Auditing the Ark

Science based Monitoring of Biodiversity

Report of a Electronic Conference, September 2002

BIOplatform

EPBRS EUROPEAN PLATFORM FOR BIODIVERSITY RESEARCH STRATEGY

Danish Biodiversity Platform

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

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This publication should be cited as follows:

Young, J., Esteban, A., Iversen, T.M. and Watt, A.D. (Editors) 2002 *Auditing the Ark – science-based monitoring of biodiversity, report of an electronic conference.* National Environmental Research Institute, Silkeborg.

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Preface

Research on biodiversity is essential to help the European Union and EU Member States to implement the Convention on Biological Diversity as well as other biodiversity related directives. There is a need for co-ordination between researchers working in this field, the policy-makers that need the research results and the organisations that fund research in this field.

BioPlatform is a network of scientists and policy makers that work in different fields of biodiversity and aims at improving the effectiveness and relevance of European biodiversity research, fulfilling functions that provide significant components of a European Research Area. BioPlatform supports the existing “European Platform for Biodiversity Research Strategy” (EPBRS), a forum of scientists and policy makers representing the EU countries, whose aims are to promote discussion of EU biodiversity research strategies and priorities, exchange of information on national biodiversity activities and the dissemination of current best practices and information regarding the scientific understanding of biodiversity conservation.

This is a report of the BioPlatform E-conference entitled “Auditing the Ark- science based monitoring of biodiversity” preceding the EPBRS meeting to be held under the Danish Presidency of the European Union in Silkeborg, Denmark from the 4th to the 6th October 2002. This meeting will discuss the current state of monitoring of biodiversity, consider how it may be improved and, in line with the main objective of EPBRS, identify priorities for research on biodiversity monitoring.

This report contains the introduction to the e-conference, a summary of the contributions to it and the conference final discussion and conclusions. This version of the report does not contain the full text of all contributions but a list of titles and authors is included in an annex.

Introduction

Allan Watt

Given widespread concerns about declining global biodiversity, the amount of effort spent on monitoring biodiversity is shamefully small. Yet how can we identify the factors that threaten biodiversity, accurately assess the scale of their impacts or devise policies that effectively conserve or use biodiversity sustainably without adequate information on the status and trends in biodiversity? And how do we get that information without monitoring? There are exceptions, of course, and in this electronic conference we will hear about a few monitoring initiatives. But information on trends in biodiversity is nearly everywhere inadequate. This is apparent from national reports on the implementation of the Convention on Biological Diversity. These show that only 1% of the Parties to the CBD have "comprehensive" monitoring programmes in place, 2% have a "comprehensive understanding" of activities that have an adverse effect on biodiversity, 6% are monitoring these activities and their effects and only 6% have identified national indicators of biodiversity.

Although the current state of monitoring may result from a lack of political will, inadequate research also contributes. Indeed it may be argued that research scientists have neglected this problem. A sample of the literature reveals that of 6,000 research papers published in scientific journals on biodiversity since 1997, less than 10% are even tangentially relevant to monitoring.

The aims of this e-conference, organised by the BioPlatform project, were:

1. To identify the major reasons for monitoring biodiversity.
2. To discuss some existing and planned biodiversity monitoring programmes, identifying their strengths and weaknesses.
3. To identify some developments in monitoring biodiversity and the advantages they offer.
4. To discuss the development of a core programme of biodiversity monitoring across Europe; what are the priorities for monitoring and what major gaps exist?
5. To identify where research should be focussed to develop monitoring programmes that best meet the needs of users, including the development of a core programme of biodiversity monitoring across Europe?

Summary of contributions

Juliette Young

Session 1: *To identify the major reasons for monitoring biodiversity.*

Although a review of international reporting obligations relating to biodiversity made by Gemma Smith and Adrian Newton (UNEP) indicates that relatively few require trend data on biodiversity leading to few legislative requirements for biodiversity monitoring at the international scale, most contributors in this session reached a consensus on the importance of biodiversity monitoring.

The roles of biodiversity and the threats it faces were clearly pointed out by Thomas Bolger (University College, Dublin) who also argued that more research should be done to understand the earth's "life support" systems better, all the while accepting that ecosystem monitoring was difficult to achieve. According to Ant Maddock (JNCC), a major reason for monitoring is to "ensure that biodiversity survives in perpetuity". Agreeing with Thomas Bolger, he also thought that monitoring should encompass the operation of natural processes such as gene flow, pollination, dispersal, predation, decomposition, as well as energy cycling, harvesting techniques and farmland management.

For Paul Rose (JNCC), monitoring of biodiversity was essential to "identify priorities for action, define the actions and carry them out". Most following contributions by Horst Korn, Richard Bradshaw, Thomas Bolger, Dominique Richard & Sophie Conde, and Jeremy Wilson and Ian Bainbridge agreed with him as to the importance of monitoring biodiversity in order to increase our knowledge about biodiversity and be able to predict and act upon anthropogenic threats to biodiversity.

Many contributors in this session also noted that monitoring should be integrated. Paul Rose considered that global monitoring coordinated by Multilateral Environmental Agreements and NGOs could be best achieved by aggregating monitoring schemes organised at a smaller, national scale whilst Horst Korn (Federal Agency for Nature Conservation), agreeing on the idea of integrating local, national and international level monitoring schemes, also emphasised the need for simple, long term monitoring programmes that would generate policy relevant data and build on existing systems and the need for data sets to focus on the external pressures affecting biodiversity. Dominique Richard and Sophie Condé (EEA) stressed the need for a global or at least EU scale monitoring scheme to be put in place in order to analyse the full effects of policies on biodiversity conservation and to involve decision-makers and the general public in conservation and predict possible changes. They also gave a review of schemes (both at the NGO level and EU level) already underway in Europe that could help in coordinating data collection in Europe and analysing the effects of EU policies, including the aim to stop biodiversity loss by 2010. Romain Julliard and Frederic Jiguet looked at the possibility that a better relationship between coordinators and observers could yield efficient monitoring programmes, which could help national schemes to interpret their finding, as well as elaborating European biodiversity indicators.

A few authors looked more specifically at monitoring schemes already in place. For example, Lilian van der Bijl and Torben Moth Iversen (National Environmental Research Institute of Denmark) described the implementation of the Danish National Monitoring Programme, an integrated nation-wide programme for monitoring of terrestrial habitats, water bodies and the biodiversity within these. The overall objectives are to establish the status of terrestrial habitats and water bodies and their pressures and are then used to determine the order of priority of monitoring needs established by the Danish Forest and Nature Agency. The authors also highlight the need to develop identical indicators for all levels in order to reach national action plans and international targets. This last step requires national and international agreement on methodologies for data collection, analysis, and data handling and on streamlining reporting by means of policy relevant core indicators. In response to their contribution, Richard Bradshaw (Geological Survey of Denmark and Greenland) argued that although monitoring of biodiversity should be related to the driving forces for change as they propose, different indicators were appropriate for the different spatial scales.

The concept of indicator species and their integration was discussed in Wilson and Bainbridge's (RSPB and Scottish Executive) contribution. They pointed out that a number of indicators had already been adopted at the UK level to monitor the current state of the environment and the environmental pressures that threaten biodiversity. They also claimed that monitoring should be done for a variety of different habitats in order to get a broader view.

Mikko Kuussaari (Finnish Environment Institute) emphasised the need to monitor agro-ecosystem, especially in view of the reform of the EU's Common Agricultural Policy (CAP) and the inclusion of new members into the EU. As an example of current agro-ecosystem monitoring he describes the Finnish initiative of monitoring plants, butterflies, bumblebees, birds and landscape structure in randomly selected agricultural landscapes. The monitoring aims at following the effects of the current Finnish agro-environmental support scheme and producing basic knowledge on factors affecting farmland biodiversity to further develop the Finnish agro-environmental programme in the future. The need to monitor agro-ecosystems was also taken up by Davy McCracken (Scottish Agricultural College) who noted the dynamic nature of farmland, and the need for monitoring programmes to ensure that information relating to temporal changes occurring in the agricultural landscape was gathered. He also recommended that monitoring programmes should stop focussing on particular habitats or features (such as farmland, woodland, river corridors) in isolation but instead consider and quantify the importance of the interactions between all of these elements (farmed and non-farmed) in the landscape.

Both Richard Bradshaw and Beti Piotto looked at the scope of monitoring and how it could help certain particularly vulnerable habitats. Richard Bradshaw identified the main reasons for long-term monitoring of biodiversity as being the establishment of 'natural' variation (such as fires, storms…) and 'base-line' conditions, the identification of biogeographical regions that are particularly sensitive to irreversible loss of biodiversity such as North West Europe, and finally as a tool for following the effects of management on biodiversity development. Beti Piotto (ANPA) also emphasised the need to have a deep knowledge of the subject to monitor, as a single 'segment' of the problem showing gaps of knowledge could lead to reduction of biodiversity levels. Still on the topic of forest biodiversity conservation, Valerie Kapos (UNEP) argued that in order to support decision-making effectively, monitoring efforts of forest biodiversity should focus on parameters that are directly relevant to policy and management goals.

Peter Veen (Royal Dutch Society for Nature Conservation) on the other hand looked at the advantages of the ecosystem approach as a framework for understanding biodiversity in order to understand the trends of biodiversity more coherently. Many contributors outlined the need for comparable data and standardised protocols. In this perspective, Laurent Berges and Marion Gosselin (Cemagref) propose to use a single local sampling effort (time spent and area sampled for one plot) and to reduce observer bias as far as possible.

Scot Mathieson of the Scottish Environment Protection Agency concentrated on river biodiversity monitoring, principally of river invertebrates, which is undertaken primarily to monitor the effectiveness of legal controls, from UK and European statute, on effluent discharges, and to report on the state of the river environment in the UK. He pointed out that future needs, driven by the EU Water Framework Directive, would require an expanded monitoring network, with the inclusion of fish, algae and macrophytes. Laurence Carvalho (CEH) also looked at the Water Framework Directive and agreed that major improvements in the monitoring of biodiversity could be delivered although he also stated that its effectiveness would greatly depend on the interpretation of "good ecological status" and the development of a more strategic monitoring framework that identifies nature conservation as one of its core values. He also touched on the issue of indicators by stating that macrophytes would appear to be the most suitable general measure of biodiversity.

Session 2: *To discuss some existing and planned biodiversity monitoring programmes, identifying their strengths and weaknesses.*

Taking the example of a successful new French breeding bird monitoring scheme involving voluntary amateur groups gathering data pooled together by national coordinators, Romain Julliard and Frederic Jiguet (CRBPO) argued that the lack of monitoring success was not due to the "shamefully poor…amount of effort spent on monitoring biodiversity" but rather to the poor relationship between national coordinators and observers. Caspian Richards (Macaulay Institute) then argued that these schemes involving amateur naturalist groups who collect data on a voluntary basis could be a cheap and effective way of monitoring biodiversity, but the main drawback was persuading many professional researchers and especially policy-makers/administrators that amateur groups were a credible source of scientific data. The idea of involving volunteers in monitoring schemes was also taken up by Tomas Coll and Robert Kenward (NERC). The latter acknowledged the advantages this could bring, but did insist that in order to optimise the results of such a venture, it was essential for professionals to provide guidance in sampling and recording, compile and calibrate their data and develop new techniques, create hypotheses about causation of processes, arrange experimental tests, derive biodiversity indices and communicate these to policy-makers. He also raised a number of questions that needed answering before any such schemes were to be put in place.

As an example of an existing biodiversity monitoring programme, Ben Delbaere (European Centre for Nature Conservation) discussed the long running International Waterbirds Census (IWC). He considered the census' strengths consisting of having a clearly defined goal, a large scope and a good opportunity for scientific analysis of trends over a long period of time. But downsides of the census include technical data output, limitation of the data to wetland habitats and the lack of information concerning specific impacts or driving forces. He concluded by noting the stable, consistent and targeted nature of the IWC and the advantages and disadvantages of some other monitoring schemes.

Tor-Bjorn Larsson (EEA) contributed to the issue by looking at the successful framework established by the MCPFE (Ministerial Conference on the Protection of Forests in Europe) for the assessment and monitoring of forest biodiversity. This framework is constantly being improved through the work of an MCPFE advisory group who recently encouraged the adoption of a new indicator framework. He went on to discuss the new indicator of "dead wood", which is raising certain difficult issues to be resolved by European experts.

In a collateral way, Jari Niemelä and Lauri Saaristo (University of Helsinki) looked at the progress made in Finland regarding forest biodiversity monitoring and implementation of indicators. A working group set up by the BITUMI project (Applicability of Biodiversity Research) looked at the present situation, future possibilities and identified major gaps that exist in biodiversity monitoring. One such gap is the lack of species monitoring, which has led to the development of a recent pilot project that aims to identify suitable forest biodiversity indicators.

Thomas Nilsson looked at the monitoring situation in Sweden. Like Denmark, the Swedish Government has proposed that a system for monitoring and evaluation should be tied to objectives. The Swedish Parliament recently adopted fifteen environmental objectives and a number of interim targets to guide Swedish environmental politics. The Government has also appointed an "Environmental Objectives Council" with the task of coordinating the efforts of various authorities and reporting to the Government. Also they plan to have a core set of headline indicators to show trends in the environment and the prospects of achieving the objectives. Their difficulties in choosing indicators seem due to a lack of knowledge (especially in marine ecosystems), lack of money as well as a conflict in views (where scientists on the one hand emphasize the complexity of nature and scientific uncertainty, and policy-makers and politicians on the other hand emphasize simplicity and overview). Like most contributors, he emphasises the need for reliable, cheap and effective indicators that could be used at European level. Frederic Gosselin (Cemagref) proposes two other reasons for the difficulty of monitoring biodiversity: the difficulty to measure all the biodiversity in a place and the intrinsic multidimensionality of biodiversity.

A contribution by Kalev Sepp (Estonian Agricultural University) and Antti Roose (University of Tartu) looked at the situation in Estonia where since January 1994, a National Monitoring Programme has been implemented under the supervision and co-ordination of the Ministry of the Environment. Simona Mihailescu of the Romanian academy looked at recent developments in biodiversity monitoring in Romania including the five-year National Biodiversity Conservation Strategy Action Plan (BSAP). She also looked at possible developments after the integration of Romania to the EU.

While noticing certain trends using the technique of "route monitoring", Jan Jansen (University of Nijmegen) questioned what concrete conclusions could be drawn with this kind of monitoring because it was relatively subjective and some of the route sections are not easy to repeat because of difficulties of orientation in the field. He was answered by Alan Feest (University of Bristol) who suggested a few sampling methods used in baseline biodiversity estimates.

The focus of this session was also very much on the issue of suitable indicators of biodiversity. Jari Niemelä gave a very thorough list of criteria for selecting species-level indicators of biodiversity such as their cost-effectiveness, sensitivity, synergistic value, geographic range. Following onto this, Wilson et al. described a number of potential bio-indicators for Scotland, including a bird census index, vascular plant diversity, salmonid counts, status of the otter in freshwater habitats, proportion of commercially fished stocks fished within safe limits, woodland tree species diversity, status of BAP priority species and habitats…

Richard Gregory (RSPB) and Petr Vorisek (Czech Society for Ornithology) proposed to assess the impact of changes on biodiversity using composite Pan-European bird indicators. Their scheme, will deliver, for the very first time, high quality, representative, policy relevant bio-indicators for the wider European environment as a whole. They set out to put in place common bird monitoring across European countries, generate national bird indices in a standardised manner, bring together national bird indices into a single European data set, generate Pan-European indices for individual species and generate Pan-European multi-species indicators. Ward Hagemeijer, Richard Gregory, David Gibbons, Petr Vorisek and Melanie Heath gave a Summary of a workshop held in Prague (16-19 Sept) and their decision to implement the Pan European Bird Monitoring Programme.

Strategic Environmental Assessments (SEAs) were discussed by Arnau Queralt (Catalonian Ministry of the Environment). They intend to improve on certain limitations of EIAs by getting ahead of the decision making process, thereby limiting possible negative effects of the proposals. By incorporating biodiversity into the assessment, SEAs could be valuable tools for conservation in Europe.

Session 3: *To identify some developments in monitoring biodiversity and the advantages they offer.*

Over twenty participants contributed to this session, looking at a variety of different recent developments in biodiversity monitoring. These included developments in monitoring approaches, framework establishment, indicators and databases.

Richard Bradshaw, Peter Friis Møller & Annett Wolf (Geocentre) looked at the case of Draved Forest in Denmark where there have been 50 years of observation of key factors such as tree species and tree stand structural complexity. They pointed out that in forest systems where changes can be slow, the recognition of the value of structural indicators could contribute to biodiversity monitoring. Etienne Branquart (DGRNE) looked at another forest project, FOREST FOCUS (proposed by the European Commission and the European Parliament), which aims to better understand relationships between global change, forest health and biodiversity. They also propose to use a standardised protocol for surveying forest pests (e.g. defoliators and wood-boring insects) and to assess biodiversity (e.g. structure-based indicators). Pat Neville (Irish Forestry Board) contributed by adding that a Working Group of the European Commission and ICP Forests is attempting to elaborate methods of biodiversity assessment that may be incorporated into the Forest Focus monitoring programme.

Alan Feest explained his work using macrofungi in a methodological approach to defining, setting and measuring biodiversity values, and the potential to transfer the methodology across taxonomic boundaries to include Arachnida, Collembolla, Hymenoptera, Orthoptera, nematodes etc. Following a similar idea, Josef Settele (UFZ) summarised the MacMan project, which uses *Maculinea* butterflies as indicators and tools for habitat conservation and management. Following another entomological example, Peter Bliss and colleagues (Halle University), after distinguishing between "monitoring" and "nature surveillance", discussed the potential of using supercolonial ants as a model system for biodiversity monitoring at the European scale. The advantages they offer include: abundance, facility of monitoring (possibly involving volunteers) and potential for long term studies.

Norbert Sauberer and colleagues (University of Vienna) evaluated a series of biodiversity indicators in an old agricultural landscape with mixed land use in Eastern Austria. The conclusions of the study were that land use intensity (degree of disturbance), environmental heterogeneity and habitat type were the most efficient predictors of species richness. He felt optimistic about finding a range of efficient bio-indicators capable of monitoring biodiversity successfully in these ecosystems. According to Rainer Waldhardt (University of Giessen), the three factors to be considered when monitoring at the landscape scale are: (i) the punctual species richness within specific biotopes, (ii) the local species richness within landscape tracts, which may indicate specific species densities within a landscape, and (iii) the regional species richness. Jose Garcia del Barrio (CIFOR) agreed with the landscape approach to monitoring and listed a number of steps to be included in any territorial framework approach. Paulo Sousa and P.V. Morais (University of Coimbra) noted that biodiversity monitoring schemes in terrestrial systems usually focus on evaluating animal and plant species, usually neglecting (in some cases) microbes and soil functional parameters. He emphasised the need to incorporate functional parameters in biomonitoring programmes. He also described some easy and cost-effective methods in monitoring plans such as bait-lamina sticks and the BIOLOG method.

Katalin Torok (Hungarian Ministry for the Environment and Water Management) discussed the Hungarian Biodiversity Monitoring Programme (HBMP), which carries out landscape scale monitoring of biodiversity. Thomas Walter of the Swiss Federal Research Station for Agro-ecology and Agriculture (FAL) explained the Eco-Fauna-Database project supported by the Swiss Agency for the Environment, Forests and Landscape. It could gather information on systematics, threats and distribution of species as well as behavioural and ecological aspects. The authors suggest that the database might be an essential tool in the analysis and monitoring land use changes, species assemblage changes and climate change and its effect on the behaviour of animal species. Other suggestions for improved monitoring systems included statistical models to assess the naturalness of habitats by comparison with large reference data sets (Rasmus Ejrnæs and Erik Aude of the Dannish National Environmental Research Institute). Tomas Coll (Catalonian Ministry of the Environment) added that a good approach would be to find inexpensive and safe identification systems that could be connected to Internet search engines.

Jorge Lobo and Joaquin Hortal (CSIC) outlined three different approaches to monitoring: "site directed monitoring", "pattern recovering monitoring" and "biodiversity directed monitoring" and then proceeded to underline the need to gather data (especially in poorly know areas) and make forecasts based on the data. Ben ten Brink of the National Institute of Public Health and the Environment outlined the importance of user-driven biodiversity indicators and the role of the Natural Capital Index framework in providing information on the state and changes in biodiversity due to human impacts.

Erling Berge (Norwegian University of Science and the Environment) concluded the session on a sobering note by pointing out that one needed a causal theory linking particular designs of policy instruments to outcomes of state variables of the eco-system for any monitoring system to be useful in policy making.

Session 4: *To discuss the development of a core programme of biodiversity monitoring across Europe; what are the priorities for monitoring and what major gaps exist?*

On a general note, Rainer Muessner (CIMAR) looked at weaknesses of existing monitoring programmes at the European scale and identified three major problems: unclear links between information and policy, lack of indicators of functional aspects of biodiversity and a poor harmonisation of European monitoring approaches.

Sandrine Petit and Les Firbank (CEH) identified the main monitoring methods used today such as ground-survey monitoring programmes and reports on the quality of habitats, remote sensing to assess the extent of particular land cover types at very broad scales, describing the spatial organisation of habitats from air photographs or satellite images using landscape indicators such as fragmentation indices or heterogeneity. They noted however, that while such indicators are relevant for a range of organisms at specific spatial scales, empirical knowledge of their relationships with overall species diversity is still sparse. The authors then outlined the main challenges facing monitoring schemes including the successful integration of data collected at different spatial scales, the need to monitor areas with high external pressures and the need to report changes in biodiversity in the context of changes in society and policy.

Many contributions concentrated on gaps in monitoring. Robin Moritz (Halle University) pointed out that gaps in monitoring resulted from the use of the wrong type of indicator and disagreed with the use of rare species as indicators.

Jari Niemelä identified the monitoring of biodiversity in urban areas as a major gap and emphasised how vital such monitoring was for understanding the effects of human actions in an environment overwhelmed by human-caused pressures on biodiversity. He insisted on the fact that in such habitats, the strong human presence needed to be incorporated into monitoring programmes.

Marcello Buiatti (Firenze University) concentrated on agro-ecosystems, and called for specific techniques for monitoring the complexities of agricultural and ecological systems. Some examples included the inter and intra specific analysis of biodiversity (using functional markers), network analysis (predictive modelling using gene flow, as well as looking at the impact of GMOs and of "invasive" species) and environmental accountancy.

Endre Laczko (Basel University) pointed out that soil biodiversity was a factor in regulating how terrestrial ecosystems function and was also affected by elevated carbon dioxide concentrations, by heavy metal pollution and by land use practices. Like Ant Maddock in session 1, he emphasised the need to monitor the functioning and effects of the (supposed) key interactions as opposed to individual components of the soil.

Both Fiorella Villani (CNR) and René Smulders concentrated on the currently under-represented monitoring of genetic diversity. They noted gaps in this area such as the need for indicators capable of monitoring intra-specific genetic and adaptive diversity, hotspot priorities, and "meta indices" which could link specific indicators of different biodiversity levels. Smulders and Vosman (Plant Research International) also noted the need to look at relationships between species diversity and genetic diversity, examine genetic diversity in regard to stress tolerance and also other parameters including life history and dispersal abilities.

Another gap in monitoring was identified by Annick Wilmotte (Centre d'Ingenierie des Proteines) who highlighted that only 1-5% of microorganisms had been cultivated. She pointed out that certain measurements (like diatoms and rRNA sequences) could be "…sensitive and suitable index of environmental status and trends".

On a more "regional" point of view, Snorri Baldursson (Icelandic Institute of Natural History) and Bill Heal discussed the need to monitor biodiversity in the Arctic. They looked at the uniqueness of the Arctic, existing monitoring (including CAFF, AMAP and ACIA) and priorities for monitoring to understand changes in the Arctic environment. Emilia Poli (Catania University) took up another example of under-monitored ecosystem by looking at the Mediterranean region. She argued that there is an urgent need to monitor biodiversity in the Mediterranean region where biodiversity levels and human impacts are both important. She stressed the development of monitoring programmes in the Mediterranean region, and coordination of these programmes within an international network.

Session 5: *To identify where research should be focussed to develop monitoring programmes that best meet the needs of users, including the development of a core programme of biodiversity monitoring across Europe.*

Erling Berge (Norwegian University of Science and technology) pointed out that if the goal of a core programme of biodiversity monitoring across Europe was to "bridge the gap between those who collect data on biodiversity and those who need information in a format that helps them to make decisions" it would have to be designed to test hypotheses about the impact of changes in policy instruments and to separate those impacts from other dynamic factors affecting biodiversity indices.

Richard Johnson (Swedish University of Agricultural Sciences) highlighted the need to look at the ecological scale by looking at riverine ecosystems. Like Robin Moritz, he also looked at the use of rare taxa in biodiversity monitoring and went on to list a number of alternative monitoring approaches including modelling and metrics commonly used in bio-assessment as surrogates for overall biodiversity. Luc de Meester and Steven Declerck (Katholieke Universiteit Leuven) suggested several topics that need closer attention in future research and monitoring projects on biodiversity in lakes. According to them, a validation of the surrogacy hypothesis is a prerequisite for the use of indicator taxa. They also advocate that more attention should go to processes that potentially determine diversity in freshwater communities and that a further development of reliable cost-effective indices is a prerequisite for feasible monitoring programs.

Marco Marchetti (University of Palermo) discussed the idea of High Conservation Value Forests (HCVFs) introduced by the Forest Stewardship Council (FSC) in 1999. He argued that they are suitable for testing and developing Biodiversity Evaluation Tools for European Forests. Another major European initiative, discussed by Cees Hof *et al.* of the University of Amsterdam, is the European Network for Biodiversity monitoring (ENBI) due to start in Autumn 2002. By collecting data, making it globally available, looking at the potential of tools to apply the biodiversity data and focussing on the needs of end-users, its aim is to identify biodiversity information priorities to be managed at the European scale. One similar approach on a national scale is the UK National Biodiversity Network (NBN) considered by James Munford (NBN) and Lawrence Way (JNCC). The NBN intends to improve access to information by combining different sources, integrating volunteer effort with capture mechanisms, building partnerships by integrating needs and information sources to ultimately help influence the design of surveillance and monitoring.

Klaus Henle (UFZ) argued that a major research priority should be the development of a framework for an indicator system covering all scales, from the local farm to the European level, in a consistent form. This framework should be able to identify causes of change, and be feasible from an administrative and financial point of view. He also noted that a distinction should be made between the scientific development of indicator and monitoring systems and insisted that the development of biological indicator systems should be based on rigorous statistical field designs or on field experiments.

Peter Duelli and Christoph Scheidegger (Swiss Federal Research Institute) proposed a scientific stepwise approach to choosing indicators that involves defining the value system (motivation) and the appropriate measurable aspect or entity of biodiversity, measuring that aspect or entity in a representative number of locations in a thorough way. Already existing, proposed, or newly designed indicators are measured in the same areas, or calculated from the empirical data pool. Their performance can be tested against the assessed "reality". Statistical analysis and cost decide which of the indicators are the best, the fastest, the cheapest. Finally the best concordant indicators are grouped into "value baskets". The result is an index per basket, e.g. "the biodiversity index for conservation", or "the biodiversity index for ecological resilience". On the use of indicators, Alan Feest suggested using a combination of “indicators” and “biodiversity indices” for a more thorough monitoring procedure. Another framework idea suggested by Robert Kenward, also using indices and indicators, identifies three main components (policy makers, biodiversity professionals and volunteers). The first task is to define indices, then to work with data gathering volunteers and finally to refine understanding of the processes that underpin biodiversity.

The use of a system which responds to pre-defined objectives was also suggested by Frederic Gosselin who then recommended the use of species-level indicators coupled with environmental data. Richard Fischer (BFH) responded to the Gosselin contribution by suggesting we use species level data (full species lists that are more flexible in their interpretation although they do create a heavier workload) as well as environmental data to monitor biodiversity at a pan-European level.

Both Jurgen Tack (Flemish Institute of Nature Conservation) and Romain Julliard took a very pragmatic point of view. Jurgen Tack *et al.* summarised the problem by saying that “the real challenge is to keep the balance between indicators that are suitable and practical for policies while at the same time do justice to the complexity of biodiversity”. He underlined the need to use existing knowledge and do more actual monitoring rather than continue looking for the perfect formula. Romain Julliard also insisted on using the enormous amount of monitoring data occurring at the local scale and coordinating it all at the national level. He went on to say that such coordination required research on how to monitor (sampling and field implementation) for both local managers and national coordination, on how to estimate variation of biodiversity at various scales of time and space, and on how biodiversity functions at large scale and on the long term in order to make predictions.

Alf Josefson (NERI) gave a Summary of the monitoring issues discussed during the Marbena conference: Most contributors agreed that monitoring should be undertaken and suggested a few new approaches (coupling biodiversity with ecosystem function, need for indicators which can be useful to policy makers…). The participants seemed to agree that determination of species was unavoidable in monitoring (single species, key organisms, threatened habitats?). Other issues included the scale of monitoring in marine environments, which have small physical barriers and species with good dispersal abilities and the difficulty to monitor the effects that different environmental problems could have on different organism groups.

Concluding contributions:

Melanie Heath (BirdLife International), Erik Framstad (Norwegian Institute for Nature Research) and Konstantinos Spanos (Forest Research Institute) all acknowledged the complexity of biodiversity and its importance. Erik Framstad called for a unifying framework represented by generic models that could develop our understanding of mechanisms, design effective monitoring and communicate results to the public. Melanie Heath agreed that different schemes have varying strengths and that it was not sensible or pragmatic to consider combining these numerous efforts into a single scheme. The challenge is to maximise the usefulness of data generated from these different schemes and particularly to 'bridge the gap between those who collect data on biodiversity and those who need information in a format that helps them to make decisions'. Initiatives taking up this challenge include the European Biodiversity Monitoring and Indicators Framework initiated under the Pan-European Biological and Landscape Diversity Strategy and an informal international working group for coordination and collaboration on biodiversity monitoring and indicators (IWG Bio-MIN) set up by the European Environment Agency. Riccardo Simoncini (University of Florence) also examined the integration of scientific research and biodiversity conservation policy making. He suggests four major steps towards integration: improved communication, appropriate indicators, ecological baselines and integration of biodiversity functioning.

Ben Delbaere called for the urgent need to keep policy makers and decision makers interested in biodiversity and argued for the approach of immediate implementation of methods such as the NCI at the European level all the while continuing the search for other suitable indicators.

Helena Freitas (University of Coimbra) and Andreas Troumbis (University of the Aegean) underlined once again the need for a European core programme for monitoring biodiversity, as well as a set of indicators clearly required by the European Biodiversity Strategy including regional and local monitoring schemes, scientifically driven, designed at the appropriate scale and easily interpreted by local and regional planning and management.

Hermann Ellenberg (Institute for World Forestry) asked that biodiversity monitoring schemes include coordination of efforts (both in time and space), calibration of results, standardisation of methods and stratification at the EU scale. Finally, Jacques Weber of the French Biodiversity Institute gave a social scientist’s point of view and suggested the creation of working groups involving scientists, policy makers, etc. working on the design of socially accepted (“common reference”) indicators of biodiversity situation and trends.

Discussion and conclusions

Allan Watt and Juliette Young

Overview

Contributors to this e-conference have discussed reasons for monitoring biodiversity, shared information on current initiatives on monitoring, outlined ways of improving our ability to monitor biodiversity and present the information meaningfully, discussed the concept of a core programme of monitoring biodiversity in Europe, gaps (in terms of taxa, levels of biodiversity and environments) in monitoring, and identified future priorities for research to meet the needs of users.

Reasons for monitoring biodiversity

Many contributors considered the reasons for monitoring biodiversity. Perhaps there are three major purposes (overlapping to some degree), each with more specific objectives, which relate, for example, to the management of protected areas, national and international biodiversity strategies and action plans, and the concerns and aspirations of NGOs and society generally (Table 1).

It is not difficult to list these objectives but they all pose formidable challenges. It is difficult enough to provide a series of meaningful measures of biodiversity; it is a major challenge to separate "natural" variation in biodiversity from the impacts of one or more anthropogenic influences; and it may be an impossible task to confidently separate the influences of the many policies and management actions, anthropogenic influences and natural factors on biodiversity. Ben Delbaere summarised the problem: "It is easier to develop a programme to monitor the population size of an individual species in a single site than to develop a programme that measures progress in reaching 'no further loss of biodiversity in Europe'". But most contributors clearly believe that these challenges are important enough to attempt to overcome them.

Biodiversity monitoring programmes

At the international scale, potentially the most significant influence on the conservation and sustainable use of biodiversity is the Convention on Biological Diversity (CBD). Indeed, Paul Rose argued that the coordination and harmonisation of monitoring should probably be done under the leadership of the CBD and Ben ten Brink described indicators as the "teeth" on the CBD. However, the CBD appears to have been rather toothless. National reports on the implementation of the Convention on Biological Diversity show that only 1% of the

Parties to the CBD have "comprehensive" monitoring programmes in place and only 6% have identified national indicators of biodiversity.

However, Romain Julliard & Frederic Jiguet pointed out that there is a vast amount of monitoring going on. They cited the example of the involvement of voluntary amateurs in a French breeding bird monitoring scheme, stimulating several contributions about the role of amateurs and local people in monitoring programmes[i] and indigenous knowledge[ii].

Table 1. Some objectives of biodiversity monitoring

Generic purpose	Specific objectives (examples)[iii]
Measuring status and trends in biodiversity	To quantify "natural" temporal variation (including historical) in biodiversity and establish biodiversity "baselines". To quantify spatial variation, both landscape related and biogeographical, identifying, for example, biogeographic regions that are particularly likely to show negative trends in biodiversity. To identify priorities for action.
Quantifying impacts (positive as well as negative) of anthropogenic influences on biodiversity and the impacts of policies and actions not directly related to the conservation and sustainable use of biodiversity	To identify, understand and quantify the pressures that cause species loss and the ability of biodiversity to provide life-supporting ecosystems (e.g. land use change (including urbanisation, land abandonment and intensification), effluent discharges, desertification, climate change, over-exploitation and fragmentation), identifying those which have the greatest impact on biodiversity. To identify practices that have a positive impact on biodiversity. To track the effect of the policy and actions taken e.g. UNFCC LULUCF measures, Common Agricultural Policy and Common Fisheries Policy (and their reform), inclusion of new member states in the EU, Urban Waste Water Treatment Directive. To define policy or management measures to halt or reverse any negative impacts.
Assessing the impacts of policies and actions specifically focussing on the conservation and sustainable use of biodiversity	To track the effect (and effectiveness) of the policy or management actions taken e.g. Birds Directive, Water Framework Directive[iv], Directive on strategic environmental assessment[v], the Convention on Migratory Species[vi], agri-environmental measures, biodiversity action plans. To report on the effective implementation of commitments within international Conventions

We read about several international monitoring programme such as those developed by the MCPFE[vii], ICP-Forests / Forest Focus[viii], the International Waterbird Census[ix], and the proposed Pan-European breeding bird monitoring scheme (which moved to the implementation stage while this e-conference was running)[x]. Contributors also described initiatives aimed at increasing collaboration between monitoring programme such as Bio-MIN and EBMI-F[xi]. Ben Delbaere referred to his inventory reports on monitoring and indicators and cited a few examples. Although many initiatives have started, he reported that that "only very few get to the stage of long-term implementation and direct feedback to policymakers and other stakeholders…. [and most] run in isolation, each of them resulting in a partial picture of the status of biodiversity".

Several contributors wrote about national monitoring programmes[xii]. Other contributors discussed the amount of existing data on the taxonomy, biology and ecology of species and how this information should be used to make monitoring more effective[xiii]. It was therefore heartening to read about initiatives to increase access to biodiversity data, notably ENBI and GBIF[xiv]. It is to be hoped that these major initiatives will not only increase our knowledge of biodiversity but also play a major role in its conservation.

Clearly there is a much greater amount of monitoring going on than the reports from the CBD suggest. Unsurprisingly, therefore, many contributors have argued that we should use what we have rather than invent new monitoring programmes. However, it is also clear that current monitoring programmes are not well integrated and much more could be made of the current monitoring effort. Ben ten Brink summarised the situation: "billions of dollars have been spent on monitoring ecosystems and their biodiversity components. Office and library shelves are now piled high with computer discs whose vast capacity is still too small to contain all the data which, according to many, should be recorded. But despite this plethora of information, we are still not able to tell policy makers and the public whether biodiversity is getting better or worse".

Developments in monitoring biodiversity

Many contributors outlined some desirable characteristics of a monitoring programme, including criteria for selecting "indicators" or "parameters" of biodiversity.

Table 2. Some desirable characteristics of monitoring programmes

Characteristics[xv]
• Practical to measure, with methods that are simple, cheap, consistent, robust and reliable
• Development should focus on or include already existing monitoring programmes
• Programmes should include parameters / indicators that provide early warning of irreversible declines[xvi]
• Programmes should not be limited to particular habitats or features but should include all spatial elements in the landscape, capturing the interactions between habitats in the landscape / catchment
• Programmes should incorporate existing long-term data where appropriate
• Should provide easily understandable evidence of what is happening, relevant to politicians, scientists, NGOs and the public generally and permitting measurement of progress towards targets and/or decline towards thresholds for action.
• Should provide information on biodiversity that can be integrated with environmental and socio-economic data

It is very unlikely that any monitoring programme or set of indicators will have all these characteristics. Many contributors argued for a very rigorous approach to monitoring. Mikko Kuussaari, for example[xvii], wrote that an "ideal monitoring program of farmland biodiversity would involve quantitative annual sampling of several taxonomic and functional groups of organisms in a large number of study areas, randomly stratified to produce representative results from a large geographic cover. Replicates of all significant habitat types should be included in the monitoring within all study landscapes". However, as he himself acknowledged, it is difficult to establish such ideal monitoring programmes. Similarly, Davy McCracken and others reminded us that there is more to biodiversity than birds and plants[xviii] but as he wrote "assessment of the majority of [taxa] is laborious and time-consuming".

Many contributors[xix] argued for, and gave examples of research on, the use of surrogate measures of biodiversity and sets of indicators (compositional (both taxonomic and functional), structural and process-based). Several contributors also pointed out that we already have methods that can be used to produce comparable results from place to place and year to year[xx]. As Peter Bliss and colleagues pointed out near the end of the e-conference, few contributors considered the question of which groups of plants and animals are most appropriate for monitoring at a pan-European scale. They argued that supercolonial (mound-building) ants are a suitable group. In the terrestrial context, others suggested plants[xxi] and birds[xxii] while Niemelä and Duelli & Scheidegger considered criteria for the selection of taxa. Clearly this needs further discussion.

Monitoring of natural processes (such as decomposition, dispersal and pollination) is not included in many monitoring programmes but as Ant Maddock argued "we should widen our monitoring efforts on the operation of the natural processes that ensure the survival of genes and species". Perhaps the most important points made about indicators of biodiversity are that they need to be tested / calibrated[xxiii], particularly indicators that appear to be robust but may not be[xxiv] and that while indicators are necessary Summary measures of biodiversity, we must be aware of the changes in species composition that they may mask[xxv].

