genetic disease syndromes), induction of MFO (biotransformation and detoxification) tells us that fishes are induced with elevated detoxification levels and provide us data with information on the effects of specific chemical species (warning signals). However they do not have high ecological relevance like information from immunosuppression (phagocytosis). Genotoxic damage endpoints have high ecological significance as they relate to the ability of reproduction. Stress responses at population levels have direct ecological implications even though they exhibit low specificity. There should be, therefore, a harmonized ecosystem assessment approach where the overall information (high specificity to low specifity) should be considered in parallel for a proper "ecosystem health" management.

The biomarkers will become relevant for legislative framework concerning risk assessment and monitoring but they have to meet the standardization procedures under ISO and CEN, otherwise they will not be accepted by the regulatory authorities and industry. There are already biomarkers in the regulations like "genotoxicity" by the umu-assay DIN 38415 T 3 or ISO 13829. Biomarkers for immunotoxicity (phagocytosis) and the endocrine effect related indicator assays are in the norming process under DIN UA 5 and the endocrine indicator assays under DIN UA 7 and will later standardised under ISO TC147/SC5. The biomarkers will be a new work item in the International Standardisation Organisation (ISO TC147/ SC5/WG3). The ISO Subcommittee SC5 will support for the future elaboration of "fish biomarker standards" and welcomes the offer of the ISO member body Sweden to make new work item proposals relating to: (1) aspects of sampling for biochemical responses and (2) the EROD method. For transitional and marine waters the CEN is considering in connection with implementation of the EU Water Frame Work also biomarkers = biochemical responses. In governmental regulations the term "biomarker" is replaced by "biochemical responses" and certainly there is a chance to implement biomarkers in governmental regulation at the European level. Under ISO is also a good chance to implement biomarkers in the evaluation of marine sediments and dredging materials. Under the Marine Pollution Committee of ICES (ICES=International Commission for Exploration of the Sea) there are already two biomarker protocols existing and in use for EROD (EROD=ethoyresorufin-O-deethylase) and ChE (ChE=Cholinesterase). These well known biochemical responses are classical biomarkers. A very difficult question is always the relevance of the biochemical responses e.g. for the genotoxicity biomarkers and their links to the altered reproductive success in wildlife. There are two integrated EU funded marine projects on biomarkers BIOMAR and the BEEP project (2001-2004) and also here is the question: where are the stakeholders and the end-users? If we want biomarkers used by end-users like governmental authorities and Industry (water quality objectives and criteria, effluent testing, dredging-, drilling- offshore- activities) we need at least standardisation under ISO and CEN.

In considering the impact of either natural stress or man made stress we always encounter by biomarker detoxification, disease defence, regulation and adaptation processes. This situation makes the assessment approach with biomarkers rather complicated. On the other hand symptoms analysis including functional (behaviour, activity and metabolism) and structural changes in organism (cellular, tissue and organs), the biomarkers do have a significant ecological assessment potential. For landscape planning and environmental management it is necessary to get significant biomarker data or quantitative biochemical responses for relevant and sustainable actions.

8.10 Policies and Practices for Ecosystem Integrity in the Great Laurentian River Basin

Henry Regier, Professor Emeritus, University of Toronto, Canada

My perspective on *ecosystem integrity* owes something to doctoral theses submitted at the University of Kiel: one by Ferdinand Tönnies in 1881; and another by Daniel Pauly in 1979. Within the seminal approaches of each of these two innovators is a strong commitment to *justice*, which is generally taken to be a necessary feature of *ecosystem integrity.*

The Great Laurentian River Basin, in which I have done most of my work, includes a large watery network with five Great Lakes, five Great Rivers that link the lakes to each other and to the Atlantic, as well as many aquifers, wetlands and tributaries. Overall, it resembles the Baltic Basin in many natural and cultural ways, but there are also important differences.

Five *nations* share our Basin: the Anishinabek or Algonkian Aboriginals; the Haudenosaunee or Iroquois Aboriginals; the Quebecois; the English-speaking Americans; and the English-speaking Canadians. Each *nation* has a somewhat different cultural sense of what *ecosystem integrity* means and how it could be realized. Fortunately the Basin's inter-jurisdictional governance has not been compromised by wars for almost two centuries, and mutual accommodation that is reciprocally responsible has been evolving, very slowly and imperfectly.

Within the culture of any *nation,* an *ecosystem* may be perceived dualistically as bi-phasal, with natural and cultural poles or attractors, regardless of the spatio-temporal scale of an ecosystem as nested within the Basin or beyond. With respect to any particular bi-polar ecosystem, regardless of the level of nesting, different interest groups amongst the humans have each created scientific and rhetorical conventions to serve those interests. If the overall encompassing mindset is termed *ecogenic*, then the specialties include the *ecologic*, *economic*, *ecosociologic*, *ekistic* (relating to spatial features of human settlement), *eciatric* (relating to public health of humans and domesticated animals), *ecumenic* (related to explicit or implicit ideology-based governance), etc. Each of these *ecogenic* specialties, plus others, is now involved interactively with the other specialties in the study and governance of the Great Lauretian River Basin.

Incidentally, the *eco* prefix already refers implicitly to a dualistic concept, – a living thing in its encompassing habitat or home which includes other living things. So the epistemology of ecogenics tends to be dialectical, sui generis. And the ontology is evolutionary.

With respect to the sciences and their preferred forms of rhetoric, the cultural-natural bi-polarity may manifest a constructivist emphasis with respect to the cultural pole and a positivist emphasis with the natural. Scientists who start with an a posteriori or utilitarian ethical stance have tended to favour quantitative quasi-positivism while those with an a priori or deontological stance may favour qualitative quasi-constructivism. During the emergence of an explicit ecosystem approach in our Basin, utilitarian positivist and deontological constructivist scientists have participated in an implicit and complex dialectic that has become angry only on occasion. I have always participated in studies of both types, mostly iteratively.

Several inter-linked inter-jurisdictional commissions each provide a forum for such dialectical processes that lead to integrated recommendations, to foster ecosystem integrity, by the commissions to the formal governments of the Basin. The focus of the proceedings in these commissions has gradually expanded over the past five decades from environmental and resource abuses at a local level, to the level of individual Great Lakes, to the whole watery domain of the Basin, and recently to the Basin nested within the global Biosphere.

Ferdinand Tönnies' quasi-constructivist dualism of *Gemeinschaft* and *Gesellschaft* is being rediscovered in the Basin and is seen to be helpful in understanding the implicit dialectic between local governance (especially in communities of Aboriginal peoples) and regional governance (that includes some or all of the other *nations)*. Tönnies focussed particularly on the economic, psychic and social features of the dualism, as it played out in the region around Kiel a century ago. Tönnies' dualism may be extended to the whole range of ecogenic perspectives in our Basin with respect particularly to interactions between nested ecosystems at the local and regional levels.

Daniel Pauly's quantitative approach to fisheries is based in part on inferences from the work in general systems theory by Ludwig von Bertalanffy. (Bertalanffy sought to transcend the vitalism vs mechanism dualism.) Pauly's current comparative inferences may relate most directly to ecologic and economic interactions between regional/national ecosystems and the global ecosystem or Biosphere, where *ecosystem* is to be understood in an *ecogenic* sense. But Pauly has also worked at the local to regional interface, say with respect to fisheries in South-East Asia. Pauly has used data from fisheries in our Basin to infer quantitative generalizations that are coming to be applied to forecast regional effects on fish and fisheries of global climate change, for example.

My paper will include empirical examples that relate to the scientific aspects of the generalizations sketched above.

8.11 The International Long-Term Research Initiative

James R. Gosz, ILTER Network Committee, Albuquerque, USA

Long-term data are now recognized as crucial to our understanding of environmental change and management. Historically, these studies have been difficult to maintain because of the dominance of short term funding programs, a misconception that long-term studies are merely monitoring, and emphasis on short term experimentation or hypothesis testing of specific interactions or processes under the assumption of equilibrium conditions. The complexity of the environment and the dynamic nature of environmental conditions require additional research efforts that are not only long term, but also address questions of scale dependency, complex assemblages of species and their interactions, and the role of humans in the environment. Long Term Ecological Research (LTER) sites offer this important complement to the more traditional types of ecological research. These sites also provide the opportunities for interdisciplinary research that is fundamental to understanding the environment. Such collaborations are essential for the development of sustainable management of our natural resources.

The need for collaborations among the numerous scientists and high-quality programs that are involved in understanding the various areas of our globe is an even stronger argument for the development of a worldwide network of LTER sites and programs. As a result of an international meeting in 1993 to focus exclusively on networking of long-term ecological research, an International LTER (ILTER) Network was formed with a mission to facilitate international cooperation among scientists engaged in long-term ecological research. The ILTER Network Committee, now represented by the 25 countries in the ILTER Network, has continued and broadened its activities through annual meetings. The committee has established the following mission statements, based primarily on the 1993 conference:

1. Promote and enhance the understanding of long-term ecological phenomena across national and regional boundaries;
2. Promote comparative analysis and synthesis across sites;
3. Facilitate interaction among participating scientists across disciplines and sites;
4. Promote comparability of observations and experiments, integration of research and monitoring, and encourage data exchange;
5. Enhance training and education in comparative long-term ecological research and its relevant technologies;
6. Contribute to the scientific basis for ecosystem management;
7. Facilitate international collaboration among comprehensive, site-based, long-term, ecological research programs; and
8. Facilitate development of such programs in regions where they do not exist currently.

8.12 Alpine Ecosystem Research Integrating Ecological and Social Processes

Helmut Franz, National Park Berchtesgaden, Deutschland

The National park of Berchtesgaden was established in 1978. In the same year, the professors Ellenberg, Fränzle and Müller presented a study with the title ‚Ecosystem Research regarding environmental policies and development planning’ on behalf of the German Federal Ministry of Interior. They recommended a ecological information- and evaluation system for the Federal Republic of Germany, which should be based on exemplary main research areas on the basis of ecosystems and ecosystem complexes. A terrestrial main research area should be established in the German alpine space. In the year 1981, the preparations began for the interdisciplinary research project „Human impact on high mountain ecosystems“ – later renamed in „Applied ecosystem research Berchtesgaden“ - within the scope of the UNESCO program „Man and Biosphere, task force 6, high mountain ecosystems (MAB 6)“. It analysed and evaluated in reality ecosystem complexes or landscape systems with the main question: „How do human activities have an effect in the high mountain region on the natural resources like groundwater, surface water, soils, strata, local climate, plants and animals? And what is the retroactive effect of these effects?” The test area was considered to be a network system with the parts nature, exploitation and society. Scientific project leader was

Prof. Haber from the chair for landscape ecology of the TU München-Weihenstephan. The results of this project, which ended in 1991, form the basis of an applied and practically orientated method for ecosystem research. The results and the project data are basis for the management plan of the national park, which became effective in 2001. Beyond that, the research and the geographic database of the national park were continued on the basis of this project. In the next decade, the national park focuses on two main areas:

a) HABITALP: Transfer of the analysis and method of the refined data basis of the interpreted color infrared aerial photos of the MaB 6 – to ten other protected areas in the alpine space. The project is financed by the EU in the frame of INTERREG III b.

b) Planning and implementation of the concept for integrated environmental monitoring, which was developed in the biosphere reserve Rhön, Germany. This concept is based on the projekt ‚Applied ecosystem research Berchtesgaden'.

In addition, following projects use the high density of spatial data in the national park:

- ATEAM (Advanced Terrestrial Ecosystem Analysis and Modelling. Lead Partner: Potsdam Institute for Climate Impact Research. Funded by the 5th Framework Programme of the European Commission.)
- GLOWA Danube (aims at the development and utilization of the integrated decision support system DANUBIA to investigate ways of sustainable future water use. It will integrate the large expertise of the involved partners to build a platform to commonly solve practical future problems. Lead Partner: Institute for Geography, LMU Munich. Focus in Berchtesgaden: Bayreuther Institute for Terrestrial Ecosystem Research. Funded by the Federal German Ministry of Education and Research.)
- GLORIA (Global observation research initiative in alpine Environments: detecting the effects of climate change on mountain biota on a global scale, funded by the 5th Framework Programme of the European Commission.)
- SPIN (Spatial Indicators for European Nature Conservation. Lead partner: DLR. Focus in Berchtesgaden: Landscape Analysis and Resource Management Research Group, University of Salzburg. Funded by the 5th Framework Programme of the European Commission.)