Several contributors discussed the issue of targets and baselines. Laurence Carvalho discussed some of the problems regarding the setting of targets for the Water Framework Directive, particularly in relation to "good ecological status", defined as "representing only slight deviation in the biological quality elements from an 'undisturbed' state. How do we interpret disturbance? Do we try to return mesotrophic lakes to more 'pristine', nutrient poor, reference states irrespective of their value? Or are we aiming to maintain or restore ecosystem structure (water quality, quantity and biodiversity) and function (conservation, water supply, flood storage capacity, etc.) to ensure a more sustainable use?" Ben Brink argued the case for defining baselines: "The baseline i) provides significance to meaningless data as such; ii) allows aggregation of many data to a high level; iii) makes figures within and between countries comparable, iv) is a fair and common denominator for all countries, being in different stages of economic development, and v) is relevant for all habitat types. How else could we deal with countless statistics on fish stocks, insects, birds, forest, plants and mammals and communicate it with the public?"

A core programme, priorities and gaps in monitoring

From the start of the e-conference, many contributors have been explicitly or implicitly discussing the idea of a core programme of monitoring biodiversity in Europe. Paul Rose, in the first contribution, argued for coordination and harmonisation of monitoring efforts. He wrote that international monitoring "requirements are most efficiently met by the aggregation of results from national monitoring programmes, through the establishment of monitoring standards and the filling of geographic gaps". Horst Korn wrote that "local monitoring results should feed into national and national ones into international monitoring schemes in a nested way". Richard and Condé wrote that to provide a "European picture… assessments have to rely on comparable methodological protocols." Van der Bijl and Iversen wrote that we need "national and international agreement on methodologies for data collection, analysis, and data handling and on streamlining reporting by means of policy relevant core indicators". Others made similar points.

What should a core programme of monitoring look like? Relatively few contributors considered this question explicitly. Most relevant contributions either discussed the "scientific" development of monitoring, outlining protocols and sampling strategies that are probably unsuitable for large-scale monitoring[xxvi] or they outlined relatively simple monitoring programmes (in existence or at the planning stage). I remain convinced that a core programme of monitoring should comprise two elements: an extensive network of monitoring using as simple protocols and sampling strategies as possible[xxvii] and a series of intensively monitored sites to test the methods being used in the extensive network, focus on aspects that an extensive network could not afford to cover and to quantify the contribution of natural and anthropogenic (including policy influences) on biodiversity[xxviii]. The intensively monitored sites would be most effective if placed along land-use intensity gradients[xxix] and to "target those areas and habitats where pressures are known to be high"[xxx]. These intensively monitored sites would allow the development of improved indicators and monitoring programmes. Meanwhile, we need to obtain the best possible message from the information we have. As Ben Delbaere writes: "we should have the guts to test an aggregated and simple indicator, such as the Natural Capital Index as proposed by ten Brink, and use the bottom-up data flow from local data collectors to international reporting while at the same time providing scientifically sound interpretation of results presented with a convincing and simple message to the decision makers".

How could a core programme of monitoring succeed? This e-conference has identified the major requirement: cooperation and collaboration. This is needed between policy makers and scientists[xxxi], between the many monitoring programmes in existence or being planned[xxxii] and between scientists working in monitoring networks, and other scientists working on biodiversity[xxxiii]. We also need to develop ways of integrating data from programmes operating at different spatial scales[xxxiv], collating data collected locally to larger spatial scales[xxxv], including the correct balance of pragmatism / simplicity[xxxvi], standardisation[xxxvii] and flexibility[xxxviii], maintaining a sense of perspective[xxxix], and reporting the information rapidly[xl] and in a meaningful way[xli].

Many contributors discussed gaps in current monitoring programme. Jari Niemelä argued for more monitoring of biodiversity in urban environments and Bill Heal & Snorri Baldursson emphasised the importance of monitoring the Arctic environment. Several people[xlii] provided strong reasons for monitoring genetic diversity and others[xliii] argued that microbial diversity and soil biodiversity require more attention.

Priorities for research

Throughout the e-conference, many suggestions for research were put forward and some of these have been mentioned already. Focussing mainly on the session that specifically looked at research priorities, the following priorities emerged[xliv]:

- The response of biodiversity to human-induced and natural environmental changes.
- A better understanding of the importance of ecological scale.
- Complementary methods monitoring aspects of aquatic biodiversity not included in the Water Framework Directive.
- The development of new methods for biodiversity assessment e.g. modelling approaches to biodiversity assessment (while recognising that monitoring methods have often developed from "nature surveillance"[xlv]).
- The testing of existing and proposed indicators of biodiversity[xlvi].

Overall, contributors to this e-conference have urged for research as a basis for action, not as an excuse for inaction. Nevertheless, there are some major challenges, many of them set by policy objectives. In his second contribution, Ben Delbaere outlined the challenge faced by monitoring progress towards the EU Strategy for Sustainable Development objective "to halt the loss of biodiversity by 2010". As if this isn't a large enough challenge, Jacques Weber reminds us that "biodiversity is only one issue amongst many to be taken into account in public decision-making".

Our "sister" e-conference, MARBENA, considered the monitoring of marine biodiversity. There were several common themes: the need to monitor both biodiversity *per se* and ecosystem function, the validity of indicators, scale, volunteers and the issue of adapting monitoring programmes to suit local conditions[xlvii].

Conclusions

This e-conference demonstrated that it is impossible to consider the monitoring of biodiversity in isolation from a general understanding of biodiversity[xlviii]. Perhaps this simply reflects the essential nature of monitoring, but clearly effective monitoring requires at least a basic understanding of biodiversity and an adequate understanding of biodiversity requires monitoring[xlix]. As Andreas Troumbis wrote: "Monitoring is not only about change. It is also about cataloguing the biotic richness in an area, in the sense that it offers the link between the taxonomic investigation and the understanding of the ecological structure – and function – of higher levels of biological organization". A major message of this e-conference is that we need more collaboration between people monitoring the same species in different countries and between people engaged in different monitoring initiatives. Initiatives such as the proposed Pan-European breeding bird monitoring scheme and Bio-MIN are therefore to be greatly welcomed. But perhaps there is a wider message – we need much more collaboration between scientists, stakeholders and policy-makers. We look to the EPBRS to promote this aim.

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[i] See Richards, Kenward; Ellenberg; Tack, De Bluust & Kuijken; Bliss et al.. Also note recent e-conference on participatory involvement in monitoring and evaluation of biodiversity http://www.etfrn.org/etfrn/workshop/biodiversity/index.html.

[ii] Heal & Baldursson.

[iii] See e.g. contributions by Rose, Korn, Bolger, Bradshaw, Richard and Condé, Mathieson, Waldhardt, Brink; Simoncini.

[iv] Laurence Carvalho identified several problems regarding the implementation of the Water Framework Directive. Most seriously, perhaps is the concern that with tight deadlines for implementation, there will be more effort spent on technical implementation than on a core purpose of the WFD, "to deliver major improvements in the monitoring, protection and sustainable use of biodiversity associated with aquatic ecosystems". One wonders if this may be a more widespread problem, with legislation rather than "purpose" often driving monitoring. See also Smith & Newton; Declerk and De Meester

[v] See Queralt.

[vi] Smith & Newton.

[vii] See Larsson.

[viii] See Branquart, Neville, and Fischer; also see related contribution by Marchetti on High Conservation Value Forests.

[ix] Established for the Ramsar Convention and the African-Eurasian Migratory Waterbird Agreement – see Delbaere.

[x] See Gregory & Vorisek; Hegemeijer et al.

[xi] See Richard & Condé, and Delbaere.

[xii] Austria (Sauberer et al.), Denmark (van der Bijl & Iversen; Bradshaw, Møller & Wolf), Estonia (Sepp & Roose), Finland (Saaristo & Niemelä; Kuussaari), France (Julliard & Jiguet); Germany (Waldhart), Hungary (Torok), Mediterranean countries (Poli), the Netherlands (Jansen), Romania (Mihailescu), Scotland (Wilson & Bainbridge; Wilson et al; Mathieson), Sweden (Nilsson).

[xiii] See Walter, Schneider & Gonseth; Ejrnæs & Aude; Heal & Baldursson; Julliard. Alan Feest also pointed out that for some groups, their taxonomic status is ill defined.

[xiv] See Hof, Los and de Yong.

[xv] See contributions by Rose, Korn, Kapos, Richard and Condé, van der Bijl and Iversen, McCracken, Bradshaw, Møller & Wolf, Niemelä, Muessner.

[xvi] See contributions by Ben ten Brink and Alan Feest on the use of population abundance as an early warning for species loss (Kapos).

[xvii] For other examples of a rigorously "scientific" approach to monitoring see e.g. Veen; Waldhardt; Lobo & Hortal; Garcia del Barrio.

[xviii] This is a terrestrial viewpoint – Scot Mathieson describes the invertebrate focus of much aquatic monitoring and notes that under the Water Framework Directive monitoring should be expanded to include algae, macrophytes and fish.

[xix] E.g. Sauberer; Bolger; Maddock; Saaristo & Niemelä; Johnson; Sousa & Morais.

[xx] See Feest, Settele

[xxi] E.g. Fischer.

[xxii] E.g. Rose; Hagemeijer; Heath.

[xxiii] E.g. Niemelä; Johnson; Declerk and De Meester, Henle; Ellenberg.

[xxiv] See comments on rare species by Moritz and Johnson, and on protected areas by Nilsson.

[xxv] E.g. Gosselin; Fischer.

[xxvi] Andreas Troumbis wrote that we should be wary of "a vision of monitoring as a self-defined and ultimate scientific process."

[xxvii] "Choosing a core set of indicators is the art of measuring as little as possible with the highest policy significance as possible." (Brink). Herrmann Ellenberg cites some "non-biodiversity" examples of simple but effective indicators and also warns against their use without "calibration".

[xxviii] See also Kenward; Neville.

[xxix] As in the BioAssess project (www.nbu.ac.uk/bioassess)

[xxx] See Petit & Firbank.

[xxxi] E.g. Brink: "Policy makers choose an appropriate baseline and set targets for each indicator, against which scientists establish a monitoring programme, quantify the baseline and current state, and develop pressure-effect relationships (future state). Indicators are a vehicle of communication between

policymakers and scientists. Once chosen, they are a programming tool for research, monitoring and policy making." See also arguments by Simoncini.
[xxxii] See contributions by e.g. Delbaere.
[xxxiii] Particularly those working on the impacts of anthropogenic factors on biodiversity, both natural and social scientists (Berge) and those working on bioinformatics.
[xxxiv] See Petit & Firbank; Henle.
[xxxv] Noting issues of data ownership, accessibility, funding and data quality assurance (Mathieson; Rose). See also van der Bijl and Iversen.
[xxxvi] See Tack, De Bluust & Kuijken; Julliard.
[xxxvii] See Johnson; Gosselin.
[xxxviii] See Declerk and De Meester; Freitas; Larsson (who wrote: "For pan-European assessments it is desirable to have a common standard but there may be strong scientific and methodological arguments that the "standard" must take the regional variation in forests into account.").
[xxxix] See Bradshaw; Brink; Weber.
[xl] See Queralt.
[xli] E.g. Rose, Brink.
[xlii] See Villani; Smulders & Vosman; Buiatti; Spanos.
[xliii] See Wilmotte; Laczko
[xliv] See Johnson; Declerk & De Meester; Petit and Firbank; Framstad.
[xlv] See Bliss & Katzerke
[xlvi] This was the most frequently cited research priority (see Johnson; Declerk & De Meester; Henle; Duelli & Scheidegger etc). Declerk and De Meester, for example, wrote that "the Water Framework Directive requires the monitoring of only four groups of aquatic organisms: algae, fish, macrophytes and macro-invertebrates. There is a need for well-conceived studies addressing the question of how these groups can serve as a surrogate for the biodiversity in other important components, such as zooplankton, ciliates, nanoflagellates or bacteria, and how the diversity in these groups is related to ecosystem functioning". Existing networks may also be usefully used for testing indicators (e.g. Neville; Marchetti).
[xlvii] See Josefson; Tack, De Bluust & Kuijken.
[xlviii] Among the many interesting "side" issues was an appeal from Frédéric Gosselin for the testing of different management alternatives.
[xlix] See Framstad who describes an "underlying understanding of the mechanisms involved in how natural and anthropogenic causes affect biodiversity" as one of the two pillars that science-based monitoring of biodiversity should rest. He argues that the other is "stringent sampling procedures for getting reliable data".

Annex – list of contributions

Session and title of contribution	Contributors
Session 1. To identify major reasons for monitoring	
Introduction: Auditing the ark- Science-based monitoring of biodiversity	Allan Watt, Chair
Do international reporting obligations require biodiversity monitoring?	A. Newton & G. Smith
Ensuring the conservation of our "natural capital" through monitoring	Thomas Bolger
Monitoring of natural processes	Ant Maddock
Biodiversity monitoring needs at the global scale	Paul Rose
Biodiversity monitoring needs- An international perspective	Horst Korn
Monitoring needs in support of the conservation of biodiversity in Europe	D. Richard & S. Condé
Biodiversity monitoring strategy in Denmark	L. Van der Bijl & T.M. Iversen
The need for different indicators for different spatial scales	Richard Bradshaw
Counter Reply to Biodiversity monitoring strategy in Denmark	L. Van der Bijl & T.M. Iversen
Biodiversity indicators- A national perspective	J.D. Wilson & I. Bainbridge
Monitoring biodiversity in Finnish agro-ecosystems	Mikko Kuussaari
Biodiversity monitoring needs in agro-ecosystems	Davy McCracken
Reasons for monitoring biodiversity- A North European forest perspective	Richard Bradshaw
The case of Mediterranean trees and shrubs	Beti Piotto
Monitoring and the conservation of forest biodiversity	Valerie Kapos
Biodiversity monitoring: Towards a functional approach	Peter Veen

Session and title of contribution	Contributors
Biodiversity monitoring needs in rivers	Scot Mathieson
Challenges for monitoring biodiversity in the Water Framework Directive	Laurence Carvalho

Introduction: Auditing the ark – Science-based monitoring of biodiversity- Allan Watt (e-conference chair)

SUMMARY: Little effort is spent on monitoring biodiversity, and less research is devoted to developing scientific monitoring methods. The purpose of this e-conference echoes that of the European Platform of Biodiversity Research Strategy – "to improve the effectiveness and relevance of European biodiversity research". In the first week of the conference, you are invited to help identify the major reasons for monitoring biodiversity.

Given widespread concerns about declining global biodiversity, the amount of effort spent on monitoring biodiversity is shamefully small. Yet how can we identify the factors that threaten biodiversity, accurately assess the scale of their impacts or devise policies that effectively conserve or use biodiversity sustainably without adequate information on the status and trends in biodiversity? And how do we get that information without monitoring? There are exceptions, of course, and in this electronic conference we will hear about a few monitoring initiatives. But information on trends in biodiversity is nearly everywhere inadequate. This is apparent from national reports on the implementation of the Convention on Biological Diversity. These show that only 1% of the Parties to the CBD have "comprehensive" monitoring programmes in place, 2% have a "comprehensive understanding" of activities that have an adverse effect on biodiversity, 6% are monitoring these activities and their effects and only 6% have identified national indicators of biodiversity.

This e-conference should not just be used to complain about the lack of monitoring. It should be seen as an opportunity to influence research on monitoring. A Summary of your views will be presented to the European Platform of Biodiversity Research Strategy (EPBRS) meeting to be held under the Danish Presidency of the European Union in October. The main objective of the EPBRS is "to improve the effectiveness and relevance of European biodiversity research". The theme of the next EPBRS meeting, like this e-conference, is science-based monitoring of biodiversity. This meeting will discuss the current state of monitoring of biodiversity, consider how it may be improved and, in line with the main objective of EPBRS, identify priorities for research on biodiversity monitoring.

Although the current state of monitoring may result from a lack of political will, inadequate research also contributes. Indeed it may be argued that research scientists have neglected this problem. A sample of the literature reveals that of 6,000 research papers published in scientific journals on biodiversity since 1997, less than 10% are even tangentially relevant to monitoring.

The aims of this e-conference, organised by the BioPlatform project, are to identify the major reasons for monitoring biodiversity, discuss some existing and planned biodiversity monitoring programmes, identifying their strengths and weaknesses, identify some developments in monitoring biodiversity and the advantages they offer, discuss the development of a core programme of biodiversity monitoring across Europe; what are the priorities for monitoring and what major gaps exist? And identify where research should be focussed to develop monitoring programmes that best meet the needs of users, including the development of a core programme of biodiversity monitoring across Europe?

The scope of this e-conference is biodiversity in terrestrial and aquatic habitats. The concurrent MARBENA (http://www.vliz.be/marbena/) e-conference will consider monitoring in marine habitats. The full title of the MARBENA e-conference is "Marine Biodiversity in the Baltic in the European Context – Is a general methodology for biodiversity monitoring possible and do ecosystems with high and low diversity function in a similar way?" We hope that many of you will be able to participate in both e-conferences and towards the end of this e-conference, the Chair of the MARBENA e-conference will make a contribution to the BioPlatform e-conference. We hope this will lead to a discussion on common issues. In the BioPlatform e-conference, a number of keynote contributors will discuss the aims of the over the next two weeks, moving from one aim to the next. We invite you to respond to these contributions and to make additional points relevant to each aim of the e-conference.

Over the next few days, we will consider the first aim – to identify the major reasons for monitoring biodiversity. Keynote contributors will discuss the monitoring of biodiversity in relation to conservation and sustainability, in different habitats (e.g. forests, agroecosystems and freshwater habitats) and at different scales, from monitoring at the national scale to monitoring biodiversity across Europe and global monitoring of biodiversity.

We look forward to receiving your contributions, however short. Please restrict your comments to the aim of this "session". Next week we will discuss different approaches to monitoring biodiversity.

Do international reporting obligations require biodiversity monitoring?- Gemma Smith and Adrian Newton, UNEP- World Conservation Monitoring Centre

SUMMARY: A review of international reporting obligations relating to biodiversity indicates that relatively few require trend data on biodiversity. Therefore, there is little legislative requirement for biodiversity monitoring at the international scale.

The volume of international biodiversity legislation has significantly increased over the last 20 years. All of these pieces of legislation have some form of reporting obligation, however the frequency, approach and degree of detail for reporting vary significantly. Additionally, most biodiversity-related conventions, agreements and regulations rely on the good will of Contracted Parties to submit national reports. Countries are encouraged and requested to submit reports, however if they fail to do so, they face no penalty.

Our recent review of reporting obligations (Newton et al. 2002) has confirmed that most biodiversity-related conventions have requested Contracted Parties to report on their compliance with legislation (their means and success of implementation of policies, strategies and action plans), rather than focusing on regular quantitative reporting on the status of biota that the Convention represents. European Directives and Regulations have had a similar focus. In contrast, legislation relating to air and water pollution often requires detailed monitoring of water and air quality, and levels of specific emissions and chemical elements.

Only over the last few years have many international Conventions, associated agreements and regional Directives and Regulations begun to develop improved and more focused reporting guidelines that may incorporate the need for detailed or quantitative biodiversity data or trends. Chief amongst these is the Convention on Migratory Species (CMS). At present, the CMS provides the clearest need for trend data to assist with meeting reporting obligations, being the only Convention that requests trend information with regard to species listed on its appendices. This is only a very recent development that is still awaiting full approval by all Contracting Parties. This approval should be given in mid-September 2002 at the CMS Conference of Parties (COP).

The Convention on Biodiversity (CBD) potentially has scope for making use of biodiversity trend information, however only after reporting needs and guidelines have been further refined. National reporting currently focuses on the implementation of Article 6 *General Measures for Conservation and Sustainable Use.* In recent years Contracting Parties have been invited, as a result of *Decisions* made at the Conference of the Parties (CoP), to voluntarily submit information on the status and trends of selected ecosystems and associated components, such as forests, inland waters, dry and sub-humid lands as well as protected areas. This information is being used to guide and further refine the Convention's Thematic Programmes of Work. Trend data could clearly be of value in this context.

Article 7 of the Convention (Identification and Monitoring) requests each Contracting Party to identify and monitor components of biological diversity important for its conservation and sustainable use. At present no guidelines have been developed and accepted by Contracting Parties for the incorporation of such information into national reports, although work is being undertaken on identifying key biodiversity indicators that could be used to support this need.

At the regional level, the recent acceptance of the European Water Framework Directive (2000/60/EC) is likely to offer the best opportunity for the use of trend data to meet or assist with reporting obligations. Acting as an umbrella for all existing water legislation, the Directive establishes a strategic framework for managing the water environment. It establishes a common approach to protecting and setting environmental objectives for all groundwaters and surface waters (defined as rivers, canals, lakes, reservoirs, estuaries and coastal waters up to one mile from the shore) within the European Community.

Ensuring the conservation of our "natural capital" through monitoring- Thomas Bolger, University College Dublin

SUMMARY: The rapid rise in the rate of species loss due to human activities may impair the ability of the biota to provide life supporting ecosystem services. We therefore need to monitor biodiversity in order to understand the extent and causes of change.

Up to 50% of biotic diversity will be lost in the next century as a direct result of human economic activities (Soulé 1991, Splatt 1997). Earth's resources are finite and must be managed in a sustainable way if they are to continue to serve as our principal source of sustenance. Therefore the loss of species has led to a worry about the unpredictable risks that biological impoverishment could mean for the continuous dynamic functioning of the biosphere (Lubchenco *et al.* 1991).

It is a tenet of conservationists that biodiversity is crucial to the earth's "life support system": as we loose species, we also alter the integrity of the processes that maintain the ecosystem services (Baskin 1994). Some undetermined level of biological diversity is obviously necessary to maintain ecological function and resilience. However, authors such as Lawton and Brown (1993) and Walker (1995) have suggested that communities may contain functionally redundant species that potentially play very similar ecological roles. If this is true, then key aspects of community and ecosystem processes may remain unchanged by changes in species composition as long as each broad functional group retains at least one functionally competent species (Morin 1995). Gaining an understanding of this has proved to be controversial and it has become obvious that there is an urgent necessity for integration between the areas of natural history, population, community and ecosystem ecology.

It is not a simple matter to "rigorously assess the ecosystem function of biodiversity in a manner that speaks plainly to the concerns of the public and policy makers" (Kareiva 1996a, Bolger 2001). However, despite the debate about the appropriateness of experimental design that has been ongoing in this area, it is becoming obvious that loss of species does influence ecosystem function and that removing key species, such as ecosystem engineers or some top-predators, can have particularly detrimental effects. However, for other species we do not know the exact form of the relationship between ecosystem function and species richness.

Given this uncertainty, it would be wise to follow the argument as outlined by Costanza *et al.* (2000) where the management of the Earth's 'Environmental Portfolio' is in the format of game theory. They use a payoff matrix where the policy that has the least bad potential outcome is selected and conclude that the costs of being wrong if we assume that species can be lost are far greater and less reversible than the costs of being wrong in pursuing conservative policies.

Adopting this argument will involve preserving our 'natural capital', not putting ecosystem services at risk and having 'environmental insurance' (Costanza *et al.* 2000) all of which argue for the preservation of as many species as possible. We therefore need to be able to monitor changes in biodiversity and in population dynamics, in order to alert us to changes, to understand the pressures that are leading to species loss, to contribute to our knowledge of how species are assembled in systems and to understand changes in the relationships between species under different environmental conditions.

Monitoring of natural processes- Ant Maddock, Joint Nature Conservation Committee (JNCC).

SUMMARY: An important role of conservation is to ensure that biodiversity survives in perpetuity. Biodiversity has evolved in response to natural processes and our role in monitoring should be to ensure that these processes are functional in the ecosystems and landscapes we aim to conserve.

Perhaps a major reason for monitoring biodiversity is to examine if, under current management, biodiversity at a site will survive in perpetuity. (Note: management may range from detailed intervention by humans to a no management or hands off approach). If an understanding of biodiversity is that it has evolved in response to various selective pressures, then we need to ensure that at least some of these natural processes still operate. Natural processes include gene flow, pollination, dispersal, predation, decomposition, as well as energy cycling etc. but also include harvesting techniques and farmland management.

How are these processes operating? Perhaps, in conjunction with other measures of biodiversity (taxic, genetic, cladistic, trophic diversity / richness), we should widen our monitoring efforts on the operation of the natural processes that ensure the survival of genes and species.

Undoubtedly, this is an exceptionally tall order but this approach may provide a number of advantages:

- We may be better able to estimate if biodiversity will survive at a site.
- We may also be better able to understand natural ecosystem functioning leading to better site management.
- Introduce a way of thinking that sees conservation from the point of the needs of the organisms that we aim to conserve. Just a suggestion…

Biodiversity monitoring needs at the global scale - Paul Rose, Joint Nature Conservation Committee (JNCC)

SUMMARY: Monitoring of biodiversity is essential to identify priorities for action, define the actions and carry them out. Global monitoring coordinated by MEAs and NGOs can be best achieved by aggregating monitoring schemes organised at a smaller, national scale. In order to help identify monitoring needs, a set of guidelines as to what biodiversity should be monitored at a national scale and what essential research is needed before undertaking any aggregation of data is specified.

From a user perspective, and a conservation user at that, the highest level requirements for biodiversity monitoring are the same at any geographic scale. Monitoring is needed to identify priorities for action, to assist in defining actions that address these priorities and to track the effect of the actions taken.

Given this assumption it is reasonable to assume that global biodiversity monitoring requirements are always most efficiently met through an aggregation of monitoring schemes organised at a smaller, usually national, geographic scale. Only if there was a unique global requirement for information that did not apply at the national level would there be justification for co-ordinating and implementing monitoring at the global level. I don't think this is ever likely to exist.

There are some actions taken at the global level by Multilateral Environmental Agreements (MEAs) or international NGOs for which it is very important that the information needed to monitor and inform these actions is collected in a standardised way throughout the geographical area of action impact. Although national monitoring is still the most likely source of information, it is essential that the co-ordinating MEAs and NGOs set the standards necessary to pull this information together and promote solutions to fill gaps in the national monitoring programmes (of which there are many).

A requirement for larger scale monitoring, at least at the biogeographic level if not the global level, is created by the national monitoring programmes themselves and the need to put national results in a biogeographic context. This is especially true for migratory species and for components of biodiversity with rapidly changing distribution patterns or nomadic characteristics.

As a starting point for discussion, I emphasize that global monitoring requirements are primarily created through the actions of MEAs, international NGOs and the need for national monitoring programmes to place their results in a biogeographic context. Global requirements are most efficiently met by the aggregation of results from national monitoring programmes, through the establishment of monitoring standards and the filling of geographic gaps. This type of global monitoring activity needs to carefully coordinated and harmonised probably under the leadership of the Convention on Biological Diversity (CBD).

Having touched on how to deliver global biodiversity monitoring how do we decide on what to monitor? The global issues are largely set by the deliberations and actions of the MEAs but what biodiversity do we measure to help address the major factors causing biodiversity loss and decline? I propose the following as a first attempt to define criteria to assist this selection.

- We must understand the relationship between the biodiversity measured and the factors causing loss or decline.
- The biodiversity must be practical to measure.
- The biodiversity must be measured nationally, locally or regionally across much of the geographical area of interest.
- Monitoring methods must be reasonably consistent, robust and reliable.

Based on my own rather limited experience and expertise, I can immediately identify wetland inventory and waterbirds as two subjects that fit these criteria. To take the example further, it is also possible to imagine analyses and information products that could be created from global aggregations of national wetland inventory and waterbird monitoring programmes to help inform global issues such as such as climate change, agricultural reform, fisheries policy, atmospheric nitrogen deposition, coastal squeeze and probably more.

Before any comprehensive selection of global biodiversity monitoring priorities can be conducted using this style of approach it is essential to:

- produce metadata about biodiversity monitoring schemes
- link biodiversity monitoring to the actions and customers it can most usefully inform and support
- develop and implement standards to facilitate aggregation of data
- provide sufficient access to monitoring results for aggregated analysis products to be created and tailored to specific uses.

Finally is this selection of global biodiversity monitoring priorities any different from the selection of global biodiversity indicators? Personally I can see very little difference.

Biodiversity monitoring needs - an international perspective - Horst Korn, Federal Agency for Nature Conservation

SUMMARY: We need simple, long term monitoring programmes that generate policy relevant data and build on existing systems. Data sets should focus on the external pressures affecting biodiversity, and integrate local, national and international level monitoring.

Biodiversity monitoring is urgently needed to generate data sets that

1) Reflect the status and trends of representative sets of biodiversity (not only species!)
2) Show the possible effects of policy or management measures and
3) Indicate when political or management actions are needed to halt or reverse negative trends.

The design of monitoring programmes should focus on the possible integration of local, national and international levels. All levels should be compatible and integrated. This means that local monitoring results should feed into national and national ones into international monitoring schemes in a nested way.

Since many local and national monitoring programmes are already in place, emphasis should be given to develop a European-wide system that tracks changes in biodiversity, irrespective of the actual methodologies used in the different regions or countries.

Internationally, the most policy relevant data should reflect trends in biodiversity that are comparable between countries and regions, which means that the same items are monitored by different countries or regions. This way we could relate observed trends in one country to a wider range of countries where the same subset of biodiversity (species, habitat etc.) occurs. Only then we can see if a specific country follows a general trend or if it is an "outlier" on a wider scale.

The most valuable data sets would be those linked directly to external "drivers" and "pressures" that effect biodiversity. Relationships must be obvious in order to convince politicians and other decision makers. Priority should be given to develop simple and cheap monitoring schemes that could be applied widely in Europe, building on and incorporating already existing monitoring programmes.

Monitoring needs in support of the conservation of biodiversity in Europe - Dominique Richard and Sophie Condé, European Topic Centre on Nature Protection and Biodiversity.

SUMMARY: In order to analyse the full effects of policies on biodiversity conservation and to involve decision-makers and the general public in conservation and predict possible changes, it is essential to monitor at the EU level. The needs for monitoring are listed here, as well a review of schemes (both at the NGO level and EU level) already underway in Europe that could help in coordinating data collection in Europe and analysing the effects of policies.

The need for biodiversity conservation has gained increasing concern in the political agenda resulting in a number of statements and commitments at all levels. At EU level, biodiversity conservation is part of the four priorities addressed by the 6th EU Environmental programme (http://europa.eu.int/comm/environment/newprg/), which has a target to stop biodiversity loss by 2010.

As a direct consequence, effects of policies and other initiatives should be scrutinised in the light of their efficiency to halt degradation of biodiversity. Both decision-makers and the wider public need easily understandable evidence of what is happening, should it be better or worse. This is translated in different biodiversity monitoring needs.

At the European level, needs are the same than those faced by any national authority in charge of the proper management of biodiversity. However, results should provide a European picture, which means that assessments have to rely on comparable methodological protocols from one country to another. They can be grouped in three main categories:

1) The need to keep an overview of the general state and trends of biodiversity at the European scale, with, as far as possible, a clear understanding of the underlying causes of changes, particularly in relation to human activities (land-use changes in protected areas and in the wider countryside, defoliation in forests, trends in species populations, phenological changes…). The questions behind are "does it matter?" and "can we improve and how?"
2) The need to assess the efficiency of policies and other management activities specifically implemented to preserve biodiversity or to counteract negative effects of other policies (efficiency of the Bird and the Habitat Directives, of LIFE-nature projects, of agro-environmental measures, of biodiversity action plans…)
3) The needs of the EU to report on the effective implementation of commitments within international Conventions

In all cases, monitoring schemes should answer specific questions, if possible both in a qualitative and quantitative way. They should also be strong enough to provide background for predictions on future trends in relation to different scenarios of environmental change.

As a close counterpart to monitoring activities, the development of Indicators, which so many decision-makers call for should both guide the design of such monitoring schemes (What do we try to demonstrate? Can we apply it to other similar situations? With which type of socio-economic data can we compare the results?) and be a systematic output of them (does the monitoring show any progress/ deterioration? Can this be related to the implementation at a given moment of a certain policy?).

In Europe, several international monitoring programmes are on the way (see B. Delbaere's and T-B. Larson's contributions), each one responding to specific purposes, but thus often disconnected. On the other hand, a number of recent initiatives are arising, which should help to focus on priorities for future monitoring:

- The European Environment Agency (EEA) is developing a "core set of indicators" (including biodiversity) to target future collection of data to better answer policy questions.
- In relation with the implementation of the EU Biodiversity action plans, a series of ndicators are being developed to assess the efficiency of these EU action plans (Commission's responsibility) (http://biodiversity-chm.eea.eu.int/stories/STORY1016812291)
- At the initiative of the EEA, a Biodiversity Monitoring and Indicator Working Group is being set-up to better coordinate international approaches involving collection of biodiversity-data. The "European Biodiversity Monitoring and Indicator Framework" (EBMI-F) (http://www.strategyguide.org/ebmf.html), presented during CBD-COP6 in The Hague, was recognised as being a good process to stimulate better coordination on these issues at the Pan-European level.

Biodiversity monitoring strategy in Denmark - no monitoring without objectives, and no objectives without monitoring - Lilian van der Bijl and Torben Moth Iversen

SUMMARY: The authors describe the need for biodiversity monitoring in Denmark and the implementation of the Danish National Monitoring Programme, an integrated nation-wide programme for monitoring of terrestrial habitats, water bodies and the biodiversity within these. The overall objectives are to establish the status of terrestrial habitats and water bodies and their pressures. These objectives are used to determine the order of priority of monitoring needs established by the Danish Forest and Nature Agency. The authors also highlight the need to develop identical indicators for all levels in order to reach national action plans and international targets. This requires national and international agreement on methodologies for data collection, analysis, and data handling and on streamlining reporting by means of policy relevant core indicators.

Useful monitoring is policy relevant monitoring for decision-making at national and regional levels. The overall Danish monitoring strategy stipulates: *No monitoring without objectives, and no objectives without monitoring.* In accordance with this principle there must be no monitoring without predefined objectives, and conversely, defined objectives claim monitoring.

Thus a monitoring programme must be relevant to politicians, but also to the public, to scientists, NGOs etc. It must be economically reasonable as there are limited resources available. It must be based on a scientific foundation and allow integration of knowledge acquired. Finally a monitoring programme must be able to establish statistical changes and trends towards targets.

The monitoring of biodiversity, like other forms of monitoring, falls under strategic planning. Strategic planning requires that the monitoring activities are organised in accordance with the so-called DPSIR concept, i.e. Driving forces, Pressures, State, Impacts and Responses. The P, S and I elements of the concept will constitute the backbone of the monitoring programme as they are measurable elements.

Biodiversity monitoring (i) measures progress towards strategic targets, (ii) reaches national and international targets and (iii) provides the scientific basis for identifying the need for further measures. Biodiversity monitoring should also be seen in relation to the expected implementation of habitat quality planning.

The Danish National Monitoring Programme is an integrated nation-wide programme for monitoring of terrestrial habitats, water bodies and the biodiversity within these. The overall objectives are to establish the status of terrestrial habitats and water bodies and their pressures. The programme must be designed to:

- Fulfil Denmark's international monitoring obligations and commitments (Conventions and EU directives)
- Prove the effects of national action plans and targets
- Provide information on the effect of other programmes of measures, including establishing the status of habitats and water bodies in relation to national legislation
- Improve the scientific basis of decisions for future national action plans or international initiatives to introduce improvements on the quality of terrestrial and aquatic habitats.

These objectives are used to determine the order of priority of monitoring needs established by the Danish Forest and Nature Agency. According to these objectives, monitoring needs include essential habitats and species of high priority in compliance with the Habitats Directive. This directive includes many aquatic habitats and the monitoring strategy should be consistent with the strategy of the Water Framework Directive.

To ensure that biodiversity monitoring is policy relevant for decision-making at national and regional levels and to attain international monitoring obligations, indicators must be developed to fulfil the reporting needs on each level. A crucial point is the need to develop identical indicators for all levels in order to follow the information flow from assessment of status in relation to habitat quality objectives to realization of national action plans and international targets. This requires national and international agreement on methodologies for data collection, analysis, and data handling and on streamlining reporting by means of policy relevant core indicators.

Reply to: Biodiversity monitoring strategy in Denmark - no monitoring without objectives, and no objectives without monitoring - Richard Bradshaw, Geological Survey of Denmark and Greenland

SUMMARY: In response to the contribution made by Van der Bijl and Torben Iversen, the authors argues the need for different indicators adapted to different spatial scales.

Van der Bijl and Torben Iversen stress the need for "identical indicators (of biodiversity) for all levels (regional, national and international)". I question the scientific basis of this need. Different factors impact biodiversity at different spatial scales. For example, climate change acting on genetic diversity is a major determinant of diversity change when viewed at the continental scale, while land-use change is a major driving force at the regional scale. At local scales, disturbance processes are of major importance - but this importance does not scale-up to the continental scale.

Monitoring of biodiversity should be related to the driving forces for change as they propose, but I would argue that different indicators are appropriate for the different spatial scales they mention.

Counter-reply to "Biodiversity monitoring strategy in Denmark - no monitoring without objectives, and no objectives without monitoring" - Lilian van der Bijl & Torben Moth Iversen

SUMMARY: In our keynotes we stressed the need for "identical indicators (of biodiversity) for all levels (regional, national and international)". Richard Bradshaw questions the scientific basis of this need and argues that different factors impact biodiversity at different spatial scales and that different indicators are appropriate for the different spatial scales they mention.

The Danish national monitoring programme is primarily designed to fulfil Denmark's international monitoring obligations and to answer policy-relevant questions e.g. provide information on whether or not an action plan is realised and the objectives of that action plan attained. We believe that indicators must be developed to meet these requirements.

As the policy-relevant questions are expressed on the national or international level, the data coming from the local samplings must basically be comparable at the local level, and both data handling and indicators chosen for reporting must be identical to facilitate the establishment of a comprehensive overview and policy-relevant answers.

Threatened species on the red-list could be an example of an appropriate indicator on all levels. On the regional level, the indicator would describe the status (e.g. a threatened butterfly species in different habitats). On the national scale, the indicator would describe the number of threatened butterflies and the geographic distribution of the problem. On the international scale, the indicator would identify the number of threatened species e.g. within an eco-region and whether the international targets are met.

Reuse of indicators at all levels is economically sound and also gives rise to shared understanding among decision-makers. We agree that additional indicators may be needed. On all levels the DPSIR-approach must be integrated in the development of indicators.

The monitoring programme must be based on a scientific foundation. By this we mean that sampling, data handling and reporting must be done with scientifically approved methodologies. The interpretation of the data must not conflict with universally accepted scientific knowledge either. Of course the design of the monitoring program must be knowledge-based as emphasised in our keynote (6 September 02). By using uniform data sampling, analysis and data handling methodologies and comparable indicators locally/regionally/internationally, the statistic foundation will be improved to potentially give rise to scientific spin off. For this purpose we do agree with Richard Bradshaw that additional indicators may be needed for instance for certain eco-regions.

Biodiversity indicators - a national perspective - Jeremy D. Wilson, Royal Society for the Protection of Birds (RSPB) & Ian Bainbridge, The Scottish Executive.

SUMMARY: A number of indicators have already been adopted at the UK level to monitor the current state of the environment and the environmental pressures that threaten biodiversity. In Scotland, the development of a national set of indicators of sustainable development is in progress. Some of the factors being taken into account in the development of the monitoring of biodiversity in Scotland are discussed.

Biodiversity indicators are regularly monitored measures of pressures on the environment, current state of the environment and human responses to changes in that state. For example, the rate of extraction of peat from lowland peat bogs (a pressure indicator) affects the quality and extent of remaining bog habitats (a state indicator) and a Government response may be to encourage the production of peat alternatives (a response indicator). This 'pressure-state-response' model is now widely accepted as the basis for generating suites of environmental indicators to help focus attention on key issues within the very broad concept of sustainable development. The UK now contributes to the development and application of indicators of sustainable development at all scales from global and European to national, regional and local. At the UK level, Government has now adopted a set of 150 indicators and 15 headline indicators published in *Quality of Life Counts: Indicators for a Strategy of Sustainable Development in the UK* (www.sustainable-development.gov.uk/sustainable/quality99/). The distinction between a larger suite of general indicators and a smaller suite of 'headline' indicators reflects the need both to stimulate debate across a wide range of sectors of human activity with environmental impacts, and to identify key indicators with strong public resonance in order to focus attention on the three main pillars of sustainable development - social, economic and environmental.

Biodiversity (biological diversity at all scales from genes to species to ecosystems) is a fundamental component of environmental state. Development is not sustainable if it results in unacceptable deterioration in the stock or condition of biodiversity, yet current environmental pressures (e.g. land use change, pollution, climate change and invasive species) threaten biodiversity as never before. Against this background, it is critical that any suite of indicators of sustainable development should include measures related to biodiversity state, the pressures upon it, and responses to biodiversity trends.

At one of a series of meetings to develop a Scottish Biodiversity strategy, a working group considered the issue of monitoring. The group agreed that terrestrial habitat monitoring was vital to assess progress, but in many habitats, adequate data was not available. We therefore need a thorough review to:

- Analyse the monitoring needs to meet requirements for assessing habitat change
- Develop schemes compatible with UK, EEA requirements to enable cross-assessment.
- Ensure good co-ordination between organisations monitoring habitats, and not develop ad-hoc schemes for immediate requirements only.
- Ensure that monitoring assesses outcomes, and not just processes and inputs.
- Resolve the debate over whether "habitat quality" monitoring is more appropriate than systems that attempt to assess "ecosystem function or health".
- Ensure that monitoring is fit for purpose and provides value for money.
- Assess the value of remote system monitoring for terrestrial habitats.

Clearly, data availability remains one of the primary constraints on the selection and reporting of statistically powerful biodiversity indicators within Scotland. A review of the kind proposed by this working group would help to lift some of this and other constraints.

Part of this contribution is an edited version of a draft of "Biodiversity Indicators of Sustainable Development in Scotland (A report by the Action Plan and Science Group of the Scottish Biodiversity Forum).

Monitoring biodiversity in Finnish agro-ecosystems - Mikko Kuussaari, Finnish Environment Institute.

SUMMARY: Monitoring of agro-ecosystem is particularly called for in view of the reform of the EU's Common Agricultural Policy and the inclusion of new members into the EU. Simultaneous monitoring of plants, butterflies, bumblebees, birds and landscape structure in randomly selected agricultural landscapes has recently started in Finland in order to monitor the progress of current schemes and develop future Finnish agro-environmental programmes.

Agriculture and its intensification has long been the single most influential factor causing changes in European biodiversity. During the last ten years, the European Union (EU) has made large economic efforts to maintain and increase biodiversity through national agro-environmental support schemes. Despite the large amounts of money put into these schemes, recent studies have shown that in some schemes the benefits for biodiversity have remained relatively small or even non-existent, stressing the need for good quality monitoring.

Effective agro-ecosystems biodiversity monitoring programs are particular needed now, as the EU is going to reform its Common Agricultural Policy (CAP) and new member countries are joining the EU. The reform of the CAP is likely to re-target agricultural subsidies away from production based subsidies and towards environmentally based subsidies, potentially benefiting farmland biodiversity. On the other hand, adoption of the CAP and intensification of agriculture in the joining countries may threaten the often rich farmland biodiversity of the currently less intensively cultivated agricultural landscapes of those countries.

An ideal monitoring program of farmland biodiversity would involve quantitative annual sampling of several taxonomic and functional groups of organisms in a large number of study areas, randomly stratified to produce representative results from a large geographic cover. Replicates of all significant habitat types should be included in the monitoring within all study landscapes. There is also a need to monitor parameters of environmental quality in the areas where the abundance of species is being monitored. Finally, the monitoring should be able to answer questions at different spatial scales, from national to regional scale and down to the local scale of a specific patch.

In practice, it is difficult to get an ideal monitoring scheme established. In many countries, monitoring of different taxa has started independently and the schemes are running in different sites with incompatible methods. This issue is likely to hinder any attempts to develop monitoring of farmland biodiversity at the European scale, even though from the EU's point of view, compatible monitoring at the European level would be highly desirable.

In Finland, an attempt towards systematic monitoring of several indicator taxa of farmland biodiversity (vascular plants, butterflies, bumblebees and birds) and landscape structure started in 2001 in 58 agricultural landscapes (each study area 1 km^2 in size), which were selected for the study using stratified random sampling in four parts of southern Finland. The monitoring was designed to serve two primary purposes:

1) Following the effects of the current Finnish agro-environmental support scheme and
2) Producing basic knowledge on factors affecting farmland biodiversity in order to further develop the Finnish agro-environmental programme in the future.

In addition to collecting species data, environmental quality is measured in the field and data on the details of farming practices is obtained from the national farmland database and landscape structure is monitored based on aerial photographs and GIS methods.

Biodiversity monitoring needs in agro-ecosystems - Davy McCracken, Scottish Agricultural College.

SUMMARY: Biodiversity monitoring in agro-ecosystems must put greater emphasis on considering spatial and temporal changes across all elements of the wider landscape.

European farming systems and practices have been responsible for the creation and continued maintenance of many landscapes, habitats and wildlife communities of high biodiversity. It is, however, often forgotten that farming systems are dynamic, with management practised on any one area of farmland changing constantly with time. Such changes may be marked (in terms of the move from one land cover to another) or more subtle (in terms of differences in timing and/or intensity of grazing pressure). In addition, it is also often forgotten there is an extremely complex relationship between the biodiversity value of a particular field or area of farmland and the associated land form and land use in the wider landscape. Biodiversity monitoring on individual sites and farmland habitats can therefore obviously help identify priorities for management action. But without an appreciation of the importance of pattern in the wider agricultural landscape, it will be impossible to predict the impact of land-use change upon this pattern and the associated biodiversity value.

Much emphasis has been placed to-date on birds and plant communities, but it is essential to ensure that representatives from the full range of biological taxa are considered so that the full implications for all the different components of biodiversity can be taken into account in the appraisal of the monitoring. It also needs to be recognised that detailed ecological assessment of the majority of these groups is laborious and time-consuming. While one solution may be to call for increased financing of monitoring programmes, it would be more practical to make greater use of information on surrogate measurements (such as vegetation structure) which not only may be more cost-effective to obtain but also may actually be more informative in explaining the underlying processes.

By the same token, any monitoring of the biodiversity resource itself needs to put much more of an emphasis on a functional approach (e.g. considering the life traits of the species involved) rather than focusing solely on the species or assemblages concerned. Such an approach is likely to be the only way to allow a comparison of the effects of any type of impact on similar habitats in different geographical areas of Europe, where the species concerned are likely to differ but the functions performed by the species present are likely to be more directly comparable.

However, detailed ecological monitoring data will only be of value if additional contextual information is available. Given the dynamic nature of farmland, it is therefore also essential that any biodiversity monitoring programmes ensure that information is also collected on the temporal changes occurring in the agricultural landscape. As such information is currently collected as a matter of routine through CAP subsidy control measures, this does not mean that additional information needs to be collected but rather that existing information needs to be integrated into biodiversity monitoring programmes.

Finally, it is important that biodiversity monitoring stops focusing on particular habitats or features (such as farmland, woodland, river corridors) in isolation but instead consider and quantifies the importance for biodiversity of the interactions between all of these elements (farmed and non-farmed) in the landscape. It is also essential that monitoring programmes are focused at a large enough scale (such as a catchment) in order to obtain an understanding of the wider impacts of land use on the different biodiversity elements occurring across the area as a whole, rather than focusing solely on individual sites or areas.

Reasons for monitoring biodiversity - a north European forest perspective - Richard H.W. Bradshaw, Geological Survey of Denmark and Greenland.

SUMMARY: The main reasons for long-term monitoring of biodiversity include:
1. Establishment of 'natural' variation and 'base-line' conditions.
2. Identification of biogeographical regions that are particularly sensitive to irreversible loss of biodiversity.
3. A tool for following the effects of management on biodiversity development.

A long-term perspective is valuable in the analysis of biodiversity change in forest ecosystems where generation times of the dominant species can be several centuries. Research into long-term forest dynamics in northern Europe has helped identify at least three general reasons for monitoring biodiversity.

1. Long-term monitoring is helping generate a picture of the scale and causes of 'natural variation' in forest biodiversity (Davis, 1989). Not all biodiversity changes are driven by anthropogenic activity. Natural disturbances such as fire, animal browsing and wind-storm have a long-term influence on local forest diversity, some of which may be interpreted as undesirable by local land managers. Climate change (previously natural but now most likely with an anthropogenic component) is another major driving force for long-term change in species composition. Understanding of this natural element provides an important background for interpretation of any biodiversity change.

2. Long-term studies have demonstrated that land-use change is the major driving force in altered biodiversity, at least in north-west Europe during the last few centuries (Birks *et al.*, 1988). Systematic study has helped identify the biogeographical regions that have been most affected and those that are most sensitive to anthropogenic impact. Some boreal forest regions return to a near virgin state after human impact (Segerstrom *et al.*, 1994), while in others, irreversible changes have occurred. For example, the change from rich, mixed deciduous forest in southern Scandinavia to semi-natural mixtures of *Picea abies* and *Fagus sylvatica* has led to a loss of species diversity (Lindbladh *et al.*, 2000).

3. Monitoring biodiversity development is an important way of assessing the impacts of management on the biological environment. This applies whether the management is aimed at conservation or exploitation of natural resources.

Monitoring and deep knowledge of the subject to monitor have to complement each other, the case of Mediterranean trees and shrubs - Beti Piotto, Agenzia Naz. Protezione Ambiente (ANPA).

SUMMARY: It is necessary to have a deep knowledge of the subject to monitor, a single 'segment' of the problem showing gaps of knowledge could lead to reduction of biodiversity levels.

I think any kind of monitoring has to be completed or complemented with a deep knowledge of what is being monitored. One such example is the following: Nearly 27% of the Italian territory, mainly located in areas with Mediterranean climate and vegetation, is threatened by processes of degradation, erosion or desertification. Desertification in the European Mediterranean countries is linked to a number of characteristics of the region such as the vulnerability of the environment due to particular climatic and geomorphological characteristics combined with frequent unsustainable land uses, human pressure, extensive forest cover losses, etc).

As we know, vegetation strongly conditions the quality and evolution of soils and it is essential to mitigate degradation, erosion or desertification. Mediterranean flora is well described from a botanical point of view. Abundant information is available for botanical and ecological characteristics, distribution and occurrence, value and use of many species but little is known about their natural and artificial regeneration.

The absence of this information is particularly serious because it represents a lack of knowledge essential to address a multipurpose approach to forestation and restoration and may explain the reason why tree planting is often limited to a narrow number of species that are easy to grow in nurseries. This practice greatly reduces levels of biodiversity and it is even more worrying with regard to shrubs and minor hardwood that constitute the greater part (60 to 70%) of the Mediterranean woody flora. As a contribution to this issue, the Italian Agency for Environment Protection has published a handbook about propagation by seed of 120 Mediterranean trees and shrubs (the Italian version is in the web:http://www.sinanet.anpa.it/aree/Biosfera/documentazione.asp#propagazione)

Monitoring and the conservation of forest biodiversity- Valerie Kapos, UNEP- World Conservation Monitoring Centre.

SUMMARY: To support decision-making effectively, monitoring efforts of forest biodiversity should focus on parameters that are directly relevant to policy and management goals.

Forest biodiversity has been widely altered by human action. In the contemporary world, human activities, such as logging, land conversion, fuelwood and charcoal production, shifting cultivation, non-timber forest product harvesting, hunting and mining, are almost certainly the most important influences on forests' capacity to maintain their original biodiversity. Climate change is also affecting the distribution and status of forest biodiversity. Each of these types of human influence affects forest biodiversity differently, and the magnitude of the effects depends strongly on the methods employed locally, the forest type, and on other factors within and around the ecosystem. Thus, many factors influencing forest biodiversity are affected in varying and complex fashions by human activity.

Policies and management decisions about forests and their use are crucial factors in efforts to conserve forest biodiversity. Decision-makers need access to adequate relevant information in order to try to minimise the adverse impacts of human activities on forest biodiversity. Biodiversity monitoring is a fundamental tool in the provision of the necessary information.

The role of biodiversity monitoring is scale-dependent. At national and international scales the information it provides is an essential tool for evaluating progress towards policy goals and targets. At local scales monitoring is fundamental to assessing the impact on forest biodiversity of management decisions and practices. At all scales biodiversity monitoring has roles in both supporting decisions that are perceived as directly relevant to biodiversity and ensuring that the implications for forest biodiversity of decisions in other sectors (and locations) are adequately understood.

Much work on biodiversity has so far focused on one-off assessments at a range of spatial scales. Biodiversity assessment is often used to identify areas that are important for biodiversity, or elements of biodiversity present in a given area that are of interest or concern, and thereby establish priorities for policy and management. Monitoring is distinct from assessment in its focus on change through time. To support decision-making effectively, monitoring efforts should focus on parameters that are directly relevant to policy and management goals. Because these are often stated vaguely, substantial effort may be required to identify which elements of biodiversity should be monitored. It is also important to choose parameters for which change can be detected before it becomes irreversible. Thus, for example, population sizes of forest species or forest quality may be more relevant for monitoring than total species number or simple measures of forest extent. Establishing useful programmes of forest biodiversity monitoring therefore demands that resources be used fairly intensively and be committed on a long-term basis. It also requires that careful attention be paid to the likely use of monitoring data to inform decision making. These factors are vital in selecting parameters for monitoring.

Biodiversity monitoring: towards a functional approach- Peter Veen, Royal Dutch Society for Nature Conservation.

SUMMARY: Monitoring of biodiversity means principally that we are monitoring response variables in ecosystems such as plant coverage, etc. This type of monitoring does not fit with the requirements from the society, because sustainability cannot be evaluated solely on response variables. The causal relationship with so-called positional and conditional abiotic variables needs more attention in order to make a bridge with impacts from the society. I propose to use 'ecosystem monitoring' as a unified framework for all types of monitoring which will cover all aspects of biodiversity in connection with impacts from the society.

The past decades have enabled ecologists, like botanists and zoologists to have a broad experience in mapping the distribution of plants and animals. The distribution-atlases of plants and birds have been available in some European countries like the U.K. and the Netherlands since the 19th and early 20th century. This type of monitoring is very important, because this information can provide us with a base-line for future monitoring results. For instance, in the Netherlands, we used the plant base-line from the 1900-1950 period for calculating the Red List status of the plant species in our country (R. van der Meijden et all, 2000, Endangered and vulnerable vascular plant species in the Netherlands, Gorteria 26-4, Leiden/NL). In fact, simple distribution-atlases can be seen as the first generation of biodiversity monitoring results and they provide us with interesting information on different scales, including the European scale (Atlas of European Mammals (1999), Atlas of Amphibians and Reptiles in Europe (1997), the EBCC Atlas of European Breeding Birds (1997)).

CBD accepted the ecosystem approach as a framework for understanding of biodiversity in different geographical scales. Based on the ecosystem approach, biodiversity monitoring means more than monitoring of habitats or species. It means that we have to identify the most essential components of ecosystems in the biodiversity monitoring concept. For that I propose that we use the following hierarchical structure:

- On the supra-regional scale: positional factors like soil type and hydrological regime
- On the regional scale: conditional factors like base status or macro-ion status
- On the sub-regional scale: operational factors like nutrient status, mineralisation process…
- Response variables on different scales: plant and animal species.

This data should be monitored on a quantitative scale, enabling the data to be interpreted using different statistical techniques such as "Correspondence Analysis", which can reach quantified conclusions.

By using this concept of biodiversity monitoring, the results are multi-interpretable. The data can be used to look at impacts of agriculture (amelioration impacts), of urbanisation and infrastructure development (fragmentation impacts) or of river catchment management (dissification impacts). The DPSIR concept as mentioned by Van der Bijl and Iversen can become operational if we are able to identify the critical components in the ecosystem approach.

Until now, the ecosystem approach has not been implemented in biodiversity monitoring. This means that the subject of our discussion needs more attention, especially concerning 'verification value' and 'prediction strength'. In truth, most countries do not include biodiversity monitoring in the policy making process. This is mainly because of problems linked to 'language': politicians prefer to speak in terms of "EUROs/ha" production rather than "*Otis tarda*". In conclusion, I believe that in connecting the biota with the abiota, the framework will be much stronger and more open for 'falsification discussions' and 'sustainability prognoses'.

Biodiversity monitoring needs in rivers - Scot Mathieson, Scottish Environment Protection Agency.

SUMMARY: The Scottish Environment Protection Agency's river biodiversity monitoring, principally of river invertebrates, is undertaken primarily to monitor the effectiveness of legal controls, from UK and European statute, on effluent discharges, and to report on the state of the river environment. Future needs, driven by the EU Water Framework Directive, will require an expanded monitoring network, and the inclusion of fish, algae and macrophytes.

The Scottish Environment Protection Agency (SEPA) is the government agency responsible for environmental regulation and improvement in Scotland. SEPA regulates, inter alia, sources of pollution and activities that lead to risks of pollution to land, air or water. SEPA also reports on the state of the environment, provides environmental advice and information and works in partnership with public, voluntary and private sector organisations to deliver environmental improvements.

What SEPA needs from monitoring programmes: In a strategic review of its science functions, SEPA identified three key requirements for its environmental monitoring:

- To measure environmental quality to the standards needed by SEPA;
- To provide support for regulatory decisions (on environmental licences, monitoring and enforcement);
- To detect future problems in order to pre-empt long-term environmental harm.

Further key requirements for science are implicit in SEPA's aims and objectives:

- To provide information on regulated and unregulated emissions, environmental quality relevant to national/ international commitments, and the state of the environment.
- To operate to high professional standards, based on sound science.

Why SEPA needs biodiversity monitoring of rivers: SEPA has duties to promote the cleanliness of Scotland's rivers and the conservation of river environments and wildlife. This is achieved principally through a duty to control discharges to surface waters, including rivers. The control exerted through the issuing of a legally binding 'Consent' to a discharger is also the principal means of ensuring implementation of several European Directives, e.g. Urban Waste Water Treatment and Dangerous Substances Directives. Consents are kept under review to ensure that the conditions imposed on discharges remain adequate to protect water quality. This process is supported by an extensive river water quality-monitoring programme, with chemical and biodiversity assessment as key components. Monitoring data are used to classify and report on the quality of river waters.

To deliver the commitments above, SEPA requires biodiversity monitoring to address a number of business needs:

- Quality characterisation, combining biodiversity, chemical and aesthetic data into a single default-based river quality classification scheme, with 5 quality classes from "Excellent" to "Seriously Polluted";
- Establishing baseline understanding for river management;
- Assessing applications for Discharge Consents, and their subsequent reviews;
- Diffuse-source pollutant impact assessment;
- Environmental impact assessment for proposed developments;
- Detection of pollution incidents and assessing their environmental impacts;

- Post-remediation assessment;
- Ensuring that SEPA's actions maintain and protect habitats, fauna and flora requiring conservation, e.g. priority habitats and species listed in the UK Biodiversity Action Plan, in EU Directives, and in IUCN categories.

What SEPA monitors in rivers: Monitoring of biological quality of Scottish rivers has been principally through sampling and assessment of invertebrate assemblages at a wide network of river sites, with more limited assessments of river macrophyte, diatom and fish assemblages. The Biological Monitoring Working Party (BMWP) Score system is used to convert invertebrate assemblage data into a set of simple numerical values, based on the perceived tolerances of invertebrate families or other taxonomic groupings to organic pollution. As different types of river support different invertebrate assemblages, the software package RIVPACS (River Invertebrate Prediction and Classification System) is used to predict two indices of biological condition from BMWP, the taxon richness and Average Score Per Taxon (ASPT) to be expected at each river site from physicochemical attributes of the site. The biological condition of sites is assessed by comparing the observed and expected values of taxon richness and ASPT. SEPA also monitors river habitat quality using the UK's River Habitat Survey method, assessing the geomorphological structure as a surrogate measure for overall river biodiversity and providing an assessment of the degree of human modification of river habitats.

Future needs: In future, SEPA's river biodiversity monitoring requirements will be driven principally by the demands of the EU Water Framework Directive (WFD). The full monitoring and classification capabilities as specified by Annex V of the WFD must be provided by 2006. This will involve expanding biological monitoring from primarily river invertebrates, to include algae, macrophytes and fish, and expansion of the sampling network. The monitoring programme must be sensitive to impacts from river engineering and water Summaryion, new regimes to be introduced in Scotland under the WFD. SEPA is currently preparing by contributing to UK and European method research and development, and is expanding its monitoring capacity towards delivering wider Directive requirements. This is likely to require data from other organisations. Proposals include the development of a Scottish monitoring strategy to bring together the various sources of biological, chemical, hydrological and geomorphological data for Scottish rivers. This raises challenging questions of data ownership, accessibility, funding and data quality assurance and inter-calibration that are now beginning to be addressed between the relevant organisations.

Acknowledgements: The author is grateful to SEPA colleagues, Ian Fozzard and Ross Doughty, for helpful comments during the preparation of this paper.

Challenges for monitoring biodiversity in the Water Framework Directive- Laurence Carvalho, Centre for Ecology and Hydrology.

SUMMARY: The Water Framework Directive could potentially deliver major improvements in the monitoring of biodiversity. Its effectiveness will greatly depend on the interpretation of "good ecological status" and the development of a more strategic monitoring framework that identifies nature conservation as one of its core values.

The primary objective of the Water Framework Directive (WFD) is to promote "a sustainable, balanced and equitable water use". The long-term protection of freshwater resources is highlighted as a key mechanism to achieving this with a specific objective of attaining "good ecological status". In terms of monitoring, the WFD represents a radical shift from a focus on chemical water quality to a much broader ecological assessment that incorporates information on four main biological groups (or quality elements): algae, macrophytes, invertebrates and fish. In essence, a core purpose of the WFD is to deliver major improvements in the monitoring, protection and sustainable use of biodiversity associated with aquatic ecosystems.

There is, however, a real risk that these great intentions are forgotten in the frantic dash to deliver technical implementation by the appointed deadlines. The effectiveness of the WFD will greatly depend on two aspects of the legislation: (1) The interpretation of "good ecological status” and (2) The development of a more strategic monitoring framework that targets ecosystem functions, or services, rather than two or three pollution pressures.

Ecological status is defined as "an expression of the quality of the structure and functioning of the system”. Good ecological status is further defined as representing only slight deviation in the biological quality elements from an “undisturbed” state. How do we interpret disturbance? Do we try to return mesotrophic lakes to more ‘pristine’, nutrient poor, reference states irrespective of their value? Or are we aiming to maintain or restore ecosystem structure (water quality, quantity and biodiversity) and function (conservation, water supply, flood storage capacity, etc.) to ensure a more sustainable use?

How can the quality elements represent sustainable use? Because of the tight deadlines in WFD implementation, most monitoring tools being developed are based on existing tools that represent chemical water quality (particularly organic pollution and eutrophication). There could be great redundancy, repeating the failings of earlier water policies. How will the monitoring directly assess the impact of the other pressures highlighted in the WFD (morphological alterations, Summaryion, etc.) as well as services we place great value on? There is still time to think strategically and develop an array of monitoring tools that explicitly target conservation status alongside other measures of sustainable use.

Of the four biological quality elements, macrophytes would appear to be the most suitable general measure of biodiversity, or conservation status. They play a key structuring role in healthy ecosystems and have been shown to be the best ‘umbrella’ indicator of biodiversity in general with many invertebrate, fish and bird species dependent on their presence. There are still a number of challenges for devising an effective macrophyte monitoring programme for the WFD. In particular, there is a need to develop a standard, practical sampling methodology and ensure supporting environmental data is collected at appropriate temporal and spatial scales for interpretation of community change.

Session and title of contribution	**Contributors**
Session 2. To discuss existing and planned monitoring programmes and identify their strengths and weaknesses.	
Introduction to the second session	Allan Watt, Chair
Lessons from the French breeding bird monitoring programme	R. Julliard & F. Jiguet
Advantages and challenges arising from amateur monitoring	Caspian Richards
Innovative approaches to monitoring and conserving biodiversity	Robert Kenward
European site-based monitoring: An illustration	Ben Delbaere
The development of biodiversity indicators within the MCPFE	Tor-Bjorn Larsson
Forest biodiversity monitoring under discussion in Finland	L. Saaristo & J. Niemelä
Environmental objectives and indicators- The Swedish example	Thomas Nilsson
Reply to "Environmental objectives and indicators"	Frederic Gosselin
Landscape and biodiversity monitoring in Estonia	K. Sepp & A. Roose
Biodiversity and protected areas in Romania	Simona Mihailescu
Monitoring routes in the Dutch province of Noord-Brabant	Jan Jansen
Methods used in cross-cutting baseline estimates	Alan Feest

Introduction to the second session of the e-conference: existing and planned biodiversity monitoring programmes- Allan Watt (e-conference chair)

SUMMARY: In the first "session" of the e-conference several common themes emerged, notably the need for coordination and harmonization of biodiversity monitoring across Europe. E-conference participants are now invited to write about existing and planned biodiversity monitoring programmes.

During the last few days, a wide range of contributors has argued convincingly for the need to monitor biodiversity. So convincing are these arguments that it left me wondering why there is so little monitoring of biodiversity. Is there a lack of political will? Or has science failed to come up with methods that provide the sort of information on biodiversity that is needed?

There were several striking common themes in the contributions to the e-conference in its first "session". Paul Rose, in the first contribution, succinctly outlined why monitoring is needed – "to identify priorities for action, to assist in defining actions that address these priorities and to track the effect of the actions taken". Others, including Horst Korn, Richard Bradshaw, Dominique Richard and Sophie Condé, and Jeremy Wilson and Ian Bainbridge made similar points.

Many contributors, including Mikko Kuussaari, emphasised the need for coordination and harmonisation. Lilian van der Nijl and Torben Moth Iversen described the commonly held view that a core programme of biodiversity monitoring is needed when they emphasised the need for "national and international agreement on methodologies for data collection, analysis… data handling and [the] streamlining [of] reporting."

Many other valuable points were made. Peter Veen was amongst those who emphasised the need to understand trends in biodiversity, not just monitor them, Beti Piotto pointed out that monitoring has to go hand-in-hand with increasing research on what is being monitoring and Richard Bradshaw discussed the influence of natural factors on biodiversity.

Although most contributions focussed on monitoring in a very pragmatic way, Tom Bolger usefully reminded us that the conservation of biodiversity is not just about preserving plants and animals but about maintaining the biological diversity that provides life-supporting ecosystem services.

It is therefore encouraging to read from Dominique Richard and Sophie Conde that the 6th EU Environmental Programme has a target to stop biodiversity loss by 2010. But how are we going to do this (and know we have done it) if, as I wrote in my introduction to this e-conference, ten years after Rio, we have made such poor progress in even monitoring biodiversity?

In this session of the e-conference we will discuss some existing and planned biodiversity monitoring programmes. A few keynote contributors will describe some monitoring initiatives in Europe. Please write to tell us about other initiatives, from the local to the international scale.

Lessons from the national coordination of the French breeding bird monitoring- Romain Julliard & Frédéric Jiguet, CRBPO.

SUMMARY: A new breeding bird monitoring scheme has been implemented for the last 3 years in France and enjoyed an unexpected adhesion from amateur observers. We interpret

this success as a change in the relationship between the national coordinators and the observers.

In the introducing paper, the first sentence stated "the amount of effort spent on monitoring biodiversity is shamefully small". It seems to us that the amount of monitoring is actually enormous since almost every single protected or managed area has its own monitoring system in place, and most local naturalist amateur groups collect survey data on many kinds of organisms. What is "small" is rather our ability to co-ordinate local monitoring at a larger national or European scale.

In the last three years, we restored a national monitoring scheme of breeding bird abundance in France, based on point counts by amateur ornithologists. Despite a previous failure of such a scheme, despite introduction of random sampling of surveyed sites, and despite the fact that we were young unknown researchers, we have about 800 amateurs participating, which is about three times more than during the first 1989-1995 attempt, and we predict that the scheme should increase by a further 50% next year.

We spend a lot of effort on communication, in particular, and there is now a yearly publication of results from the scheme, which certainly contributes to its success. However, we are convinced that there is a more fundamental reason for its success. We realised that previous attempts relied on the theory that national monitoring was such a wonderful project that everybody should participate in order to make it as effective as possible. Implicitly, any candidate should feel guilty in not participating since it would weaken the whole scheme. We tried to avoid using such argument, rather focusing on the own interest a participant would have. Most participants are indeed members of local ornithologist groups, and are therefore primarily interested in what is going on around them. However, we underlined that the local scale was all the most interesting if it could be compared to a larger scale. We thus encourage local co-ordination of the scheme in order to allow production of local indices comparable to national ones. In other words, instead of implementing a new national scheme, we actually merge local (potential) ones.

Such methods have some advantages: while the scheme grows, it is more and more attractive. Because participants gain direct benefit from the data they collect, they tend to be rigorous and there is efficient quality control by local coordinators. Furthermore, protected and managed area networks also think that it is their interest to use monitoring methods that allows to separate local variation (in particular response to management) from larger scale processes. A partnership is rapidly establishing whereby protected area networks implement compatible monitoring method and send monitoring data to the national co-ordination, which in turn produces national indices on the effect of protection and management at a local and national scale. Any new local scheme now has the choice of benefiting by participating to the national scheme. The national coordination has to be humble (it is only part of a monitoring network instead of being at the head of a big project) and efficient if it wants to attract participants.

We do not pretend we have discovered something really new, as many monitoring schemes must already work in this way. The main question is whether such type of coordination could be implemented at a European scale: a scheme which could help national schemes to interpret their finding, as well as elaborating European biodiversity indicators.

Reply to 'Lessons from the national coordination of the French breeding bird monitoring'- Caspian Richards, Macaulay Institute.

SUMMARY: Monitoring of the kind described by Romain Julliard & Frédéric Jiguet, where local amateur naturalist groups collect data, has many obvious benefits, but may depend on better relations between professional researchers and amateurs if it is to be coordinated on a more widespread basis.

The scheme described by Romain Julliard & Frédéric Jiguet is encouraging for several reasons: Firstly, they are surely right in claiming that many monitoring schemes already draw on the efforts and expertise of amateurs, even if many such schemes are not yet integrated into monitoring networks run by professionals. The concept of 'biodiversity' accords very well with the work of many amateur naturalist groups, for whom identifying the full range of species within their local environment has long (always?) been a primary interest - in many parts of Scotland, for example, species lists are regularly published by amateur groups. The expertise within such groups is often enormous, and some members will be able to draw on a lifetime of experience and knowledge of their local habitats. Secondly, there are likely to be significant social benefits in terms of developing avenues of communication between professional scientists and the wider public, including encouraging a wider interest in and understanding of biodiversity. Thirdly, the cost of working with existing amateur groups is surely much lower than establishing a new network of professional researchers.

Nevertheless, there are evidently significant challenges to be faced if such a strategy could ever produce an integrated network - Romain Julliard & Frédéric Jiguet have identified some of these, such as the need to persuade people working on a voluntary basis of the benefits to them of a larger monitoring network. In particular, sustained rather than periodic effort and the need to carry out administrative work seem likely to require considerable powers of persuasion on the part of co-ordinators, and a good deal of commitment from amateurs. The relationship between national and local co-ordinators is also, as they say, all the more crucial when involvement is voluntary. In addition, the coverage of amateur groups is probably very patchy, depending on the locations of a critical mass of interested individuals with time on their hands (it would be interesting to hear how extensive such groups are in other parts of Europe - I speak here purely from a knowledge of Scotland). Perhaps the most significant challenge, though, is in persuading many professional researchers and especially policy-makers/administrators that amateur groups are a credible source of scientific data. Those of us who have had some contact with such groups will probably take little convincing of this, but given the mistrust that is evident between 'scientists' and 'the public' over issues such as GM techniques, with the latter accusing the former of arrogance and remoteness, while the former see the latter as ignorant and ill-informed about scientific matters, there are clearly social tensions between these groups that may make working together difficult or impossible.

However, schemes such as the one described can potentially help to establish communication and trust on both sides, and as such, have benefits much wider than the monitoring of biodiversity.

Innovative approaches to monitoring and conserving biodiversity- Robert Kenward (NERC)

SUMMARY: The author looks at the potential of volunteers in monitoring programmes and the roles of both volunteers and professionals in ensuring the success of these schemes. He also lists a few questions raised by volunteer monitoring at the local level.

The first session of the conference started by addressing the "why" of monitoring biodiversity. The whys included the need to identify, implement and record effects of actions to conserve biodiversity. Much discussion has followed on how to sample and what biodiversity indicators to use. Another important area, introduced in the last session by Romain Julliard & Frederic Jiguet, then developed by Caspian Richards and also implicit in messages from Ben Delbaere, Richard Gregory and Petr Vorisek, has been the role and motivation of volunteers and professionals in monitoring.At the start of the third session, it is worth using a consideration of volunteer and professional roles to set discussions in a wider context that indicates new approaches for future monitoring systems. Crucial factors are (a) abilities and (b) motivations.

There is a bigger "why" about monitoring to conserve biodiversity – why conserve biodiversity? A wide answer is "for people". Some aspects of biodiversity may be critical for human life support: public goods, for which governments may pay. Other aspects may be recreational, with "user-pays" opportunities for conservation. Given guidance, users can pay with time spent monitoring. Many already volunteer, and as Caspian Richards reminds, can create local groups that educate and involve yet more. Think how much the popularity of bird watching has grown.

However, to contribute to useful monitoring, volunteers need professional guidance in sampling and recording, for example to advance their methods from presence/absence to counting and even counting-with-qualifiers. They need professionals to compile and calibrate their data. Professionals are also important for developing new techniques, creating hypotheses about causation of processes, arranging experimental tests, deriving biodiversity indices and communicating these to policy-makers.

Often there may be too little volunteer ability in particular locations or taxa, so that professionals must monitor. However, this tends to "narrow and deep" monitoring, whereas volunteers can provide the "broad and shallow". If conserving biodiversity for recreation is to become mass-market like video-films, rather than a minority interest like ballet, we need "broad and shallow" engagement. Why depend on reserves if we could have countrywide restoration of biodiversity, with local adaptive management through volunteer monitoring?

The European Sustainable Use Specialist Group of IUCN recently proposed such a local-level countrywide approach to UNEP's High-Level Conference on Agriculture and Biodiversity (http://nature.coe.int/conf_agri_2002/agri16erev.01.doc). ESUSG is working with the UK Centre for Ecology and Hydrology to engage partners for a Framework 6 Network of Excellence bid to start building appropriate support systems. Such systems will depend on volunteer monitoring at local level, which raises many questions. How best to recruit volunteers? How to design monitoring, to provide appropriate indices but not be so demanding that it demotivates? How best to provide training? How to optimise interaction with professionals? How to reduce tensions between the consumptive and non-consumptive users so that both contribute maximally?

Sociological studies are needed to answer these questions, but Europe, benefiting from its diversity of cultures and development stages across nations, is a good place to collect the comparative data.

European site-based monitoring: An illustration - Ben Delbaere, European Centre for Nature Conservation (ECNC).

SUMMARY: An ongoing inventory in Europe illustrates the need for more coordination among the various monitoring programmes in order to ensure one unified and clear message on the status of biodiversity in Europe and the effectiveness of European policy instruments in terms of their biodiversity objectives.

No biodiversity monitoring programme, whether at the local or regional level, can be effective if no specific targets or objectives are formulated. The objectives that form the reference for monitoring programmes are more difficult to define in measurable units with increasing geographical scope. It is easier to develop a programme to monitor the population size of an individual species in a single site than to develop a programme that measures progress in reaching 'no further loss of biodiversity in Europe'.

For the purpose of this contribution, a logical framework is used to analyse monitoring programmes. Such a framework starts with the identification of a goal ("What is the problem?"), which is translated into a purpose and component objectives that are linked to outputs that can be achieved by carrying out activities.

The example given below is taken from an inventory of some 50 international site-based biodiversity monitoring networks in Europe[i]. Because of the high degree of variation between them, it was hard to select one fully operational network that directly met policy requirements. However arbitrary, I chose the International Waterbird Census (IWC) because it is probably the longest running network in Europe and has a relatively close link to policy needs. Also, birds are the species with the best developed monitoring programmes.

[i] Carried out by ECNC for the EEA's Topic Centre on Nature Protection and Biodiversity

The strength of the IWC is that it has a clearly defined goal, which in this case is to tackle the lack of adequate information to monitor the conservation objectives of the Ramsar Convention and the African-Eurasian Migratory Waterbird Agreement. Six objectives have been drawn up to tackle this problem. Another strength of the IWC is that its activities have been running for a long time (since 1967) in a standard approach covering a network of over 20,000 wetland sites. This provides good opportunities for scientific analyses of trends over time.

The weaknesses, however, are that data gathering is to a large extent based on numerous voluntary counters and that the output is pretty technical. It also only looks at waterbirds and wetlands. An additional weakness is that the results from the monitoring programme are not linked to specific impacts or driving forces, making it impossible to assess the effectiveness of the policy instruments concerned.

Still, despite these weaknesses, the IWC is probably one of the most stable, consistent and targeted monitoring programmes in Europe. Naturally, other examples can be given, each with strengths and weaknesses. Some may be better in terms of bringing across a simple message to policymakers (such as WWF's non-site based Living Planet Index), while others may be better in terms of linkage to policy targets (e.g. the Trilateral Monitoring and Assessment Programme for the Wadden Sea area).

In general terms, the inventory of monitoring networks reveals that many initiatives are developed. At the same time it shows that only very few get to the stage of long-term implementation and direct feedback to policymakers and other stakeholders. Also, the study shows that much of the programmes run in isolation, each of them resulting in a partial picture of the status of biodiversity. What is really needed, if one is to seriously consider the matter at the European level, is more coordination among the monitoring programmes in order to ensure one unified and clear message on the status of biodiversity in Europe. As indicated by the paper of Richard and Condé, initiatives such as the BioMIN Informal Working Group and EBMI-F may facilitate such coordination process.

The development of biodiversity indicators within the MCPFE- Tor-Bjorn Larsson, European Environment Agency.