All these projects and responsibilities include ecological and social analysis and evaluation.

MATERIALIEN 9: REPORTS OF THE WORKING GROUPS

Overview:

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9.1 Working Group A: Conceptual, Methodological and Strategic Experience and Problems of Ecosystem Research

“Group coordinator“: J.C. Munch
“Rapporteur”: M. Hauhs
“Impulse paper”: J. Filser
“Group assistent”: M. Bredemeier

Bold: proposed text
Englisch: results of the working session
Englisch: later completion

Thesis 1:

Ecosystem research has promoted integrative thinking in the analysis of the human-environment interaction.

True within science, but it is only partly true between science and ecosystem management. Integration (between science and management) has worked for agriculture, it should also become true in forestry and nature conservation.

The difficulties are partly due to resistance of practitioners to accept science results and partly due to science results not being designed well enough for practical needs.

These 1 - Continuation:

Despite the immanently high expenditure, ecosystem research is still efficient and economical since the data collected in the projects can be used and interpreted to a far larger degree...

Yes, but there is no efficiency and economy in basic research, only checks on quality standards.

The distinction of applied and basic aspects of ecosystem research remains difficult to delineate, if not even impossible.

Thesis 4:

Only a stronger accentuation of research programmes into applied and fundamental ecosystem research makes sure that ecosystem research can achieve the expected and promised results.

No, we strongly disagree. Though we agree that basic research should be funded and given room in this context, it remains a crucial part of ecosystem research and cannot be reasonably separated from applied research or management issues.

Thesis 8:

...
Successful interdisciplinarity manifests itself in convincing, integrated synthesis reports.

Well, a synthesis report is an essential part of the results of an ecosystem project, but can never be the only one (in the sense of a measure of success or failure).

...too short

Focus Questions:

1st Question: What are the most important advances/results of ecosystem research regarding ...

Ecological topics: yes, we have learnt at lot. Today we have more knowledge about ecology *of systems*, we have results that address ecosystems, ecology of populations, organisms,…

We have learnt how they respond to past changes in their environment (decreased SO_4, continuing N input,…)

We can sometimes explain our process level observations across spatial compartments, spatial /temporal scales, or hierarchical levels.

The data sets characterising the various ecosystem over time and regions are a major achievement.

Methodological topics:

In many instances new methods were developed and introduced (theoretical, modelling, experimental).

Many tasks became easier to solve when humans were included into the working concepts of research projects (relative to preceding projects that excluded management issues), This also indicates that applied and basic approaches are still deeply intermingled

Organisational topics:

We have lived interdisciplinarity,

we have successfully cooperated e.g. with colleagues from geosciences and biology, modelling has been established besides experiments and theory and must of course be integrated with both.

We need a more rigorous (informed by theory) organisation of data collection and management.

Applied topics: The success in reorganisation of science pre-requires success in the two preceding items:

We have acquired and disseminated knowledge about effects with economic implications (productivity changes, risks, human health, quality of services,…)

The patterns of use of products and technologies have changed due to knowledge about ecosystems (e.g. toxicology applications,…)

2nd Question: How did the ecosystem science approach affect ecological and environmental research – in the applied as well as in the fundamental domain, or regarding the general organisation of research? Were paradigm shifts initiated?

It had a large impact in reorganising research and teaching. In ecosystem projects geosciences became integrated contributors side by side with biosciences. The claim that ecology is only part of biology has been replaced by more comprehensive approaches.

The integration of social and engineering science is still on its way?

Ecosystem research is the forum where paradigms from different disciplines got into fruitful competition, …

but without a clear winner yet.

3rd Question: Which examples are suitable to demonstrate emergence, a phenomena that is regarded as an important focal point of several ecosystem approaches? (but "more is different") **Where, how, and when "is the sum more than its parts"? Which conclusions can be drawn for environmental research and management?**

We define emergence: as a property of a composite which has no inductive approach for inferring it or generating it from the parts of that system.

The concept of ecosystems captures irreducible aspects (hence strong reductionism is in the defensive).

Any example from successful sustainable ecosystem management illustrates an emergent property. Successful means a feature was discovered that could be turned into a function for a civilisation, if this can be done without changing that potential use of the function can be sustained.

(more on this is possible…)

4th Question: Which are the most significant research deficits that arose in the last 25 years of ecosystem research?

Firstly to address this question we reassessed the overall task of ecosystem research Thesis I.1 and I.2 (page 5):

Thesis I.1 can be reformulated as: We seek increased understanding, mostly in the sense of dynamic system theory (the system has a state, etc.)

Thesis I.2 can be formulated as: Then we will provide predictions based on increased understanding in particular in the framework of scenarios.

Today we see this differently: Now the severity of communication problems has become more appreciated: That is why we regard as the foremost societal (environmental) problem:

- Erosion of managerial and valuation experience-based competence (e.g. consider "forester decline").
- Scale remains a critical issue,
- does the "space for time" substitution really work as well as has been often claimed?

- Search after relevant environmental indicators continues
- Redundancies in ecosystems (replacing one group of organisms by another functional taxon)
- Interactive models (models as communication tools)

5th Question: Which are the most important problems which became apparent in ecosystem research? With which strategies, methodologies or approaches can be solved these problems regarding ...

Methods: We need methods to deal with scale issues, this topic remain open to technological progress. Try to investigate and measure forces and fluxes within one ecosystem successfully. We need methods to deal more appropriately with the multitude of scale-dependent relationships between structures and functions.

Organisation: Coordinators of ecosystem projects need to be properly trained for and empowered in interdisciplinary project management. This is a long-term commitment and needs professionalism.

Science is linked to careers: in stagnant (academic) job markets it becomes a high risk to work on interdisciplinary topics, because faculty grant open positions in the centre of existing disciplines rather than at the edges where they foster interdisciplinarity.

In the long-term interdisciplinarity must be a forerunner to new disciplines.

Funding: Quality of peers (e.g. funding agencies pretend that projects are split into applied and basic when in fact they are not). Science organisation in Germany is not well set up to deal with problems that fall in between existing classical disciplines. Funding institutions in Germany, such as the DFG, should have established peer systems to properly address ecosystem research programmes. Funding agencies should be more patient and appreciate the temporal scales of the systems under study and of the problems addressed. People must be aware that ecosystem research must involve whole ecosystem complexes for many, and in particular, for practical issues

Applied: Management issues should also appear on the “input side” of knowledge and competence and not only on the “output side”.

6th Question: What does the working group recommend taking into consideration the experiences of ecosystem research with regard to fundamental ecosystem research, applied ecosystem research, the organisation and management of science, the practice of sponsoring and the orientation of the sponsoring institutions, environmental management and politics?

Strategic:

Ecosystems are different and variable and they will remain so in the future. The bottleneck for management lies not only in difficulties in predicting these variability, but to acquire, maintain and update the competence of valuating, assessing and judging them on different scales.

The underlying problem of disseminating the knowledge of complex systems and the ability of good judgement and recommendations is a communication problem. This communication task appears currently not sufficiently supported by funding institutions.

A new technology (in the form of Information Technology) is available, but is not yet exploited up to its full (interactive and communicational) potential.

Information sciences ought to gain a similar importance in ecosystem research that chemistry has acquired in the past decades.

If scientists have to deal with interdisciplinary basic and applied approaches at least on a mid-term perspective funding agencies should face a mid-term cooperation between basic (e.g. DFG) and applied (e.g. UBA) funding sources. E.g. try it on a decision support system…

9.2 Arbeitsgruppe B: Ökosystemforschung und Ökosystemmanagement - Leitlinien für eine integrative Umweltpraxis

"AG-Leiter": F. Beese
"Rapporteur": H. Regier
"Impulsreferent": W. Windhorst
"Koordinator": J. Barkmann

In Gruppe B wurde zunächst betont, dass eine Reihe von heute selbstverständlichen Prinzipien, nach denen umweltwissenschaftliche Analysen vorgenommen und die bei umweltpolitischen Entscheidungen berücksichtigt werden, auf Ansätzen aus der Ökosystemforschung beruhen. Zu nennen sind hier beispielsweise der *Massenbilanz-Ansatz* (Ionen-Bilanzen der Waldschadensforschung, CO_2-Emissionshandel, regionale Massenbilanzen), der *Bioakkumulations- bzw. Biokonzentrationsansatz* (Ermittlung von Schadstoff-Grenzwerten), die Einsicht in die Erforderlichkeit *dynamischer* und *adaptiver* Managementstrategien und Wirkungsabschätzungen (Naturschutz, UVP).

Unmittelbare Anwendung fanden diese Prinzipien in der *Forstwirtschaft* (Kalkung von 3,5 Mio. ha Wald, politische Bemühungen zur Reduzierung der Schwefel- und Stickstoff-Emissionen z.B. von Großfeuerungsanlagen und Kraftfahrzeugen). Neben Bodendauerbeobachtungsflächen und einer Waldbodenzustandserhebung wurde das EU Level II-Programm eingerichtet (ökosystemares Monitoring auf 800 Flächen in Europa). Im *Agrarbereich* beruht die Düngeverordnung unmittelbar auf einem (vereinfachten) Massenbilanzansatz. Die „gute fachliche Praxis" wird – zumindest dem Prinzip nach – sektoren- und medienübergreifend definiert. Nicht ausschließlich, aber stark die Agrarwirtschaft betreffend ist der integrierte, ökosystemare Einzugsgebietsansatz der EU-Wasserrahmen-Richtlinie. Für den *Naturschutz* ist neben der Dynamisierung von Schutzkonzepten die Berücksichtigung der ökosystemaren Wechselwirkungen in der Umweltverträglichkeitsprüfung von Bedeutung. Die Anwendungsbedeutung für das Nationalparkmanagement in jüngster Zeit ist kaum zu überschätzen (z.B. Muschel- und Fischereimanagement, systemare Umweltbildungskonzeption, Renaturierung der Salzmarschen, sozio-ökonomisches Monitoring). Unter wissenschaftspolitischen Gesichtspunkten muss auch die Einrichtung einer Reihe von integrativ arbeitenden Umweltforschungseinrichtungen nach 1990 in Ostdeutschland als mittelbarer Effekt der Übernahme ökosystemaren Gedankenguts in die politische Praxis gewertet werden.

Hinsichtlich der systemar inspirierten Schutzkonzepte *Ecosystem Health* und *Ecological Integrity* empfiehlt die Arbeitsgruppe, eine strukturelle Komponente von einer funktionalen zu unterscheiden. Die strukturelle Komponente wird im anglo-amerikanischen Raum mit Phänomenen wie *naturalness* und *wilderness* identifiziert. Für diese strukturellen Komponente stehen ausreichende und besser angepasste kontinentaleuropäische Naturschutzkonzeptionen bereit. Die funktionale Komponente könnte als Leitlinie für einen langfristigen ökologischen Risikoschutz interessant sein, da sie bislang schlecht greifbare, Generationen-übergreifende Aspekte des Schutzes der Leistungs- und Funktionsfähigkeit des Naturhaushalts operationalisiert.

Obwohl es keine scharfe Abgrenzung gibt, favorisiert die Gruppe einen größeren Stakeholder-Input für Programme *angewandter* Ökosystemforschung und eine größere *wissenschaftliche Autonomie* für grundlagenorientierte Forschung. Universitäre Ökosystemforschung muss durch Möglichkeiten zur Mitnutzung der Forschungsplattformen der Großforschungseinrichtungen erleichtert werden. Schwerpunkte für die Weiterentwicklung der internen Forschungsorganisation betreffen Fragen der inhaltlichen und finanziellen Rechenschaftspflichten, der Sicherstellung der Datenqualität und des freien Zugangs zu Daten, die mit Hilfe öffentlicher Mitteln erhoben wurden („sunshine principle"). Ein engere Austausch mit den Kommunikationswissenschaften wird angeregt (Partizipation, Technologie- und Wissenstransfer, Interdisziplinarität).