SUMMARY: The MCPFE (Ministerial Conference on the Protection of Forests in Europe) has established a successful framework for the assessment and monitoring of EU forest biodiversity. This framework is constantly being improved through the work of an MCPFE advisory group. Finally, the author looks at how the new indicator of "dead wood" raises certain difficult issues to be resolved by European experts.

A well-known framework for assessing and monitoring forest biodiversity is the "Helsinki" set of indicators from 1993 established by MCPFE. MCPFE stands for the "Ministerial Conference on the Protection of Forests in Europe". The MCPFE presents itself on the website established by the Vienna Liaison Unit - http://www.minconf-forests.net/ as "an ongoing initiative for co-operation between around 40 European countries to address common threats and opportunities related to forests and forestry".

The Criteria and Indicator framework for sustainable forest management (SFM) endorsed by the 1993 Ministerial Conference in Helsinki is also widely recognised. As a consequence, although MCPFE is not a monitoring activity per se, any pan-European forest monitoring activity must take the MCPFE biodiversity Criteria and Indicators into account.

The Helsinki indicators e.g. for biodiversity reflect a positive political will. But there is without any doubt potential for improvement. A general need for improvement of all MCPFE indicators for SFM has been recognised and MCPFE established an "Advisory Group on the Improvement of Pan-European Indicators for Sustainable Forest Management". This Advisory Group has recently suggested a new indicator framework, after a process comprising four pan-European workshops. The proposal is now discussed on a more political level in preparation for the adoption at the upcoming Ministerial meeting (2003).

One of the new biodiversity indicators now being discussed within MCPFE is "Dead wood". The importance of dead wood for biodiversity is well recognised and scientifically verified e.g. with respect to the boreal forests (see the report "Ecology of woody debris in boreal forests", edited by Jonson & Kruys and published as Ecological Bulletins no 49 in 2001). In spite of this, few European countries can present data based upon monitoring programmes on the amount of dead wood in their forests. It can be foreseen, if endorsed by MCPFE, that this will become more widespread. We will, however, face several problems related to the complexity of this indicator – how do we measure and classify dead wood? Is it feasible (or relevant?) to use a standardised approach or should we use different classifications systems and/or monitoring methods in different countries and/or forest types? For pan-European assessments it is desirable to have a common standard but there may be strong scientific and methodological arguments that the "standard" must take the regional variation in forests into account. This is a very technical but nevertheless extremely difficult discussion that experts – including scientists! - need to involve themselves with in order to successfully implement the political will of MCPFE.

Forest biodiversity monitoring under discussion in Finland- Lauri Saaristo & Jari Niemelä, University of Helsinki.

SUMMARY: The authors discuss the progress made in Finland regarding forest biodiversity monitoring and implementation of indicators. A working group set up by the BITUMI project (Applicability of Biodiversity Research) looked at the present situation, future possibilities and identified major gaps that exist in biodiversity monitoring. One such gap is the lack of species monitoring, which has led to the development of a recent pilot project that aims to identify suitable forest biodiversity indicators.

Forest biodiversity monitoring and indicators in Finland have been important topics in a series of meetings arranged by the BITUMI-project (Applicability of Biodiversity Research), which is an integration project of the Finnish Biodiversity Research Programme FIBRE. One task of the BITUMI-project is to arrange and coordinate the meetings of the working group of forest managers and researchers. We used this working group as a forum to discuss how we could determine the effectiveness of biodiversity conservation efforts.

Since the development of alternative silvicultural methods in the 1990s, the forest managers have wanted to know if the new practices are able to reverse the previously declining trend in the biological diversity of forest flora and fauna. Potential biodiversity indicators have been listed in some national processes, as for example in the development of criteria and indicators of sustainable forest management and forest certification.

We organized three meetings concerning this question. In the first meeting (December 2001) the results of the pan-European indicator project BEAR and the existing Finnish forest biodiversity monitoring processes were presented and discussed. In the second meeting (March 2002) we heard presentations about the practical challenges in forest biodiversity monitoring. Before the third meeting we asked FIBRE researchers to give us their opinions about developing biodiversity indicators and using them as practical tools. The answers were then presented in the third meeting (May 2002).

The meetings highlighted the existing situation, future possibilities and knowledge gaps of biodiversity monitoring and indicators in Finland. Biodiversity monitoring can be based on two complementary approaches: species monitoring and habitat monitoring. Forest biodiversity monitoring in Finland is at the moment almost completely focussed on habitat monitoring and in the simplest form the forest managers are just describing what they are doing. There is no target setting, except in relation to some forest certification criteria demanding certain amount of retention trees in the logging sites.

Based on current scientific knowledge there are reasons to be suspicious about the fact that we could monitor certain indicator species and trust that these would inform us about the changes in other taxa. A recent pilot project in Finland aims to find suitable species groups and methods for forest biodiversity monitoring by using habitat indicators. The project aims to find links between stand structure and species composition of different taxa. In the long term, it should be possible to explain and predict the changes and trends in species diversity by the changes in forest structural characteristics.

Environmental objectives and indicators - the Swedish example - Thomas Nilsson, Swedish Environmental Protection Agency.

SUMMARY: This contribution describes the progress in Sweden regarding environmental objectives, biodiversity monitoring and indicators. It also discusses some difficulties in developing appropriate indicators for biodiversity.

In Sweden we have come to the same conclusion as Denmark (van der Bijl and Torben Iversen 10/09/2002) that monitoring has to be closely linked to objectives. The Swedish Parliament recently adopted fifteen environmental objectives and a number of interim targets to guide Swedish environmental politics. The objectives cover not only biodiversity but also most relevant environmental problems.

Let me give "Thriving wetlands" as an example. The objective is that "the ecological and water conserving function of wetlands in the landscape must be maintained and valuable wetlands preserved for the future". Interim targets connected to this objective are for example that "long-term protection should be provided by 2010 for the wetland areas listed in the national Bog Protection Plan" and that "action programmes should be under way by 2005 for endangered species that are in need of targeted measures". To enable informed judgments about the objectives and their accomplishment, the Swedish Government has proposed that a system for monitoring and evaluation should be tied to the objectives. The Government has also appointed an "Environmental Objectives Council" with the task of coordinating the efforts of various authorities and reporting to the Government. So far, the Council has published one report (in 2002): "The fifteen environmental objectives - are we on the track?" (http://miljomal.nu/las_mer/rapporter/dF02E.pdf). The approach of this report is similar to the European Environmental Agency's Environmental Signals.

In the future a core set of headline indicators will be used to show trends in the environment and the prospects of achieving the objectives. We have so far, however, experienced great difficulty in designing and establishing appropriate indicators for biodiversity, especially a limited set of headline indicators. This seems to be a problem that we share with many others. The most commonly used, and often the only, biodiversity indicator in public reports on the state of the environment is "number of protected areas". This is certainly not enough and gives no deeper understanding of biodiversity. Why is it so? Why is it particularly difficult to design indicators for biodiversity compared to other environmental issues? A real lack of knowledge might be one reason, especially in rather unexplored biological systems like the sea. Another reason might be a lack of money. Most environmental monitoring programmes in Sweden have been designed in response to other environmental problems, e.g. pollution, acidification and eutrophication, and since all monitoring programmes claim the importance of continuity and long time series it is difficult to change priorities. There is also a conflict in views, where scientists on the one hand emphasize the complexity of nature and scientific uncertainty, and policy-makers and politicians on the other hand emphasize simplicity and overview. Finally, reliable and cost-effective methods have to be developed. Many existing monitoring programmes focus on the local situation and are not designed to give input to a national or European level. It is a challenge for experts on biodiversity, both scientists and experts at environmental authorities, to take part in the development of appropriate indicators that can be used in communication between scientists, authorities and politicians. And we also need the indicators rather quickly to be able to follow up and evaluate the already adopted environmental objectives and interim targets!

Reply to: 'Environmental objectives and indicators – the Swedish example'- Frédéric Gosselin, Cemagref.

SUMMARY: Thomas Nilsson gives very interesting arguments for why it is so difficult to design indicators of biodiversity and to monitor biodiversity. We propose two other reasons for this situation: the difficulty to measure all the biodiversity in a place and the intrinsic multidimensionality of biodiversity.

As outlined by Allan Watt, Thomas Nilsson ends his presentation about the Swedish case with a very interesting analysis of why biodiversity is so hard to monitor, whether directly or through indicators. We especially agree with the point about the conflict in view between "scientists on the one [who] emphasize the complexity of nature and scientific uncertainty, and policy-makers and politicians on the other hand [who] emphasize simplicity and overview". Actually, we might expect that a common work between scientists, policy-makers and politicians around a scientifically sound monitoring network might help them share their views.

When comparing biodiversity with other environmentally related fields I think that two other reasons make it difficult to deal with:

1- Compared to meteorology, pollution or water quality (to a certain extent) for example, it is very difficult to have a complete "biodiversity measure" for one place, if we mean "all the biodiversity". If we were to "measure" all the living organisms in one place, we would include perhaps only one or two places in a monitoring scheme! To a certain extent, this difficulty disappears when we restrain biodiversity to narrower taxonomic sets.

2- Biodiversity is essentially a multidimensional quantity: it has at least as many dimensions as the number of species detected in a monitoring scheme; we can try to reduce it to one dimension - e.g. by studying only species richness - but we are not sure that the whole story of biodiversity has been well summarized by this single dimension - e.g. there can be strong variations in species composition or species identities in parallel to a global stability of species richness.

To our knowledge, we have not yet found simple quantities - such as temperature, pressure, humidity in physics and meteorology - that summarize very well the state of a whole community of species.

Landscape and biodiversity monitoring in Estonia- Kalev Sepp (Estonian Agricultural University) and Antti Roose (Estonian Environmental Monitoring Program).

SUMMARY: The authors outline landscape and biodiversity monitoring in Estonia, the sub-programs of the biodiversity monitoring program, and the objectives of biodiversity monitoring program.

Since January 1994, a National Monitoring Programme has been implemented in Estonia under the supervision and co-ordination of the Ministry of the Environment.

The main purposes of the programme are:

- To monitor long-term and large-scale changes in the environment and thus identify the problems which call for quick countermeasures or complementary studies in the future. - To provide data for determining the current state of the environment and for making quick updates for short term reporting;
- To keep track of the exchange of pollutants with adjacent countries for estimating the Estonian role in regional pollution load, and in co-operation with other countries compile the national overview for transboundary pollution;
- To develop and continuously improve the system of environmental indicators for generating EMP data
- To determine the state and the amount of renewable natural resources.

In 1999, a new Act on Environmental Monitoring was approved by *Riigikogu* (the Parliament). This Act constitutes the part and obligations of the state, local administrations, business enterprises and private property owners in carrying out monitoring on the state, local, and enterprise levels. All monitoring activities of the National Programmes are funded by the state budget. The National Monitoring Programme comprises of 12 entities: Meteorological monitoring; Air monitoring; Ground water monitoring; Coastal Sea monitoring; Monitoring of biological diversity and landscapes; Forest monitoring; Integrated monitoring, Radiation monitoring; Seismic monitoring; Soil monitoring; Support and development.

The current landscape and biodiversity monitoring program includes the following categories of projects:

- Landscapes (3 sub-projects): Assessment of the impact of land use on habitat diversity.
- Plants (15 sub-projects): Monitoring and prognostication of the status of valuable plant species and communities in Estonia.
- Birds (9 sub-projects): Monitoring and prognostication of the status of populations and habitats of rare species and indicator species of bird fauna in Estonia.
- Animals (7 sub-projects): Monitoring and prognostication of the status of populations and habitats of rare species and indicator species of animal fauna in Estonia.
- Invertebrates (10 sub-projects): Monitoring and prognostication of the status of populations and habitats of rare species and indicator species of invertebrates in Estonia.

Why do we need biodiversity monitoring and what purpose does it serve?

We need biodiversity monitoring to inform the management and the public on the state of biodiversity in Estonia. Evidently the state of biodiversity has to be compared both within the country as between countries to answer this question. If it is declining we need to know if this is caused naturally (climatically influence) or caused by human influence. Therefore, we also need to monitor possible threats to biodiversity simultaneously. The management needs to know if there is cause for taking actions. We therefore need to inform the management on the strength of the change and assess what cost-effective measures can be taken to prevent the change from being too serious (unless it can be completely stopped). In most cases, biodiversity monitoring is a strategic tool for management (particularly nature conservation management). Even if the monitoring is tuned for management purposes, it will also provide a lot of scientific data, which can (and it should be encouraged to do so) be used for scientific purposes. But biodiversity monitoring can never be planned with the sole objective to serve merely scientific purposes. It is too expensive for that (Estonian Biodiversity Monitoring masterplan).

Biodiversity and protected areas in Romania- Simona Mihailescu, Romanian Academy.

SUMMARY: The author looks at certain aspects of biodiversity and nature conservation measurement in Romania, the most important problems of biodiversity conservation in Romania and aspects of nature conservation, landscape changes, biodiversity protection etc. in Romania that seem particularly important in view of the future integration with the EU.

In my opinion, the answers to the following questions are as follows:

1. What are the most important problems of biodiversity conservation in Romanian?

Biodiversity has a great number of fields and it is very difficult to mention the important problems for each one. However, there are a few common aspects for biodiversity conservation:

-Development of an adequate research framework programs based on the real and concrete aspects of biodiversity conservation.

-Research, inventory and monitoring are still difficult in protected areas. They must be sustained by the financial support of governmental and non-governmental institutions based on a long-term strategy and action plan. Between 1995 and 1996, Romania prepared the National Biodiversity Conservation Strategy and Action Plan (BSAP). The priorities identified in the BSAP have led to an action plan implemented over a five-year period commencing in the autumn of 1999.

-Another aspect regarding biodiversity conservation is a permanent correlation of the Romanian environment legislation with international (especially EU) legislation in biodiversity.

-It is also very important not only to have good laws but also applicable ones; in this respect a number of actions will be focused on how the new legislation is applied.

-One realistic objective is the gap assessment in the collaboration between institutions implicated in biodiversity research and administration; this is not an easy task and it involves all actors and stakeholders in this field.

-Education, information and public awareness regarding biodiversity and a reasonable use of its components for a sustainable development of the society.

2. What aspects of nature conservation, landscape changes, biodiversity protection etc. in Romania seem particularly important regarding the future integration with the EU? Certain aspects include the correlation of Romanian legislation with Acquis Communitaire, especially in the field of environment and a continuous contact and participation of the Romanian research programs in FP6 and contribution to development of common projects with EU member states. Biodiversity data sets found in Romanian institutions should be listed and catalogued according to their quality, quantity and relevance to biodiversity conservation planning needs. It is important to provide the information basis to assess, demonstrate, defend and improve the effectiveness of the existing National Protected Area network in connection with Natura 2000 network. It is also important to involve research institutions, NGOs and individuals in biodiversity data gathering and data exchange.

3. Which fields of biodiversity research are well developed in Romania and which should be further developed in next years? The taxonomy of different groups of plant and animal species are well known but it is necessary to complete the information with population distribution and ecological aspects. It is necessary to continue with the taxonomy studies for groups that are less well known. On the other hand, it is important to identify areas of high conservation importance that are currently not included in the Protected Area network (i.e. under-represented habitats, important ecological corridors, areas with high number of species which are include in the Bern Convention, Birds Directive and Habitat Directive etc.). This means that the monitoring of species and habitats will become a current research project, especially in protected areas. This action must be contained in the management plan for each protected area. The identification of priority actions towards the strengthening and expansion of the existing Protected Area network (i.e. identify new sites to be protected, update existing datasets, map boundaries of all protected areas, establish ecological corridors and establish permanent monitoring systems) is the basis for decision-making in the formulation of the strategy to fill identified gaps. We also need to identify existing gaps in biodiversity data and to provide the basis for further action to enhance national capacity to fill the information gaps.

In order to facilitate the circulation and sharing of data, we should operate on a widely used and accessible database format. For example, we can mention some important monitoring projects developed in two very well know protected areas in Romania. One of them is the Danube Delta, including the Razim-Sinoe lake complex, with an area of 580,000 ha, representing the largest costal wetland complex in Europe. The Danube Delta has a triple status: It has been a World Natural and Cultural Heritage Site (since December 1990) with more than 50% of its territory in Romania (the other parts are in the Republic of Moldova and Ukraine), a Biosphere Reserve within the UNESCO-MAB Reserve Network (since September 1990) and a Ramsar Site (since May 1991). Since 2000 it has been an international protected area (the Ukraine part was also declared a biosphere reserve). In the last decade, biodiversity monitoring plans testing the implementation of some indicators were made. Another important Romanian protected area is the National Park of Retezat Mountains (since 1935) covering an area of 38,047 ha; it is both the Retezat Scientific Reservation (since 1956) and Biosphere Reserve within the UNESCO-MAB Reserve Network (since September 1980).

Practical alternatives to monitoring flora and vegetation on the basis of monitoring-routes in the Dutch province of Noord-Brabant- Jan Jansen, University of Nijmegen.

SUMMARY: During the last six years the Dutch province of Noord-Brabant has collected numerous data on flora and vegetation. One of the methods used is route-monitoring. The subjective estimation and difficult orientation in the field raise the question of how reliable the route-monitoring method is.

In management planning there is an increasing need for distribution data of plant species and habitats in order to deal with existing and potential threats. A solid basis for collecting these data is a defined list of species (flora) and plant communities, preferably on a national or international (e.g. European) level. Optimal information transfer and exchange can be achieved by standard sampling based on standard classification.

A good monitoring programme should measure the effectiveness of the applied management techniques and will identify the impacts upon habitats and species. An appropriate monitoring programme is an indispensable tool for decision makers to measure the effectiveness of nature policy and to screen the likely effects of all kind of activities in or near the sites where the habitats and species occur. But what kind of sampling is the most reliable?

In 1995, the province of Noord-Brabant started monitoring plant species and vegetation on the basis of so-called monitoring-routes, developed by Everts & De Vries (1994). Each route comprises a number of sections approximately 50m long, in which every second year the occurrence and abundance of previously selected key-species is being estimated according to the Tansley-scale. Following specific route instructions, the occurrence and abundance of key-species and vegetation in each section are observed: e.g. "start at the marked Oak tree and walk up north until the bridge (25 m) then turn to 60 degrees in the direction of marked Poplar tree (35 m) until you reach a ditch (50 m"). There are hundreds of these routes distributed over the province in all kinds of areas (protected areas like nature reserves, but also unprotected agricultural areas, with various management regimes and abiotic qualities). So far we have examined over 10.000 sections many of which for three consecutive times (see Van der Linden & Verbeek 2001). We can see some trends, but I am wondering what concrete conclusions can be drawn with this kind of monitoring. Estimation is relatively subjective and some of the sections are not easy to repeat precisely because orientation in the field is sometimes difficult. I suppose that in fauna circles such monitoring is better known.

I know that usually for flora & vegetation samples, permanent (multiple) plot sampling is applied. Has someone in the conference experience with monitoring-routes and does anyone have ideas what kind of practical alternatives could be supplied? All suggestions are welcome!

Reply to 'Practical alternatives to monitoring flora and vegetation on the basis of monitoring-routes in the Dutch province of Noord-Brabant' - Alan Feest, University of Bristol.

SUMMARY: In reply to Jan Jansen's contribution, the author outlines certain sampling methods used in cross-cutting baseline biodiversity estimates.

The principle of sampling is that for random environments a regular system will work and vice versa. The important thing in cross-cutting baseline biodiversity estimates of a defined area/habitat is that whilst the recording method must be the same, the exact sites should vary or any bias in the original choice of sites will be compounded.

For long-term studies (>10years) this might not be so important since measurement is against an established baseline over some time. A second factor would be the number of sites to be sampled per taxonomic group in order to establish a stable species-area curve. For macrofungi it seems that 20 samples are needed but for bryophytes in woodland, 10 samples seem to be enough as they are far less particular in their preferences. What you are doing sounds extremely interesting but I am afraid my Dutch is not up to reading the original papers!

Criteria for selecting species-level indicators of biodiversity- Jari Niemelä, University of Helsinki.

SUMMARY: For selecting species-level indicators several kinds of suitability lists have been produced, and one list of criteria is presented below (Niemelä 2001, adapted from Jones & Riddle 1996).

Attribute	Description
biologically relevant	related to structure, function etc. of biodiversity
sensitive	responsive to stressors of concern
geographic coverage	occurrence and response cover large area
diagnostic	helps uncover potential source of the problem
interpretable	unambiguously distinguishes between conditions
cost-effective	inexpensive to measure, maximum data/effort ratio
integrative	represents a few to many processes of biodiversity
historical databases	historical data allows comparisons with observed trends
anticipatory	provides an early warning
capable of scaling	possible to aggregate through temporal and spatial scales
synergistic	adds value to other measurements, yet provides unique information

However, this kind of a list should only be the starting point for evaluating the suitability of a biodiversity indicator. The evaluation can be done, for instance, according to the step-wise procedure presented by McGeoch (1998). After a preliminary selection of an indicator group based on a number of criteria, such the ones below, its suitability needs to be tested. The first task is to accumulate quantitative data both on the indicator group and on the condition (such as disturbance or state of biodiversity) to be evaluated. Thereafter, relationships between the indicator and the environmental or ecological state (e.g. habitat fragmentation or occurrence of some other taxa) need to be established. The critical step is to find out whether there are significant, strong correlations between this state and measured qualities of the indicator. If these do not exist, the tentatively selected group should be rejected as a bioindicator. If correlations exist, the procedure continues to establish the robustness of the indicator by developing and testing appropriate hypotheses under different conditions.

This testing procedure has been developed for evaluating species-level biodiversity indicators, but could be extended for testing indicators at higher or lower ecological scales. During the next few days the contributors to the e-conference may explore ways for selecting and developing biodiversity indicators at several scales. Happy journey!

Biodiversity Indicators of Sustainable Development in Scotland- Jeremy D Wilson, Royal Society for the Protection of Birds (RSPB), Ed C Mackey, G Saunders, P Shaw, Scottish Natural Heritage, Scot Mathieson, Scottish Environment Protection Agency, Allan Watt (CEH) & Vicky West, Forestry Commission.

SUMMARY: There is a need to compile a list of biodiversity indicators for Scotland, which may differ from the UK level indicators. However both sets should be consistent in order to measure Scotland's contribution to sustainable development. A list of possible indicators that may be used to monitor Scottish biodiversity is outlined.

In a previous contribution to this e-conference, Wilson and Bainbridge discussed some of the background to the development of indicators of biodiversity in Scotland. Indicators are needed that satisfy the criteria of ecosystem and policy relevance, data quality and public resonance. We propose that the following indicators meet these criteria:

- Status of Biodiversity Action Plan Priority Species.

These species include plants, mammals, birds, terrestrial invertebrates, fish, amphibians and reptiles. This can be an indicator both of biodiversity status and Government biodiversity policy.

- Status of UK Biodiversity Action Plan Priority Habitats.

These include mountains, heaths and bogs, forests and woodland, farm and grassland, freshwater, coastal and marine habitats. Again, this can be an indicator of biodiversity, policy and sustainable development.

- Breeding Bird Index.

There is probably a stronger research knowledge of the impacts of human-induced ecological change on bird populations than exists for any other group. A multi-species index of abundance and range size of birds could be done by various groups such as the British Trust for Ornithology (BTO), the Royal Society for the Protection of Birds (RSPB), the Joint Nature Conservation Committee (JNCC), and other volunteer observers. The index could give a good picture of the broad condition of habitats. Seven species of birds have already been identified as being good bird indicators for Scotland.

- Abundance of non-breeding waterbirds.

The Wetland Bird Survey (WeBS) aims to identify population sizes, determine trends in numbers and distribution, and identify important sites for waterbirds in the UK. The UK, including Scotland, is of outstanding importance for waterbirds. Although waterbird populations could be an indicator of the wider condition of coastal and estuarine habitats, the migratory nature of most species can make it difficult to distinguish effects of ecological change at those sites from effects of change on breeding grounds elsewhere. However, the importance of many of these bird populations in an international context suggests that an indicator of their trend is justified in its own right.

- Abundance of seabirds.

Scotland's breeding seabird populations are of international importance and are thus an important component of marine and coastal ecosystems in their own right, but those species high on the food chain feeding primarily or solely on other marine organisms are good indicators of changes in the marine environment as a whole. Impacts on seabird populations include commercial fisheries, the introduction of non-native predators and chronic or accidental oil pollution.

- Vascular Plant Diversity

This indicator will be an important measure of biodiversity at the primary producer level across terrestrial ecosystems within Scotland. Changes in plant diversity are sensitive indicators of a wide range of anthropogenic changes to different habitats including agrochemical use on farmland, effects of atmospheric deposition on fertility and pH, grazing pressure and muirburn.

- Woodland Tree Species Diversity

This indicator concerns the diversity of the tree flora in 17 % of Scotland's land area. The species richness of woodland is of interest in its own right, particularly that of native woodland, since an increase in the diversity of the tree species will lead to increases in the associated animal diversity, especially of invertebrates, vertebrates and mammals.

- Terrestrial Insect Abundance

Lepidoptera and other flying insects are known to be sensitive indicators of environmental change in a wide variety of habitats subject to both policy influence (e.g. agriculture and forestry), as well as to many anthropogenic ecological processes amenable to policy influence (e.g. agrochemical use, air pollution).

- Proportion of notified species populations in favourable condition on SSSIs.

There are 1,129 biological and 'mixed' SSSIs in Scotland (covering 12% of the total land area), supporting over 2,300 notified species populations. Although taxonomically, the sample shows a distinct bias in favour of vertebrate (especially bird) and vascular plant species, SSSIs are the principal mechanism available to statutory conservation agencies for safeguarding important areas for wild flora and fauna.

- Proportion of notified habitats in favourable condition on SSSIs.

Notified habitats on SSSIs span the full spectrum of terrestrial and freshwater ecosystems and would therefore be obvious indicators.

- Status of the otter in freshwater habitats.

This could generate estimates of range size, and a crude measure of population density, based on the percentage of sites occupied. The presence of otters is an indication of low pollution levels and a plentiful supply of fish and other prey items. Pressures include habitat fragmentation, reduced food supply, disturbance, persecution, acidification and other pollution effects. The otter could have an important role in convincing the public of the need to control environmentally damaging pollution, making it a potential flagship species.

- Salmonid counts

These counts integrate estuarine and riverine water quality, fish habitat quality in rivers, fishing pressure and climate change effects on salmonids at sea.

- Benthic riverine invertebrate diversity

The diversity is an indicator of water quality, habitat quality and flow regime, along with airborne *deposition* (acidification, eutrophication), land use and water use in each river catchment.

- Estuarine fish species diversity

This indicator integrates the effects of water quality and habitat structure. It is also used as an indicator for fish eating bird and mammal populations.

- Proportion of commercially exploited fish stock fished within safe limits.

These include both 'Continental shelf species' and 'deep-water' species. There is an overwhelming consensus of scientific opinion that fishing has, and continues to have, an impact on the entire north-eastern Atlantic region and may even be the main ecological structuring force on the benthos in areas of intense exploitation. The conservation of commercial fish stocks is of prominent international importance and Scottish waters constitute one of the primary European fishing areas.

Part of this contribution is an edited version of excerpts from a draft of "Biodiversity Indicators of Sustainable Development in Scotland" (A report by the Action Plan and Science Group of the Scottish Biodiversity Forum).

Biodiversity indicators in a changing environment: the Pan-European Breeding Bird Monitoring Scheme - Richard D. Gregory (The Royal Society for the Protection of Birds) & Petr Vorisek (Czech Society for Ornithology).

SUMMARY: The pace of change in the European environment has arguably never been so great reflecting broad-scale, integrated policies acting across an enlarging European Union. We propose to assess the impact of these changes on biodiversity using composite Pan-European bird indicators.

Research has shown biodiversity on farmland to be in severe decline across much of northwest Europe driven by the intensification of agricultural methods. There is growing evidence of environmental change in other sectors across Europe associated with both habitat loss and habitat degradation. Some of the seminal work in this area has been carried out on birds and here we use birds as an exemplar, or bio-indicator group, of biodiversity. While there are many examples of biodiversity loss in European countries, we are, at present, unable to bring this information together in a meaningful and representative manner for Europe as a whole. At a time of rapid policy change in Europe, there is a need to assess the impacts of policies on biodiversity. There have been a number of impressive reviews of the state of the European environment, and yet there remain considerable challenges for the future. It is imperative that we develop cohesive biodiversity monitoring across Europe and we are in the unique position to be able to take this idea forward for one important exemplar taxa, birds. Indicators are seen as the key to effective environmental monitoring and reporting. Here we describe an innovative bird monitoring scheme for Europe, which will deliver, for the very first time, high quality, representative, policy relevant bio-indicators for the wider European environment as a whole.

Working examples of Biodiversity Indicators

There is a long tradition of bird monitoring across much of Europe; recent years have seen resurgence in interest in common bird monitoring and new national schemes have been established in over a dozen countries in the past few years (e.g. United Kingdom, Spain, France, Hungary, Poland, Republic of Ireland). These data are increasingly being used to develop bio-indicators of wider environmental change.

Arguably, two of the most prominent countries in this respect are the Netherlands and the United Kingdom (UK). In 1999, UK Government published the White Paper *'A Better Quality of Life'*, which contains 150 indicators of the sustainability of lifestyles. Several of these indicators relate to landscape and wildlife. Within a set of 15 'headline' indicators is one based on population trends of breeding birds, which is updated annually. The publication of a wildlife indicator among more familiar economic and social indicators is a considerable step forward. It shows that the UK Government has recognised that the maintenance of biodiversity is a key measure of sustainability. Birds have been chosen partly because the data are so good but also because their varied ecology and widespread distribution across the UK allows them to be used as 'barometers' of change in the wider environment. Added to this, birds have a wide appeal among the public, and resonance among policy/decision makers too (http://www.sustainable-development.gov.uk/indicators/headline/h13.htm). Although we are mindful that birds are not always the most appropriate bio-indicators, and need to be used with care in this respect. The headline wild bird indicator, which incorporates information on all common native species in the UK, is disaggregated by habitat to reveal the underlying trends. Pilot work also has tested this approach for regions within UK using identical methods (http://www.sustainable-development.gov.uk/indicators/regional/2001/h13.htm).

There are a number of key attributes to effective bio-indicators, they must be; quantitative, simplifying, user driven, policy relevant, scientifically credible, responsive to changes, easily understood, realistic to collect, and susceptible to analysis. The UK wild bird indictor has proved highly successful, and has been extremely effective, because it meets all of these criteria.

Parallel work in the Netherlands has developed a similar set of indicators based on an identical statistical approach. In this case, they are termed Species Group Trend Indices (http://arch.rivm.nl/natuurcompendium/). In brief, the method involves combining trend information on a geometric scale with appropriate weighting. Here we propose to use this method to develop Pan-European indicators collaboratively for the European environment.

The adoption of bird indicators in individual European countries illustrates the potential to use birds as one indicator of sustainability at a wider European scale. To develop common birds as indicators however we need to:

- Set in place common bird monitoring across European countries
- Generate national bird indices in a standardised manner
- Bring together national bird indices into a single European data set
- Generate Pan-European indices for individual species
- Generate Pan-European multi-species indicators

At first sight, this list appears daunting but a great deal of work has already been done to integrate bird-monitoring information. Published work for example, has shown how data from different countries can be brought together into Pan-European indices for individual species. The next step, which is to produce pan-European indicators, is straightforward given the appropriate collation of existing data.

Common breeding bird monitoring forms one part of a three-pronged BirdLife International strategy to improve the monitoring of European birds and their habitats. The three components are: common birds, threatened birds and important sites.

Plans to develop a *Pan-European Breeding Bird Monitoring Scheme* have moved one step closer with the appointment of a project co-ordinator in early 2002. The new post is for 18-months in the first instance, with the possibility of extension. The post holder will lead the development of the scheme and put in place a basic system for collation and reporting of trends for common birds. In the first phase of work, they will bring together and assimilate existing monitoring information from across Europe. The project will produce a series of indices and outputs with partial European cover (from up to twenty countries) to illustrate the potential of the scheme. We will then look forward to developing representative indices for all-Europe based upon a much larger Pan-European scheme, which would incorporate new national and international monitoring initiatives. The second phase of work will require additional funding and the post holder will work to promote and facilitate fund raising.

The first phase of work is well underway, a Pan-European Common Bird Monitoring workshop will be held in Prague 16-19 September 2002. The workshop objectives are:

- To bring together individual experts and organisations responsible for bird monitoring across Europe to agree a programme of development and data provision for Pan-European Common Bird Monitoring.
- To produce a review of the status of common bird monitoring projects across Europe.
- To agree on a country-by-county basis, the species data, indices and years of data provision to feed into pan-European indices.
- To produce an enlarged set of Pan-European indices for birds, incorporating data from as many countries and species as possible.
- To produce Pan-European multi-species indicators, based on the headline indicator model.
- To produce the first *State of Europe's common birds* report based on the outputs above. This would be a short, glossy, semi-popular document intended for a wide audience.
- To formulate plan to take Pan-European Common Bird Monitoring forwards over the next five years.

In a second phase of work, we will work to promote of a comprehensive long-term Pan-European Breeding Bird Monitoring scheme. A new larger scheme would build on the achievements of the existing network, but advance its scope and capacity to be representative of European landscapes. There are four inter-linked components of an operational scheme:

- A common bird-monitoring network consisting of well over twenty countries with a central co-ordinator working with the shared goal of creating policy relevant pan-European biodiversity indicators.
- New national monitoring schemes in key European countries where there is no existing scheme and where capacity is high. Priority countries would be those where environmental change is likely to be particularly severe, e.g. pre-accession countries, where volunteer and professional capacity can be built, and where national monitoring is a high priority within country.
- A new over-arching international monitoring scheme to cover key European countries where the capacity to build a national scheme is low. In this case, a small number of 'international' survey plots would be established in each country which, when taken together, would provide adequate monitoring.
- Frameworks to integrate pre-existing national monitoring data sets with new ones and generate Pan-European indicators of the European environment on an annual basis.

The European Bird Census Council and BirdLife International lead this proposal; major partners are the Royal Society for the Protection of Birds (the BirdLife partner in the UK), SOVON, Statistics Netherlands, and the British Trust for Ornithology.

Successful workshop in Prague (16-19 September 2002) marks the start of Pan European Common Bird Monitoring- Ward Hagemeijer (Wetlands International), Richard Gregory, David Gibbons (both from RSPB), Petr Vorisek (Czech Society for Ornithology) and Melanie Heath (BirdLife International).

SUMMARY: The authors give a Summary of the recent workshop organised by the European Bird Census Council and BirdLife and the decision to implement a Pan European Bird Monitoring programme.

Six years after a workshop in Villa Cipressi, Italy, where the concept of Pan-European Bird Monitoring was first discussed, the European Bird Census Council (EBCC) and BirdLife International have organised the Pan-European Common Bird Monitoring workshop in Prague, Czech Republic, from 16-19 September 2002. Petr Vorisek and Richard Gregory have already submitted a contribution about the background of this workshop to this e-conference. Within the framework of a European Bird Monitoring Strategy, that builds on three pillars: monitoring of 1. Sites, 2. threatened species and 3. common species, the Prague workshop was focussing on the latter aspect: the Pan- European monitoring of common species. This is a Summary report from this very successful workshop, where it was decided to start with the implementation of Pan European Bird Monitoring.

Since the first meeting in 1996 addressing the idea of Pan European Monitoring was organised in Villa Cipressi, Italy, a lot of progress has been made, mainly in the following areas:

- Growing links with policies, both national and international;
- Additional countries have started national monitoring schemes, bringing the total number of countries with national common bird monitoring schemes to at least 18 countries. This provides a very firm basis for bringing together data into a Pan European scheme.
- Better understanding of the need to disaggregate with regards to policy measurements and/or habitats
- Developments at national levels have been considerable, both with regards to the design of monitoring schemes and the application of the data in the form of indicators. This has resulted in best practice examples including the UK headline indicator.

Despite the progress mentioned above, in 1996 there was a large gap between policy 'customers' and monitoring efforts. This has effectively resulted to a great extent in a halt of implementation of the ideas of a Pan European scheme so far. Now, in 2002, as it turned out during the Prague workshop, the monitoring community is very much closer to the policy 'customers', which is improving the chances for getting the data applied and for obtaining funding for this important work. At the national level, the situation has evolved from having one scheme in Europe in the 1960s to 18 national schemes at the moment and this number is still increasing at an average rate of one country per year. We hope to maintain this rate of increase and even to give an additional boost in the light of the implementation of the Pan European Common Bird Monitoring scheme.

The design of schemes has generally improved, and as a general rule, the value of long standing schemes has been strengthened by the application of post-hoc stratification and weighting methods. Roughly half of Europe is currently covered by monitoring schemes for common breeding birds. A vision for the other half assumes substantial increase of national schemes, and proposes one additional scheme that covers all the remaining countries by 'cooperative plots'. In this additional scheme these 'remaining countries' would cooperate by collectively gathering information in enough plots to follow the population developments of species in the total area of those countries together.

There was general enthusiasm for this model, with some hesitations about the cooperative part. Pros and cons of the model were discussed. The feasibility of the solution will have to be studied in more detail. In the meantime, working with the data that already exists could make a start.

With respect to the organisation of the Pan European programme, it was proposed that an international coordinator was necessary. This coordinator will be supplied with data by focal points (most likely the current data coordinators). Agreement has been reached about the establishment of the species list and data flow models.

Now it is time to generate the first Pan European trends and indicators, by starting the actual data gathering and processing based on existing schemes. In order to ensure progress in the year to come, a detailed work programme is presented, with a time scale for implementation, which runs until the end of 2003. The following targets for outputs and activities have been included in this work plan:

Workshop follow-up:

- Produce outputs of the workshop: publication of workshop proceedings, including all material, discussions, conclusions and recommendations
- Publication of the review of Europe's common breeding birds
- Production of a 'best practice guide for national monitoring schemes'.
- Agreement on species, methods and indicators
- Agreement on data formats
- Pursue funding sources/opportunities.
- Bird monitoring schemes
- Further collation of data
- Publication of a first 'State of Europe's common breeding birds'

In a pilot the following procedures should be tested:
- Provision of national indices or raw data from national coordinators to the central coordinator
- Production of Pan-European indices by the international coordinator.
- Production of Pan-European multi species indicators.

For the continuation of the work, a 5-year plan needs to be developed and funding needs to be secured for long-term sustainability. In Summary the successful Prague 2002 workshop marks the start of the implementation of Pan European Bird Monitoring, and has brought a lot of inspiration and challenges for both the monitoring community and the policy that will use this information. This date and event will be remembered!!

A final contribution about biodiversity monitoring and the new Directive on Strategic Environmental Assessment- Arnau Queralt

SUMMARY: The author discusses the potential and challenges of strategic environmental assessments.

During the e-conference, some contributors have outlined the importance of biodiversity monitoring in the context of the Water Framework Directive. In my opinion, there is another recent EU directive which should be also considered carefully: the Directive 2001/42/EC of the European Parliament and of the Council on the assessment of the effects of certain plans and programmes on the environment.

This directive, also known as the Directive on strategic environmental assessment, aims to achieve greater integration of the environment in sectorial policies –a basic objective of the Treaty of Amsterdam-, through the assessment of the proposals of new plans and programmes that are likely to have an impact on the environment.

Strategic Environmental Assessment (SEA) consists of an assessment at the initial phases of any planning process. This strategic approach is intended to improve some important limitations shown by the practice of environmental impact assessment (EIA), which has allowed progress in the minimisation and correction of the environmental impacts derived from the execution of specific projects.

The potential of SEA is rather obvious, due to its ability to put forward other strategic alternatives and to get ahead, right from the start of the decision-making process, of possible negative effects on sustainable development and the environment.

However, there are some challenges that can make its implementation difficult. One of them is related to biodiversity and biodiversity monitoring. Article 5 of the Directive sets: "Where an environmental assessment is required, an environmental report shall be prepared in which the likely significant effects on the environment of implementing the plan or programme, and reasonable alternatives taking into account the objectives and the geographical scope of the plan or programme, are identified, described and evaluated".

Apart from an outline of the contents and the main objectives of the plan or programme which is assessed, this report should contain "the relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan or programme", "the environmental characteristics of areas likely to be significantly affected", and "the likely significant effects on the environment". This last statement includes effects on issues such as water, soil, cultural heritage and, of course, biodiversity. This last point could be an implicit recognition of the importance of biodiversity monitoring (genetic, specific, ecosystem and landscape biodiversity), which can provide all or part of the information required in the Directive.

However, there are some issues to be considered that shade the previous statement. Certain contributors have pointed some of them out but it is nonetheless interesting to remind us of them. The first one is the opposition between the complexity of monitoring, which requires a lot of time, and the dynamism of planning. Is biodiversity monitoring feasible in a political and technical context that generally tries to minimize time? And, will scientists be able to convince politicians and public managers about the importance of biodiversity monitoring? That is, will they be able to justify the delay in the planning processes due to monitoring?

All this will depend on the capacity to find a common language, as it has been suggested in many contributions. However, it will also depend on the willingness and commitment of the key actors responsible for planning: infrastructures or urban industrial settlements have an economic value, the value of biodiversity still seems to be an intangible one.

Session and title of contribution	**Contributors**
Session 3. To identify some developments in monitoring biodiversity and the advantages they offer	
Introduction to the third session	Allan Watt, Chair
Existing forest monitoring programmes- Building on the legacy of the past	R. Bradshaw *et al.*
FOREST FOCUS, a new European monitoring scheme	Etienne Branquart
Reply to "Forest Focus, a new European monitoring scheme"	Pat Neville
Establishing a common framework of biodiversity monitoring	Alan Feest
Development of biodiversity indicators and monitoring- the MacMan project	Josef Settele
Using mound-building ants as a model system	P. Bliss *et al.*
Auditing the ark- thoughts about terminology	P. Bliss *et al.*
Innovative approaches to monitoring and conserving biodiversity	Robert Kenward
New developments in biodiversity indicators: The Austrian experience	Norbert Sauberer
Spatial scaling in biodiversity monitoring	Rainer Waldhart
Monitoring biodiversity at the landscape level	Jose Garcia del Barrio
Incorporating functional parameters in soil biodiversity monitoring schemes	P. Sousa & P.V. Morais
Hungarian Biodiversity Monitoring Programme	Katalin Torok
The Swiss Eco-Fauna-Database	T. Walter *et al.*
A reference based approach to monitoring	R. Ejrnaes & E. Aude
Biodiversity monitoring needs- an international perspective	Tomas Coll

Session and title of contribution	Contributors
Using a PC software package to collect data	Tomas Coll
Why and what to monitor? Indicators vs. biodiversity	J.M. Lobo & J. Hortal
Monitoring strategies for biodiversity	J.M. Lobo & J. Hortal
An optimal spatio-environmental sampling	J.M. Lobo & J. Hortal
How to monitor biodiversity and communicate results to policy makers	Ben ten Brink
Monitoring of complex systems for policy purposes	Erling Berge

Introduction to the third session of the e-conference: developments in monitoring biodiversity- Allan Watt (e-conference chair)

SUMMARY: In the second "session" of the e-conference, the need for coordination was, once again, a common theme. Other major themes were the problems of scale (of monitoring), the involvement of volunteers and the challenges faced by monitoring progress towards national and international targets for the conservation of biodiversity. Recent contributions also included encouraging reports of national and international efforts to establish monitoring programmes and to coordinate these programmes. E-conference participants are now invited to write about recent work on the development of monitoring and indicators of biodiversity (e.g. landscape indicators, the involvement of volunteers, the selection of indicator taxa and the integration of data).

Contributors continue to argue convincingly for the need to monitor biodiversity. But this week, several contributors have described the progress that has been made in the development and implementation of monitoring initiatives.

Going back to the contributions made in the first "session" on why we need monitoring, Davy McCracken argued for the need for monitoring needs in agro-ecosystems, and both Scot Mathieson and Laurence Carvalho discussed the monitoring requirements of the Water Framework Directive. They all emphasised the challenges of monitoring biodiversity in these environments. I hope contributors will continue to send their views on the challenges associated with particular environments and in relation to particular policies (Biodiversity Action Plans, Directives etc.).

Ant Maddock raised a question on Tuesday that is also worth considering. He argued that "we should widen our monitoring [to include] the natural processes that ensure the survival of genes and species". I think this is a valid point, particularly in relation to providing an early warning of the loss of species (or genetic diversity). But such a monitoring effort would be very expensive. If you think that this type of monitoring is important, what are the priorities and how can we achieve them "cost-effectively"?

In the last few days most contributions have considered existing and planned biodiversity monitoring programmes. At the European level, Tor-Bjorn Larsson discussed the work on assessment and monitoring of forest biodiversity within the Ministerial Conference on the Protection of Forests in Europe and Peter Gregory & Petr Vorisek outlined the proposal to develop a Pan-European breeding bird monitoring scheme. We also had contributions on monitoring in countries such as Finland, the Netherlands, Scotland and Estonia from Lauri Saaristo & Jari Niemelä, Jan Jansen, Jeremy Wilson & colleagues, and Kalev Sepp & Antti Roose

Taking the example of a successful new French breeding bird monitoring scheme, Romain Julliard & Frederic Jiguet described the involvement of voluntary amateur groups gathering data pooled together by national coordinators. The success of this scheme is presumably due, not just to the enthusiasm of the volunteers, but to the comparability of the data collected and, therefore, that their data can be aggregated to the national (and potentially international) scale. Is this feasible for many groups of plants and animals or do we need to agree and apply standardised protocols to ensure that data are more widely applicable? Caspian Richards argued that these schemes could be a cheap and effective way of monitoring biodiversity, but the main drawback was persuading many professional researchers and especially policy-makers/administrators that amateur groups were a credible source of scientific data. This problem may be solved by the use of standardised protocols. But would this "top-down" approach be acceptable to amateur groups? Richard Bradshaw made points relevant to the issue of data collection at different spatial scales and, later today, Robert Kenward will continue the discussion on the involvement of volunteers.

Thomas Nilsson discussed the development of biodiversity monitoring and indicators in Sweden. But he could have been writing about any country (and Europe generally) when he asked the question: "Why is it particularly difficult to design indicators for biodiversity compared to other environmental issues?" He made a few suggestions: a real lack of knowledge, lack of money, "conflict in views, where scientists on the one hand emphasize the complexity of nature and scientific uncertainty, and policy-makers and politicians on the other hand emphasize simplicity and overview". What do you think?

Ben Delbaere referred to an inventory of 50 international site-based biodiversity monitoring networks in Europe and, in common with others in this e-conference, called for more coordination. And, like an earlier contribution, he suggested that initiatives such as the BioMIN Working Group could facilitate such coordination (in Europe). This Working Group, meeting for the first time this week in Copenhagen, welcomes input from individuals, organisations and e-conferences such as this – another reason to present your views!

Some of the major themes of the second "session" were (as last week) coordination of biodiversity monitoring and the associated problems of scale (of monitoring) and the involvement of volunteers and the challenges faced by national and international targets for the conservation of biodiversity. Of particular importance, perhaps, were the reports of national and international efforts to establish monitoring programmes and to coordinate these programmes and the need for scientists to become involved in the technical development of these programmes.

Several contributions have considered the technical problems inherent in the development of monitoring programmes. In this session of the e-conference we will discuss some examples of recent work on the development of monitoring and indicators of biodiversity. Keynote contributors will discuss diverse issues such as landscape indicators of biodiversity, the involvement of volunteers, the selection of indicator taxa and the integration of data in simple indices. Please write to tell us about your research, your experience, your ideas, and please continue to respond to other contributions.

Existing forest monitoring programmes - Building on the legacy of the past- Richard H.W. Bradshaw, Peter Friis Møller & Annett Wolf, Geological Survey of Denmark and Greenland.

SUMMARY: The recognition of the value of structural indicators of forest biodiversity means that long-term observations of structural dynamics in forests contribute to biodiversity monitoring. Long-term data sets are particularly valuable in forests where changes can be slow.

Forests tend to alter rather slowly and the longer a biodiversity monitoring programme has been in operation the more useful it will be. Therefore special consideration should be given to existing programmes that have been in operation for many years. The BEAR project identified key factors of forest biodiversity at national, landscape and stand scales and also distinguished structural, compositional and functional indicators (Larsson 2001). The stand-scale structural key factors can be rather easily linked to several long-term, non-intervention forest monitoring programmes in Britain and Denmark (Mountford *et al.* 1999, Møller 2000). The observations from Draved Forest in Denmark for example contain 50 years of observation of key factors such as tree species and tree stand structural complexity. These comprise the conceivable indicators: basal area, presence and spatial distribution of size classes, horizontal and vertical structure among others. The associated fossil pollen data record the stand continuity indicator for several millennia. Dead wood has only recently been specifically recorded, but the reconstruction of mortality patterns in space and time allow a reasonable estimate of past dead wood generation. The Draved data records significant changes in stand composition and structure typical for the many European forest areas that were previously managed but have lacked direct intervention in recent years. These changes include a 40-50% increase in total basal area and a gradual loss of light-demanding trees. These structural changes have had a large and significant effect on associated biodiversity.

Long term ecological research has many applications even when the original aims of a programme may now seem irrelevant. We argue for the incorporation of existing long-term data sets into biodiversity monitoring programmes where the observations are appropriate.

FOREST FOCUS, a new European monitoring scheme - Etienne Branquart, Centre de Recherche de la Nature, des Forets et du Bois (DGRNE).

SUMMARY: The new scheme to monitor and safeguard Europe's forests, FOREST FOCUS, constitutes a nice opportunity to better understand relationships between global change, forest health and biodiversity. Indicators for assessing forest health and biodiversity still need to be defined.

As previously stated in this electronic conference (see e.g. Saaristo & Niemelä and Bradshaw et al.), I also think that a large-scale monitoring of forest biodiversity in Europe should use habitat or structure-based indicators rather than individual species. Numerous structure-based biodiversity indicators have been proposed at European scale, as for example through the MCPFE process or within individual projects such as the BEAR one. However, the validity of such indicators has rarely been tested carefully. We urgently need field studies to identify the best set of indicators, looking at relationships between them and species composition of different key taxonomical groups (Lindenmayer 1999, Lindenmayer et al. 2000, Noss 1999).

The Belgian Forum on Forest Biodiversity includes Belgian researchers interested in forest biodiversity and gathers scientific information useful for biodiversity management in forest ecosystems. As in the BITUMI project, several research teams involved in this forum intend to study relationships between structure-based indicators frequently measured in forest inventories (dead wood amount and quality, stand structure and composition, wood margin structure, etc.) and the richness and composition of key indicator groups such as marcrofungi, plants, beetles, butterflies, hoverflies and birds (http://www.biodiversity.be/bbpf/forum/forest/forestforum.html).

According to the priorities identified in the DIVERSITAS science plan, the next major step is to study the functional relationships between the stability of forest ecosystems (e.g. resilience-resistance to global change and pest outbreaks) and their biodiversity.

The new scheme to monitor and safeguard Europe's forests proposed by the European Commission and the European Parliament, Forest Focus, is a nice opportunity for the EU to expand the monitoring activities developed in ICP FOREST set up in response to the UNECE Convention on Long-Range Transboundary Air Pollution. FOREST FOCUS will develop new activities to monitor biodiversity, climate change, carbon sequestration and soils (http://europa.eu.int/comm/environment/nature/forest-regulations.htm).

The working programme of FOREST FOCUS is not yet established. One can wonder what kind of indicators will be used to assess biodiversity and forest health in this programme. In addition to the classical crown condition and pollutant measurements, I suggest we use a standardised protocol for surveying forest pests (e.g. defoliators and wood-boring insects) and to assess biodiversity (e.g. structure-based indicators). In order to know, for example, how global change and/or the naturalness of forest stands affects biodiversity and the frequency of pest outbreaks…

Reply to: Forest Focus , a new European monitoring scheme - Pat Neville, Chairman of the EU and ICP Forests Biodiversity Working Group.

SUMMARY: A component of forest biodiversity assessment is included in the new European Commission Scheme, Forest Focus. A Working Group is currently elaborating methods to assess aspects of biodiversity within the pan-European monitoring programme.

Etienne Branquart makes reference to the new scheme proposed by the European Commission and European Parliament to monitor and safeguard Europe's forests, so called Forest Focus; in particular the component of biodiversity associated with this programme. Full details of this proposal may be found at: http://europa.eu.int/comm/environment/nature/forest-regulations.htm

As outlined by Branquart, this scheme concerns the development of Council Regulation 3528/86, which in close co-operation with ICP Forests has been monitoring the health of Europe's forests since 1986. As part of the new scheme and the recently amended mandate of ICP Forests, the monitoring programme is investigating the possibility of contributing, by means of the monitoring activities, to aspects of biodiversity assessment in forests. See also: http://www.icp-forests.org/Objectives.htm

At present, a Working Group of the European Commission and ICP Forests is attempting to elaborate methods of biodiversity assessment that may be incorporated into the monitoring programme (a programme essentially elaborated to monitor the effects of air pollution on forest health). There has been much discussion indeed in this electronic conference and elsewhere on the use of indicators in assessing forest biological diversity, e.g. structural vs. species approach, plot vs. landscape approach and as yet there appears to be no consensus for any particular ecosystem or land use type, much less a standardised approach for the forests of Europe!

After a number of meetings the Working Group has decided, as Etienne Branquart has suggested, that structure-based indicators should be used in this assessment. The reason for this is essentially that the monitoring programme routinely collects a variety of information on stand structure and that this information together with information from the ground vegetation dataset of the programme may allow us to say something about components of forest biodiversity.

However with over 6,000 Level 1 and approximately 900 Level II monitoring plots a cautious approach is required before any large scale implementation is considered. The purpose of this programme is essentially one of monitoring and not one of forest research per se, therefore the intention of the programme is not to validate indicators of biodiversity but to implement those indicators already developed, tested and proven by the scientific research community.

In the absence of a definitive "shopping list" of biodiversity indicators, the approach being taken by the Working Group is to initiate a test phase in the field of a large number of structural indicators of forest biodiversity on a selected number of plots and relate this to the ground vegetation dataset. In this way perhaps, fewer more salient parameters may then be employed at a larger scale in the future. This gives only a "broad brush" picture of European forest biodiversity, which could then be refined by more intensive European research programmes such as BioAssess and national programmes such as Bioforest in Ireland. A working document has been prepared by the group and is available for comments to any interested parties, indeed I would welcome this opportunity to obtain feedback from experts actively involved in this field.

Establishing a common framework of biodiversity monitoring- Alan Feest, University of Bristol.

SUMMARY: Bringing together the concerns of previous contributors to the conference, a methodological approach to defining and setting biodiversity values and how to measure them using macrofungi, is presented here. The possibility of using this methodological approach with other taxa than the macrofungi used in the experimental approach is suggested.

Combining the range of biodiversity indices that give the quantitative values of biodiversity can be used to provide the qualitative value of the survey taxa.

I wish to address the issues already touched upon by the first correspondents:

The conference chairman (Alan Watt) lists the aims of the conference to include the discussion of existing and planned biodiversity monitoring programmes, identifying their strengths and weaknesses; the identification of some developments in monitoring biodiversity and the advantages they offer and then the development of a core programme of biodiversity monitoring across Europe.

Richard H.W. Bradshaw addresses the need for the establishment of natural and baseline biodiversity conditions and then for tools to follow the effect of management upon these baselines. Horst Korn identifies the urgent need to generate datasets that: reflect status and trends in biodiversity; show the possible effects of policy or management measures and indicate when political action is needed. He states that priority should be given to develop simple and cheap monitoring schemes that could be applied widely in Europe, building on and incorporating already existing monitoring programmes. Paul Rose states that biodiversity indicators must be practical to measure; the biodiversity must be measured nationally or regionally across much of the geographical area of interest and monitoring methods must be reasonably consistent, robust and reliable. Dominique Richard and Sophie Conde request that in all cases monitoring schemes should answer specific questions, if possible in both a qualitative and quantitative way. Lilian van der Bijl and Torben Moth Iversen state that a crucial point is the need to develop identical indicators for all levels in order to follow the information flow from assessment of status in relation in relation to habitat quality objectives to realization of national action plans and international targets. Finally Jeremy D Wilson and Ian Bainbridge state that clearly, data availability remains one of the primary constraints on the selection and reporting of statistically powerful biodiversity indicators.

In Summary these colleagues are asking for two difficult but possible targets to be addressed by the conference:

1. The devising of a series of standardized sampling methodologies such that biodiversity can be sampled and compared across the geographical region.
2. The estimating of biodiversity should respond to the need to define what is represented by the term biodiversity.

I am fortunate in that I have been addressing these issues for the last five years and I would like to share my progress so far. In terms of sampling we already have some robust methodologies capable of producing comparable results across a geographic range. In particular I refer to the methods for birds (Common Bird Census Methodology) and day flying Lepidoptera (Pollard and Yates method). The principle of a series of spot samples and walking a random walk encompassed in the above methods allows the taking of a generalized sample of a defined habitat. Using this general principle I have sampled macro fungal fruit bodies from defined habitat areas to derive a number of biodiversity indices (Feest 1999). The method requires that in a random habitat a straight line walk with regular stopping points are used to take sub samples. For macrofungi we have found that twenty sample points is normally enough for the species area curve to be flattened out. Interestingly for bryophytes we have found that only ten sample points are needed. For macrofungi we count every fruit body within a 4m radius circle (=almost exactly $50m^2$) and thus 1000 m^2 are sampled in twenty stop points. Using the enumerated data of the species (allowing that the taxonomy of macrofungi is not as stable as for some other taxonomic groups) it is then possible to derive the following indices of biodiversity as a generalization for the whole of the sampled site:

- Species Richness (number of species in a unit area; in this case $1000m^2$)
- Cap Area Index (derived from reference text given sizes of species and shown to be directly related to the dry weight). This will give a relative biomass for the site.
- Species Value Index (attaching rarity values as derived from reference texts but also subject to regional variation)
- Fruit Body Density (the number of fruit-bodies per unit area e.g. m^2)

- Biodiversity Indices e.g. Shannon-Wiener, Simpson's, Berger-Parker. These indices are compiled from both the individual number of fruit bodies and also from the cap area indices since one individual may be represented by more than one fruit body.
- Species List is the total number of species found on the site for all visits. This must be qualified by the number of visits made.

Using this range of indices (of which the biodiversity indices seem to be the least valuable due to the mathematical effect of dominance by a species) the biodiversity baseline values of a site can be measured. Thus using this suite of biodiversity measures, the varying property of biodiversity can be derived and sites defined. Sampling in this way also allows the setting of baselines for future comparison. This calculation has in the past taken longer (3-4h) than the sampling (2-3h) to complete for sites that are rich in species but we have now devised a computer programme to simplify the process and calculation can be completed in a matter of minutes. I am actively working on the transfer of the methodology across taxonomic boundaries and hope to have a similar scheme for Arachnida in the near future. I surmise that this approach would be equally applied to other taxonomic groups such as Collembolla, Hymenoptera, Orthoptera, nematodes etc.

So this is a way of providing the baseline and measurable data that the above authors have requested: The quantitative measure of biodiversity. In the defining of the qualitative measure of biodiversity I would suggest that the reviewing of the full range of the quantitative measures will provide a sense of the qualitative value of the biodiversity of site. A site may therefore be one rich in rare species or have a high number of species (all of which might be common?) or have a high biomass of the taxonomic group. All of these or maybe even other measures should be kept in mind if considering the biodiversity of a site for a taxonomic group. This approach of using several measures of biodiversity has been used by the British Trust for Ornithology in its Integrated Bird Monitoring project that has already shown to be of major importance in alerting the British Government to the critical decline of some British bird species that might not otherwise have been detected.

A final thought is that this approach is very different, but by no means antagonistic to the simpler methodology of defining indicator species for biodiversity value. The use of indicators may be the only useful method for some purposes but I suggest that there are likely to be occasions when a habitat may be threatened but a useful indicator species is not easy to identify. More than one approach is necessary.

Development of biodiversity indicators and monitoring - the MacMan project- Josef Settele, Centre for Environmental Research Leipzig-Halle.

SUMMARY: As one example of recent work on the development of indicators (and monitoring) let me briefly summarize the aims and contents of the MacMan project (further details: www.macman-project.de).

Title of project: *Maculinea* Butterflies of the Habitats Directive and European Red List as Indicators and Tools for Habitat Conservation and Management

Problems to be solved: *Maculinea* butterflies are typical representatives of endangered European biodiversity. All species are listed by IUCN as globally threatened, and for all species, Europe is an important part of their global distribution and thus the special responsibility of Europe. This responsibility is reflected in the fact that 3 of the species are listed in the Appendix of the Habitats Directive and the Bern Convention, and all are on the European red list of endangered butterflies. In addition, MacMan will promote the implementation of the Natura 2000 and Habitats Directive in two eastern Central European EU candidate countries (Hungary and Poland). As we intend to study diversity within species as well as between species, we are clearly within the aims of conservation of biodiversity as agreed upon within the Convention on Biological Diversity. As the whole project furthermore aims at an improvement of Environmental Impact Assessments (EIA), it directly addresses 85/337/EEC on this very topic. Thus, the work very strongly relates to Europe's commitments and supports legal obligations.

Scientific objectives and approach: The project has four main objectives:

1) To increase knowledge in inter- and intraspecific variation in the functional ecology of *Maculinea* systems across Europe;
2) To assess the suitability of *Maculinea* butterflies as indicators of biodiversity along a European transect;
3) To develop standards for monitoring *Maculinea* butterflies as indicators and tools for grasslands and their management, and
4) To promulgate and exploit these monitoring standards.

At the end of the project we will know the ecological variability within the species and their suitability as indicators. Thus, we will know the geographical range of the applicability of simplifications for habitat management. Consequently we will use a European transect approach.

Expected impacts: The reliability of simplified methods across large geographical ranges has so far only been postulated, but never systematically tested. To avoid extreme mistakes in environmental impact assessment and conservation planning the results will be extremely important. The only reason why the problem could not be solved would be the lack of sufficient data even after this project, which we do not expect to happen. If it should happen, the solution would be even more intensive research. We will provide tools for users that are simple rules/models of land use change and human impact on biodiversity (exemplified with *Maculinea* butterflies), general guidelines for the practical management of sites, a handbook of methodology, and databases on biological interactions and ecological traits of our model taxon.

Further comments and experiences so far: Objectives 2) and 3) particularly relate to the topic of this e-conference. It seems that the development of monitoring standards of the species group alone will not be trivial. Due to the fact that the species are normally not widespread, general monitoring (as e.g. conducted in the UK or the Netherlands) will not be suitable for these species (as for many others - also recognized by the monitoring schemes in UK and NL). In general I think we need specific monitoring methodologies for the more endangered species. They do not necessarily have to be complicated, but have to be conducted on very particular sites and not randomly within the landscape. The suitability as indicators is an even more difficult aspect of the project. However, we are sure that the presence of species of "our" genus indicates a certain minimum quality of habitat (e.g. presence of certain ant species, which again function as keystone species for other organisms) and is a clear indication of moderate land use intensity in cases where the species depend upon land use (which is the rule rather than the exception). But one should not expect to use the absence of the species as an indication of lower quality. In the latter case one simply has to acquire additional information that we are not forced to have in the case of the presence of *Maculinea* species. This surely is a pragmatic approach, but consequently has a high potential to be of practical relevance.

Auditing the ark - thoughts about our terminology- Peter Bliss and Andreas Katzerke, Martin-Luther-Universität Halle-Wittenberg.

SUMMARY: Following a proposal of the JNCC (Joint Nature Conservation Committee, UK) the authors discuss advantages of using the term “nature surveillance” in site monitoring schemes.

The title of this e-conference is ‘Science based monitoring of biodiversity’, so consequently all participants are using the term ‘monitoring’. But is all what we read really monitoring? Should we use a more precise language to avoid misunderstanding and inflation? And, if we distinguish between ‘nature surveillance’ and ‘monitoring’, would it bring advantages?

An interesting proposal comes from the JNCC, published in 1998 (URL: http://www.jncc.gov.uk/idt/csm/approach.htm). This committee says that it is important for site monitoring to define what monitoring means:

‘Surveillance relates to a continued programme of surveys systematically undertaken to provide a series of observations over time. Such programmes of repeated observations are very valuable for establishing the trends in the components of nature conservation at different geographic scales. Monitoring is, in contrast to surveillance, the making of an observation to establish whether a standard is being met. This can be established in a single visit or observation and does not require information collected over time. The purpose of site monitoring is essential to:

- Determine whether the desired condition of the feature(s) of interest for which the site was designated is being achieved. This can enable judgements to be made about whether the management of the site is appropriate, or whether changes are necessary.

- To enable managers and policy makers to determine whether the site series as a whole is achieving the required condition, and the degree to which current legal, administrative and incentive measures are proving effective.’

The first advantage of these definitions is that we can divide the time axis of (planned) monitoring activities:

Period 1: Round table. This is the cooperative process of finding the feature(s) of interest (objectives of the monitoring programme). Ideally, both the conservation body and conservation ecologists cooperate in searching for priorities and define their different interests. Scientific objectives should be focused ‘on learning and developing an understanding of the behaviour and dynamics of the monitored system’ (Yoccoz et al. 2001).

Period 2: Identification of suitable monitoring organism(s) and the relevant factors influencing the system(s). This is the first phase of surveillance.

Period 3: Surveillance of the state variables of interest in the field to provide information on the system response to management actions and the development of standards for surveillance and monitoring.

Period 4: Using surveillance data to distinguish between competing scientific hypotheses about system response to management and the creation of a model.

Period 5: Monitoring in a strong sense. Validation of the model with monitoring data (from standardized methods), and, if necessary, modification of management actions.

This is not a complete proposal for structuring a monitoring programme (see Yoccoz et al. 2001 for much more information). What we want to say here, is, that it might be useful to use a differentiated terminology in establishing a new monitoring project. Furthermore, it allows us better communication with conservation authorities and the scientific community (this is the second advantage).

We should clearly say (not at least in our negotiations with the sponsors of conservation and science) that both interests (management and science) have to be taken into consideration. That’s why an integrated project has a differentiated scientific depth during the course of time (e.g., surveillance is often empirically data sampling - not more and not less). A fact that should not be swept under the carpet.

We established a pilot project in the Müritz National Park with the help of the conservation body to monitor mound-building ants (see also our contribution in last years’ e-conference “Biodiversity conservation in theory and practice’, Belgian EPBRS-Meeting). In doing this, we have found that it is helpful to use clear language. But is it really correct to say nature surveillance is the (often neglected) basis for science-based monitoring? Do the participants of this e-conference have any experience or alternative proposals?

Towards biodiversity monitoring at the European scale: using mound-building ants as a model system - Peter Bliss, Peter Neumann, Andreas Katzerke & Robin F. A. Moritz, Martin-Luther-Universität Halle-Wittenberg.

SUMMARY: We propose to use mound-building ants (e.g. supercolonial *Formica*-ants) and their colony dynamics as a model system for biodiversity surveillance and monitoring at a European scale within the framework suggested by Frederic Gosselin.

We believe that the contribution of Frederic Gosselin to this conference provides a very useful framework for developing biodiversity monitoring at a European scale. We particularly agree that biodiversity monitoring must have clearly pre-defined objectives, as Gosselin concludes from the first session of this conference. The objectives should cover estimation of trends for parts of biodiversity and the impact of human activities, including changing European-level policies.

It is obvious that not all biodiversity aspects can be covered with surveillance or monitoring. Therefore, we have to focus our activities and should promote fieldwork in the real world (see also the contribution by Jurgen Tack, Geert De Blust & Eckhart Kuijken). However, we are wondering about the obvious lack of proposals in this conference regarding which species and/or groups of species should be selected as model systems and monitored at a European scale. Are there any gaps or imbalances? For example, we agree with Peter Duelli and Christoph Scheidegger who stated in this conference: "… most countries tend to collect the same groups: Birds, plants, butterflies, etc. But do they really represent biodiversity?"

Model organisms should fulfil certain criteria as pointed out in Frederic Gosselin's earlier contribution (18/09/2002). Clearly, not all points can be covered by a single species. But groups of species can and should be selected, based on objective criteria and not subjective ones. We believe this is particularly important in order to convince third parties (e.g. government agencies) of nature conservation goals based on straightforward scientific arguments.

Here we propose supercolonial ants (e.g. mound-building ants of the *Coptoformica*-group) as one of model organism. This model system has certain advantages fulfilling important criteria:

1. Despite the fact that these ants can be rare in some countries (e.g. Falk 1991, Glaser 1999, Hoare et al. 1996, Seifert 1996) they can be extremely abundant on local and regional scales. They can even ecologically dominate entire habitats by establishing large long-living polydomous (many connected nests) and polygynous (many queens per nest) colonies with hundreds of nest hills (Bliss et al. 2001, Buschinger & Jochum 1999).
2. It is easy to locate and monitor nests and entire colonies for long periods of time because nests are stationary therefore resembling plants (Agosti et al. 2000). Thus, it is even possible to involve qualified non-myrmecologists in established monitoring programs and to test hypotheses by manipulation experiments.
3. Mound-building ants change soil conditions, thereby modifying the microrelief and creating microhabitats (e.g. Bliss et al. 2002).
4. Nests can be extremely long-living (the life span of queens ranges up to 20 years, Pamilo 1991) exceeding the life span of many vertebrates. Because nests may contain more than one queen, nests can potentially exist forever or until the habitat has changed in its integrity. Therefore, they are ideal for long-term studies (Cherix 1994).
5. The nest mound offers an environmental buffering capacity. This minimises stochastic effects and thus the responses of the ant system only reflect major habitat changes (Lorber 1986).
6. It is possible to test changing environmental conditions and indicator qualities at three different levels: a) the individual nest, b) the whole polydomous colony and c) the landscape dimension via interconnected populations.

All these qualities mentioned above allow for a science-based monitoring of our proposed system. A combination of several such systems may help to avoid monitoring that is judged unsatisfactory but may instead help develop adaptive management strategies (see example in Soerensen 1993).

Innovative approaches to monitoring and conserving biodiversity- Robert Kenward (NERC)

SUMMARY: The author looks at the potential of volunteers in monitoring programmes and the roles of both volunteers and professionals in ensuring the success of these schemes. He also lists a few questions raised by volunteer monitoring at the local level.

The first session of the conference started by addressing the "why" of monitoring biodiversity. The whys included the need to identify, implement and record effects of actions to conserve biodiversity. Much discussion has followed on how to sample and what biodiversity indicators to use. Another important area, introduced in the last session by Romain Julliard & Frederic Jiguet, then developed by Caspian Richards and also implicit in messages from Ben Delbaere, Richard Gregory and Petr Vorisek, has been the role and motivation of volunteers and professionals in monitoring.

At the start of the third session, it is worth using a consideration of volunteer and professional roles to set discussions in a wider context that indicates new approaches for future monitoring systems. Crucial factors are (a) abilities and (b) motivations.

There is a bigger "why" about monitoring to conserve biodiversity – why conserve biodiversity? A wide answer is "for people". Some aspects of biodiversity may be critical for human life support: public goods, for which governments may pay. Other aspects may be recreational, with "user-pays" opportunities for conservation. Given guidance, users can pay with time spent monitoring. Many already volunteer, and as Caspian Richards reminds, can create local groups that educate and involve yet more. Think how much the popularity of bird watching has grown.

However, to contribute to useful monitoring, volunteers need professional guidance in sampling and recording, for example to advance their methods from presence/absence to counting and even counting-with-qualifiers. They need professionals to compile and calibrate their data. Professionals are also important for developing new techniques, creating hypotheses about causation of processes, arranging experimental tests, deriving biodiversity indices and communicating these to policy-makers.

Often there may be too little volunteer ability in particular locations or taxa, so that professionals must monitor. However, this tends to "narrow and deep" monitoring, whereas volunteers can provide the "broad and shallow". If conserving biodiversity for recreation is to become mass-market like video-films, rather than a minority interest like ballet, we need "broad and shallow" engagement. Why depend on reserves if we could have countrywide restoration of biodiversity, with local adaptive management through volunteer monitoring?

The European Sustainable Use Specialist Group of IUCN recently proposed such a local-level countrywide approach to UNEP's High-Level Conference on Agriculture and Biodiversity (http://nature.coe.int/conf_agri_2002/agri16erev.01.doc). ESUSG is working with the UK Centre for Ecology and Hydrology to engage partners for a Framework 6 Network of Excellence bid to start building appropriate support systems. Such systems will depend on volunteer monitoring at local level, which raises many questions. How best to recruit volunteers? How to design monitoring, to provide appropriate indices but not be so demanding that it demotivates? How best to provide training? How to optimise interaction with professionals? How to reduce tensions between the consumptive and non-consumptive users so that both contribute maximally?

Sociological studies are needed to answer these questions, but Europe, benefiting from its diversity of cultures and development stages across nations, is a good place to collect the comparative data.

New developments in biodiversity indicators, essential tools in monitoring biodiversity: the Austrian experience - Norbert Sauberer, University of Vienna.

SUMMARY: Biodiversity indicators were developed and tested in an agricultural landscape in Eastern Austria and the utility of indicator taxa and landscape variables for the prediction of total species richness are reported.

Biodiversity monitoring requires indicators, and such indicators need to be cost-efficient in their assessment, effective in their predictive power and calibrated to a particular scale and context. We evaluated and tested a series of biodiversity indicators in an old agricultural landscape with mixed land use in Eastern Austria (www.klf.at, BD1: Biodiversity of Austrian Cultural Landscapes).

To date, most studies on biodiversity indicators have been carried out at the point scale (< 1 ha) or national and continental scales. But the landscape scale has been largely ignored, even though it is at that particular scale at which most conservation issues in agricultural landscapes need to be addressed. In our study, we evaluated eight different taxa at the landscape scale (approximately 600 x 600 m, or 36 ha), which is about twice the size of an average Austrian farm. We explored cross-taxon species richness correlations and we searched for useful environmental surrogates.

The pessimistic view expressed by some authors (e.g. Lawton & Gaston 2001) suggests that the search for efficient indicator groups will be a fruitless one. However, our results demonstrate the usefulness of single taxa (especially vascular plants or birds) or the combination of two taxa (e.g. ants plus gastropods) in predicting overall species richness at the landscape scale. We reported these results shortly in last years' electronic conference 'Biodiversity conservation in theory & practice' (Belgian EPBRS-Meeting). With regard to environmental surrogates, regression analysis shows that land use intensity (degree of disturbance), environmental heterogeneity and habitat type are the most efficient predictors of species richness. A simple semi-quantitative approach using composite measures (e.g. fertiliser input; frequency and intensity of soil disturbance; removal of biomass; number of planted species etc.) for mapping and detecting agricultural land-use intensity in the field, and its impact on biological diversity has been tested with considerable success by Zechmeister & Moser (2001). Using aerial photographs, the advantage of a new index named 'landscape shape complexity' in predicting species richness has also been shown (Moser et al., in press). The rationale behind this index is that increasing land use intensity has a negative effect on landscape shape complexity and species richness.

Apart from human disturbance, species richness in these landscapes is also influenced by environmental (e.g. topographic) heterogeneity. Significant positive correlations between environmental heterogeneity and species richness have been confirmed by several studies for many taxa and across a wide range of spatial scales, but the question of how to quantify heterogeneity remains a challenge.

Habitat continuity (i.e. the long-term persistence of habitat remnants) is another important factor determining species richness in agricultural landscapes. In a recent German study in comparable agricultural landscapes, the quantitative importance of semi-natural habitats for pollinator species richness was convincingly demonstrated (Steffan-Dewenter et al. 2002).

The main conclusion of our research programme is optimistic. We cannot expect the one-and-only indicator, but we can develop a set of biodiversity indicators for particular landscapes that can be put to effective use in monitoring biodiversity.

Spatial scaling in biodiversity monitoring- Rainer Waldhardt, University of Giessen.

SUMMARY: In monitoring species richness at the landscape scale, three factors have to be considered: (i) the punctual species richness within specific biotopes, (ii) the local species richness within landscape tracts, which may indicate specific species densities within a landscape, and (iii) the regional species richness.

Until the late 1970s, the main task and objective of nature conservation was to protect particular habitats or small areas with a high protective value in nature reserves. Common instruments of conservation policy were the enforcement of restrictions on land use or the implementation of specific management systems that were supposed to maintain and develop the nature reserve in a sustainable way. When carried out, the area wide monitoring and efficiency controls of the measures were easy to accomplish due to the small size of the protected habitats / areas.

In many small reserves though, the management was not successful and a decline of their original value (e.g., a decline of species richness) was observed. This was mainly due to inadequate management plans, but also a consequence of neglecting the relevance of the habitat matrix (i.e. the habitat pattern of the surroundings and its management). It was increasingly recognized that the preservation of species richness could only be achieved through sustainable land use at the landscape scale. This resulted in the establishment of large-scale reserves with an alleged sustainable development (e.g. Biosphere reserves).

From a landscape ecological point of view, an area-wide monitoring of these large reserves is neither practical nor useful, whereas monitoring at various spatial scales seems to be target oriented and necessary to evaluate the development of the punctual, local and regional species richness:

Monitoring of the punctual species richness must be conducted with adequate sampling within representative biotopes. Recent approaches, based on geostatistical analyses of remote sensing data (Haines-Young et al. 2000, Hoffmann-Kroll et al. 2002), are suitable methods for the selection of representative plots.

Monitoring of the local species richness must consider landscape tracts that should ideally contain the local diversity. Depending on the specific landscape structure (heterogeneity of site conditions and land use), these plots will have a varying size and may indicate specific species densities within a landscape. To determine the size of such landscape tracts for the monitoring of vascular plant species richness in traditional agricultural landscapes, our research team has developed a multiscale methodology that is based on the mosaic concept (Duelli 1992, 1997).

In our approach, we analysed habitat patterns of exponentially enlarged area units by means of GIS techniques. The number of habitat types (habitat variability) and their patches (habitat heterogeneity) were determined for each area unit. Based on a region-wide random sampling of the floristic species diversity in all habitat types, we derived habitat specific frequencies for all species. These were used to estimate the species numbers in the area units by means of probability calculations. The minimum size of landscape tracts that contains the local diversity can finally be inferred from species area curves. We applied our methodology in a traditional small scale mosaic landscape, and found that the local diversity levels were reached within areas of approximately 30 ha.