9.3 Arbeitsgruppe C: Erfahrungen und Probleme aus der Ökosystemforschung in der Anwendung, Anforderungen aus Politik und Planung

"AG-Leiter": K. Dierssen
"Rapporteur": T. Höpner
"Impulsreferenten": B. Hain & K. Tobias
"Koordinator": K. Schönthaler

1. Welche Anforderungen wurden und werden von Seiten der Umweltpraxis an die Ökosystemforschung gestellt? Wurden diese Anforderungen erfüllt oder bestehen hier noch Umsetzungsdefizite?

Beispiele: UBA erbat von Ökosystemforschung Berchtesgaden eine Prüfung der Eignung des vorhandenen Wald-Datensatzes für Formulierung von Umweltqualitätszielen. Später wurde vom UBA und dem Land Bayern eine Fallstudie über Waldschäden angeregt und von dem Ökosystemforschung-Team auch durchgeführt. Gesamtbericht Ökosystemforschung Schleswig-Holstein war Start der Novellierung des Nationalparkgesetzes. Dass der angewandte Endbericht den Untertitel „Grundlagen für einen Nationalparkplan" hat, stieß nicht auf uneingeschränkte Akzeptanz. Die positive Wirkung ist trotzdem vorhanden. Anforderungen der Umweltpraxis sind im Antrag zur Ökosystemforschung Schleswig-Holstein schon vorgesehen gewesen. Ökosystemforschung Wattenmeer Niedersachsen beriet die Landesregierung vor dem Erlass eines Miesmuschel-Managementplans. UVP Europipe (1996/97) wurde weitgehend durch Mitarbeiter der Ökosystemforschung unter Benutzung von Material aus der Ökosystemforschung und Anwendung eines ökosystemaren Ansatzes erstellt. Die Ökosystemforschung hat außerdem folgende Beiträge für die Umweltpraxis geliefert: Beiträge über Wattenmeer-Biosphärenreservate in „Biosphärenreservate in Deutschland" (AGBR 1995), Zulieferungen an das Trilaterale Wattenmeer-Sekretariat für den Wadden Sea Quality Status Report 1999. Außerdem Rolle der Ökosystemforschung bei der Entwicklung des TMAP. Flemings Sedimentbilanz und die Auswirkungen auf CZM.

Wichtig ist, dass Anforderungen der Umweltpraxis schon in das Projektdesign aufgenommen werden. So sollte schon während der Datenerhebungen geprüft werden, wer welche „Übersetzung" für die Umweltpraxis leisten wird und wie die Daten bereitgestellt werden. Auch wenn sich die Erwartung der Umweltpraxis in erster Linie an die angewandte Ökosystemforschung richtet, können auch Grundlagenvorhaben Beiträge für die Umweltpraxis liefern (z.B. Solling-Projekt).

2. Welche Anforderungen wurden und werden von Seiten der Ökosystemforschung an die Umweltpraxis gestellt? Wurden diese Anforderungen erfüllt oder bestehen hier noch Umsetzungsdefizite?

Die Nationalparkverwaltungen waren bei den drei alten Ökosystemforschung jeweils an den Konzeptionen und Anträgen beteiligt. Ökosystemforschung kooperierte in allen drei alten Vorhaben gut mit den Nationalparkverwaltungen, die ihrerseits in den Leitungsgremien vertreten waren. Die Nationalparkverwaltungen profitierten an Stellen und Sachmitteln, z.B. durch Einrichtung oder Erweiterung von EDV-Ausrüstungen und Einrichtung von GIS und Datenbanken. Deshalb wurden die Anforderungen der Ökosystemforschung an die Nationalparkverwaltungen in der Regel erfüllt. Es gab in allen drei Fällen die jeweils gemeinsame Überzeugung des gegenseitigen Gewinns durch Zusammenarbeit.

Daten zu Tourismus, Fischerei, Seehunden, Vogelzählungen, Schifffahrt usw. wurden in der Regel von den zuständigen Behörden ohne Probleme bereitgestellt.

Erschwernisse: Übergabe von Daten von Behörden an Ökosystemforschung scheiterte manchmal an noch bestehendem Misstrauen oder Konkurrenzgefühlen. Umgekehrt trauten Mitarbeiter der Ökosystemforschung den Daten der Behörden nicht unbedingt und erhoben sie lieber selbst.

Das Bewusstsein, das Bund und Land die Ökosystemforschung gemeinsam betrieben und dass deshalb die gewohnten Fronten (Forschung versus Praxis) nicht zutrafen, setzte sich erst langsam durch.

3. Welche konkreten Beispiele können herangezogen werden, um einen erfolgreichen Wissens- und Methodentransfer zu demonstrieren?

ÖSF Berchtesgaden: Fallstudien Waldschäden, Winterolympiade, Almen-Auflassung, Nationalparkplan an das Land und den Nationalpark. Ökosystemforschung Schleswig-Holstein: Ökologische und vor allem ornithologische Informationen für Anlage und Änderung von Wegeführungen im Nationalpark, Inhalt und weitgehend auch Zusammenstellung des Umweltaltas Wattenmeer, so auch in Niedersachsen; ebenso in beiden Fällen Sozioökonomie der Fischerei und des Tourismus. Ökosystemforschung Niedersachsen: das Land übernahm Grundlagen eines Miesmuschelmanagements, die Zusammenstellung der Nutzungen und Belastungen des Nationalparkgebiets, die Luftbildinterpretationen der Bestandserfassungen und Biotopklassifizierungen sowie die Datenbankentwicklungen. Praxis der Kompensationskalkung, Waldumbau (Göttingen, Bayreuth), forstliches Monitoring (EU-weit realisiert). Ergänzungen sind nötig und sicherlich auch möglich.

4 Hat sich Ökosystemforschung förderlich ausgewirkt auf...

- Planungsmethoden,
- Umweltbeobachtungsstrategien,
- Indikatorenableitungen,
- Modellanwendungen,
- Lösungen konkreter Umweltproblemfelder ?

Planungsmethoden: Die flächendeckende Einführung des GIS und die Verteilung der dafür nötigen Personalkompetenz ist das Ergebnis der Ökosystemforschung. Dies gilt auch für die Umweltdatenbank mit später dezentraler Datenhaltung in Wilhelmshaven und Tönning, auch wenn noch Mängel bestehen. Naturschutzfachliche Bewertung in Nationalparken. Das Denken in Wirkungsstrukturen und –netzen wurde gefördert, auch wenn es sich noch nicht in Methodenbausteinen niedergeschlagen hat. Die Ökosystemforschung hat die Diskussion um Zielhierarchien (Umweltqualitätsziele und -standards) befördert. Beispiele: trilaterale Ecotargets, Umweltqualitätsziel-Projekte in allen Ökosystemforschung, Szenariotechnik.

Umweltbeobachtungsstrategien: Die Parameter und die Erhebungsmethoden der Umweltbeobachtung kommen im Wesentlichen aus der Ökosystemforschung und konnten bis in den Bereich der trilateralen Zusammenarbeit vermittelt werden (TMAP, im terrestrischen Bereich der Kerndatensatz der ökosystemaren Umweltbeobachtung, Level II, Ökologische Planung, Sondergutachten 1990, Umweltprobenbank, GIS-Umweltbeobachtung.

Indikatorableitungen: critical levels, critical loads, Input in TMAP, stoffliche Kombinationen der Waldschadensbilder (neu).

Modellanwendungen: Messerli-Konzeptmodell (Berchtesgaden) hat sich als Standard etabliert. Simulationsmodell Sylt-Rømø-Watt wartet noch auf Anwendung bzw. geht in die GKSS-Arbeit ein. Modelle der ÖSF sind der Kern der Modellvorhaben der DFG-geförderten „Forschergruppe Watt“ in Oldenburg. Manches ist praxis- und planungsrelevant, aber noch nicht anwendungstauglich. Depositionsmodelle aus der Waldschadensforschung. Diese Aufzählung ist sicherlich ergänzungsbedürftig.

Lösungen konkreter Umweltproblemfelder: Schiff-Folgen durch Seevögel erkannt als wesentliche Verschiebung der Nahrungsbasis, rationale Grundlagen für ein Miesmuschelmanagement, Eutrophierungsproblematik und Erklärungsmuster Schwarze Flecken, Einrichtung einer Schweinswal-Schutzzone, Linderung von Konflikten zwischen Besuchern und Brutvögeln, Vorlandmanagement-Konzept.

Welche Empfehlungen können aus Sicht der Arbeitsgruppe aufgrund der Erfahrungen aus der Ökosystemforschung ausgesprochen werden in die Richtungen...

- Grundlagenforschung,
- angewandte Forschung,
- Projektsteuerung, Struktur, Wissenschaftsmanagement,
- Förderpolitik und Förderinstitutionen,
- Umweltmanagement und Umweltpolitik?

Engere Kooperation zwischen Umweltpraktikern und –forschern erreicht, z.B. durch Mitgliedschaften in Gremien (wie durch Mitglieder der Ökosystemforschung praktiziert).

Verallgemeinerbarkeit der Ergebnisse der Ökosystemforschung kann wichtiger sein als inhaltliche Tiefe.

Neue Themen für die grundlagen- und angewandte Forschung: Ökologie der gentechnisch veränderten Organismen, Nahrungsmittelproduktion und Naturschutz, Ökotoxikologie und Naturschutz, Klimafolgenforschung, Stofftransporte, z.B. Waldböden, Wasserrahmenrichtlinie.

Grundlagenforschung: Ökosystemforschung Watt klärte offensichtliche Fragen an Grundlagenforschung (z.B. Import von abbaubarem C in den Wattbereich hinein) so weit, dass DFG-Förderung möglich wurde.

Projektsteuerung: Leitungsstrukturen der Ökosystemforschung sehr bewährt und als Muster für andere Gelegenheiten verwendet, auch von Umweltpolitik anerkannt.

Empfehlungen: Verbesserung des Transfer der Forschungsergebnisse sollte Projektbestandteil sein, a) in struktureller Hinsicht, b) in inhaltlicher Hinsicht. Beispiele: Indikatoren, praxistaugliche Planungsmethoden (z.B. Wirkmodelle, Landschaftspotenziale und Wechselwirkungen, routinetaugliche Messverfahren).

Daten länger aufheben (wie GLP), Datenmanagement verbessern, technische Standards anpassen. Analog der Umweltprobenbank sollte es Umweltdatenbank geben (vgl. Zentralarchiv für empirische Sozialforschung), verbesserte rechtliche Grundlagen für Datenhaltung, deutlichere Kooperation der fördernden Institutionen.

9.4 Arbeitsgruppe D: Zukunft der Ökosystemforschung

"AG-Leiter": E. Matzner
"Rapporteur": H. Wiggering
"Impulsreferent": F. Müller
"Koordinator": F. Müller

Folgende Fragen werden durchlaufend den Ausführungen hinterlegt:
- Welchen Kenntnisstand haben wir erreicht?
- Offene Fragen!
- Angestrebte Zielsetzung?

1. Inhalte für die zukünftige Ökosystemforschung

- Leitbilddiskussion/Nachhaltige Entwicklung
- Regionalisierung/Skalierung
- globale Änderungen/Ökosystemfunktionen
- Biodiversität und Funktionen
- Interaktionen zwischen Ökosystemen
- Extremereignisse
- Rückkopplung zu gesellschaftlichen Prozessen

zu: Leitbilddiskussion/Nachhaltige Entwicklung
- ÖF in weiterreichenden Kontext stellen
- Ansätze zur effektiveren Umsetzung der ÖF aufzeigen
- Beiträge zur Zielediskussion leisten
- *Funktionsräume* definieren/Belastbarkeiten
- Indikatoren mit adäquaten Aggregationsniveaus bereitstellen

zu: Regionalisierung/Skalierung
- räumlicher Bezug/räumlich gültige Aussagen
- Regionalisierung der Ökosystemfunktionen
    > Vorgehensweise auf unterschiedlichen Skalenebenen
    > Validierung

- Indikatoren entwickeln, um Funktionen abzubilden
- aus Theorieansatz notwendige Einzeluntersuchungen ableiten
- adäquate Modellansätze entwickeln

zu: globale Änderungen/Ökosystemfunktionen

- biologische Senken/Monitoringansätze/regulatorische Funktionen/Adaption der Ökosysteme
- Erkenntnisse der Ökosystemforschung weiterreichend in Klimamodellierung einbinden

zu: Biodiversität und Funktionen

- Biodiversitätsproblematik stärker systemisch angehen
- testbare Hypothesen aufstellen/welchen Ansatz verfolgen?/Methodenentwicklung notwendig/ experimentelle Ansätze

zu: Interaktionen zwischen Ökosystemen

- stärker urbane Systeme mit in die Betrachtung einbeziehen
- noch nicht behandelte Ökosysteme identifizieren und untersuchen

zu: Extremereignisse

- Beiträge zu Risikoforschung sowie Vorhersagemöglichkeiten bereithalten
- stärker historische Betrachtungen einbeziehen
  - > Langzeituntersuchungen/Lanzeitdatenanalysen
  - > Erholungsfähigkeit
  - > Reversibilität
- experimentelle Ansätze entwickeln/nichtlinerare Prozesse

zu: Rückkopplung zu gesellschaftlichen Prozessen

- gesellschaftliche Bewertung von Ökosystemfunktionen
- Akteursgruppen sollten stärker aufeinander zugehen
- Politiken und Programme auf ökosystemare Relevanz prüfen

2. Strukturen für die zukünftige Ökosystemforschung

- Interdisziplinarität
- Wissenstransfer
- Monitoring-Systeme
- Experimente (mit Ökosystemen)
- institutioneller Rahmen/Netzwerkbildung

zu: Interdisziplinarität

- weitere Öffnung v.a. in die Sozialwissenschaften notwendig
- entsprechendes Projektmanagement aufbauen
- von Anfang an als Ziel vorgeben und verschiedene Disziplinen nach dem jeweiligen Bedarf einbeziehen/Identifikation erzeugen
- fachspezifische Innovationen sicherstellen
- gute fachliche Praxis/Kriterienkatalog für Interdisziplinarität weiterentwickeln

zu: Wissenstransfer

- themenspezifisch Zielgruppendiskussion erforderlich
- Adressaten frühest möglich einbeziehen
  - > Fachdisziplinen

> Hochschulen/Studierende
> Entscheidungsträger
> Gesellschaft insgesamt

- Publikationsverhalten ändern

zu: Monitoring-Systeme

- bestehende Monitoringsysteme für Ökosystemforschung nutzen
- Zusammenführung unterschiedlicher Messprogramme notwendig
- Entwicklung neuer Ansätze/Datenqualität/Harmonisierung von Methoden
- aus DSS aufzeigen, welche Monitoringanforderungen im systemaren Kontext erforderlich sind

zu: Experimente (mit Ökosystemen)

- in situ-Experimente in den Ökosystemen
- harte Tests für die Modelle/Hypothesen notwendig/Validierung
- Zwischenschritte in der Skalierung ausfüllen

zu: institutioneller Rahmen

- Netzwerkbildungen
  > europäische Netzwerke
  > nationale Netzwerke/Geschäftsstelle
- deutsches LTER-Programm/deutsche Beiträge zum internationalen LTER
- Förderpolitik beeinflussen
- Möglichkeiten der Fortführung bestehender Strukturen/Verpflichtungen ausloten/nutzen

APPENDIX 10: IMPORTANT RESULTS OF ECOSYSTEM RESEARCH PROJECTS

only available in german

Überblick:

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10.1 Auskünfte aus der Fragebogenerhebung

Die im Folgenden in alphabetischer Reihenfolge wiedergegebenen Zusammenfassungen von Forschungsergebnissen sind wörtlich den Antworten aus der Fragebogenerhebung entnommen. Es wurden lediglich kleine redaktionelle Änderungen vorgenommen. Die Darstellungen sind Antworten auf Frage Nr. 6.3 in Fragebogen 1 (s. Materialien 2.2) mit dem folgenden Wortlaut:

> Welches sind die wichtigsten konkreten Ergebnisse, die „Ihr/Ihre" Vorhaben der Ökosystemforschung hervorgebracht hat/haben und die im Kontext der Umweltwissenschaft wichtige Impulse und Fortschritte angeregt oder bewirkt haben (nennen Sie z.B. stichpunktartig die Ihres Erachtens 10 wichtigsten Resultate)?

Überblick über die Projekte, zu denen Informationen überliefert wurden:

Titel des Vorhabens	Durchführende Institutionen
Across Trophic Level System Simulation Program	U.S. Geological Survey, Biological Resources Division
Biodiversität und Ökosystemfunktionen in bewirtschafteten Grünländern	Universität Jena, MPI für Biogeochemie Jena
Einfluss des Menschen auf Hochgebirgsökosysteme - Nationalpark Berchtesgaden (MAB 6)	TU München-Weihenstephan
Erfassung und Bewertung von Landschaftsfunktionen und ihren Veränderungen in Testgebieten Sachsens	Sächsische Akademie der Wissenschaften, TU Dresden, UFZ Leipzig/Halle
Forstliches Umweltmonitoring	BMVEL und Versuchsanstalten der Länder
Grundlagen zur nachhaltigen Entwicklung von Ökosystemen bei veränderten Umgebungsbedingungen	BITÖK, Universität Bayreuth
IBP (International Biological Programme), NSSE (Nordic Subarctic-Subalpine Ecology), HIBECO (Human interactions with the Mountain Birch Forest Ecosystems) – Fennoscandian Tundra Studies	mehrere skandinavische Universitäten und Forschungsinstitutionen
KUSTOS-Projekt (Küstennahe Stoff- und Energieflüsse – der Übergang Land-Meer in der Südöstlichen Nordsee)	Zentrum für Meeres- und Klimaforschung der Universität Hamburg
Louisiana crayfish, alien species in Portugal: Bioecology, impact and control	IMAR University of Coimbra
LTER in Loch Vale Watershed, Rocky Mountain National Park	U.S. Geological Survey, Colordo State University
Network for forest ecosystem data in Norwegian Russian border area	Norwegian Forest Research Institute, Soil Science Faculty Moscow, Physica Faculty of Moscow State University

Titel des Vorhabens	Durchführende Institutionen
Ökosystemforschung im Bereich der Bornhöveder Seenkette	Universität Kiel
Ökosystemforschung Schleswig-Holsteinisches Wattenmeer	Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer, Tönning
PRISMA-Projekt (Prozesse im Schadstoffkreislauf Meer-Atmosphäre)	Zentrum für Meeres- und Klimaforschung der Universität Hamburg
SHIFT-Teilprojekt „The Central Amazon Floodplains – Actual Use and Options for a Sustainable Management“	MPI für Limnologie Plön, Universität Stuttgart-Hohenheim, Universität Kiel, Instituto Nacional de Pesquisas da Amazonia Manaus, Universidade Federal do Amazonas Manaus
Sonderforschungsbereich (SFB 248) Stoffhaushalt des Bodensees	Universität Konstanz, Universität Heidelberg, Institut für Seenforschung Langenargen
SYKON-Projekt (Synthese und Neukonzeption von Nordseeforschung)	Zentrum für Meeres- und Klimaforschung der Universität Hamburg
Verbundprojekt Veränderungsdynamik von Waldökosystemen	Forschungszentrum Waldökosysteme der Universität Göttingen
WET	Ökologiezentrum der Universität Kiel
ZISCH-Projekt (Zirkulation und Schadstoffumsatz in der Nordsee)	Zentrum für Meeres- und Klimaforschung der Universität Hamburg

Across Trophic Level System Simulation Program

Auskunft erteilte: Dr. DeAngelis, Donald L., U. S. Geological Survey, Biological Resources Division, Department of Biology, University of Miami, USA

1. A number of landscape "index" models have been developed, which have served as performance measures for how future water regulation may affect biota.
2. Several landscape computer simulation models of particular species have been developed, calibrated, and to some extent validated.
3. Specific information has emerged from the modeling, such as a better understanding of the habitat use of certain species, that will be useful in management.

Biodiversität und Ökosystemfunktionen in bewirtschafteten Grünländern

Auskunft erteilte: Dr. Nina Buchmann, MPI für Biogeochemie, Jena

- Bodenatmung ⇒ 50% Wurzelatmung (Nature 2001)
- N-Deposition wird zu 80% im Boden vollständig festgelegt, wichtige Rolle der Begleitvegetation (Oecologia, Biochemistry)
- Isotopensignatur des CO_2-Nettoaustauschs spiegelt Vegetationsgeschichte des Bestandes wieder (Agr. Forest Meteo)
- Bodenatmung: enger Zusammenhang mit GPP (Global Biochemical Cycles)
- Kohlenstoff-Isotopenverhältnisse von Blättern kann hinzugezogen werden, um funktionale Gruppen zu bilden (Oecologia)
- CO_2-Profile im Bestand können mit einfachen Größen gut modelliert werden (Funct. E-col.)

Einfluss des Menschen auf Hochgebirgsökosysteme - Nationalpark Berchtesgaden (MAB 6)

Auskunft erteilte: Prof. Dr. Dr. hc Wolfgang Haber, Lehrstuhl für Landschaftsökologie der TU München in Weihenstephan, Freising

- Weiterentwicklung des Nationalpark- und Biosphärenreservatskonzeptes
- hierarchische Systemmodelle
- Konzept der ökosystemaren Umweltbeobachtung
- Szenariotechniken
- GIS-Weiterentwicklung
- Biodiversitässtrategie
- ...

Erfassung und Bewertung von Landschaftsfunktionen und ihren Veränderungen (Landschaftswandel, Monitoring) in Testgebieten Sachsens

Auskunft erteilte: Dr. Olaf Bastian, Sächsische Akademie der Wissenschaften zu Leipzig, Arbeitsstelle „Naturhaushalt und Gebietscharakter“, Dresden

- Brauchbarkeit des Ansatzes „Landschaftsfunktionen/Naturraumpotenziale“ im Rahmen der Umweltbeobachtung (Monitoring) wurde bewiesen
- Auswahl und Testung geeigneter Indikatoren
- Methodische Ansätze der Interpretation der Ergebnisse im Hinblick auf gesellschaftlich relevante Leistungsfähigkeit des Naturhaushaltes
- Hierarchisch abgestufte Bearbeitungsweise in verschiedenen Maßstabsbereichen

Forstliches Umweltmonitoring

Auskunft erteilte: Thomas Haußmann, BMVEL, Bonn

- Verbreitung der Waldschäden (regional, Baumarten)
- Entwicklung der Waldschäden
- Belastbarkeit des Ökosystems (Critical Loads)
- Ursachen der Waldschäden
- Wirkungszusammenhänge innerhalb des Ökosystems

Grundlagen zur nachhaltigen Entwicklung von Ökosystemen bei veränderten Umgebungsbedingungen, BITÖK

a) Auskunft erteilte: Prof. Dr. Michael Hauhs, BITÖK, Universität Bayreuth

Die folgende Liste bezieht sich auf die Punkte, die wir als wichtige Meilensteine für die Arbeitsgruppe ansehen. Ich möchte damit keine Antwort auf die Frage nach der Außenwirkung dieser Resultate geben.

1. Ökosysteme sind keine Zustandssysteme, sondern nur über interaktive Schnittstellen zu managen. Dementsprechend sind die Modelle zu entwickeln, wenn es um Fragen der Lenkung, Kontrolle und Bewertung von Ökosystemen geht.