To cover the variability of local species richness in a region, a varying number of such landscape tracts should be incorporated in a monitoring programme – depending on the prevailing heterogeneity of landscape structure. Similarly to the approaches mentioned above, the selection of representative plots may be derived by means of geostatistical analyses of classified local habitat patterns. An aggregation of data from the selected landscape tracts of a region will finally - according to our multiscale approach for monitoring - allow a spatially explicit evaluation of its species richness at the iii) regional scale.

In our view, such a multiscale approach is also suitable for the monitoring of potential effects that the introduction and release of abiotic or biotic pathogens or organisms (e.g., genetically modified plants, alien species) could have on plant species richness.

Monitoring biodiversity at the landscape level - José M. García del Barrio, Centro de Investigación Forestal.

SUMMARY: Territorial integration of datasets for species and habitats biodiversity at landscape level is necessary for a meaningful ecological knowledge of diversity and for the settlement of adequate tools for monitoring biodiversity.

During the last few days, contributors have argued about the aims of this E-conference and have described some regional or national initiatives of monitoring biodiversity. Many of these contributions go in the same direction and have pointed out national and international targets for the conservation of biodiversity. I agree with much of them but especially with Dr. Kenward in the need for two speed monitoring: a "broad and shallow" effort provided by volunteers (specially in widely known taxa like vertebrates or vascular plants) and a "narrow and deep" effort that only professionals can monitor (in particular locations or taxa).

How extensive and valuable are the two datasets and how can we put them together for a more comprehensive knowledge of biodiversity? Surely it depends on the scale. Nowadays there is a lot of information about many species' distribution, habitat types, and land use changes but there is a lack of information concerning the assemblage of this information within an ecological meaning. In this sense we think that a territorial framework at the landscape level is a good approach for understanding and monitoring biodiversity. This includes some successive steps:

- Territorial delimitation of main landscape typologies at regional and national level. We may take into account a set of variables (land uses distribution, climatic, topographic and edaphic, socio-economic…)
- Characterization of each landscape in relation with its composition (habitat types) and structure (cores, edges, corridors).
- Evaluation of a biodiversity baseline for habitats and species of well-known taxa and relationships between taxa.
- Establishing appropriate indicators (species indicators, species richness, diversity indexes, landscape metrics) for monitoring biodiversity at landscape level.

This integrated approach has it basis on a minimum landscape size: the local landscape of a municipality. A single municipality or a set of them constitutes a landscape unit for evaluating and monitoring biodiversity. All databases may be integrated in a Geographical Information Systems (GIS) and the aggregation of databases of adjacent landscapes, from local to regional level, can provide a realistic perspective about trends in biodiversity changes and strategies for biodiversity conservation.

Incorporating functional parameters in soil biodiversity monitoring schemes- Paulo Sousa & P.V. Morais, Universidade de Coimbra.

SUMMARY: Biodiversity monitoring schemes in terrestrial systems, particularly those aimed at evaluating changes in the habitat function of soil (e.g. soil as a living space for organisms) caused by anthropogenic disturbances, usually focus on evaluating animal and plant species, neglecting (in some cases) microbes and functional parameters in soil. Since we cannot separate structure and function, this contribution aims to alert those doing the work (scientists) and those requiring the work (stake holders and decision makers) to the need of incorporating functional parameters in biomonitoring programmes. We do not intend to enter in the old, but actual, debate on species redundancy (for this topic you may want to check the recent paper from Bolger[1]), nor speak about the plethora of microbial methods available; we just wanted to remind the advantages of using a couple of easy and cost-effective methods in monitoring plans.

In terrestrial systems the decomposition of organic matter is the gateway for most (if not all) processes occurring in soil. Since the majority of soil organisms (from microbes to soil macrofauna) are directly or indirectly related with the decomposition process, the measurement of it is, *per se*, the most integrative parameter available; if some shift occurs from the normal decomposition pattern (when comparing with a reference site), maybe something is wrong with the system either in terms of function, structure or both. To measure decomposition (weight loss) is easy and demands a small amount of money. Moreover, standardized protocols are being developed (e.g. to assess effects of agrochemicals in soil at functional level) and can also be adapted to other situations allowing more straightforward comparisons.

Of course, if we only evaluate the weight loss, we probably are not able to depict the cause beyond the change, unless we perform other types of measurements. One of these can be the evaluation of the feeding activity of soil fauna by using a very easy method like the bait-lamina sticks. This method allows the assessment of the activity of soil fauna both on a spatial basis (comparing control and impacted sites, or different soil use or vegetation types) and along the soil profile. It is currently being used in field monitoring programmes in soil ecotoxicology, but it has great potential in other situations also.

Other types of measurements, also useful to depict changes at functional level, are those related to the characterisation of the functional potential of the microbial community. The most used is the BIOLOG method. Originally developed for classification of bacterial isolates based on their ability to oxidize 95 different carbon sources, this method is now used in several research areas to obtain the metabolic fingerprinting of soil bacteria. Microbial communities produce habitat-specific and reproducible patterns of carbon source oxidation, and so the method can be used to discern temporal and spatial differences among microbial communities from bulk soils.

The observed pattern of substrate used may only reflect the functional characteristics of organisms that are able to grow in the BIOLOG plate wells under the assay conditions. This limitation can be overcome by assessing the true structure of microbial communities. Until recently, methods of analysing microbial ecosystems were able to provide data on processes or bacterial numbers but were not suitable for the analysis of the microbial community composition or diversity. The amplified ribosomal DNA restriction analysis (ARDRA) is quite a new molecular method use to analyse microbial community structure and diversity. Sequence variation in the rRNA has been exploited to infer phylogenetic relationships among organisms, to determine the genetic diversity of microbial communities and to identify several uncultured microorganisms. With this method we can achieve the determination of the genetic diversity of the microbial community and compare microbial communities from different samples getting information with respect to microbial ecology in a reduced time and with improved sensitivity.

Just to end this contribution, let us say that the methods mentioned here are not, *per se*, the solution for a complete picture of effects on soil processes. Many others exist (e.g. enzymatic methods, respiration), but these, due to their low cost, the rapid results, thee robustness and ecological relevance, are good candidates to include in monitoring programmes. As said earlier, the idea was not to discuss the methods, but just alert the different players to keep in mind that other type of information can (and should) be collected when implementing monitoring programmes to assess changes in habitat function in soil.

Habitat mapping – landscape scale sampling within the Hungarian Biodiversity Monitoring System- Katalin Török (Ministry for Environment and Water Management, Hungary)

SUMMARY: Landscape scale monitoring is carried out by a standard mapping procedure in the HBMS. More than half of the 124 plots of 25 km^2 have been mapped by 2002 (see maps).

The main principles of the Hungarian Biodiversity Monitoring System (HBMS), elaborated in 1998, defined the general approach to monitor biological diversity. The aim of the HBMS is to supply information repeatedly on the state of living organisms for different conventions, nature conservancy, for policy decisions and the general public. Monitoring is coordinated and financed by the Authority for Nature Conservation of the Ministry for Environment and Water Management. Sampling is carried out for 4 years with an increasing number of components and sites at landscape, community and species level.

HBMS is organised in projects, each with clear aims that determine the selection of components, attributes and methods. Detailed protocols are elaborated for each project component. Most of the protocols have already been tested, and some are under way. By the end of the year 2002, revised protocol manuals will be edited in Hungarian.

At the moment 12 experts, 3 responsible for national, 9 for regional coordination operate HBMS with the help of several external scientists and volunteers. Parallel to professional education, courses to learn standard data collection are organised for volunteers. The full operation of HBMS will require a substantial increase of staff.

Landscape scale sampling is carried out with the help of a comprehensive habitat classification system for Hungary. This system includes natural and degraded habitat types, as well as cultivated land and man made habitats, like wine cellars (for categories see: http://www.gridbp.ktm.hu/biodiver/html/angol/index.htm). Approximately 3% of the

Hungarian territory is monitored by means of 124 sampling plots of 25 km^2. The plots are mapped every 8 years primarily by the regional coordinators with the help of independent scientists. A handbook describing the mapping procedure was edited in 1999. The main steps of sampling are as follows:

1. Preparation phase: collection of maps, archive information and aerial photographs of the sampling plot, identification of participating experts.
2. Preliminary field survey: control of the applicability of maps, photographs, testing site access.
3. Mapping in the field (1:25 000): identification and description of habitat types, assessment of degradation, regeneration of types, design of habitat polygons on the basis of aerial photograph, collection of species list, permanent plot sampling (if necessary), description of sampling route on the map, design of specific map legends.
4. Data processing: archiving of data, final design of the map, digitisation, and description of comments for each polygon.
5. Post field survey: for the clarification of questions, if necessary.
6. GIS data processing.

Community and population observations are included within these plots, unless the selected taxa or community can only be found outside the plots. Habitat maps will serve as the basis of synthesis for the monitoring results gathered at other levels of organisation: community and population.

The Swiss Eco- Fauna-Database: A tool for determining the faunistic potential and evaluating the impacts of land use on animal species- Thomas Walter, Karin Schneider from the Swiss Federal Research Station for Agro-ecology and Agriculture (FAL) and Yves Gonseth, Centre Suisse de Cartographie de la Faune (CSCF).

SUMMARY: The Eco-Fauna-Database is supported by the Swiss Agency for the Environment, Forests and Landscape and managed by FAL and CSCF. Its aims are to form a database to gather expert information on a large number of animal species. The database gathers information on systematics, threats and distribution of species as well as behavioural and ecological aspects. The authors suggest that the database might be an essential tool in the analysis and monitoring of data sets such as land use changes, species assemblage changes, climate change and its effect on the behaviour of animal species.

The main objective of the Eco-Fauna-Database is to facilitate the planning of a quick and easy application of the widespread knowledge of wildlife's needs. A relational database using MS Access has been designed to gather relevant information on a large number of animal species. Experts on various animal groups provided inputs to the database using both information from literature and from their personal knowledge and expertise. At present, the expert system contains information on nearly 3000 animal species consisting of Mammalia, Aves (breeding birds), Reptilia, Amphibia, Apidae, Carabidae, Rhopalocera as well as Hesperiidae, Heteroptera, Saltatoria, Odonata and Mollusca. The database records features such as:

- Systematics: Lists of the scientific and vernacular (German, French and Italian) names;
- Threats: Red List status of the individual species;
- Distribution: in accordance with 11 bio-geographical regions and 4 altitudinal belts (colline, montane, subalpine, alpine);
- Climate: the presence or absence of each species in relation to the various categories of climatic features such as: mean July temperature, degree days (the sum of the mean daily temperatures) and mean annual total precipitation have been identified.

The needs and behaviour of many animal species may vary during their life cycle. It is therefore appropriate to register these features individually according to the development stages of the species (e.g. egg, larvae, adult):

- Habitat: This list specifies the habitat types (e.g. raised bog, semi dry meadow, hedgerow, spruce forest) in which a specific development stage may thrive or stay;

- Structure: This list indicates the use of individual habitat structures (e.g. dry stone wall, cave, litter, field layer) in relation to the individual development stage;
- Species traits: Including the circadian rhythm, width of the niche, favoured moisture range, favoured temperature range, etc;
- Mobility: Description of the ability of the species at each development stage to swim, fly, run, walk, creep or hop;
- Phenology: A record of the months during which a specific development stage may occur;
- Diet: A record of the diet at each specific development stage.

The database enables the rapid listing of the faunistic potential of a certain area. This in turn is helpful in choosing indicator species. The database permits the estimation of the impact of interference in a habitat, such as mowing a meadow or trimming a hedgerow. It lists the species and development stages that are concerned, and provides information on the level of mobility of species concerned. The Eco-Fauna-Database might be a very useful tool in the analysis and monitoring of data sets such as land use changes, species assemblage changes, climate change and its effect on the behaviour of animal species. The database is supported by the Swiss Agency for the Environment, Forests and Landscape. FAL and CSCF are responsible for both its management and further development.

A reference-based approach to monitoring- Rasmus Ejrnæs & Erik Aude, National Environmental Research Institute of Denmark.

SUMMARY: We suggest that monitoring may benefit from using statistical models to assess the naturalness of habitats by comparison with large reference data sets.

The EEC Habitats Directive requires member countries to map and monitor the state of natural and semi-natural habitats. The mapping should follow the guidelines and type definitions in the interpretation manual. The habitat monitoring should provide data for the evaluation of state and trends in 1) the natural area and range of protected habitats, 2) the necessary structure and functions of habitats, and 3) the typical species of protected habitats.

The identification and mapping of natural habitats is complicated in highly cultivated landscapes, as uncultivated habitat fragments are dispersed along continuous gradients from unnatural to natural. Also, the design of monitoring and evaluation of data is almost hopeless without clearly defined and operational criteria for favourable conservation status. From this emerges a need for standardised methods in the assessment of naturalness.

Naturalness is suggested as the natural imperative of conservation (Angermeier, 2000). In water resource management, the quantification of naturalness as the deviation from a defined reference condition is already in use (Barbour et al. 2000). A related terrestrial approach is the use of indicator species. Unfortunately, the selection of indicator species typically relies on expert experience, resulting in ambiguous ecological interpretations (Nordén & Appelquist, 2001).

We suggest a reference-based approach which benefits from the large data collections already present in most countries. Samples of species composition in habitats of known naturalness (reference vs. disturbed) may be projected in a few dimensions by methods such as correspondence analysis. The position of samples along these dimensions may then be used as predictors in a classification model of naturalness. A subsequent ecological interpretation of the biotic dimensions may lead to further insight in the factors behind an eventual deviation from reference condition. New data may easily be compared to reference data by passive ordination, and the model may be made available for the public through the Internet. The development and functioning of the model is described in more detail in Ejrnæs et al (2002).

Reference-based models for the assessment of physical and chemical naturalness may supplement the modelling of biological naturalness. Reference-based assessment should be combined with monitoring of changes in the area and distribution of types, and trends in the populations of target species. Such monitoring would satisfy the requirements of the Habitats Directive.

Using a PC software package to collect data- Tomas Coll, Departament de Medi Ambient.
SUMMARY: The author argues for the use of volunteers in data collecting as well as inexpensive and safe identification systems connected to Internet search engines.

Rasmus Ejrnaes and Erik Aude argue for the use of statistical models and a high level of care during the data input process. With their own words " the design of monitoring and evaluation of data is almost hopeless without clearly defined and operational criteria for favourable conservation status...". We must agree with them as well as promote caution in the labelling (labels, tattoos etc.) of individuals during the data processing.

In my last communication I proposed a wide use of non-skilled people in the harvest of data because of the vastness of the task. I also showed the danger of using some metal or plastic labels on birds. In order to avoid this, we may try to search for another data scanning method using a safe and inexpensive identification system for individuals. For instance, an eye-iris scanning on birds (and other individuals) connected with an Internet worldwide search engine. Such an open computerized programme could follow on-line the entire life of a large number of individuals when these are re-scanned by non-skilled volunteers and entered in a specific software package. Such a tool, which nowadays is available, could help research in many of the problems we find in the study of biodiversity.

Biodiversity monitoring needs – an international perspective - Tomas Coll, Departament de Medi Ambient.
SUMMARY: The author highlights the need to gather data on biodiversity monitoring in an organised manner in order to process it efficiently and make it available to a large amount of people through an Internet database.

In order to follow Dr. Robert Constanza's recommendations on biodiversity monitoring, it is necessary to implement an efficient international method. Before any monitoring takes place, we must gather and manage data. That data must be successfully collected and be useful both for the data collector and ultimately for an international data bank. In order to process the data, a simple and homologue labelling system or norm (including easy and readable codes) must be implemented. Because of the large quantity of data regarding species and lives of individuals involved, a general use of the Internet must be implemented in order to make the data available to a wide audience.

Why and what to monitor? Indicators *vs*. biodiversity- Jorge M. Lobo & Joaquín Hortal, Museo Nacional de Ciencias Naturales (CSIC).
SUMMARY: We argue that the criteria for indicators and monitoring sites selected for conservation depend of the procedures used to define these areas as protected. If we want a reserve network able to protect biodiversity (the actors), we must look for biodiversity patterns, and include them in our network. Only then will biodiversity monitoring become more logical.

Through the Habitats directive, Europeans have decided to restrict nature conservation to a network of "sanctuaries". Criteria used for reserve allocation have been heterogeneous and, sometimes, arbitrary. For example, a lot of them aim to protect a given landscape architecture, including both natural habitats and man-made ones (such as 'Las Médulas' region in Spain, an old Roman gold mine). Others are placed in old open-mines where ducks feed, or around religious sanctuaries (Covadonga National Park).

In order to monitor the 'health' of these sites (hereafter, "site-directed-monitoring" or SDM), how can we do it? From our point of view, the discussion about what indicators must be used to monitor these places is "usefulness": this criteria is yet to be included in the definition of sites or areas to be protected. If a river has been protected due to the existence of a given fish, we should monitor the health of its populations. If we decide to protect a given landscape due to its 'natural' beauty, we should monitor changes in land use, and therefore protect its architecture. If a given mountain range is included in the natura2000 network due to the presence of several endemic species, monitoring should be focused in those species.

Now, we want to protect biodiversity, that is, all the actors (i.e. species) that play in nature's theatre. As the protection of ecological processes does not ensure the protection of the actors, a good taxonomic and biogeographic knowledge of the species is needed. However, we lack such information. Therefore, we propose:

- i) To compile all the available taxonomic and distributional information (see www.gbif.org)
- ii) To identify the territorial units with well-surveyed inventories, and decide where to survey to maximize the knowledge about biodiversity patterns in the region, minimising the sampling-effort carried out (Pattern-recovering-monitoring, or PRM)
- iii) To obtain predicted maps through modelisation of the patterns observed in those areas
- iv) To perform a reserve selection procedure that takes into account the former predictive maps

The thus selected reserves must be monitored to: i) validate and improve the predictive models built; ii) compare the adequacy of these reserves with the former ones, designed without taking biodiversity into account; and iii) look for temporal changes in biodiversity. We call this monitoring process "Biodiversity-directed-monitoring (BDM)". But, how can we monitor biodiversity? It is necessary to investigate which species or groups of species can be used as indicators of the whole attributes that describe biodiversity (species richness, rarity, complementarity, endemicity, phylogenetic richness, etc.).

What are we talking about when we talk about monitoring? Here, we have identified three different approaches to monitoring protected areas. We think more discussion on criteria for SDM is worthless: you should monitor the arguments that motivated the selection of each area. We think we should rather reach a consensus about PRM, that is, the protocols to obtain good biological databases, reliable predicted maps about the distribution of species, and a cost-effective selection procedure to develop networks of protected areas. Then, it will be the time to discuss how to change from present SDM to new BDM approaches. In a later contribution, we will discuss the process of developing a PRM for a given, poorly- and patchy-known, region.

Monitoring strategies for biodiversity- Jorge M. Lobo & Joaquín Hortal, Museo Nacional de Ciencias Naturales (CSIC).

SUMMARY: After more than two centuries of biodiversity sampling, in many countries knowledge on biodiversity patterns is scarce and patchy. We need to design our biodiversity monitoring strategies to account for all patterns present in nature, obtaining data able to: a) be interpolated to unstudied gaps; b) validate these interpolations; and c) be easily repeatable through time.

Since Natural History was born, more than two centuries ago, occidental scientists and amateur collectors have been gathering information about biota's distribution throughout the world. If this effort had been carried out in a systematic way, our knowledge about biodiversity patterns should be quite accurate, at least for a number of taxonomic groups. However, except for a little number of groups in Britain (Lawton et al. 1994) and other developed countries, our knowledge of biodiversity is far from being extensive, even adequate. Nowadays, existing distributional information is being exhaustively compiled in databases, such as the GBIF (see Edwards et al. 2000). When this information is mapped in developed countries, a common picture appears of some patchy, species rich, intensively sampled areas and a great extent of poorly known areas (see Lobo & Martín-Piera 2002). This picture is even worse in developing countries, where inventorying has only recently started.

Accurate and detailed biodiversity data are required not only for research purposes but for conservation too (Dennis et al. 1991). With such biased information, we lack good knowledge about patterns of biodiversity and the processes that lead to them, so designing good conservation policies becomes a matter of luck. If we want to obtain such an information we have to choose one of the following: continue with present uneven sampling for at least five centuries, or improve our efficiency through well planned surveys of at least a group of easily inventoried groups. Unfortunately, the former, although more romantic, would prevent us obtaining the information we need to preserve biodiversity from present crises. It is obvious that the amount and quality of species distribution data in Great Britain is quite difficult and expensive to reach for almost the rest of the world in terms of money, staff and time. It would be desirable to survey most areas up to a good sampling level, but the majority of the biota from these areas may have disappeared when the sampling campaigns were barely starting.

Thus, at present we know where we want to go, that is, what we want to know. We need to obtain a good and accurate knowledge of the patterns of biodiversity of the studied groups. Existing information compiled in databases may cover part of these patterns. So, our survey must be adequately designed to gather information that completes previous knowledge in a way that allow us to:

a) Obtain good forecasted maps of the distribution of species or biodiversity attributes, such as species richness or endemicity (Hortal et al. 2001);

b) Validate the accuracy of this maps through sampling unknown sites; and

c) Repeat survey campaigns to monitor changes in biodiversity through time.

There is a scientific methodology for each historic time. If we want to catch the train of conservation before it leaves the station, perhaps we have to forecast instead of make inventories. This latter part of science is still useful and necessary, but only if there is something to inventory. With directed survey campaigns in the most threatened areas, a reserve network that include species richness, rarity, endemicity, complementarity and many other features should be quickly developed if we want to preserve adequately the Earth's biota.

A research initiative such as this, including information gathered through well-designed surveys and extrapolating this knowledge to the rest of the territory (survey-forecast-validate, or SFV), has been developed successfully by the Australian CSIRO during the last 15 years (Austin 1998). So, jointly with the development of great databases that compile distribution and taxonomic information, research policies must include this issue. Investment must be directed to SFV initiatives rather than to less practical big survey campaigns. Once we assure the conservation of the main components of biodiversity, we could start with the task of obtaining a really exhaustive knowledge of biodiversity.

An optimal spatio-environmental sampling- Jorge M. Lobo & Joaquín Hortal, Museo Nacional de Ciencias Naturales (CSIC).

SUMMARY: A specific procedure to select sampling localities to have a good coverage of biodiversity is proposed, taking into account both environmental and spatial information.

While conservation planning requires good biodiversity data, our knowledge of most living groups is scarce and patchy even in well-known regions, and worse in the rest of the world. So, it is necessary to develop new methodologies that allow rapid assessment of a given group in a given region. Maps of any surrogate of biodiversity can be interpolated from even a few well-known sites, but such places are usually lacking. We therefore propose a new sampling methodology for the design of field surveys to obtain good coverage of the variations in biodiversity patterns in a given region.

Variations in environment and through space cause biodiversity patterns to vary. To cover them well, a rule-step site-allocation procedure that takes into account these two components of variation, together with criteria such as survey costs seems to be useful. A preliminary assessment of the adequacy of site sampling is made. Then a set of complementary sites is selected for further sampling. A p-median analysis is applied to both an environmental distance matrix made up of the main requirements of the studied taxa, weighted in accordance to their different influence on its distribution, and a spatial distance matrix, during the stepwise process to maximize the amount of variation covered by our survey planning.

This rule-set allocation procedure is integrated into a continuous sampling design protocol directed to assure we can sample all biodiversity of a region. This protocol provides for the gathering of both biological and environmental information, an assessment of previously available information, the choice of sampling methods and dates, and a continuous assessment of the success of the survey being carried out.

This protocol improves on gradsect and environmental stratified sampling design methodologies, allocating sampling units throughout the environment of the studied taxa, and across all spatial and environmental gradients in the studied region. Moreover, it takes advantage of previous sampling of the area, when it does exist, minimizing the costs of rapid assessment of the biodiversity in many regions and taxa, useful for conservation policies.

How to monitor biodiversity and communicate results to policy makers - Ben ten Brink, National Institute of Public Health and the Environment.

SUMMARY: The author outlines the importance of user-driven biodiversity indicators and the role of the Natural Capital Index framework in providing information on the state and changes in biodiversity due to human impacts.

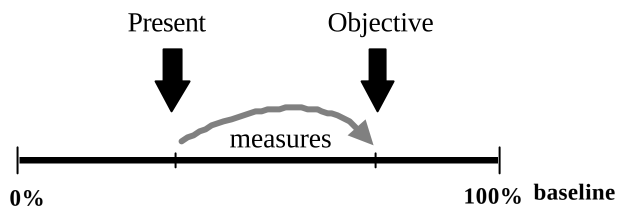
Worldwide, billions of dollars have been spent on monitoring ecosystems and their biodiversity components. Office and library shelves are now piled high with computer discs whose vaste capacity is still too small to contain all the data which, according to many, should be recorded. But despite this plethora of information, we are still not able to tell policy makers and the public whether biodiversity is getting better or worse. It is often said: "we are data-rich and information-poor". How could we provide data in a economical and policy useful way and how could we transform these in simple and policy significant information?

Biodiversity indicators aim to quantify biodiversity data into a policy-significant perspective that is easily understood. They are tools to answer key questions such as:

1. What are the current status and trends in biodiversity
2. Which human influences have the most important impact on biodiversity?
3. How effective are various alternative measures and what do they cost?

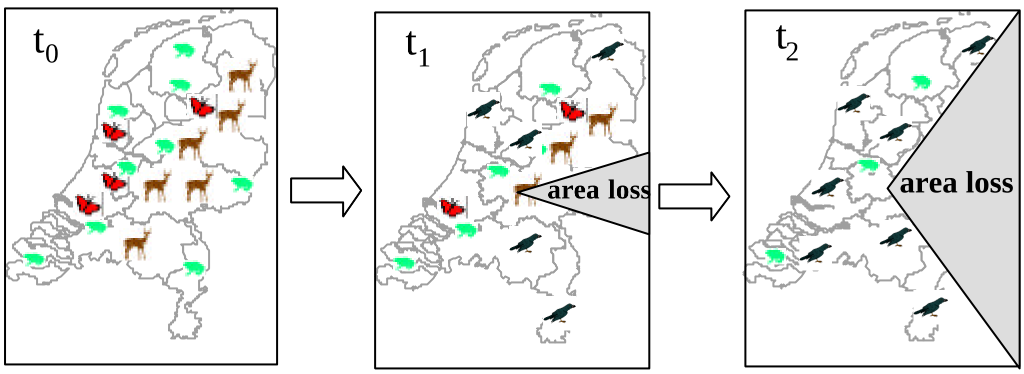
Indicators are necessary in the national reporting and in the CBD's regional and global overviews. They give "teeth" to the Convention, and teeth to national conservation policies, as is common practice in the socio-economic field. Indicators are essential tools for effective ecological policy based on the "feedback mechanism", which requires three basic elements: i) Verifiable targets; ii) Timely and sufficient knowledge about the current and projected state, and testing target achievement and iii) A means for making corrections.

Choose user driven indicators. That means starting at the end: what information does the minister of nature conservation need? Then identify a suitable set of indicators and underlying data needed for that. Indicators link monitoring (current state), research (dose-effect relationships -> future state) and policy-making (targets) on one-single yardstick. Consequently, establishing indicators requires co-operation between policy makers and scientists. Policy makers choose an appropriate baseline and set targets for each indicator, against which scientists establish a monitoring programme, quantify the baseline and current state, and develop pressure-effect relationships (future state). Indicators are a vehicle of communication between policymakers and scientists. Once chosen, they are a programming tool for research, monitoring and policy making.



Biodiversity cannot be assessed without defining a baseline. Baselines are starting points for measuring change from a certain state or date. They are common practice for such areas as medical care, economics, water quality indicators and climate change. The baseline i) provides significance to meaningless data as such; ii) allows aggregation of many data to a high level; iii) makes figures within and between countries comparable, iv) is a fair and common denominator for all countries, being in different stages of economic development, and v) is relevant for all habitat types. How else could we deal with countless statistics on fish stocks, insects, birds, forest, plants and mammals and communicate it with the public?

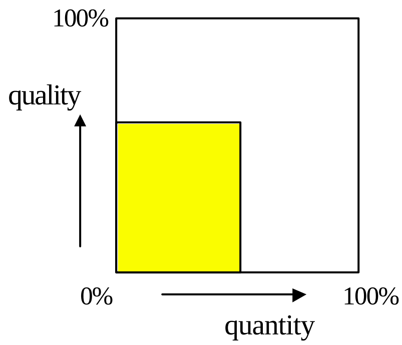
The Natural Capital Index (NCI) framework has been developed under the CBD, given the set of requirements mentioned above. The NCI framework intends to provide information on the state and changes in biodiversity due to human interventions. It measures the process of biodiversity loss, which is characterised by a decrease in the abundance of many species and the increase of a few other species. Habitat loss and loss of quality in the remaining habitat are the main causal factors. Loss of ecosystem quality is the result of over-exploitation, pollution, climate change, fragmentation etc.



It is not possible to measure all biodiversity. Arbitrary choices are inevitable. Criteria for choosing a representative core set of indicators can be found in UNEP (1997) and OECD (2002). Choosing a core set of indicators is the art of measuring as little as possible with the highest policy significance as possible.

The natural capital is defined as the product of the size of the remaining area (ecosystem quantity) and its quality. *NCI= ecosystem quantity (%) x ecosystem quality (%)*

Ecosystem quantity is defined as the size of the ecosystem (% area of country or region). Ecosystem quality is defined as the ratio between the current and the baseline (% of baseline). Ecosystem quality is a function of a number of quality variables such as the abundance of species.



Ecosystem quality is the average of a number of quality variables. Using species abundance as a quality variable has various advantages: they are well-defined, well measurable and often already monitored. Species have specific dose-effect relationships with pressures and are linkable to socio-economic scenarios, they are the building stones of ecosystems, are specific for each country, are policy relevant and easy to communicate to the public. Furthermore, species abundance is a sensitive measure. Nevertheless, other quality variables are also possible, e.g. at the ecosystem or genetic level, but these are less advantageous. If state variables are lacking, pressures indicators could be used as a substitute (the higher the pressure, the lower the chance on high quality).

NCI can independently be established by every country and still provide comparable information, meeting the set of requirements mentioned above. The results can be presented in one single figure at the national level (or more detailed), providing significant information on the state of biodiversity in terms of average abundance of species compared with the natural state, or for agricultural areas compared with the average abundance of species in traditional agricultural ecosystems.

Monitoring of complex systems for policy purposes- Erling Berge, Norwegian University of Science and Technology

SUMMARY: Eco-systems are complex. Political systems are complex. Monitoring ecosystems for policy purposes becomes doubly complex. To design effective policies one needs a causal theory linking particular designs of policy instruments to outcomes of state variables of the eco-system.

If we look beyond the simple and straightforward cases of gross misconduct (pollution, wanton destruction, etc.) and protected areas where humans can be kept out, and take on the task of governing the ecosystems where humans live and work, how can we know which policy change will work towards the goals set? Is it possible to deduce effective policy instruments by means of common sense from changes in biodiversity indicators? I think not. Shall we develop policy by the old and repeated method of trials and errors? Most current working policies have been developed this way. But do we have time to wait for the lucky policy decision?

I have attached a figure (go to www.gencat.es/mediamb/bioplatform/figure1.htm) I use when talking about the need for a comprehensive cross-disciplinary approach to bio-diversity policy. A basic point is that the relative strengths of causal factors responsible for changes in biodiversity indicators make a real difference in the choice of policy instruments. Another important point is that because of correlations and interactions, the relative strengths of the various causal factors cannot be measured independently.

My conclusion is that without developing a better theory for the impacts and interactions between society and eco-system, the fate of bio-diversity indicators will be about the same as the fate of social indicators: biologists will learn a lot about the eco-system just as social scientists learned a lot about society from trying to develop social indicators, but you will be just as sorely frustrated in terms of policy impacts. Politicians will continue having to relay on the old trial-error-correction method of policy development. The lack of "will" is usually a sign of inadequate knowledge or constraints put on the political system to keep it straight.

Reflections on the third session of the e-conference: developments in monitoring biodiversity- Allan Watt (e-conference chair)

SUMMARY: In the third session, major themes were the value of baseline information, the development of standardised protocols and sampling strategies, the identification of "indicator taxa", the use of structural and process (e.g. decomposition) indicators, the need to critically evaluate proposed indicators, the need for "early warning" indicators, the use of volunteers in monitoring programmes and the problem of assessing the effectiveness of policy instruments from simple indicators.

A major issue discussed during the third session of the e-conference was the use of baseline information. Richard Bradshaw and colleagues argued for the incorporation of long-term data sets into monitoring programmes where possible (see also Jari Niemelä's contribution earlier) and the value of existing knowledge of species was argued by Thomas Walter & colleagues, and Rasmus Ejrnæs & Erik Aude. Ben ten Brink's contribution underlines the importance of baseline information.

Another major issue raised was the development of indicators. Alan Feest and Josef Settele gave some examples of the development of protocols for the assessment of diversity of birds, butterflies, fungi and other taxa and Norbert Sauberer outlined recent research in Austria with promising results on the use of single or few taxa in estimating biodiversity. Rainer Waldhart outlined some recent research on the development of reliable sampling strategies for biodiversity assessment. Several contributors focussed on the assessment of forest biodiversity. Many scientists have suggested that forest biodiversity can best be assessed by a combination of compositional (species), structural and process indicators. It was interesting, therefore, that Paulo Sousa and P.V. Morais argued that we should include the assessment of the decomposition process when considering soil biodiversity and Etienne Branquart argued for the need to critically test proposed indicators such as structural indicators in forests.

Several contributors identified areas that require further development. Val Kapos argued that, in monitoring biodiversity, we need to choose parameters "for which change can be detected before it becomes irreversible". The issue of volunteers was raised again. Robert Kenward discussed the limitations of their usefulness and raised some key questions about how they might be integrated in complex monitoring programmes. And perhaps the most telling contribution in terms of demonstrating that more research is needed was by Erling Berge who wrote "Is it possible to deduce effective policy instruments… from changes in biodiversity indicators? I think not." and argued that we need a "better theory for the impacts and interactions between society and ecosystem[s]".

Many of these (and other) contributions are relevant to the next session, starting today, and introduced in a separate contribution to the e-conference.

Session and title of contribution	Contributors

Session 4. The development of a core programme of biodiversity monitoring across Europe, priorities for monitoring and major gaps.

Introduction to the fourth session	Allan Watt, Chair
Weaknesses of existing monitoring programmes and priorities for research	Rainer Muessner
An integrative approach to monitoring European habitats and biodiversity	L. Firbank & S. Petit
Selection of indicators of biodiversity	Robin Moritz
Monitoring biodiversity in urban environments	Jari Niemelä
Integrated monitoring of dynamics of agricultural and "natural" networks	Marcello Buiatti
Monitoring biodiversity in the soil	Endre Laczko
The need for genetic diversity monitoring	Fiorella Villani
Monitoring genetic biodiversity	R. Smulders & B. Vosman
Out of sight, out of mind- microbial diversity	Annick Wilmotte
Biodiversity in the Arctic: Auditing the Auk!	B. Heal & S. Baldursson
Monitoring biodiversity in the Mediterranean region	Emilia Poli

Introduction to the fourth session of the e-conference: development of a core programme of biodiversity monitoring across Europe, priorities for monitoring and major gaps - Allan Watt (e-conference chair)

SUMMARY: The aim of this session of the e-conference is to consider the development of a core programme of biodiversity monitoring across Europe, define the priorities for monitoring and identify major gaps in monitoring.

Over the last ten days, we have discussed many reasons for monitoring biodiversity. And, despite the disappointing amount of monitoring that is being done, we have shown that governments, intergovernmental organisations, NGOs, amateur naturalists and scientists are working hard to rectify the situation. Indeed, it has been argued that enough monitoring is being done – it just needs to be better coordinated.

The first aim of this session of the e-conference is, therefore, to consider the development of a core programme of biodiversity monitoring across Europe. As such, we are not ignoring the monitoring of biodiversity for local or national purposes. Nor do I think we need to argue any further about whether biodiversity monitoring across Europe is desirable. We do, however, have to acknowledge that monitoring at the European scale requires national, and ultimately local monitoring of biodiversity. Thus issues such as scale (see e.g. contributions by Rose; Bradshaw; van der Bijl & Iversen), the involvement of volunteers (e.g. Julliard & Jiguet; Kenward), the need for standarised protocols (e.g. Feest; Sousa & Morais) and the duplication of effort become very important.

Do we need a core programme of biodiversity monitoring across Europe? And, if so, should it involve collection of data through standardised protocols? Or should it involve the coordination of existing monitoring programmes? If existing monitoring programmes are adequate, can initiatives such as Bio-MIN (Richard & Condé) coordinate them? Would the data tell us what we wanted to know?

Personally, I would like to see further development of standardised methods of data collection. It is therefore very encouraging to see initiatives such as those described by Delbaere, Larsson and Gregory & Vorisek. But I also feel that we need data on trends in biodiversity urgently and that existing programmes, despite the fact that they may vary from country to country, can tell us a lot. In this regard, Ben ten Brink describes a powerful approach for integrating data and quantifying trends in biodiversity.

The other aims of this session are to define priorities for monitoring and identify major gaps in monitoring. In addressing these issues, it is important to remember the major reasons for monitoring biodiversity – assessing trends in biodiversity (and the possible need to take (further) action); measuring the success of actions intended to conserve biodiversity; measuring the impact of national and international policies related to agriculture, energy, transport etc; quantifying the impact of the many anthropogenic influences on biodiversity. Could the integration of information from existing monitoring programmes satisfy these needs? Could a core programme with standardised protocols do so? We must also remember that there are limited resources for monitoring.

What, then are our priorities for a core programme of monitoring? Should we focus on the integration of data from existing programmes or develop a core programme with standardised protocols? What elements of biodiversity should we focus our attention on? Are there major gaps that should be addressed and how should we address them? What should we monitor to satisfy the needs outlined above?

Over the next two days, keynote contributors will consider the concept of a core programme, and discuss the environments and elements of biodiversity that are neglected. Please write to tell us about your views on a core programme, priorities for monitoring, and the environments and elements of biodiversity not covered adequately by existing monitoring programmes.

Weaknesses of existing monitoring programmes and priorities for research - Rainer Muessner, Centre for Marine and Environmental Research.

SUMMARY: In spite of several developments in the research of indicators and monitoring programmes in the last years, the overall effectiveness measured in terms of political relevance is rather poor. Underlying reasons are the missing link of scientific based monitoring to political decision making, as well as gaps in methodology of indicator development and monitoring programmes.

One major weakness of monitoring programmes in general is the fact that the link between information and policy is not always clearly defined (Wascher 2000). One of the reasons why monitoring programmes of biodiversity are not very popular amongst policy makers and other stakeholders (beside the reason that they are generally very expensive) is due to the fact that these groups are left alone to interpret the results and face the possible consequences of the results. Existing guidance on interpreting the data and conclusions is fairly generic.