2. Zeitreihen aus hydrologisch definierten Ökosystemen zeigen im Hinblick auf ihren Informationsgehalt eine Charakteristik, die sie von anderen Datensätzen der Umweltforschung unterscheidet. Dieses Ergebnis liefert einen Ansatzpunkt zum Verständnis der oben genannten Probleme der traditionellen Auswertungs- und Modellansätze (dieser Punkt ist offen und in der Diskussion).
3. Erfahrungswissen aus dem (reproduzierbaren) Ökosystemmanagement kann nicht durch naturwissenschaftliche Erkenntnis “de novo” ersetzt, sondern nur im Nachhinein erklärt, kompakt dargestellt und wirksam kommuniziert werden.
4. Vorhersagen, die über die bisherigen Beobachtungen hinausführen, sind darum im Unterschied zu physikalisch/chemischen Systemen nicht möglich.
5. Im Unterschied zu rein physikalisch/chemischen Systemen lässt sich die Geschichte eines gegebenen Ökosystems interaktiv rekonstruieren, wenn die Nutzungsgeschichte auf reproduzierbaren Effekten beruhte.
6. Die bisherige Fixierung der Ökosystem-Modellierung auf Vorhersageziele wird weder dem Problem (veränderte Umwelt von Ökosystemen), noch den vorhandenen Kompetenzen der Praxis, noch den technischen Möglichkeiten der heutigen IT gerecht.
7. Neue nichtlineare Verfahren der Zeitreihenanalyse verfeinern die Entdeckung von Inhomogenitäten in ökologischen und hydrologischen Datensätzen.
8. Für die Beschreibung von Leben (von der Zelle bis zum Ökosystem) kann Interaktivität als eine „ontische” Kategorie betrachtet werden.
9. Der Wechsel von interaktiver Selektion und algorithmischer Berechnung verbindet das Forschungsgebiet des künstlichen Lebens mit dem der Ökosystemmodellierung.
10. Das Konzept der (interaktiven) Modellierung bietet einen Ansatzpunkt zur Operationalisierung von Nachhaltigkeit.

b) Auskunft erteilte: Prof. Dr. Egbert Matzner, BITÖK, Bodenökologie, Universität Bayreuth

- Prognose der Sickerwasserausträge durch Indikatoren ist für einige Mineralstoffe möglich.
- Wechselwirkungen bestehen zwischen N und Zersetzung von Streu sowie der Akkumulation von Humus: Folge erhöhte C-Sequestrierung in Böden.
- Bedeutung von gelösten organischen Komponenten für den C-Umsatz in Waldökosystemen: hoch, vermutlich wichtige Quelle für langfristig im Boden festgelegten C.
- Bedeutung anaerober Prozesse in Böden für den C, N und S Umsatz in Waldökosystemen ist hoch.
- Einfluss von Bestandesstrukturen und klimatischen Randbedingungen auf den Wasserverbrauch der Vegetation kann quantifiziert werden.
- Bedeutung der Deposition von Nebel für die Stoff- und Wassereinträge. Besonders für N bedeutsam.
- Rolle vermoorter Bereiche in der Landschaft für den Stoffhaushalt: Reduktive Prozesse haben eine große Bedeutung.
- Fließwege im Untergrund bestimmen die Dynamik der Qualität des Oberflächenwassers.
- Reversibilität von Boden- und Gewässerversauerung ist verzögert.

- Abnehmende Ca- und Mg-Einträge aus der Deposition machen Kalkungen nach wie vor erforderlich.

IBP (International Biological Programme), NSSE (Nordic Subarctic-Subalpine Ecology), HIBECO (Human interactions with the Mountain Birch Forest Ecosystems) – Fennoscandian Tundra Studies

Auskunft erteilte: Prof. Dr. Wielgolaski, Franz-Emil, Department of Biology, University of Oslo, Norway

The ten most important results from our IBP, NSSE and HIBECO studies in Fennoscandian tundra and Nordic subalpine-subarctic (mountain birch) ecosystems are:

1. Structure, production, functioning and response patterns.
2. Growth form studies as related to water and nutrients.
3. CO_2, light and temperature responses.
4. Nutrient uptake rates as related to growth.
5. Vegetation mapping and phenology.
6. Phenology and growth in mountain birch populations in transect gardens.
7. Climate effects on survival and distribution of autumnal moth and other invertebrates.
8. Population dynamics in small rodent populations.
9. Interaction between birch and undergrowth, and ungulate grazing (sheep, reindeer).
10. Sustainable use of ecosystem resources.

KUSTOS-Projekt (Küstennahe Stoff- und Energieflüsse – der Übergang Land-Meer in der Südöstlichen Nordsee)

Auskunft erteilte: Prof. Dr.Jürgen Sündermann, Institut für Meereskunde, Hamburg

Die notwendige Datenbasis für die empirische Bestimmung von Stoff- und Energieflüssen, für die Formulierung von physikalischen, chemischen und biologischen Prozessen und für den Antrieb und die Verifikation der atmosphärischen und ozeanischen Modelle wurde durch die drei KUSTOS-Zentralexperimente im Frühjahr, Sommer und Winter geschaffen.

Insgesamt sind einmalig vollständige und vielseitige Datensätze gewonnen worden, die eine ausgezeichnete Referenz für die Realitätsnähe und Robustheit von Modellsimulationen darstellen.

Als weitere Beobachtungskampagne wurden Mesokosmos-Experimente im August und September 1995 auf Helgoland durchgeführt. Es wurden einerseits Effekte unterschiedlicher N/P-Verhältnisse bei ausgewählten Salinitäten des Mediums und andererseits Auswirkungen der Spurenstoffe Kupfer und Mangan in Kombination mit Silikat auf die Planktonentwicklung und Kohlenstoffbilanz untersucht.

Die Modellsimulationen bildeten einen integralen Teil von KUSTOS. Sie betrafen Strömungen, Temperatur, Salzgehalt und Schwebstoffkonzentrationen im Wasserkörper, einen limitierenden Nährstoff (Phosphor) sowie die Primärproduktion. Meteorologische Modelle liefern den atmosphärischen Antrieb, Stofftransporte auf dem Luftpfad und Depositionsraten. Ferner gestatten berechnete Rückwärtstrajektorien eine realistische Interpretation von Depositionsmessungen.

Das aus dem PRISMA-Projekt übernommene hydro- und thermodynamische Modell des Wasserkörpers wurde auf die Anforderungen der KUSTOS-Thematik insofern erweitert, dass der küstennahe Bereich inklusive der Watten aufgelöst werden kann. Dafür war es einerseits erforderlich, das Trockenfallen von Wattflächen zu implementieren, andererseits die Wärmeflüsse zwischen dem Watt, der Atmosphäre und dem Wasserkörper bestmöglich zu parametrisieren. Als weiterer Schwerpunkt wurde die Kopplung der meteorologischen Modelle mit den ozeanographischen Modellen gesetzt.

Die hochauflösenden ozeanographischen und meteorologischen Modelle sind zur Simulation der Zentralexperimente eingesetzt worden. Die dabei erzielte Übereinstimmung beobachteter und berechneter hydrographischer Felder ist auch im europäischen Maßstab beispielhaft.

Bezüglich der Biologie wurden ein Wassersäulenmodell und ein horizontales Transportmodell zu einem dreidimensionalen Primärproduktionsmodell für die Nordsee gekoppelt. Insgesamt zeigen die zusammengetragenen Datensätze, dass das Modell die regionalen Strukturen der Phytoplanktondynamik gut abbildet. In der Endphase wurde der Primärproduktionsmodul in das Nordsee-Schwebstofftransportmodell eingesetzt.

Louisiana crayfish, alien species in Portugal: Bioecology, impact and control

Auskunft erteilte: João Carlos Marques, IMAR – Institute of Marine Research, Department of Zoology, Faculty of Sciences and Technology, University of Coimbra, Portugal

- Definition of a best possible strategy for the use of crayfish living in rice fields as a resource.
- Impact, at regional level, on decreasing the pollution due to the use of chemical to eradicate crayfish populations from rice fields.
- Contribution to the development of more holistic ecological indicators of the state of ecosystems.
- Improvement of the interface between modelling and empirical research and between research (as a whole) and decision making.

LTER in Loch Vale Watershed, Rocky Mountain National Park

Auskunft erteilte: Ph.D. Jill S. Baron, U.S. Geological Survey, Natural Resource Ecology Laboratory, Colorado State University, Fort Collins

Slight excess N deposition hat caused subtle but measurable changes in ecosystem nutrient cycling, lake productivity, and aquatic assemblages. The deposition is an order of magnitude lower previously studied, showing the very beginnings of ecological change.

Network for forest ecosystem data in Norwegian Russian border area

Auskunft erteilte: Serguei Koptsik, Faculty of Physics, Moscow State University, Moscow, Russia

1. The use of the two qualitatively different (macroscopic and microscopic) approaches to investigation of ecosystems.
2. Conclusion about the statistical character of the Sverdrup's law (1990) for surface area of coarse-textured soils. Suggestions about an extension of use of this law to the distinct soil components.

3. Estimation of forest ecosystem vulnerability to air pollution in fragile boreal environment in the Northern Fennoscandia.
4. Forest is damaged through both direct am indirect (via soils) effect of air pollution.
5. Demonstrate that subarctic coarse and thin podzols prevailing in the area seem to be highly sensitive to acid deposition. According to the field observation there is no evidence for strong soil acidification effects close to the smelter. That is a result of the geological features of the territory and alkaline dust deposition. However, the deep penetration of acidity, close correlation of exchangeable acidity with base cation content and their depletion form the topsoil, decreased concentrations of exchangeable potassium and magnesium on organic horizons towards the pollution source confirm the started soil acidification in the study area.
6. Model estimation (PROFILE) of soil weathering rates and their steady-state BC/Al values. According to model calculation (SMART) the soils of forest ecosystems will acidify severely within the next 20-30 years unless there are drastic reductions of the SO_2 emissions from the “Pechenganikel” smelter.
7. Calculation and mapping critical loads of acid deposition for forest ecosystems in the Kola Peninsula and in the European Russia.
8. Estimation of plant and soil contamination by heavy metals in forest ecosystems in the Kola Peninsula.
9. The objectively structured patterns (multivariate ordination diagrams) of the ecosystem and soil state and plant-soil relations were obtained.
10. Stressing the significance of soil quality and diversity for plant diversity conservation in terrestrial ecosystems.

Ökosystemforschung im Bereich der Bornhöveder Seenkette

Auskunft erteilte: Prof. Dr. Otto Fränzle, Geographisches Institut der Universität Kiel

1. Quantifizierende Erfassung und Modellierung von Stoff- und Energieflüssen in und zwischen Ökosystemen;
2. paläontologisch und isotopenchemisch unterbaute Analyse der Entwicklung und unterschiedlichen anthropogenen Belastung von Ökosystemen anhand der einen Zeitraum von 9000 Jahren umfassenden saisonalgeschichteten Bodensedimente des Belauer Sees;
3. Vergleich verschiedener Modelltypen für die quantitative Fassung von Stoffströmen zwischen terrestrischen und aquatischen Ökosystemen;
4. Untersuchung der Extrapolationsmöglichkeiten von kalibrierten und validierten Ökosystemmodellen;
5. Bestimmung der Struktur und Funktion terrestrischer, lotischer und lentischer Ökosysteme;
6. Bereitstellung von Daten der Ökosystemforschung für die Umweltprobenbank;
7. Quantifizierung der anthropogenen Energieeinträge in Agrarökosysteme;
8. Bedeutung der atmosphärischen Deposition für den Stoffhaushalt von Forst- und Agrarökosystemen;

9. hochauflösende Analyse der horizontalen und vertikalen Strömungsverhältnisse in holomiktisch-dimiktischen Seen und die damit im Zusammenhang stehenden Stoff- und Energieflüsse;
10. Entwicklung von Szenario- und Expertensystemtechniken für das Ökosystemmanagement.

Ökosystemforschung Schleswig-Holsteinisches Wattenmeer

Auskunft erteilten: Dr. Bernd Scherer, Dr. Adolf Kellermann, Dr. Christiane Gätje, Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer, Tönning

s. auch Kap. 10.2.1

Ergebnisse bitte vgl. Syntheseberichte:

- STOCK M., SCHREY E., KELLERMANN A., GÄTJE C., ESKILDSEN K., FEIGE M., FISCHER G., HARTMANN F., KNOKE V., MÖLLER A., RUTH M., THIESSEN A. & R. VORBERG 1996: Ökosystemforschung Wattenmeer - Synthesebericht: Grundlagen für einen Nationalparkplan. Schriftenreihe Nationalpark Schleswig-Holsteinisches Wattenmeer, Heft 8: 784 S.
- GÄTJE C. & K. REISE (Hrsg.) 1998: Ökosystem Wattenmeer: Austausch-, Transport- und Stoffumwandlungsprozesse. Springer Verl., Berlin, Heidelberg, New York. 570 S.

Produkte sind: Verfahren „Von der Forschung zur Politikberatung", Synthesebericht, Novellierung Nationalparkgesetz, Vorlandmanagement, Eckpunkte Bewirtschaftung Miesmuscheln und öffentlich-rechtlicher Vertrag mit Muschelfischern, Besucherinformationssystem, NationalparkService und MULTIMAR Wattforum, TMAP, Sozio-Ökonomisches Monitoring (SÖM)

PRISMA-Projekt (Prozesse im Schadstoffkreislauf Meer-Atmosphäre)

Auskunft erteilte: Prof. Dr.Jürgen Sündermann, Institut für Meereskunde, Hamburg

PRISMA war der zweite Teil eines längerfristigen Gesamtvorhabens zur Beschreibung, Analyse und Modellierung der Schadstoffdynamik in der Nordsee. Dieser Teil bezieht sich auf die relevanten Prozesse im Ökosystem einschließlich der inneren Quellen und Senken; er zielte entsprechend auf die kleineren räumlichen und zeitlichen Skalen (Kilometer, Stunden). Eine adäquate prozessorientierte Messstrategie wurde in der Deutschen Bucht realisiert (Driftexperimente). Die höhere Auflösung erforderte die Entwicklung einer neuen Klasse mesoskaliger Modelle für den Luftkörper über und den Wasserkörper in der Deutschen Bucht. Wegen der essenziellen Einwirkung des Geschehens in der Nordsee auf die Vorgänge in der Deutschen Bucht musste das Fernfeld weiter im Auge behalten werden.

Es liegen neue Beobachtungsdaten aus fünf Feldexperimenten vor:

- eine Fahrt in die nordwestliche Nordsee zur gezielten Untersuchung der Schadstoffbelastung (Herbst 1990);
- drei prozessorientierte, hochauflösende Messkampagnen in der Deutschen Bucht (Frühjahr, Sommer 1991, Frühjahr 1992) mit Kombination eines regelmäßigen Messrasters und Beobachtungen vom driftenden Schiff (Zentralexperiment);
- eine schwebstofforientierte Messfahrt im Winter 1993.

Es konnte bestätigt werden, dass es am nordwestlichen Ausgang der Nordsee erhöhte Schwermetallkonzentrationen (besonders Cadmium) in Wasser, Schwebstoff und Zooplankton gibt. Wahrscheinliche Ursache ist ein weitreichender atmosphärischer Eintrag im Zusammenwirken mit Auftriebsprozessen an der Schelfkante.

Die Messstrategie einer (Lagrangeschen) Messung vom driftenden Schiff, eingebettet in mobile Umgebungsmessungen und ein festes (Eulersches) Grundraster, konnte wiederholt erfolgreich realisiert werden. Es liegen umfassende synoptische, hochauflösende Datensätze meteorologischer, hydrographischer, chemischer und biologischer Parameter vor.

Die Messfahrt mit Schwerpunkt Schwebstoffuntersuchung diente der experimentellen Bestimmung der Sinkgeschwindigkeiten suspendierter Partikel in der Deutschen Bucht. Das Absinken von anorganischem und organischem Schwebstoff als Funktion von Konzentration und Turbulenzgrad ist ein zentraler Prozess beim Teilchentransport (und damit bei der Ausbreitung angelagerter Schadstoffe, z.B. Blei). Die experimentellen Ergebnisse sind direkt in die Modellformulierungen eingeflossen.

Eine weitere Messserie betraf Mesokosmen, die bei Helgoland exponiert wurden. U.a. wurde nachgewiesen, dass der Schadstoff Kupfer die Artenzusammensetzung des Planktons signifikant verändert, dass dessen Wirkung durch den Nährstoff Silikat aber teilweise neutralisiert wird.

Schließlich seien als Feldexperimente auch noch die Depositionsmessungen für atmosphärische Schadstoffe in der Deutschen Bucht und in der freien Nordsee und das CODAR-Messprogramm zur kontinuierlichen, flächendeckenden Fernerkundung der Oberflächenströmungen östlich von Helgoland genannt. Die luftchemischen Messungen über dem offenen Meer (und deren Interpretation durch begleitende Trajektorienrechnungen) sind einmalig und bestärken die essentielle Rolle atmosphärischer Einträge auch weitab von der Küste. Die CODAR-Messungen liefen operationell über ein halbes Jahr (9.08.1991-10.02.1992); ein vergleichbar umfassender Datensatz liegt an keiner anderen Stelle vor.

Auf der Modellseite wurde eine Hierarchie mesoskalig auflösender Modelle (d.h. unter der Kohärenzskala von ca. 5 km in der Deutschen Bucht) fertiggestellt:

- mesoskaliges Atmosphärenmodell der Deutschen Bucht mit Berücksichtigung von Inseln und Wattflächen, das Zirkulation, Niederschlag, Schadstoffausbreitung und -deposition liefert;
- mesoskaliges, baroklines Strömungsmodell der Deutschen Bucht, angetrieben durch Impuls-, Wärme- und Stoffflüsse aus der Atmosphäre, der angrenzenden Nordsee und den einmündenden Flüssen;
- mesoskaliges Transportmodell der Deutschen Bucht für Schwebstoffe sowie gelöste und partikulär transportierte Schadstoffe;
- dreidimensionales Modell des Ökosystems Deutsche Bucht mit einem limitierenden Nährstoff und Primärproduktion. Die beiden letztgenannten Modelle erhalten ihren Antrieb aus dem dreidimensionalen Strömungsmodell.

Wegen der signifikanten Einwirkung des gesamten nordwesteuropäischen Schelfes auf die Nordsee müssen sowohl die atmosphärischen wie die ozeanischen Mesoskalen-Modelle in entsprechende Fernfeldmodelle eingebettet sein. Diese werden schon fast routinemäßig im Hintergrund betrieben.

Ein vergleichbar umfassendes Modellsystem ist uns bislang bei anderen europäischen Gruppen nicht bekannt.

Auf dieser Basis wurde erstmalig versucht, Jahresbilanzen für einige ausgewählte Schadstoffe für das Gebiet der Deutschen Bucht aufzustellen; es handelt sich um Cadmium, Blei und einige organische Schadstoffe.

SFB 248 Stoffhaushalt des Bodensees, Cycling of matter in Lake Constance

Auskunft erteilte: Prof. Dr. Ursula Gaedke, Institut für Biochemie und Biologie, Universität Potsdam, Potsdam

Im genannten Projekt wurde viel zur Klimafolgenforschung erabeitet, was ursprünglich gar nicht geplant war. Es wurden viele Erkenntnisse zur Reaktion eines komplexen Systems auf veränderte Nährstoffverhältnisse gewonnen. Es wurde Maßgebliches zum grundsätzlichen Systemverständnis erarbeitet und welche Modellierungsstrategien dafür erfolgreich sein können.

SHIFT-Teilprojekt „The Central Amazon Floodplains – Actual Use and Options for a Sustainable Management“

Auskunft erteilte: Prof. Dr. Wolfgang Johannes Junk, Max-Planck-Institut für Limnologie, Arbeitsgruppe Tropenökologie, Plön

- Übertragung des Flutpuls-Konzeptes in die Anwendung. Kosten-Nutzen-Abschätzung unterschiedlicher Nutzungsformen unter Berücksichtigung der Umwelteinflüsse. Empfehlungen für eine multiple nachhaltige Nutzung der Überschwemmungsgebiete am mittleren Amazonas unter Berücksichtigung sozio-ökonomischer Aspekte

SYKON-Projekt (Synthese und Neukonzeption von Nordseeforschung)

Auskunft erteilte: Prof. Dr.Jürgen Sündermann, Institut für Meereskunde, Hamburg

In diesem Projekt ging es nicht darum, eigene Forschungsergebnisse zu erzeugen, sondern die bisherige Nordseeforschung zu evaluieren und künftigen Forschungsbedarf zu formulieren. Als Ergebnisse von SYKON liegen vor:

- 12 aufeinanderfolgende Bände der „Berichte aus dem Zentrum für Meeres- und Klimaforschung“, Reihe Z (ISSN 0947 – Z136) (Auflage 160):

    1. The Changing North Sea – Knowledge, Speculation and New Challenges: Synthesis and new conception of North Sea Research (SYCON); J. Sündermann, S. Beddig, I. Kröncke, G. Radach, K.H. Schlünzen (Eds.). –2001.
    2. Synthesis and new conception of North Sea Research (SYCON): Working Group 1: Data Inventory and Documentation; P. Damm, S. Zabanski, G. Becker. –2001.
    3. Synthesis and new conception of North Sea Research (SYCON): Working Group 2: Hydrodynamical Parameters; T. Pohlmann, H. Lenhart. –2001. Working Group 3: Suspended Particulate Matter; H. Giese, S. Rolinski, J. Sündermann. –2001.
    4. Synthesis and new conception of North Sea Research (SYCON): Working Group 4: Atmospheric Parameters; U. Krell and K. H. Schlünzen. –2001.
    5. Synthesis and new conception of North Sea Research (SYCON): Working Group 5: Fluxes of matter; D.H. Topcu, U. Brockmann. –2001.
    6. Synthesis and new conception of North Sea Research (SYCON): Working Group 6: Review of three-dimensional ecological modelling related to the North Sea shelf systems; A. Moll, G. Radach. –2001.
    7. Synthesis and new conception of North Sea Research (SYCON): Working Group 7: Phytoplankton; U.Tillmann and H.-J. Rick. –2001.
    8. Synthesis and new conception of North Sea Research (SYCON): Working Group 8: Zooplankton; H. Fock, W. Greve, B. Heeren, M. Krause, G. Winkler. –2001.

9. Synthesis and new conception of North Sea Research (SYCON): Working Group 9: Higher Trophic Levels; J. Floeter, A. Temming. –2001.
10. Synthesis and new conception of North Sea Research (SYCON): Working Group 10: Review of the Current Knowledge on North Sea Benthos; I. Kröncke and C. Bergfeld. –2001.
11. Synthesis and new conception of North Sea Research (SYCON): Externe Expertise: Organic Pollutants in the North Sea – Review and assessment of data on input, occurrence, distribution, fate and methods of determination; S. Weigel. –2001. Externe Expertise: Metals in North Sea waters; L. Brügmann. –2001. Externe Expertise: Overview on measurements and monitoring of air-sea exchange of anthropogenic inorganic compounds in the North Sea region; M. Schulz. –2001. Externe Expertise: Organische Schadstoffe in der Atmosphäre der Nordsee; K. Bester. –2001.
12. Synthesis and new conception of North Sea Research (SYCON): Externe Expertise: Bakterioplankton; K. Poremba. –2001. Externe Expertise: Geochemical processes; B. Behrends. –2001.