What are therefore urgently needed are thresholds for specific indicators of biodiversity, although scientists traditionally refuse to set them. The reasons are that setting thresholds can't be done on a scientific basis only; it is a very normative procedure that should be done in close cooperation with scientists and end users. Linking data with thresholds makes the difference between presenting results and evaluation. The fact that the number of species in a specific area is declining is of no direct policy relevance. Only the interpretation in the face of societal objectives (thresholds) leads to consequences and action.

To set thresholds for biodiversity is even more difficult than in ecotoxicology, but it should be possible if using appropriate tolerance limits and it is important to improve the effectiveness of the monitoring programmes.

On the subject of bioindicators, most of them (probably more than 80%) characterize specific components of biodiversity (i.e. species, habitats) or structural features representing it (habitat structure, land use pattern). Despite a lot of research done in this area over the last years, there is still a lack of balance between these groups and the functional aspects of biodiversity (Framstad 2000, Plachter 1995), which is partly due to their complexity (Riley 2001) and the difficulties in addressing them properly. Community interactions, ecosystem processes and functional criteria like disturbances are very difficult to monitor or to be represented by indicators. To enhance the ecosystem approach in conservation highlighted by the COP (Decision V/6) and others (Korn et al. 1998), the above mentioned group of indicators is of specific importance, and should therefore be represented in a core set of indicators accordingly.

The use of indicators, instead of measuring directly the objects of interest, has several advantages, which have already been discussed in detail and are well known, but one of the big disadvantages in the use of indicators is a certain level of uncertainty of the results, which is specific for each indicator. For the end users of monitoring programmes, the degree of reliability of the results or trends indicated is one of the major questions. On one hand scientists should make it clear that indicators are not representing the reality, but during discussion of the results they should accept this fact as set. A common agreement about the level of uncertainty that is acceptable (quality of indicator) should be elaborated in the scientific community.

Besides what is said above, at the current state-of-the-art we should not focus too much on developing new monitoring programmes or indicators, but rather test the weaknesses and strength of existing ones, like the DPSR from the OECD, in field studies to improve their quality. The possibilities for harmonisation of the European monitoring approaches should be prioritised on the agenda. An agreement on a core programme of biodiversity indicators is an important step to create consistent data from the whole European Community to detect some general trends and threats in Biodiversity. Besides that, the very important monitoring on national and regional level has still its eligibility and should incorporate the national peculiarities.

An integrative approach to monitoring European habitats and biodiversity- Sandrine Petit and Les Firbank, Centre For Ecology and Hydrology.

SUMMARY: The strengths and weaknesses of current monitoring techniques used in Europe are split into three main categories and described. The authors then outline the main challenges facing monitoring schemes including the successful integration of data collected at different spatial scales, the need to monitor areas with high external pressures and the need to report changes in biodiversity in the context of changes in society and policy.

Assessing biodiversity trends at the scale of Europe is not an easy task. Current monitoring exercises attempting to do so can be split into three main categories.

The first approach consists of assessing the extent of particular land cover types at very broad scales using remote sensing [1]. The main challenge here is the translation of broad land cover categories into ecologically relevant units.

The second approach is based on landscape ecological theory and consists of describing the spatial organisation of habitats from air photographs [2] or satellite images [3] using landscape indicators such as fragmentation indices or heterogeneity. However, while such indicators are relevant for a range of organisms at specific spatial scales, empirical knowledge on their relationships with overall species diversity is still sparse.

The last category encompasses all ground-survey monitoring programmes and reports on the quality of habitats [4,5]. Here, because of the sheer cost of direct species monitoring, programmes are frequently restricted to small geographical areas and to small sets of species.

The first challenge for setting up an effective European biodiversity monitoring system is the successful integration of information collected at these different spatial scales. This can only be achieved by using a rigorous and nested stratification of Europe. A broader level would allow splitting Europe into main ecological regions in which the extent of main land cover categories could be quantified by remote sensing [6]. A second step would aim at translating, within each region, the composition of specific land cover categories into habitat types using a standard classification such as EUNIS. This can be achieved by integrating existing national databases on habitats [7] and/or by conducting a stratified random sampling of a land cover type using a finer stratification. The sample areas would be assessed in terms of spatial organisation and species distribution using existing databases or by collecting new data.

The second challenge is to increase the efficiency of biodiversity monitoring. The rationale behind monitoring is the detection of potential responses to a number of environmental pressures such as climate change, pollution, land use change and environmental policies. The current intensity of such pressures is usually known and in some cases, like pollution, the future levels of emissions can be predicted. An efficient way to monitor biodiversity in Europe would be to target those areas and habitats where pressures are known to be high, by concentrating survey sites and/or increasing the survey frequency in such areas. There also needs to be more general surveillance across European habitats, in order to provide contextual information on biodiversity change, and also to detect unanticipated biodiversity changes.

Existing frameworks have been developed to translate the intensity of environmental pressures into expected levels of impacts on habitats for ecological of regions of Europe [8], although only semi-quantitatively. It is therefore becoming possible to compare observed changes in biodiversity with those expected on the basis of different scenarios for environmental pressures. Therefore, we would be able to report changes in biodiversity in the context of changes in society and policy, making them much easier to interpret, and the contribution that people can make to biodiversity conservation much more transparent.

Selection of indicators of biodiversity- Robin Moritz, Martin-Luther-Universität Halle.

SUMMARY: Gaps in monitoring result from using the wrong species for monitoring. Often rare red list species are considered for monitoring. In most cases these are not suitable indicators for evaluating the success of biodiversity conservation measures.

Monitoring is clearly a way to obtain measures of biodiversity and therefore an important tool in biodiversity conservation. It is a particular efficient control tool to see how and if conservation measures have been effective. However as soon as we want to make predictions from monitoring data I am afraid I do not see the potential of the technique. Too often will accidental correlations and stochastic processes mislead us. In complex systems (such as eco-systems) it will be extremely difficult (and in most cases simply impossible) to extract causal relationships among species abundance and other biotic and abiotic parameters. The only way to overcome this problem is to test monitoring tools (species) for their feasibility to address relevant questions (as already indicated by Jari Niemelä).

Just observing numbers of “important” species often yields only little information if any. Observing important “red list” species, as suggested in few contributions, may be particularly unhelpful, because these species are typically rare. I find it very difficult to understand why these rare species can be useful tools to help us understand conservation of biodiversity. If a species is rare, it is primarily not that frequent, and any changes in monitored population density and abundance may be more (or entirely) due to stochastic sampling processes. By monitoring these gaps we will gain very little in both understanding ecosystem functioning and biodiversity conservation.

From what I have learned so far (not only in this e-conference) I can see that the field is often divided in this respect: There are those that monitor specific questions and have defined goals in mind (see for example the MacMan project in Josef Settele’s contribution among many others). But then there are also those who monitor specific species, because it is important to monitor biodiversity of important species. The biggest gap or deficiency in monitoring is in my view the arm waving on what is an important species. Certainly “nonimportant” species will often by far exceed the impact of most “important” species on ecosystem functioning (and we have heard about this by Annick Wilmotte on absolutely "unimportant" microbes). A monitoring species does not need to be “important”, it just needs to be a good indicator.

Monitoring biodiversity in urban environments - Jari Niemelä, University of Helsinki.

SUMMARY: Monitoring biodiversity in urban areas is vital for providing understanding about the effects of human actions in an environment overwhelmed by human-caused pressures on biodiversity. Methods and approaches to be used in urban biodiversity monitoring can be the same as used elsewhere, but the strong human presence needs to be incorporated into monitoring programmes.

Urban green areas and their associated biodiversity are essential for urban residents, for recreational purposes… Furthermore, urban green areas have an ecological value of their own (intrinsic value). Thanks to the richness of habitat types ranging from strongly human-modified to near-natural, urban landscapes often have higher species diversity than their rural surroundings even including rare and threatened species. For instance, Eversham et al. (1996) reported that manmade habitats (such as roadsides) support as many as one third of the rare carabid species in Britain.

But urbanisation can also be a threat to biodiversity. For example, nearly 200 plant species have gone extinct in Munich (Duhme and Pauleit, 2000). To counteract such adverse effects of urbanisation on biodiversity, and to ensure that urban expansion proceeds sustainably, ecological knowledge needs to be considered in urban planning. Furthermore, the effects of city planning, and the increasing pressures (e.g. increased recreational use of urban green areas) on urban biodiversity need to be monitored in order to provide a basis for corrective measures.

In urban areas, there is already a considerable amount of environmental monitoring taking place, such as levels of air pollution. What is lacking is monitoring of changes in biodiversity. Criteria and indicators for monitoring urban biodiversity are basically the same as for monitoring rural landscapes or wilderness. Monitoring may focus on various ecological scales (e.g. species or ecosystems) and indicators must be developed accordingly. The difference, however, between rural and urban biodiversity monitoring is the overwhelming effect of humans on urban biodiversity, and the rapid changes that take place in urban environments. Thus, monitoring systems for urban biodiversity should consider the human presence and the rapid changes in biodiversity. Indicators of human-caused disturbance could, for instance, be the numbers of visitors in green areas, or degree of trampling damage in vegetation and soil. The development of such indicators and criteria is an important research task.

URGE (Development of Urban Green Spaces to Improve the Quality of Life in Cities and Urban Regions) is a European Union funded research project developing an integrated tool kit of criteria and indicators to be used by urban planners in order to assess ecological, social and economic sustainability of urban green areas. Focus is on two levels: whole city scale and single urban green areas. Suggested ecological criteria on the city scale include, among others, (1) fragmentation of urban green (indicators: size, shape, isolation, connectivity), (2) level of nature protection (indicator: proportion of protected urban green), and (3) biodiversity, both species diversity and habitat diversity (indicators: diversity of breeding birds and vascular plants, biotope diversity). On the site scale the suggested criteria and indicators include, among others: (1) fragmentation (can be used to assess single sites as well), (2) biodiversity (species diversity and habitat diversity) (indicators: diversity of birds, vascular plants, carabid beetles, butterflies, and biotope diversity). Here, the first two taxa form the minimum set of indicators, while carabids and butterflies can be monitored if resources allow, and (3) naturalness (indicator: degree of disturbance/wear, exotic and rare species). For details see http://www.urge-project.org/reports.htm.

These criteria and indicators have been developed in close collaboration with several major European cities, and they will be tested by these cities. One of the prerequisites from the cities' side was that the criteria and indicators should be affordable to monitor. However, there is a trade-off between useful indicators reflecting changes in urban biodiversity and cost. Finding inexpensive yet effective indicators and criteria is not easy, but we are trying our very best.

Integrated monitoring of the biodiversity dynamics of communicating agricultural and "natural" networks is needed for Agenda 21 practices implementation- Marcello Buiatti, University of Firenze.

SUMMARY: Agenda 21 aims to tackle environmental problems through integrated monitoring in order to achieve overall knowledge of the dynamics involved in particular ecosystems. In the case of agro-ecosystems, specific techniques need to be developed to monitor the complexities of agricultural and ecological systems. Some examples include the inter and intra specific analysis of biodiversity, network analysis and environmental accountancy.

The process suggested by Agenda 21 to tackle environmental problems involves integrated monitoring of chosen homogeneous areas both from an economic and environmental point of view. The aim of the process is to achieve a good knowledge of the dynamics of the area allowing prediction of local environmental loads, economic balances and planning of consequent management choices. A large part of the European territory has been moulded for centuries in a way that often makes the word "natural" almost meaningless. Cultivated land therefore should not only be considered as a cause of habitat fragmentation but as an agro-ecosystem communicating with the surrounding area. Communication dynamics will strongly depend on the agricultural model chosen in terms of energy and chemical impacts, agricultural practices but also on the choice of plant cultivars and animal breeds used. Specific techniques need to be developed to monitor these dynamics.

The following activities are only some examples of what could be done, and should include the collaboration of ecologists, geneticists, microbiologists, botanists, zoologists, modelling experts, agronomists and economists.

1) Inter and intra specific analysis of biodiversity

Given the assumption that the species and cultivars used play a significant role in the dynamics of the agro-ecosystem in terms of management, influences on the microbial, plant and animal components of the soil, water consumption etc. and may contribute to the inter and intra-specific gene flow, diversity should be monitored. At the intra-specific level, up to date molecular tools, including so called "neutral" and "functional" markers should be used. Functional markers in this case should be polymorphic sequences located in genes known to affect fitness-related characters.

2) Network analysis

Patterns of connections between components of living systems are not random and their structure and dynamics may be critical for the homeostatic power of the system. It is therefore useful to analyse the distribution of the number of links between components (demes, or local breeding populations/avatars, local economic populations) within and between the agricultural and natural subsystems of the area studied. Predictive modelling can be further implemented through the development of synaptic functions for the connections, particularly useful for the evaluation of gene flow between organisms living in the two subsystems. Attention should be given, whenever possible, to a comparison between gene and transgene flow in the presence of GMOs. The study of the effect of "invasive" genes, also through the use of molecular markers, should be completed by the analysis of the effect of transferred genes on the fitness of the receiving organisms.

3) Environmental accountancy

All the analyses should obviously be carried out on different systems particularly from the point of view of the agricultural practices. Monitoring should be done on general environmental impact levels, physical and biological parameters within the subsystems, as well as matter, organism and energy flow between them. This could lead to improved integrated indicators of environmental impact to be used on all the single farms of a chosen area in order to provide comparable economic parameters.

Monitoring biodiversity in the soil – ensuring rooting of above ground biodiversity-

Endre Laczko, Botanisches Institut Uni Basel.

SUMMARY: Soil biodiversity is a key factor of terrestrial biodiversity and has to be monitored if sustainability of natural or managed grasslands and forests is to be reached. It is suggested that we should start large scale monitoring of soil biodiversity with a pragmatic and user oriented approach assessing biochemical or genetic diversity of soil micro-organisms along with activity and resilience measures of soil micro organisms, assessment of mycorrhizal diversity and assessment of one or more traits of the plant coverage (productivity, species diversity, plant health). Such an approach should be underpinned with specific research projects investigating basic questions concerning soil biodiversity and the methodology of its assessment.

Life below and above ground is without any doubt interdependent. Yet, recent research provides insights beyond the classical ecological view of soils as recycling site of organic debris and plant mineral pool. Evidence is at hand that soil biodiversity is a factor in regulating how terrestrial ecosystems function:

- Mycorrhizal fungi connect individuals of same or different plant species, enabling direct interactions between the members of a grassland or forest community (see the reviews of Wiemken and Boller 2002, Copley 2000).
- Consequently, "mycorrhizal fungal diversity determines plant biodiversity, ecosystem variability and productivity" (van der Heijden et al. 1998) and plants investigate huge amounts of carbohydrates into the below ground network of roots and symbiotic fungi (Högberg et al. 2001).
- Interactions with pathogenic bacteria are likely to be important for plant rarity and invasiveness in communities (Klironomos 2002).
- Symbiotic and saprophytic fungi as well as bacteria are grazed by a large variety of protozoa and invertebrates causing much the same complex interactions and effects as above ground animals (e.g. the contributions of Coleman and Clarholm in Ritz et al 1994).

On the other hand it is convincingly demonstrated that soil biodiversity and the activity of soil micro-organisms is affected by elevated carbon dioxide concentrations (Wiemken et al. 2001), by heavy metal pollution (Reber 1992, Laczko et al. 1997) and by land use practices (Ovreas and Torsvik 1998, Zeller et al. 2001). The key factor-character and obvious vulnerability of various soil microbial groups contrasts sharply with the almost complete lack of data and monitoring programs informing us about the nature, the natural spatial and temporal variability and state of soil biodiversity beyond the local scale of particular investigations. In this situation one can safely claim that large scale biodiversity monitoring programs that include not only the assessment of soil quality and gross soil biological activities (e.g. respiration, nitrification), but also the assessment of any soil biodiversity related parameter will provide more convincing and useful data sets.

Although established methodologies, including sufficiently well defined classification concepts (e.g. Mayden 1997, Rossello-Mora and Amann 2001, Schloter et al. 2000) for all soil organisms exist, soil biodiversity cannot be monitored in its entity. Limitations are due to the complexity of the soil biota, the time consuming procedures and the non-cultivability of many ecologically relevant bacterial and fungal species (e.g. Ovreas and Torsvik 1998). Nevertheless, out of the panoply of new methods analysing the genomic information, the biochemical composition or biochemical processes of the soil community, several might be useful to monitor the presence-absence as well as abundance of more or less specific information units, marker molecules and enzymatic activities which provide indirect information about species diversity as well as the function and structure of the community (e.g. Rochelle 2001).

Monitoring soil biodiversity has to include the monitoring of key processes and responses of the soil biota as well as of the above ground (plant) community. Therefore priority should not be on the deep description of one or another group of soil organisms, plants or animals but rather on co-tracking the functioning and effects of the (supposed) key interactions. This will enable the most indirect and incomplete measures of soil biodiversity and terrestrial biodiversity to be interpretable in terms of defined and communicable objectives as well as sound decision making, controlling and hypothesis testing.

This or similar claims were recently presented by plant, animal and microbial ecologists after reviewing the state of the art of soil biology and ecology (e.g. Ohtonen et al. 1997, Ogram 2000, Wolters 1998). In practical terms, say in view of developing a realistic large-scale monitoring program, the following core procedures and priorities might be followed:

- Assessment of the biochemical (phenotype) or genetic diversity of the whole community and the main groups of soil micro-organisms (bacteria, fungi, protozoa) by analysing the community lipiome, proteome or genome. Selection of one of the methods depends on the goals and needs careful evaluation. No general financial advantage is related to one or the other cluster of methods.
- Assessment of the mineralization rate and the resilience of the community composition upon a pulsed stimulation (e.g. by the amendment of glucose) of the bacteria by analysing carbon dioxide evolution and FAME profiles in a standardized laboratory experiment.
- Assessment of the mycorrhizal diversity and functionality by simple laboratory trap cultures (grasslands) or field observation of fruiting bodies and tree roots (forests).
- Assessment of the plant productivity, diversity or health (or all together). The sampling design in time and space should be harmonized for all assessments and adopted toward the objectives framing the monitoring program and declared by the users of the monitoring data.

The above selection is appropriate for all habitats and scales and can be focused on the subspecies, species or supra species levels. This means that data from a wide range of temporal, spatial and hierarchical levels are comparable and may be evaluated within the same frame settings. Ideally such a pragmatic monitoring program should be tied with specific research projects, which focus on open methodological and ecological questions like:

- What is the relationship between biochemical and genetic diversity data and diversity of species as well as functionality of the assessed community?
- Which are the most suitable methods for the assessment of the diversity of distinct groups of soil organisms and how can these set up in speedy and cost effective ways?
- Are there redundant soil species and how can redundancy in soil biodiversity be evaluated?

Although these questions have priority, other important questions will also surely be raised during the preparation and operation of any given monitoring program.

The need for genetic diversity monitoring- Fiorella Villani, Instituto Biologia Agroambientale e Forestale.

SUMMARY: Genetic diversity is still under-represented in biodiversity monitoring programmes. The goals of monitoring genetic diversity are ultimately to guarantee a species long-term gene conservation, but there are significant gaps in this area such as the need for indicators capable of monitoring intra-specific genetic and adaptive diversity, hotspot priorities, and “meta indices” which could link specific indicators of different biodiversity levels.

Among the three biodiversity levels, intra-specific genetic diversity is a key requirement for both short-term adaptation to environmental change and long-term impact on species and communities. Over the past decades, we have witnessed a huge scientific venture looking to assess spatial and temporal intra- and inter-specific genetic variability by means of an exponentially increasing number of newly developed neutral molecular markers. On the other hand, most of the Intergovernmental Bodies (FAO, OECD, WRI, CSD) dealing with biodiversity conservation, concentrate their efforts into the definition of criteria and indicators to be transferred from scientists to stakeholder and policy-makers. To combine scientific findings and their applicability has so far been a difficult task for people involved in genetic diversity conservation.

Since the goal of monitoring genetic diversity is to evaluate the adaptive potential of a species, numerous gaps can be identified within the following three areas:

1. Identification of indicators suitable for an appropriate and comprehensive monitoring of intra-specific genetic and adaptive diversity.

The major unresolved issue is the relationship between molecular measures of genetic diversity (neutral markers) and the estimate of additive variance for quantitative traits of adaptive significance: the former being rather independently used to infer either the past (phylogeny) or the present (population genetics), the latter being used to infer on the future (evolutionary and quantitative genetics) of a species.

It is important to note that there is a great ongoing dispute over which of these three research fields has conservation priorities. A possible solution to this dispute includes recognition that conservation is about protecting dynamic processes (life) and not just a "steady state". Conservation can only have a real meaning when looked at from a temporal perspective. From this consideration, the following major gaps and needs can be highlighted:

- Despite the rapidly developing information technologies, organisation and standardisation of the data are still lacking and are urgently needed to facilitate the communication flow among scientists.
- The identification of indicators to compare and/or integrate information derived by systematics, ecology and evolutionary biology, using neutral molecular markers and quantitative traits are also urgently needed.
- Better definition of intra-specific evolutionary units and minimum effective population size would greatly contribute to select the most appropriate conservation and management criteria.

2. Identification of species and geographic regions ("hotspots") to be prioritised for genetic diversity evaluation.

Areas of particular biological value can be selected, such as:

- Areas of origin of the species;
- "Hotspots" for number of species and/or for endangered species;
- Transition/hybrid zones as new sources of genetic variation;
- Areas at particular risk due to climatic change (i.e. desertification, coastal erosion) or over-urbanisation, factors which, increasing the habitat fragmentation, are likely to induce a dramatic decrease of intra-specific gene flow, increase of genetic drift and consequently increase the probability of species extinction.

Focusing genetic studies on these areas will mean more *in situ* rather than *ex situ* conservation and will have to overcome policy boundaries since the areas of greater diversity are often located in countries outside Europe.

3. Identification of appropriate and measurable links with indicators for species and habitat biodiversity levels;

As genetic diversity underlie population, species and habitat evolutionary processes, it would be appropriate to create meta-data and develop "meta indices" which could link specific indicators of different biodiversity levels.

In conclusion, the ultimate goal of genetic diversity monitoring is the application of appropriate management practices by the end-users. Improved communication between scientists, stakeholders and policy-makers can focus and overcome conflicts.

Monitoring genetic biodiversity- René Smulders & Ben Vosman, Plant Research International.

SUMMARY: Monitoring of genetic diversity among individuals in populations is an integral part of monitoring biodiversity. The authors examine the two current monitoring approaches: measuring genetic data to estimate population processes, and monitoring genetic biodiversity to investigate evolutionary potential. Finally, the authors list a number of goals to be achieved for successful genetic monitoring.

Biodiversity exists at the levels of the ecosystem, the species and the genome. Therefore, the monitoring of genetic diversity among individuals in populations is an integral part of monitoring biodiversity. Tools for comparing the amount of genetic diversity are available in the form of molecular marker systems, while tools for measuring functional diversity are in the process of development. Two monitoring approaches exist, each useful for different purposes: measuring genetic data to estimate population processes, and monitoring genetic biodiversity to investigate evolutionary potential. In the first approach, genetic diversity data are produced as a versatile tool to determine population parameters and processes essential for species survival. One such process is the amount of migration and connectivity between subpopulations. Migration is essential to avoid inbreeding in small populations and to allow recolonisation of empty habitat patches in a mosaic landscape. It is even more important now that human activity has resulted in highly fragmented landscapes. Another important parameter is the effective population size, which may be quite different from the census population size.

The second approach is to monitor genetic diversity as essential raw material for evolution: conserving the evolutionary potential. For this, several populations may be compared for a given species, and those with the highest (neutral) diversity are deemed to have the highest potential. Functional biodiversity may also be assessed directly, in the form of differences in alleles and genes in those areas where natural selection has increased the frequency of the allele sufficiently.

The research that has been carried out so far has focussed on species of agronomical importance (mammals, fishes, and agricultural crops) and on a small number of endangered species that receive much attention. Here the diversity across the distribution area of the species is being mapped. It is an impossible task to monitor or protect all genetic diversity on this planet. Fortunately, this is not necessary. In the history of life on earth, much genetic diversity has been produced and was subsequently lost. Therefore, we have to maintain sufficient genetic variation in genes and genotypes to allow selection to take place, so that species may adapt to a changing environment. Genetic biodiversity exists in individuals in populations that are in interaction with the physical and biological environment, and it will therefore be necessary to conserve habitats that are sufficiently diverse to provide different selection pressures.

We propose that major goals for the near future are:

- To generate and test hypotheses regarding the extent and substructuring of genetic diversity in view of life history parameters, environmental parameters, dispersal capacity, and population history (including phylogeography)
- To determine whether there exists a relationship between species diversity in an area and genetic diversity of the species in that area (can we predict genetic biodiversity hotspots; do they coincide with refugia?)
- To monitor genetic biodiversity in species groups that diverged a long time ago, and to boost the number of unrelated alleles or the number of genes that only occur in a small set of species. The species groups will be functionally different and will include those in which morphological characterization is difficult or non-existent.
- To systematically look for genetic diversity involved in environmental stress tolerance, in order to predict the effects of global change.

Out of sight, out of mind – microbial diversity- Annick Wilmotte, Centre d'ingénierie des proteines.

SUMMARY: Microbial diversity offers a wealth of monitoring tools and indicators that are neglected.

In this contribution, the term 'micro-organisms' includes prokaryotes and eukaryotes of small size that generally must be visualised using a microscope. However, their presence can sometimes be recognized with the naked eye when they form macroscopic colonies, scum at the surface of lakes, slimy biofilms on stones, crusts on soils, etc.

Everybody agrees that microorganisms drive the functioning of our planet, and that they represent most of the genotypic diversity present on Earth. We have only started to explore their biodiversity, as molecular techniques have revealed that only 1-5% of them had been cultivated. We still know too little about their ecology.

In the case of microalgae, "we do not know, for example, which algae should be present in a water body, which are extinct or which invaded the biotope recently. We know neither the full range of the original algal biodiversity nor the changes to be expected in the future" (Mollenhauer et al., 1999). In spite of these problems, their potential as monitoring tools and indicators must not be neglected. As stated by the American Society for Microbiology (2000), "microbial diversity measurement can be a sensitive and suitable index of environmental status and trends". Mollenhauer et al. (1999) also warn that cyanobacteria and algae may be endangered, mainly due to human influences. In general, the risk of microbial taxa's extinction is problematic to assess.

Monitoring based on the phenotypic diversity of microalgae:

The microalgae whose potential as ecological indicator has been most recognized are the diatoms. For example, a Trophic Diatom Index was designed to monitor eutrophication in rivers (Kelly & Whitton, 1995, Kelly, 1998). Mollenhauer et al. (1999) showed that macroscopic species of the genus *Nostoc* (cyanobacteria, blue-green algae) could be used for monitoring and are "sensitive indicators of alteration of aquatic and some terrestrial habitats". To come to this conclusion, they used ancient material from herbaria, literature data, and new field surveys.

The main obstacles to use microalgae for monitoring of environmental quality are the taxonomic problems, lack of ecological data, and shortage of trained taxonomists. Still, very interesting efforts are being made. On the basis of available literature data and with the help of several specialists, a review was recently published by the Bavarian Agency for Water Research concerning the tropic indexes of benthic diatoms, cyanobacteria, other microalgae, mosses, ferns and higher plants (Bayerisches Landesamt fûr Wasserwirtschaft, 1998).

Monitoring based on the genotypic diversity of microorganisms:

The taxonomic problems encountered to identify most of the microorganisms have boosted the use of genotypic markers (like Small Subunit rDNA sequences) to study their taxonomy and evolution. This has caused an exponential accumulation of these 'signature' sequences in the databases. In addition, the databases contain a huge number of sequences of functional genes that will also increase as more sequences of Microbial Genomes (92 in August 2002) are being completed. All these sequences can now be used for environmental diagnostics using High Throughput Screening methods like the DNA microarrays. For example, the monitoring of large numbers of lakes could be carried out by the hybridisation of the extracted DNA (or RNA) from several litres of water with DNA microarrays containing thousands of probes for relevant microorganisms or functional genes. The patterns of spots observed, where hybridisation has taken place, could characterize certain ecological states, and shifts in the pattern would indicate quality changes. Though such comprehensive monitoring seems costly, mass production of DNA chips would certainly decrease the costs. Such an approach id developed in the EC project MIDI-CHIP (http://www.itba.mi.cnr.it/midi-chip). As stated by Crozier (1997), "Complete enumeration of biotas in terms of phylogeny is desirable to avoid uncertainties in the use of indicator groups, and this is now achievable for bacteria".

Biodiversity monitoring in the Arctic: Auditing the Auk!- Bill Heal & Snorri Baldursson, Icelandic Institute of Natural History.

SUMMARY: The authors outline the importance of monitoring Arctic biodiversity, the current status of monitoring and priorities for understanding changes in the Arctic.

Why is monitoring Arctic biodiversity internationally important?

- Global models predict rapid and severe climate change in the Arctic region (2-5°C rise). Exploitation of Arctic resources and pollution effects are increasing. Therefore, pressure on Arctic biodiversity will continue to rise.
- The Arctic is a relatively simple biological system - albeit logistically complex - with low species diversity (1.8% of global biota; higher in some taxa: mosses <7%; lichens <6.5%; collembola < 8%).
- Many species are genetically diverse and still evolving - Arctic ecosystems are mostly less than 10,000 years old. Some species and systems illustrate adaptive responses to climate variability.
- The Arctic region is "owned" by 8 developed nations, with sophisticated science infrastructure. These nations extend Southwards and can integrate Arctic experience into a Temperate and Global context.
- The Arctic ocean and atmospheric systems are dominated by internal circulation with the North Atlantic as the key gateway. Terrestrial, freshwater, marine and atmospheric systems are intimately linked with positive and negative feedbacks.
- Many Arctic species are globally important because they are migratory or have ranges extending to temperate regions.

Therefore, the Arctic offers unique opportunities for integrated research, monitoring, modelling and management. In addition, changes in the Arctic have important European and Global consequences.

What is the state of current monitoring programmes?

- Biodiversity monitoring is the responsibility of the eight Arctic nations, individually, but currently, there is limited focus on circumpolar Arctic change. Integration is being developed through the Arctic Council programmes of CAFF (flora and fauna, www.caff.is) and AMAP (pollution, www.amap.no). An Arctic Climate Impact Assessment is in progress (ACIA www.acia.uaf.edu).
- Circumpolar information on changes in biodiversity is severally limited and focussed on birds, mammals and some fish. Data on flora (except for the ITEX project) and invertebrates (the base of many food webs) are particularly weak.
- Most biodiversity information is based on a very small number of intensive research sites and summer observations. Some excellent long-term data exist for individual sites. More extensive monitoring is essential to assess spatial variation and causal relationships.
- There is evidence that monitoring by resident communities can provide extensive observations of change, build on indigenous knowledge and enhance winter observations. Phenological observations are particularly effective and relate to climatic drivers.
- The integrity of the circumpolar Arctic system and the importance of North-South interactions demand development of more integrated monitoring programmes.
- CAFF recently initiated 8 species-based circumpolar monitoring networks (plants, polar bear, ringed seal, seabirds, reindeer/caribou, waders, geese, Arctic char) but, as with other species and site networks, long-term support is lacking.

What are the priorities for understanding changes in Arctic biodiversity? (not in order of priority):

- Establishment, with long-term security, of additional circumpolar species and site networks to fill ecological gaps. Development of associated data management and modelling strategies and links to European and Global networks
- Establishment of 'community-based phenological monitoring' (an identified priority for CAFF)

- Integration of biodiversity and pollution monitoring through CAFF and AMAP to determine causes and distribution of change.
- Analyse and interpret existing long-term biodiversity data to define past responses to environmental change, including responses of migratory birds and mammals.
- Assess implications of ACIA for monitoring biodiversity.
- Enhance connection between atmospheric, marine, freshwater and terrestrial researchers to assess physical and biological interactions between systems as a basis for improved integrated monitoring.
- Formulate the expected social and economic decadal changes and assess the consequences for Arctic biodiversity as a basis for testing the effectiveness of biodiversity monitoring.

Monitoring Biodiversity in the Mediterranean region- Emilia Poli, Universita di Catania

SUMMARY: There is an urgent need to monitor biodiversity in the Mediterranean region. It is, as many authors emphasized, one of the regions with the greatest biodiversity that is also the most endangered by human impacts. There are also major gaps in monitoring biodiversity in this region. It is particularly important to organize and develop monitoring programmes in the Mediterranean region, and to coordinate these programmes within an international network.

Monitoring biodiversity is of the greatest importance in areas where the human impact is very high and where climate change could deeply affect the structure and ecological balance of ecosystems. The Mediterranean region is one such area. The circum-Mediterranean region is also a geographical zone with a great biodiversity, as several authors emphasized. This region is, in fact, considerably rich both in its number of floristic species and its number of endemics, two commonly used attributes of biodiversity. Due to an increase of human impact in this region, some ecological balances have been upset in most places by overexploitation of natural resources. The biodiversity is consequently very threatened: several areas where the biodiversity is in great danger of decrease have been defined red alert areas or "hot-spot areas". These areas are of the greatest importance for monitoring biodiversity. In several areas of the circum-Mediterranean region, there are great gaps in biodiversity monitoring, a real lack of knowledge and a lack of will and action plans by local administrations and policy-makers. There is, moreover, an urgent need to monitor biodiversity in this region.

Therefore, it is particularly important to organize and develop monitoring programmes and to coordinate these programmes within national and international networks. The main purposes of these programmes could be (at least):
- To monitor the main environmental and biological factors (landscape and effect of land-use on habitat diversity; plant species and plant communities; animal populations; habitats of rare and endangered species, of endemic species or of species with a particular biogeographical importance; refugia, etc.)
- Development of biodiversity indicators (landscape indicators; indicator species and indicator populations and communities)
- No further loss of biodiversity
- Biodiversity increase and conservation, particularly in hot-spot areas, isolated areas, protected areas, botanic gardens
- Development and implementation of biodiversity monitoring network programmes across Europe, which need coordination regarding objectives, methodologies for data collections and definition of actions taking priority.

Session and title of contribution	Contributors
Session 5. To identify where research should be focussed to develop monitoring programmes that best meet the needs of users, including the development of a core programme of biodiversity monitoring across Europe.	
Introduction to the final session	Allan Watt, Chair
Reply to "Introduction to the final session"	Erling Berge
Monitoring biodiversity in rivers	Richard Johnson
Priorities for future research on biodiversity in lakes	S. Declerck & L. De Meester
High Conservation Value Forests (HCFs)	Marco Marchetti
The European Network for Biodiversity Information (ENBI) and biomonitoring	C. Hof *et al.*
The NBN UK example	J. Munford & L. Way
Research priorities for indicators and monitoring schemes in agroecosystems	Klaus Henle
Value-specific indicators- to meet the needs of stakeholders	P. Duelli & C. Scheidegger
Establishing the biodiversity of a site or region	Alan Feest
Three tasks in a Biodiversity monitoring sandwich	Robert Kenward
Towards biodiversity monitoring at the European scale	Frederic Gosselin
The use of full species lists in biodiversity monitoring	Richard Fischer
The more we speak about monitoring, the less we do it!	Jurgen Tack
Monitoring with pragmatism	Romain Julliard
MARBENA E-conference: monitoring approaches strategies and indicators	Alf Josefson

Introduction to the fifth session of the e-conference: research priorities- Allan Watt (e-conference chair)

SUMMARY: Although the main aim of the fourth session of the e-conference was to consider the development of a core programme of biodiversity monitoring across Europe, few contributors considered it explicitly. However, several major gaps in monitoring were identified – the urban environment, genetic diversity, microbial diversity and soil biodiversity. The aim of the last session of the e-conference is to identify where research should be focussed to develop monitoring programmes that best meet the needs of users, including the development of a core programme of biodiversity monitoring across Europe. This session also includes a report on the discussion on monitoring in the MARBENA e-conference.

The aim of the fourth session of the e-conference was to consider the development of a core programme of biodiversity monitoring across Europe, define the priorities for monitoring and identify major gaps in monitoring.

Few contributors considered the concept of a core programme of biodiversity monitoring. Only Etienne Branquart and Pat Neville explicitly considered a European biodiversity network, specifically the very practical proposal to expand the ICP Forests network to include monitoring of forest biodiversity. Likewise few people discussed priorities for monitoring. However many contributors discusses major gaps in current monitoring programme. Jari Niemelä argued for more monitoring of biodiversity in urban environments. Genetic diversity is relatively neglected but Fiorella Villani, René Smulders & Ben Vosman and Marcello Buiatti provided strong reasons for the monitoring it. In probably the two best-titled (and best-referenced) contributions to the e-conference, Annick Wilmotte and Endre Laczko argued that microbial diversity and soil biodiversity require more attention.

We would welcome more contributions on these topics over the next two days. We particularly want to hear your views on a European core programme of biodiversity monitoring. My own view is that such a programme is very desirable and could be the outcome of initiatives such as Bio-MIN, which aim to increase collaboration between existing and developing programmes such as the MCPFE indicators of biodiversity, an expanded ICP Forests and a Pan-European breeding bird monitoring scheme. I also feel that a core programme should be an integrated programme, as argued by Robert Kenward and Jose M. Garcia del Barrio, with an extensive network of relatively simple monitoring activities combined with a smaller network of research projects, testing and improving the monitoring of biodiversity, quantifying the impact of anthropogenic influences on biodiversity and increasing our understanding of those neglected areas, such as those discussed over the last few days. A core programme must also do what Rainer Muessner, Ben ten Brink and others have argued and bridge the gap between those who collect data on biodiversity and those who need information in a format that helps them to make decisions.

The aim of the last session of the e-conference is to identify where research should be focussed to develop monitoring programmes that best meet the needs of users, including the development of a core programme of biodiversity monitoring across Europe. Many contributions have considered this aim already – time is running out for you to send your views.

It is worth repeating my comments at the start of this e-conference – it is an opportunity to influence research on monitoring. A Summary of your views will be presented to the European Platform of Biodiversity Research Strategy (EPBRS) meeting in October. The main objective of the EPBRS is "to improve the effectiveness and relevance of European biodiversity research" and the next meeting will identify priorities for research on biodiversity monitoring. With the Sixth Framework Programme approaching fast, this is a good time to make your views felt.

Reply to " Introduction to the fifth session of the e-conference: research priorities"- Erling Berge, Norwegian University of Science and Technology.

If the goal of a core programme of biodiversity monitoring across Europe is to "bridge the gap between those who collect data on biodiversity and those who need information in a format that helps them to make decisions" it will have to be designed to test hypotheses about the impact of changes in policy instruments and to separate those impacts from other dynamic factors affecting biodiversity indices.

Monitoring biodiversity in rivers - Richard Johnson, Swedish University of Agricultural Sciences.

SUMMARY: The author highlights the importance of improving our understanding of ecological scale in the conservation and restoration of riverine ecosystems. He also looks at existing gaps in riverine monitoring efforts and alternative modelling approaches.

When conducting an audit, whether of economic or biological entities, it is not sufficient to know merely how much is in the cash box. The knowledge of how much is there in relation to how much should be there is decisive for any audit. When trying to audit local or regional biodiversity, a number of problems arise such as what to measure, when, where and how. Since we seldom know the "universe" of our study (i.e. how much is actually in the cash box), we often need to sample to obtain some estimate of what and how much is present at a site. Reliance on sampling to obtain population estimates may be straightforward for a number of biological elements, but becomes increasing more difficult as organism size and abundance become smaller. In addition, the negative effects of human-induced stress on aquatic ecosystems often result in lower population sizes, confounding the "sampling problem" even more.