- 9 aufeinanderfolgende Bände von „Senckenbergiana maritima“ (erscheinen 2002) (Auflage 600)
- Die Broschüre „Die Nordsee – Gefährdungen und Forschungsbedarf“ (Auflage: 10.000)

Verbundprojekt „Veränderungsdynamik von Waldökosystemen“

Auskunft erteilte Dr. Michael Bredemeier, Forschungszentrum Waldökosysteme Göttingen

s. auch Kap. 10.2.3

- Ausweisung vollständiger Ionenbilanzen mit Quantifizierung der internen und externen Protonenquellen
- Mobile Lysimetersonde
- Experimentelle Ökosystemmanipulation mit Dachkonstruktionen und gesteuertem Wasser- und Elementinput
- Befahrung des Kronenraumes mit einem Messkran im Dachprojekt Solling
- Beschreibung der Reversibilität von Versauerungsparametern unter entsauernder Beregnung
- Untersuchung von Effekten starker Austrocknung im Dachexperiment
- Charakterisierung der Dynamik langfristiger biogeochemischer Messreihen aus Waldökosystemen als Diagnosewerkzeug für Ökosystemzustand und -trend (Risikoabschätzung)
- Globale Szenarienanalyse für die Verfügbarkeit von (Brenn)holzressourcen
- Globale Szenarienanalyse der Landnutzung und Bodenzerstörung
- Identifikation stofflicher bzw. bodenbezogener Indikatoren für die nachhaltige, multifunktionale Waldnutzung

WET

a) Auskunft erteilte: Dr. Michael Trepel, Ökologie-Zentrum der Universität Kiel

- praxistaugliches Messprogramm für Stoffretention in Niederungen
- mehrstufiges Modellkonzept (siting- sizing desiging – monitoring)
- Integration von Biologen, Hydrologen, Geographen und Hydroingeneuren

b) Auskunft erteilte: Prof. Dr. Giuseppe Bendoricchio, University of Padova – DPCI, Italy

- look at wetlands as ecosystems and not as treatmant plants
- use of models in wetlands designing
- emphasis on multipopose designing

ZISCH-Projekt (Zirkulation und Schadstoffumsatz in der Nordsee)

Auskunft erteilte: Prof. Dr.Jürgen Sündermann, Institut für Meereskunde, Hamburg

Zwei umfassende Aufnahmen von Schadstoffen, Nährstoffen und weiteren Ökosystemparametern für die Atmosphäre, das Wasser, die Schwebstoffe, die Sedimente und die Organismen wurden für die ganze Nordsee durchgeführt. Diese Messungen wurden begleitet mit Simulationsmodellen, die Aufschluss über Herkunft und Verbleib der Stoffe ergaben. Wichtige Aussagen des Projektes betrafen:

- Konzentrationsverteilungen sowie saisonale und interannuelle Variabilität von physikalischen, chemischen und biologischen Parameter. Die gesamte Nordsee ist mit Schadstoffen belastet, aber die verschiedenen Regionen sind unterschiedlich betroffen. Im allgemein sind die Küstengebiete stärker belastet als die zentrale Nordsee. Insbesondere die Deutsche Bucht wird durch Flusseinträge belastet. Die mittlere Strömung (gegen den Uhrzeiger) bewirkt, dass Einträge aus Großbritannien, Belgien und den Niederlanden später die deutsche und dänische Küste erreichen. In einigen Ökosystemkompartimenten wurden aber Konzentrationsmaxima weitab von den Küsten gefunden (z.B. Cd-Konzentrationen in Einsiedlerkrebsen).
- Schwermetallmessungen zeigten, dass die Atmosphäre ein wichtiges Transportmedium für Schadstoffe in der Nordsee ist.
- Modellsimulationen der Stoffausbreitung zeigten gute Übereinstimmung mit den Messdaten. Darüber hinaus konnten die Modelle Aussagen zu Variabilitäten der Schadstoffbelastung aufgrund von Wetterfluktuationen machen. Die Variabilität ist so groß, dass - unter konstanten Eintragsbedingungen – die Konzentrationen von sehr niedrig bis sehr hoch sein können.
- Gelöste Schadstoffe mit hinreichend konservativen Eigenschaften verlassen die Nordsee in 2-4 Jahren. Für den überwiegenden Anteil der Schadstoffe, der mit Partikeln assoziiert ist, ist die Residenzzeit 10-100 Jahre. Die Norwegische Rinne wirkt wie eine Art „Endlager“ für kontaminierte Sedimente, die aber bei veränderten Bedingungen (wie Klimawechsel) wieder mobilisiert werden können.
- Kriterien wurden erarbeitet, nach denen die statistische Belastbarkeit von Messdaten aus dem hochvariablen Ökosystem geprüft werden können bzw. optimale Messstrategien entwickelt werden können.

10.2 Auskünfte auf direkte Anfrage

10.2.1 Ökosystemforschung im Schleswig Holsteinischen Wattenmeer - Anwendungserfolge

Ergebnisse der Ökosystemforschung haben zur Novellierung des Nationalparkgesetzes geführt und maßgeblichen Einfluss auf die Inhalte gehabt. Dazu gehören u.a. die

- Seewärtige Erweiterung des Nationalparkes und die

- Zonierung innerhalb des Nationalparks
  - Neuschneidung der Zone 1 auf der Basis von Wattstromeinzugsgebieten,
  - Einrichtung einer Nullnutzungszone (Referenzgebiet) und
  - Einrichtung eines Schutzgebietes für den Schweinswal (*Phocoena phocoena*).

Das Trilaterale Wattenmeermonitoring- und Bewertungsprogramm (TMAP), das auch zur Erfolgskontrolle des Trilateralen Wattenmeer-Managementplans dient, ist im Wesentlichen aus der Ökosystemforschung heraus entwickelt worden.

Ergebnisse der Ökosystemforschung haben maßgeblich die Inhalte des Schleswig-Holsteinischen Programms zur Bewirtschaftung der Muschelressourcen im Nationalpark bestimmt, das einen weitgehenden Schutz des Lebensraumes sowie eine Aufwandsbegrenzung bei gleichzeitiger Berücksichtigung der betriebswirtschaftliche Belange und einer langfristigen Sicherung der Ertragsgrundlage der Fischerei gewährleistet.

Ergebnisse der Ökosystemforschung haben die Grundlagen für das gemeinsame Vorlandmanagementkonzept gelegt, das zwischen Landwirtschaftsministerium und Nationalparkamt vereinbart und umgesetzt wurde und das einen pragmatischen Ansatz für die Zusammenarbeit zwischen Küstenschutz und Naturschutz darstellt.

Ergebnisse der Ökosystemforschung waren Grundlage des Besucherlenkungs- und Informationssystems (BIS), das in Zusammenarbeit von Nationalparkamt, NationalparkService GmbH, Gemeinden und Ämtern für ländliche Räume umgesetzt wurde. Es hilft den Gästen, sich zu orientieren, verbessert die Naturerlebnismöglichkeiten im Nationalpark und minimiert Störungen und Belastungen der Natur. Damit leistet es einen Beitrag zur Entschärfung der Konflikte zwischen Naturschutz und Tourismus. Ökosystemforschungsergebnisse hatten außerdem maßgeblichen Einfluss auf die Schaffung des NationalparkService sowie auf die Entwicklung des größten Nationalpark-Infozentrums Multimar Wattforum.

Ergebnisse der Ökosystemforschung haben dazu beigetragen, sozio-ökonomische Aspekte im Management stärker zu berücksichtigen und entsprechende Parameter im Monitoring (Sozio-ökonomisches Monitoring - SÖM Watt) zu verankern.

Entscheidende Erfolgsfaktoren:

Konzept: Das von LEUSCHNER (1988) für die Ökosystemforschung Schleswig-Holsteinisches Wattenmeer entwickelte Forschungskonzept sah einen interdisziplinären anwendungsbezogenen Ansatz vor, der naturwissenschaftliche und gesellschaftswissenschaftliche Fragestellungen integrierte. Die Forschungsziele leiteten sich aus den Schutz- und Entwicklungsaufgaben des Nationalparkes ab und wurden vom Nationalparkamt definiert. Aufgrund der anwendungsbezogenen Konzeption wurden bereits während der Laufzeit des Projektes praktisch umsetzbare Forschungsergebnisse und Handlungsempfehlungen bereitgestellt, die direkt für die Lösung von Konflikten und für die Entwicklung und Optimierung von Schutzkonzepten genutzt werden konnten. Die problem-orientierte Erarbeitung von wissenschaftlich fundierten Entscheidungsgrundlagen sollte eine auf Langfristigkeit angelegte, vorausschauende Umweltpolitik ermöglichen. Bereits im Konzept wurde klargestellt, dass dies am Ende auch auf Neufassungen von (gesetzlichen) Regelungen zielen kann.

Projektmanagement: Den gesamten Prozess koordinierte ein Team aus drei WissenschaftlerInnen (sog. „Steuergruppe"), die im Nationalparkamt angestellt und in die Arbeitsabläufe der Behörde eingebunden waren. Dies war von entscheidender Bedeutung für die direkte

Anwendbarkeit wissenschaftlicher Ergebnisse schon während der Projektlaufzeit und für die Umsetzung der auf Forschungsergebnissen basierenden Schutz- und Management-Konzepte in Verwaltungshandeln. Die Steuergruppe fungierte als Schnittstelle und erlaubte permanente Rückkopplung und iterativen Austausch von Informationen und Diskussionen zwischen Wissenschaft und Verwaltung. Sie hat sich dabei durch ihre Nähe zu beiden Bereichen als Instrument der Projektlenkung, -koordination und -kommunikation bewährt. Diese Struktur hat außerdem die Voraussetzungen für eine optimale Abwicklung eines Projektes dieser Größenordnung in organisatorischer und haushaltstechnischer Hinsicht geschaffen, so dass z.B. der komplette Projektabschluss inkl. Abgabe des Schlussberichtes pünktlich zum Projektende erfolgen konnte.

10.2.2 Transfer aus der Ökosystemforschung (ÖSF) im niedersächsischen Wattenmeer

(Persönliche Äußerung von Prof. Dr. Thomas Höpner)

1. Transfer in Trilaterale Kooperation

Beiträge zu TMAP, TMAP-Datenbank, (Trilaterales Monitoring and Assessment Programme)

2. Transfer in Gesetze und Verordnungen etc. des Landes und des Bundes

- Befahrensregelung 1994 (auf Basis von GIS-Konfliktkarten)
- Miesmuschel-Managementplan 1999
- Vorland-Managementpläne Krumhörn bis Norddeich
- Biosphärenreservat, Weltnaturerbe

An Land Niedersachen, jedoch dort nicht umgesetzt: Entwicklungszone des Bioshärenreservats, Vorarbeiten für Nationalparkgesetz-Novellierung, neue Zonierung, Referenzgebiet, Nationalparkplan.

3. Anschluss-Forschung

national:

- Schadstoffmonitoring mit Seevögeln, IfV 1995 – 1998, Nds. Wattenmeer-Stiftung.
- BMBF-Küstenländer-Forschungsprogramm „Klimaänderung und Küste“, Koordination und diverse Einzelvorhaben; ICBM 1995-1999.
- DFG-Schwerpunktprogramm „Wandel der Geo-Biosphäre während der letzten 15.000 Jahre“; diverse Einzelvorhaben; ICBM 1995-1999.
- Eiswinter 1995/96. ICBM 1996. BP.
- Schwarze Flächen 1996. ICBM 1996. UBA, NP.
- Nahrungskonsumption von Wat- und Wasservögeln im Nds. Wattenmeer. IfV ab 1997.
- BMBF-Projekt „Datenintegration und Qualitative Dynamik im System Wattenmeer“; ICBM 1998-2001.
- Auswirkungen von TBT auf die Blutphysiologie von Möven. IfV ab 1999.
- DFG-Forschergruppe „BioGeoChemie des Watts“; Koordination und diverse Einzelvorhaben; ICBM 2001 bis 2004, Verlängerung bis 2007 in Aussicht gestellt.

international:

- Langzeitbeobachtungen im Wattenmeer des arabischen Golfes nach der Ölkatastrophe, ICBM 1991 – 2001. EU, BMFT, DGG.

- EU-Projekt “SeaGIS – GIS for coastal zone planning and management”; ICBM 1999-2001.
- LANCEWAD - Landscape and Cultural Heritage in the Wadden Sea Region, CWSS, NP 2001.

4. Umweltverträglichkeitsstudien durch ÖSF-Teams

- EUROPIPE 1993 – 1994. Team aus ÖSF und NP.
- Bohr- und Förderplattform in den Blöcken A6/B4 der deutschen Nordsee 1998. ARSU GmbH.
- Pipeline Mittelplate – Dieksand. 2002. ARSU GmbH.

Anmerkung: Vollständigkeit ist trotz Umfragen nicht garantiert. Rückfragen: thomas.hoepner@icbm.de. Der Berichterstatter hat den subjektiven Eindruck, dass die Bereitschaft zur Übernahme von ÖSF-Erkenntnissen und –Ergebnissen in Verordnungen und Gesetze etc. in Schleswig-Holstein besser ist als in Niedersachsen.

10.2.3 Anwendungserfolge der Ökosystemforschung in Göttingen und ihre Auswirkungen auf Politik, Verwaltung und Gesetzgebung

Der Schwerpunkt der Göttinger Ökosystemforschung liegt auf der Waldökologie. Die Göttinger Waldökosystemforschung wurde sehr früh initiiert, ab Mitte der 60er Jahre im Rahmen des Solling-Projekts als Teil des MAB-Programms (Man and the Biosphere). Die führenden Wissenschaftler waren der Geobotaniker Prof. Ellenberg und der Bodenkundler Prof. Ulrich. Entsprechend lagen und liegen heute noch die Schwerpunkte der Göttinger Ökosystemforschung auf der Ökophysiologie und dem Stoffhaushalt von Wäldern. In der Stoffbilanzierung hat Göttingen konzeptionelle und methodische Pionierarbeit geleistet, die weltweit adaptiert wurde. Im Einzelnen lassen sich folgende Anwendungen bzw. Umsetzungen der Göttinger Forschung benennen:

- Messreihen und Datensätze von den Experimentalflächen, die in ihrer zeitlichen Länge weltweit einmalig sind und vielfach als Referenzdatensätze dienen,
- Motivation zur Einführung des bleifreien Benzins (Benzin-Blei-Gesetz),
- Motivation zur Einführung der Großfeuerungsanlagen-Verordnung und damit die Begrenzung der SO_2-Emission,
- Forderungen nach weiteren Maßnahmen zur Senkung der Stickstoffeinträge,
- Kalkungsempfehlungen für die forstliche Praxis,
- Hypothesen über die Entwicklung von Waldökosystemen finden zunehmend Eingang in die forstliche Planung und Praxis (Waldumbauprogramme: Reinbestände zu Mischbeständen).
- Der in Göttingen entwickelte Messansatz ist für das Monitoringprogramm der EU übernommen worden (Level II). Heute werden an mehr als 800 Stellen in Europa Depositionsmessungen nach diesem methodischen Muster durchgeführt.
- Maßgebliche Beteiligung an der Konzeption der bundesweiten bodenchemischen Zustandserhebung im Wald (BZE),

- Erholung des Waldes bei konsequenter Luftreinhaltepolitik möglich (Dachexperimente im Solling),
- Lachgasproblematik wird im Solling seit 10 Jahren messend verfolgt.
- Kooperationsabkommen zwischen dem Niedersächsischen Ministerium für Ernährung, Landwirtschaft und Forsten und der Fakultät für Forstwissenschaften und Waldökologie über das langfristige Projekt „Forschungslandschaft Solling“

APPENDIX 11: THE ECOSYSTEM RESEARCH IN THE WADDEN SEA AND THE MALAWI PRINCIPLES

only available in german

nach OESCHGER 2000

Das Vorhaben Ökoystemforschung Wattenmeer begann 1989 und damit vor Verabschiedung der Biodiversitätskonvention 1992 und dem internationalen Workshop in Malawi im Januar 1998, auf dem die 12 Prinzipien zur Implementierung des ökosystemaren Ansatzes verabschiedet wurden. Dennoch zeigte die Fallstudie Ökosystemforschung Wattenmeer, dass das Forschungsvorhaben in zahlreichen seiner Ansätze den Malawi-Prinzipien gefolgt ist. Dies soll im Folgenden in verkürzter Form deutlich gemacht werden.

1. Management-Ziele sind Sache der Gesellschaft.

Bei der Erstellung von Managementkonzepten traten Konflikte zwischen den einzelnen Interessengruppen auf, vor allem zwischen Naturschützern und Fischern. Durch entsprechende Öffentlichkeitsarbeit und Umweltbildung konnte die allgemeine Ablehnung, die in der Gesellschaft gegen die Naturschutzpläne anfangs aufkam, minimiert werden und eine größere Akzeptanz geschaffen werden. Damit wird deutlich, dass Managementziele nur umgesetzt werden können, wenn die Interessen der Öffentlichkeit mitberücksichtigt und die Konzepte akzeptiert werden.

2. Management sollte bis zur niedrigsten angemessenen Ebene dezentralisiert werden, wobei es notwendig ist, in jedem speziellen Fall zu untersuchen, welches das angemessenste Verhältnis zwischen Dezentralisierung und Zentralisierung für Ökosystemmanagement ist.

Durch dezentrales Management können einzelne Besonderheiten der betroffenen Regionen besser berücksichtigt werden. Dies bildet die Grundlage für eine Einbindung der einzelnen Interessengruppen vor Ort bei lokalen Problemlösungen. Dezentrales Management war bei dem Vorhaben durch die Aufteilung in obere und untere Naturschutzbehörden gegeben. Zentrale Steuergruppen sorgten gleichzeitig dafür, dass die übergeordneten umweltpolitischen Anforderungen erfüllt wurden

3. Ökosystemmanager sollten die Auswirkungen ihrer Aktivitäten auf benachbarte und andere Ökosysteme berücksichtigen.

Dieses Prinzip ist von großer Wichtigkeit und erfordert eine genaue Kenntnis der Wechselwirkung zwischen Ökosystemen. Bei der Ökosystemforschung Wattenmeer wurde versucht, dieses Prinzip gebührend zu berücksichtigen. Durch die Extensivierung der Salzwiesenbewirtschaftung und ihre Auswirkungen auf Brut- und Rastvögel wurden zum Beispiel die Funktionen anderer Ökosysteme in die Aufstellung von Managementplänen miteinbezogen. In anderen Bereichen wie der Garnelenfischerei lassen sich nicht alle indirekten Effekte abschätzen, so dass die Verwirklichung dieses Prinzips nur im Ansatz verwirklicht ist.

4. Um potenzielle Gewinne durch das Management zu erkennen, ist es notwendig, Ökosysteme im ökonomischen Kontext zu verstehen. In der Ökonomie sollte:
   a) der Anreiz gesteigert werden, die nachhaltige Nutzung zu unterstützen,

b) diejenigen Marktverzerrungen gemindert werden, welche die biologische Vielfalt negativ beeinflussen;
c) Kosten und Nutzen in den Ökosystemen in jeweils möglichen Maße internalisiert werden.

Durch staatliche Subventionspolitik kann es Marktverzerrungen geben, die unter Umständen Handlungen nach sich ziehen, die der biologischen Vielfalt schaden können. Im Nationalpark Wattenmeer spielt dieser Faktor eine untergeordnete Rolle. Das Management sollte so ausgelegt sein, dass bei einer nicht nachhaltigen Nutzung für die daraus entstehenden Schäden finanziell aufgekommen werden muss. Der Kosten-Nutzen-Faktor wurde zum Beispiel bei der Garnelenfischerei und dem Tourismus verwirklicht: Durch eine freiwillige Fangbeschränkung in der Garnelenfischerei konnte ein Zusammenbruch der Bestände – und somit der Lebensgrundlage der Fischer – verhindert werden; durch eine entsprechende Beschränkung der touristischen Nutzung auf ausgewiesene Bereiche konnte eine Übernutzung, die dem Fremdenverkehr geschadet hätte, verhindert werden.

5. Schutz von Ökosystemstrukturen und –funktionen

Um den Schutz der Strukturen und Funktionen eines Ökosystems zu gewährleisten, ist es notwendig, stetig über den aktuellen Zustand des Ökosystems informiert zu sein. Dies ist im Wattenmeer durch Forschung und Umweltbeobachtung gegeben. Durch die grundlagenorientierten Teile der Wattenmeerforschung konnte die Bedeutung des Prozessschutzes bestätigt werden.

6. Management der Ökosysteme muss innerhalb ihrer Funktionsgrenzen stattfinden.

Die Grenzen der Nachhaltigkeit sind beim Management von Ökosystemen unbedingt zu beachten. Diese können durch vorübergehende, unvorhersehbare oder künstlich aufrecht erhaltene Bedingungen (z.B. Deichbau) gegeben sein. Im Fall des Wattenmeeres wurde als unvorhersehbares Ereignis im Rahmen von ELAWAT der Eiswinter in die Untersuchungen miteinbezogen. Der Forderung nach einer schonenden Bewirtschaftung wurde im Wattenmeer in allen Bereichen nachgekommen.

7. Der Ökosystemare Ansatz sollte auf einem angemessenen Maßstab angewendet werden.

Ökologische Prozesse laufen auf verschiedenen räumlichen und zeitlichen Skalen ab. Das Management des Ökosystems muss dies berücksichtigen. Im Wattenmeer wurde dies durch die zeitlich begrenzte Sperrung der Brutvogelgebiete einerseits sowie die dauerhaften Sperrungen anderer Regionen andererseits verwirklicht.

8. Ziele des Ökosystemmangements sollten Langzeitziele sein, wobei die sich verändernden zeitlichen Skalen und Randeffekte, die ökosystemare Prozesse charakterisieren, beachtet werden müssen.

Dieses Prinzip entspricht der Idee der Nachhaltigkeit. Durch die Verfassung eines langfristig ausgerichteten Nationalparkplanes für das Wattenmeer wurde dieser Grundsatz berücksichtigt.

9. Management muss erkennen, dass Veränderungen unvermeidlich sind.

Ökosysteme haben mehrere potenzielle Zukunftsmöglichkeiten, die ungewiss sind. So muss auch das Management flexibel und anpassungsfähig sein. Das Wattenmeer ist von Natur aus ein besonders dynamisches System, was im grundlagenorientierten Teil des Vorhabens eingehend untersucht wurde. Die Veränderungen, die durch Faktoren wie die steigende Zahl von Touristen und das Einschleppen gebietsfremder Arten sind aber bisher sehr schwer abzuschätzen, sollten aber unbedingt berücksichtigt werden.

10. Der Ökosystemare Ansatz sollte nach dem angemessenen Verhältnis zwischen Schutz und Nutzen der Biodiversität streben.

Auf ein angemessenes Verhältnis von Schutz und Nutzen der Biodiversität wurde in vielen Bereichen hingearbeitet. Dazu zählen die Extensivierung der Salzwiesenbewirtschaftung, die mit einer Zunahme seltener und gefährdeter Arten einhergeht, sowie das Management der Muschelressourcen, das von völlig geschützten Bereichen über eingeschränkte Nutzung von Wildbänken bis zu angelegten Kulturbänken reicht. Trotzdem fehlen die wissenschaftlichen Grunddaten über das tatsächliche Gleichgewicht zwischen Schutz und Nutzung und über die Wirkung der getroffenen Maßnahmen zum Erreichen dieses Zieles.

11. Der Ökosystemare Ansatz sollte alle Formen relevanter Informationen miteinbeziehen. Beinhalten sollten diese wissenschaftliches, einheimisches und lokales Wissen, Innovationen und Bräuche.

und

12. Der Ökosystemare Ansatz sollte alle relevanten Bereiche der Gesellschaft und alle wissenschaftlichen Disziplinen beteiligen.

Um dem Ökosystemaren Ansatz Rechnung zu tragen, ist es unabdingbar, alle Interessengruppen in das Management zu integrieren. Dies bezieht sich sowohl auf einen ausgeprägten Informationsfluss zwischen den einzelnen Gruppen, als auch auf die Eingliederung aller in die Entscheidungsprozesse. Obwohl diese Vorgaben sehr allgemein formuliert sind, halfen diese Prinzipien im Wattenmeermanagement bei der Konsensfindung zwischen den einzelnen Parteien.