Riverine ecosystems are among the most threatened habitats on earth, and across Europe many organism groups have become locally extinct due to human-induced changes in stream quality. To better understand how to manage, protect and restore the structure, function and biodiversity of habitats, more knowledge is needed on how organisms respond to human-induced as well as natural environmental changes. For example, despite a long history of human alteration in European streams and rivers, little is known of the importance or the ecological scale of either natural variation or human-induced perturbation. For some organisms, little if anything is known about what factors govern changes in running waters (e.g. Palmer et al. 2000).

The importance of ecological scale in ecology is an expanding area. In fact, according to Thompson *et al.* (2001), the topic of scale is one of the four paramount frontiers in ecology for "understanding how biological and physical processes interact over multiple spatial and temporal scales to shape the earths´ biodiversity". For the conservation and restoration of riverine ecosystems, improving our understanding of the importance of ecological scale is acutely needed. Although many conservation programs are focused on conservation and protection of geographically distinct areas or ecosystems, recent studies have questioned (i) the characteristics and bias associated with site selection (e.g. Dudley and Pressey 2001), (ii) whether protected areas incorporate the spatial dynamics of ecosystems needed for ecosystem resilience (e.g. Picket and Thompson 1978), and (iii) the holiest of all, the ecosystem paradigm itself, or more specifically the assumption that ecosystems exist or can be isolated and studied as single (isolated) entities (O´Neill 2001).

A number of gaps in knowledge limit our abilities to empirically or even conceptually improve our understanding of the importance of ecological scale on riverine biodiversity. Although monitoring efforts of stream and river biota exist across Europe, the data collected are of varying quality. Here, with its focus on the use of standardized assessment methods and intercalibrations among the Member States, the European Water Framework Directive (European Commission 2000) should greatly improve our understanding of aquatic biodiversity and the effects of human-induced stressors on populations. The Directive is not, however, focused on biodiversity per se, but more on determining if the quality of aquatic ecosystems is improving, degrading or staying unchanged, and the rates and direction of change. This may mean that other, complementary, methods may be needed for assessing and monitoring changes more focused on aspects of aquatic biodiversity not included in the Directive.

A well accepted axiom in ecology is that at any given site a large proportion of aquatic biodiversity consists of rare taxa. At present disagreement exist regarding the importance of rare taxa in bio-assessment. For example, a number of studies contend that the inclusion of rare taxa increases statistical power (e.g. Cao et al. 2001), while others argue that their inclusion does not result in better discrimination of ecological change (e.g. Marchant 2002). As mentioned above, however, one of the problems in auditing biodiversity is our general poor understanding of what is actually present at a site, and subsequently our reliance on sampling to derive population estimates. Here, sampling limitations generally result in poor estimates of population sizes of rare taxa. For example, due to their often spatially patchy distribution and/or low population densities, effective sampling of rare taxa is difficult.

Accordingly, alternative approaches need to be developed for monitoring biodiversity. Modeling approaches that utilize ecological relationships to predict community composition in the absence of human-induced stress is one promising area of research (e.g. Boon 2000). Another area that shows promise is the use of metrics commonly used in bio-assessment as surrogates for overall biodiversity. Here, focus should be placed on testing how well metrics developed for diagnostic purposes are correlated with other aspects of biodiversity (such as the presence/absence of rare taxa). For example, though some studies have shown that the presence of rare taxa is correlated with metrics used for ecological assessment (e.g. Skriver 1999), other studies have shown that metrics commonly used to detect ecological change are not adequate surrogates for monitoring biodiversity. Recently, Heino et al. (unpublished manuscript) questioned the use of single taxonomic groups as indicators of overall diversity. These authors showed, for example, that due to geographic differences in temperature preferences of plecopterans (increasing richness at high altitude or latitude) the common use of the number of sum of the Ephmeroptera, Plecoptera and Trichoptera (or EPT metric) taxa as a metric for ecological quality could not be reliably used as a measure of biodiversity.

Before we can begin to address the importance of ecological scale on our perception of ecosystem structure and function or the confounding effects of sampling problems associated with measuring biodiversity more focus should be placed on:

- Improved tools for assessing and monitoring changes in biodiversity
- Standardized field sampling and laboratory sample processing protocols
- Standardized taxonomic effort.

Priorities for future research on biodiversity in lakes- Steven Declerck and Luc De Meester, Laboratory of Aquatic Ecology, Katholieke Universiteit Leuven.

SUMMARY: The authors suggest several topics that need closer attention in future research and monitoring projects on biodiversity in lakes. According to the authors, a validation of the surrogacy hypothesis is a prerequisite for the use of indicator taxa. They advocate that more attention should go to processes that potentially determine diversity in freshwater communities and that a further development of reliable cost-effective indices is a prerequisite for the set-up of feasible monitoring programs.

Some priorities for future research on biodiversity in lakes should be:

(1) Validation of the surrogacy approach

Many indicators for biodiversity are based on the surrogacy approach, assuming that high diversity in one group of (easily to study) organisms is associated with diversity in other groups of organisms. Although this hypothesis is essential for the development of feasible monitoring and management techniques, it should be well validated. There is a lack of information with respect to the validity of this hypothesis, especially in freshwater systems. The Water Framework Directive requires the monitoring of only four groups of aquatic organisms: algae, fish, macrophytes and macro-invertebrates. There is a need for well-conceived studies addressing the question of how these groups can serve as a surrogate for the biodiversity in other important components, such as zooplankton, ciliates, nanoflagellates or bacteria, and how the diversity in these groups is related to ecosystem functioning. If not, we run the risk of ignoring important aspects of biodiversity in aquatic systems.

(2) Attention for mechanisms and cause-effect relationships

A good knowledge of the functional relationship between aquatic biodiversity and the abiotic environment, human activities and ecosystem features is essential for the reliable assessment and prediction of trends that may affect biodiversity, as well as for the development of efficient, cost-effective monitoring and management strategies. Current knowledge is still very limited and present monitoring activities should go further than merely describing patterns of biodiversity. Monitoring programs should be designed in such a way that they allow a scientifically sound analysis of observed trends. Such an approach may imply higher monitoring efforts and costs, but may help to increase scientific understanding of general and more fundamental processes that affect aquatic biodiversity on a longer term. The monitoring approach remains, however, essentially descriptive, and should be complemented with research projects that are based on experimental or modelling approaches and that focus on specific mechanistic aspects. Key aspects of the solid good knowledge which can substantially increase our understanding of how biodiversity in freshwater habitats should be monitored and managed are, amongst others, the dispersal capacity of aquatic organisms and their colonisation dynamics, factors that determine the taxonomic and genetic diversity of assemblages (stochasticity and priority effects, local versus regional factors, degree of isolation.), the functional importance of resting egg banks, ecosystem functioning, stability and resilience versus, taxon diversity, functional diversity and food web complexity.

(3) Search for more cost-effective indicators

Resources for monitoring are limited. Therefore, the success of a monitoring program may strongly depend on the choice of the set of indicators used, i.e. their reliability, the amount of information they yield and cost-effectiveness. More attention should go to the development of such indicators. For example, an analysis of resting egg banks may yield a reliable, spatially and temporally integrated picture of target communities. Such a method can be very cost-effective, as it excludes the need for extensive sampling programs. On a EU-scale, we consider the development of a core monitoring programme with standardised protocols useful. However, we believe that more is needed than just an integration of existing monitoring programmes. Monitoring programs should not consist of rigid protocols but should be kept flexible: if necessary, the core programme should be extended in order to make it adapted to specific problems of the locality. Moreover, the science of biodiversity is rapidly evolving and regular revision of programs in the light of new insights is essential. One can anticipate the risk that the monitoring efforts as part of the Water Framework Directive may be not flexible enough to incorporate new findings - it is essential that a modular structure is developed which allows a flexible implementation of new findings.

Definition of a pan-European framework for the management of biodiversity in High Conservation Value Forests (HCVFs)- Marco Marchetti, Università di Palermo.

SUMMARY: The author discusses the idea of High Conservation Value Forests and their potential role in European forest monitoring.

The idea of High Conservation Value Forests (HCVFs) was introduced by the Forest Stewardship Council (FSC) in 1999. The key concept of HCVFs is the identification of forests that possess one or more attributes that are considered important from a conservation perspective and need to be protected. Three out of six of these attributes refer to biodiversity values (FSC Principles and Criteria, 2000): "HCV1 Forest areas containing globally, regionally or nationally significant concentrations of biodiversity values (e.g. endemism, endangered species, refugia). HCV2 Forest areas containing globally, regionally or nationally significant large landscape level forests, contained within, or containing the management unit, where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance. HCV3 Forest areas that are in or contain rare, threatened or endangered ecosystems." HCVx, further groups could be implemented: e.g. for Old Growth forest, actual and potential, since their presence in Europe is rather limited.

An interesting initiative led by the ProForest group (http://www.proforest.net/) is currently developing a practical methodology (HCVF Toolkit) to set national standards (also of guidance for certification purposes) on how to identify, manage HCVFs and monitor forest management performance in the conservation of such values.

HCVFs areas are very diverse forest management scenarios ranging several spatial scales (from stand level forest management to landscape level planning) where different biodiversity conservation issues can be found. HCVFs are, therefore, suitable operational contexts to test and further develop the application of Biodiversity Evaluation Tools for European Forests (Larsson, 2001). This issue also has links with the activities of EEA ETC/NC concerning monitoring biodiversity status in European Conservation Sites (Shaw, Wind 1997) and with the activities of Bioforum.

Possible lines of discussion and development are:

- Analysis of information needs for the development of a pan-European database on HCVFs, with special attention to mapping issues.

- Derivation of an appropriate forest types classification system to assess biodiversity levels within HCVFs (e.g. following Bear FTBA approach, MCPFE – EUNIS based proposal and following developments).
- Implement the Bear biodiversity key factors concept in HCVs forest management and planning activities to identify threats to HCVFs and set out biodiversity conservation measures. The concepts of FTBAs biodiversity key factors and indicators should be examined thoroughly and further developed to define HCVFs conservation objectives; conservation objectives should be set in terms of "favourable condition" of attributes of biodiversity values (see before HCV1-HCV3), e.g. selection of relevant FTBA key factors and indicators, definition of indicators reference values and critical thresholds.
- Agree a standardized monitoring system (indicators, form of measurements, intensity, methods) to assess the conservation status of HCVFs biodiversity attributes and the effectiveness of biodiversity conservation measures.

The European Network for Biodiversity Information (ENBI) and biomonitoring- Cees Hof, Wouter Los, Yde de Jong, University of Amsterdam.

SUMMARY: ENBI is an EC supported Thematic Network that will start in autumn 2002. ENBI's main objective is to establish a strong network that will identify biodiversity information priorities to be managed at the European scale. ENBI will contribute to the possibilities to monitor biodiversity by stimulating integrated access to (historical) biodiversity data and by developing a common biodiversity information infrastructure.

Introduction

Biological diversity is essential to maintain life on earth and has important social, scientific, educational, cultural, recreational and aesthetic values. However, most existing biodiversity information is dispersed and not dynamically accessible in digital format. To be able to use biodiversity information to its full potential, for both scientific and societal applications, it will be crucial to digitise our primary biodiversity data and to make these data available in an integrated shared information infrastructure. This is a complex task and there are many organisations involved. Co-ordination, to align efforts and to avoid overlap and duplication, is therefore the major problem to be addressed by ENBI. Apart from the co-ordination, ENBI will also initiate and prepare for future applications when biodiversity data can be studied in combination with data from other information domains such as molecular sequences, climate, or geography.

Scientific objectives and approach

ENBI is the European contribution to the Global Biodiversity Information Facility (GBIF). GBIF gives priority to the vast objective to make primary biodiversity data globally available. In first instance, the GBIF work programme is restricted to taxonomic data and to biological collection and specimen data, as well as to promoting the common access and interoperability between these databases. ENBI follows these priorities by concentrating on databases at the European scale and on activities that need co-operation at a European level. ENBI also explores the potential of tools to apply the biodiversity data as such, or in combination with other categories of data. In addition, ENBI will focus on the market of end-users with special attention on processes to develop specific products and services. The major objective of ENBI is to establish a strong network that will identify biodiversity information priorities to be managed at the European scale. Members of the network are the co-ordinating institutes of past and current EU biodiversity projects, and the (designated) institutes that act as, or host, the national GBIF-nodes. Other objectives are the establishment of communication platforms to inquire about the needs of end-users and to disseminate biodiversity expertise to professionals and policy makers. ENBI co-ordinates its activities with those of the European Community Clearing-House Mechanism as both give top priority to the easy access to biodiversity data.

ENBI and biomonitoring
Q. "The role on ENBI in monitoring biodiversity" - How can initiatives such as ENBI help to quantify trends in biodiversity and identify their causes"
A. ENBI will basically provide some tools and the infrastructure to quantify trends in biodiversity.

One of the four clusters of work packages within ENBI will concentrate on "Data integration, interoperability and analysis". This cluster shall focus on issues such as:

- Identification of new emerging technologies and trends to anticipate upon and to organise a critical mass of European efforts.
- Integration of standards and protocols (metadata) for taxonomic, specimen, collection, and survey data in a common interoperability structure.
- Distributed information management requirement analysis for ENBI.
- Analysis of the application of Grid's in order to integrate distributed primary data into end-user oriented products.
- Inventory of biodiversity database analysing software systems (existing and in development), and the identification of common (exchangeable) approaches (especially for GIS based analyses).
- Contribution to a common biodiversity information infrastructure in collaboration with other initiatives, e.g. those of the European Environmental Agency (EEA) and current EU database projects, in such a manner that information providers and users have a common platform for information interchange.

Obviously it is of great importance that the information infrastructure will address the needs and expectations of the (biomonitoring) users of biodiversity data. ENBI invites (future) users to communicate their thoughts on this subject.

Improved access to information will influence the design of biodiversity measures the NBN UK example - James Munford (NBN), Lawrence Way (JNCC)

SUMMARY: The UK has very large volumes of species and habitat survey information with the major proportion of the species component generated by thousands of volunteers. The information is very dispersed, and difficult to access and compare. The NBN has made progress in delivering access to the sum the information potentially available. It has a federated network structure of contributing organisations and inter-operating Internet based information services. Better access to information is beginning to influence the design of surveillance and monitoring. This is being done by combining sources, integrating volunteer effort with other capture mechanisms, and building partnerships by integrating needs and information sources, in order to provide the revenue streams needed to support long term surveillance.

Biodiversity information is created by a very large number (i) of organisations in the UK with a broad range of remits from conservation through to forestry, local planning control, environmental protection, research and promoting public understanding of nature. Techniques range from satellite and air photographic interpretation, to detailed field observation, and result in data sets managed in a very wide range of formats. In terms of volume the largest contribution is generated from the estimated (ii) 60,000 biological recorders (people making mainly species related field observations) active in the UK, most (70%) are volunteers organised through local and national societies or recording schemes. Many of these volunteers also lodge their records with an as yet incomplete network of local record centres usually based on local government boundaries. These centres act as local access points to biodiversity information.

The NBN is the mechanism designed to improve access to this large but very fragmented resource of data to meet conservation, research, and other public benefit needs. To this end the National Biodiversity Network Trust (www.nbn.org.uk) was formed in 2000 as an independent public/voluntary sector partnership to facilitate the development of the network which was begun in 1996. The NBN Trust has in its governing structure the major UK biodiversity research and nature conservation (public and NGO) institutions (iii) and the collections sector represented by the Natural History Museum. The Trust has funded programmes from membership fees, government, charitable trusts, and the Heritage Lottery Fund, providing services to allow network content and functionality development by member organisations. In essence the Trust is designed to be a neutral body through which others can share objectives and agree standards.

NBN's data gateway (www.searchnbn.net) can currently access ten million ecological species observations made by field survey, with a small percentage Summaryed from museum collections. It has also prioritised habitat inventory, ecosystem type and protected area polygons. In all 35 data sets from 17 organisations are accessible, together with metadata and indexed web content. Content is set to grow rapidly over the next 3-5 years as capacity building constraints are addressed. The initial priority applications of the NBN are for internal UK nature conservation and sustainable use objectives, whilst ensuring research and education interests remain engaged.

Functionality includes mechanisms for handling data of different qualities and of different environmental sensitivities, and means of handling raw data, meta data and interpretations. Control is distributed to custodians in the network within a framework of access principles. The data gateway is moving to a distributed architecture for contribution and to providing web services to other web systems. This latter is to meet the demands to supply biodiversity information to different sectors and organisations through their own interfaces.

An important element within the search functionality of the gateway is a species dictionary or more accurately thesaurus of cross-linked species lists. The Natural History Museum co-ordinates 129 lists, electronic collection of species nomenclature, both scientific and vernacular, so that NBN can search and translate between the large number of sources that may ultimately becomes accessible. The parallel development of a habitats dictionary has commenced.

The NBN Trust and its partners also have projects designed to develop the necessary standards to underpin the network including a data model incorporated into standard recording software. There are further projects on data quality management, access to data that is putting in place the legal frame work necessary for data exchange, also projects designed to grow the capacity of the societies, recording schemes and local record centres that support the voluntary recorders. Contributors to the network are leading their own projects to add content and develop the uses of the information becoming accessible to meet their own needs. For example the English statutory nature conservation body, English Nature, is developing content at a regional scale to provide information to the partnerships involved in delivering biodiversity conservation targets.

The co-ordinated but still federated structure of the NBN we hope will prepare the UK to make contributions to biodiversity information access initiatives operating at larger geographic scales such as the Global Biodiversity Information Initiative and the various European networking initiatives

(iii) Countryside Council for Wales, English Nature, The National Federation for Biological Recording, The Natural History Museum, the Natural Environment Research Council, the Joint Nature Conservation Committee, The Wildlife Trusts, The Royal Society for the Protection of Birds.

Research priorities for indicators and monitoring schemes in agro-ecosystems - Klaus Henle, Department of Conservation Biology and Natural Resources, UFZ Leipzig-Halle GmbH.

SUMMARY: I argue that a major research priority should be the development of a framework for an indicator system that covers all scales, from the local farm to the European level, in a consistent form. This framework should be able to identify causes of change, and feasible from an administrative and financial point of view.

Indicators and monitoring schemes are essential for the formulation and control of environmental quality standards set by policy and society. In agricultural landscapes, a large number of indicators for environmental quality have been suggested. Most indicators concentrate on a local or regional scale because of implementation measurements on the scale of individual farms and because of regional differences in agricultural landscapes.

What we need is an indicator system that is consistent across Europe for a reliable implementation of biodiversity conservation in agricultural landscapes and that covers the full scale from the local farm to major European regions. Thus, we need a hierarchical indicator system across Europe that allows for variation at the local scale. From the local to the regional scale the indicator system must allow for an adaptation to different biodiversity conservation goals for agricultural landscapes with different production intensities. On the European scale the system must allow an evaluation of the environmental state of agricultural landscapes while considering the different opportunities for biodiversity conservation across Europe. This should be a major research priority for European research projects.

The indicator systems for agro-ecosystems should be combined with socio-economic indicator systems. The monitoring of these combined indicators should allow an assessment on whether biodiversity conservation services provided to the citizens of Europe are sufficiently "rewarded" such that regions where biodiversity conservation is considered important still have fair economic, cultural, and social developmental opportunities.

Another major research priority is the distinction between the scientific development of indicator and monitoring systems and more practical considerations. Most suggested systems require far too many resources (manpower, money…) to be feasible and research on the organisation, financing, administrative feasibility and efficiency of monitoring schemes is much more important than work on yet another indicator system.

Finally, the development of biological indicator systems is too rarely based on rigorous statistical field designs or on field experiments. This requires a level of temporal, spatial, and disciplinary integration in the field that can be achieved only with a very tight planning and co-ordination. Unfortunately, suggestions for research projects with such tight integration requirements are too often regarded as too ambitious and risky. Reviewers and funding agencies should change such attitudes.

Value-specific indicators - especially designed to meet the needs of stakeholders - Peter Duelli and Christoph Scheidegger, Swiss Federal Research Institute WSL.

SUMMARY: For European and national monitoring of biodiversity, standardised sets of indicators have to be designed and tested for their correlation with value-specific entities or aspects of biodiversity measured in a representative number of locations throughout Europe.

All ongoing national monitoring programmes for biodiversity started out with a pragmatic decision as to which organisms or surrogates were suitable for standardised collecting. Consequently, most countries tend to collect the same groups: Birds, plants, butterflies, etc. But do they represent biodiversity? Each stakeholder has his or her own motivation to protect or enhance biodiversity. Those personal or professional motivations can be bundled into basic value systems: Species conservation, ecological resilience, ecosystem functioning such as biological control or pollination, sustainability, wilderness, cultural heritage etc. Since these value systems do not necessarily correlate, their indicators will hardly convince all the stakeholders.

So far the general approach in Europe was to propose an indicator and to hope that the others would accept it eventually. We call it the democratic approach. What we propose is the scientific approach, which starts the other way round. It is a stepwise approach (see also McGeoch, 1998, and the e-conference contribution by Niemelä on 11 Sept.), which will inevitably require quite a lot of further research:

1. Define the value system (motivation) and the appropriate measurable aspect or entity of biodiversity (e.g. conservation value, alpha-diversity, potential for biological control, sustainability, pollination, cultural heritage, wilderness, etc.).

2. Measure that aspect or entity in a representative number of locations as thoroughly and diligently as possible. Ideally, each country in Europe has a number of "national test areas for biodiversity". Consider also often neglected entities of biodiversity such as soil organisms and genetic diversity at the landscape level!
3. In a third step, already existing, proposed, or newly designed indicators are measured in the same areas, or calculated from the empirical data pool. Their performance can be tested against the assessed "reality". Linear correlation power and costs decide which of the indicators are the best, the fastest, the cheapest.
4. Group the best concordant indicators into "value baskets". The result is an index per basket, e.g. "the biodiversity index for conservation", or "the biodiversity index for ecological resilience", just like the "Dow Jones index for industrial average".

Dozens of indicators have been presented or proposed during this and earlier e-conferences. If assigned to and tested for the power to predict a particular motivation or entity of biodiversity, they will either drop out of the list of candidates for national and international monitoring programmes, or join a group of newly designed indicators to form stakeholder-specific biodiversity indices which are optimised to monitor European biodiversity in its diversity of aspects.

Establishing the biodiversity status of a site/region - Alan Feest, University of Bristol

SUMMARY: It is argued that no one approach can provide the information that we need to assess the biodiversity status of a site or region.

It seems to me that there are two parallel strands in the conference. One strand addresses the actual measuring of biodiversity indices in order to establish baseline data that can be used as reference against future estimations. This will also establish current status of a site. The second is to use indicator species as a shorthand way of establishing the conservation status of a site or a population.

There are problems in both of these approaches. For the estimation of biodiversity indices, the knotty problem of species delimitation and taxonomic fluidity could cause total despair in that the surveyor is trying to pin down a moving target. For some groups, the taxonomic status is very ill defined and for others the definition of such simple information as what is an individual is problematic (macrofungi). My own scientific training has always taught me that if you cannot measure it, it may not exist.

For the use of indicators, the problems relate to those taxonomic problems mentioned above but normally an indicator species would be chosen partly for the reason that what the species definition represents is clear. A more fundamental problem comes in the very word indicator. Absence and presence are only indicators and the consequence of absence or presence needs to be verified independently in population surveys of other species that are indicated by the indicator species (if you see what I mean!). The use of indicators could be open to challenge without supplementary information. Indicators could be of two kinds: population levels or presence/absence and this difference has not been a feature of the conference whilst it is a crucial element since it relates to the need to measure in order to prove the existence (see above).

So neither approach is satisfactory but a combination could be! Indicators could be used as early warning of when a more thorough investigation is needed but just using indicators is open to challenge. The use of indicators is particularly necessary when the resource for a survey is limited either in time and manpower available or in terms of the expertise that is available or the state of the expertise in the taxon is unsatisfactory. They are an effective pragmatic way of approaching a situation but in order to be of greater use they need to be backed by more in depth information.

One final comment is that I seem to be one of the few researchers actually measuring biodiversity by a range of indices to characterise the nature of that biodiversity. Most biodiversity estimation is of the indicator type and this seems a sensible starting point but perhaps the outcome of this conference would be to establish the relationship between these two approaches and a rationalization of how to proceed from the indicator methodology to the indices methodology. It has become clear that this latter part of the issue of biodiversity needs to be clearly addressed in the form of a series of protocols that establish the unified basis for biodiversity index estimation for any taxonomic group.

Three tasks in a BD-monitoring sandwich- Robert E. Kenward, Centre for Ecology and Hydrology.

SUMMARY: Administrative of pan-European work on biodiversity needs to address 3 mains tasks, whereby professionals provide connections between data-collection and policymaking.

Towards the end of the conference, I'd like to present a conceptual framework that could perhaps help to organise biodiversity monitoring trans-nationally. It is based on recognition of 3 layers, (a) policymakers, (b) biodiversity professionals and (c) data-collecting volunteers. That is a sandwich, in which the professionals are the filling. Those professionals have to interact rather well to hold the sandwich together. Institutions need to concentrate on networking those professionals and helping them in 3 tasks that require a great deal of cooperation.

Task 1 for the professionals is to define indices for transmission to public & policymakers. Networking is needed to try different indices and move towards consensus on the best ones. The indices may need to be rather broad, because policymakers will tend to push resources towards benefiting those indicators alone. Biologists proposing particular indicators have to be very honest to avoid encouraging that process!

Task 2 is to work with the data-collecting volunteers. The data need to be broad (the species lists of Frederik Gosselin and Richard Fischer), simple (to minimise training) and fun (for hunter-gatherers to collect and socialise about). There is no question of starting with a perfect system, but the fun helps recruit towards the twin aims of improving breadth of taxa coverage and fineness of scale (ultimately landowner scale as noted by Riccardo Simoncini and Herman Ellenberg). Some countries may need initially to concentrate on threatened areas and species, but an ultimate aim would be to restore or improve species richness everywhere. This needs networking of managers and social scientists, as well as of the biologists that provide outputs to the data collector layer (for example to refine the data collection process), and pull data together from different taxa if these are collected separately by different volunteer groups.

Task 3 is for biodiversity professionals is to refine understanding of the processes that underpin biodiversity. This will inevitably involve indicators as well as indices, and narrow-deep studies. Ideally it will lead eventually to models that predict from intended actions and climate change and suggest solutions than maintain improve biodiversity and other aspects of sustainability, at finer and finer scale. Biologists have got to be rather unselfish if they want this sandwich to stay together. As well as the need to avoid "gravy-train" promotion in Task 1, they need to support and encourage the social professionals in Task 2 and to hand over their monitoring "babies" to a wider participation. In Task 3 they need to come together to share the funds and join-up all the models into huge forecasting engines. Each task may need a different networking authority, in which case those networking nodes will need thorough connections.

Towards biodiversity monitoring at the European scale - proposal of principles and discussion of examples- Frédéric Gosselin, Cemagref.

SUMMARY: Biodiversity monitoring requires objectives. It also requires principles and examples. In this contribution, we propose three principles and two contrasting examples that could be used to develop biodiversity monitoring. We stress the need for species-level data, coupled with environmental data, through predefined questions or hypotheses. We also advocate the use of the adaptive management concept in parallel to this monitoring.

As stressed during this conference, biodiversity monitoring must be tied as much as possible to pre-defined objectives. In our opinion, two broad classes of objectives have been identified during the first session of the conference, namely: Objective 1. Estimate trends for parts of biodiversity; Objective 2. Try to estimate the impact human activities - and especially European-level policies - have on these trends. Once this has been said, much remains to be done: firstly, because biodiversity is essentially of a multidimensional nature - these "dimensions" include frequency and abundance of species, viability of individual species, richness and abundance of species groups, species composition; but also because, for the second type of objective, we must identify which trends can and should be studied, and which questions will be asked; and finally because we must choose which parts of biodiversity can and/or should be studied. A huge task...

Although this task is daunting, we hereby propose some general principles that, in our opinion, should be taken into account to develop a European-level monitoring of biodiversity for the two objectives above:

Principle 1: prefer species-level data rather than "indicator" data or higher taxon-level data. This is merely because biodiversity is not just species richness: because indicators of biodiversity are frequently only developed through the correlation of potential indicators with species richness, they do not tell the whole story for the variation in biodiversity;

Principle 2: as soon as possible identify the questions - or hypotheses - that will be asked, especially on the following aspects: which dimension of biodiversity is concerned (especially: which species or which species groups are thought to be more sensitive to a particular type of management...); which environmental variables identify potential mechanisms, biases... for the analysis of biodiversity response to management. For instance, when we study the impact of forest cutting on vegetation, we have enough prior knowledge to expect a different response from "non-forest species" and from "forest species" - although the difference between the two groups is not clear-cut...

Principle 3: for objective 2, we should try to identify variables, hypotheses... that might explain future variations in biodiversity. We should also assess some potential alternatives to current policies. In our opinion, this should ideally be framed through the concept of Adaptive Management, as exposed during last year's conference by Nigel G. Yoccoz (see http://www.gencat.es/mediamb/bioplatform/bp2session_28.htm).

Of course, these three principles need discussion and amendment: for instance, it might be worth thinking about a nested monitoring design, with an intensive monitoring of habitats and a more extensive monitoring of species in habitats. We then turn to two contrasting botanic examples of gathering botanical species level data - in order to illustrate what is involved in the concrete application in the field, and to show how such undertaking can be possible: The first example is the field data collection for the impressive work by Grime et al. (1988): it is based on a rigorous protocol, and includes the measuring of ecological variables. It gives interesting, data-based results on the ecology of species, which could be incorporated into data analyses of monitoring; The second example is the endeavour of French researchers who collected as many botanical datasets as possible, as presented - in French - at http://jupiter.u-3mrs.fr/~msc41www/. Here the methods and variables measured are not standardized; yet, we think this kind of data gathering is also worth considering: it has a much broader scope than the previous one (area sampled, especially) at a lower cost; however, one must carefully think about the impact of non-standardization on the possible uses of such data. Such data gathering could include data collected in the course of the application of European policies. It could even go to the extreme of gathering places where species are present - with no information on their absence -, as typically happens with data from local natural museums or associations (cf. Hirzel et al. 2002).

We think a combination of both approaches could be worthwhile, if enough means are available. Many of the points we have made above coincide with previous contributions to the forum. However, we wonder why the idea of adaptive management is not more popular in our discussions. Is it judged unoperational? On the contrary, it is surprising that very frequently, operational plans for habitats managed for the habitat directive only propose one management strategy - supposed to be the best - and then simply verify that, under the applied action plan, the habitat has remained in a satisfactory state of conservation. Why not test different management alternatives?

As a conclusion, biodiversity monitoring at the European scale is welcome (see first session) and is probably possible. It should preferably be based on species-level data, and requires that a lot of thought be invested in defining which direction the monitoring will take - identification of objectives, questions, data analyses and experiments to be carried out. Biodiversity monitoring is a difficult task, but it may turn out to be feasible...

The use of full species lists in biodiversity monitoring- Richard Fischer, Federal Research Centre for Forestry and Forest Products (BFH).

SUMMARY: Regarding vascular plants, bryophytes and lichens in forests, full species lists presently seem to be the only feasible method for monitoring biodiversity at a pan-European level.

This is a reaction and confirmation to the proposal by Frederic Gosselin to focus on species information rather then on indicators, at least when talking about vascular plants in forests. Earlier in this conference, Pat Neville introduced the presently discussed extension of the ICP Forests Monitoring Programme into the field of biodiversity monitoring. Presently preparing the related feasibility study it seems to me that registering species data is the only possibility at the moment, simply because we do not have European wide approved lists of indicator species at the moment, but we have shown than we are capable of reporting species information from 700 Level II plots. And I also sustain that, along with the species data, we need environmental data that is also collected at the Level II plots. The species approach is also true in practice for mosses and lichens. Their species-wise reporting within ICP Forests has been made mandatory only this year and we will see whether there is enough national expert knowledge to present reliable trans-national results in a few years. If not, the "reduction" to the reporting of indicator species only might be necessary, but would on the other hand require lots of research work and coordination to define these species for different (biogeographic) regions or forest types. The species lists have another advantage: they are more flexible in the evaluation. If research results suggest new or changed indicators in the future, respective evaluations and presentations can be carried out based on the "old" species lists. The disadvantage is of course a bigger workload when assessing all species, but that has to be taken into account, at least for the present time.

The more we speak about monitoring the less we do it!!!- Jurgen Tack, Geert De Blust & Eckhart Kuijken, Flemish Institute of Nature Conservation.

SUMMARY: More than ever before, the science of biodiversity monitoring is running behind its end conclusions. We know that biodiversity is decreasing. But we still need the scientific proof, which is time and money consuming.

We are always surprised to hear and read (in the case of electronic conferences) how renowned researchers are trying to find a general methodology for biodiversity monitoring. It seems the main aim of *Homo sapiens scientificus naturalensis* is to find the unique scientific formula explaining biodiversity on a multitude of levels, in a multitude of ecosystems. To be honest we do not think we will ever find this formula. The different levels of biodiversity (genetic, species, population) ask for different approaches. By searching for a general methodology, scientists give policy makers and decision takers the illusion that complexity of life can be reduced to a single formula that would be easy to work with, but totally obscuring the real biodiversity world and hence a potential facilitator of disastrous policies and decisions. The real challenge is to keep the balance between indicators that are suitable and practicable for policies while at the same time do justice to the complexity of biodiversity.

In the search for a magic formula however, major funding agencies have foreseen increasing budgets for biodiversity monitoring. While everybody is searching for a more unified methodology, the result of the search for this methodology is leading to an increasing number of monitoring tools. The result up to now: more scientific papers on monitoring initiatives than ever before (we are not able to read them any more), more symposia and workshops on monitoring biodiversity than ever before (we are not able to attend them any more), and more meetings on monitoring biodiversity than ever before (we do not have the time nor the money to attend all of them). In the few hours left, the scientist with a serious interest in methodological aspects of biodiversity monitoring is trying to create new methodologies involving more and more technological support to compensate less and less monitoring in the field. The more we speak about monitoring the less we do it in the field. That is the dilemma!!!

Terrestrial ecologists more than their marine colleagues have found the solution: volunteers. Some of them better trained than their professional colleagues (who are always attending meetings and are never in the field) because they are able to focus on a specific aspect of biodiversity while researchers have to keep a general overview of what is happening in the field. Marine ecologists too can count on volunteers, but to a lesser extent except in the coastal areas: the accessibility of the area being much lower, technical equipment needed and the vast area of their study field. This can probably explain why marine ecologists are better organised than terrestrial ones. But they too are struggling with the same questions. The Marbena electronic conference comes to the conclusion that up to now there are not really answers to the questions asked. Strange, because we know some very good indicators: our grandparents. They can evaluate a more than ninety year memory record without technological or statistical tools. They were once able to swim in our lakes, to fish in our rivers, to see birds our children will never see in the same place. They do not need a unique formula to tell the audience of this electronic conference that biodiversity is decreasing. But they do not have to take into account other social aspects and they do not know the pressure to produce facts and figures for policy makers. But they realise more than most researchers that over 3/4th of the policy questions can be solved with the existing knowledge. And the remaining questions should not be used as an excuse not to tackle the existing biodiversity problems.

Monitoring with pragmatism - Romain Julliard, CRBPO.

SUMMARY: It is argued that coordinating the enormous amount of local monitoring initiatives may be a good solution, and better than looking for the best one.

Much of the debate has, up to now, turned around looking for the best (set of) indicator. We know pretty well what such an indicator should indicate, and in particular, that it should operate at a large scale (European, no less) and on the long term. This basic feature is worrying because it hinders any attempt to test a priori the usefulness of an indicator on the long term and on the large scale: we will know if it is indeed useful afterwards, in ten years after it has been implemented in many countries. The commitment of adopting an indicator is thus enormous. What if it turns out that the chosen indicator is not appropriate? Given the complexity of biodiversity, it is already certain that some respectable scientist will tell us that we were wrong implementing such an indicator in the past and that we should have chosen another one.

Whatever our decision of choosing or not a set of indicators, an enormous amount of monitoring will occur at the local scale: almost all protected areas attempt to monitor the fate of biodiversity. Natura2000 sites should also come up with local assessment of management. This local monitoring effort also concerns agro-environmental actions, which will be increased manifold with the reform of the common agricultural policy. If these countless initiatives are not coordinated from the beginning, they will be lost for us (by us, I mean those interested by large scale monitoring of biodiversity). It is indeed hopeless to gather monitoring data afterwards: basic information such as how and why monitoring was conducted get lost at an incredible speed. Earlier in the conference, my colleague and myself suggested that a partnership between a national coordination and local monitoring initiatives by volunteers had great potential. This is all the more true when coordinating monitoring by practitioners. They are keen to adopt a more or less standard protocol, and they easily understand that they benefit from participating to large scale monitoring since it enables them to separate local from larger scale variation of biodiversity. Interestingly for the national coordination, monitoring from various managed areas is hence gathered, allowing a straightforward evaluation of the response to management. If the national coordination is efficient, it will quickly gather an enormous quantity of data, from various habitats, species groups, etc. Virtually all that is possible to monitor, is monitored. The question of selecting or defining an indicator is not necessary in that context.

Such coordination requires research (i) on how to monitor (sampling and field implementation) while keeping in mind that any suggestion should suit both local managers and national coordination, (ii) on how to estimate variation of biodiversity at various scales of time and space, and (iii) on how biodiversity functions at large scale and on the long term in order to make predictions. This is a very pragmatic solution for monitoring, but sometimes, the good may be better than the best.

MARBENA e-conference: Monitoring approaches strategies and indicators - Alf Josefson, National Environmental Research Institute.

SUMMARY: The necessity to monitor marine biodiversity was recognised by all contributors to the discussion. There were however different opinions on how to monitor. The question of whether a general methodology for biodiversity monitoring is possible for high and low diversity systems remained largely unanswered. It was emphasised by some people that marine biodiversity work, to a greater extent than before, should focus on functional aspects of diversity. Knowledge of functional relationships enables us to assess effects on the ecosystem of species loss or invasion. It was also stressed that that the work to identify indicators of diversity should continue and be intensified. After a slow start, a fair number of contributions were posted from people with experience from the Mediterranean to the eastern Baltic area.

1. Should we monitor at all even if we only can register a fraction of the total diversity?

The answer to this question was a clear yes. The reasons given varied between different contributors. Although one contributor suggested that existing monitoring programmes could take care also of biodiversity (Anda Ikauniece), most contributors suggested different new approaches. It was stressed by Ferruccio Maltagliati that diversity on several ecosystem levels both species level and individual/population level should be monitored, and he called for methods (i.e. statistical ones) to compare different levels of biodiversity. Herman Hummel stressed the importance of study coupling between diversity and ecosystem function, and so did the chair. He also emphasised the use of indicators to meet the needs of managers and politicians, even if they did not reflect total biodiversity. For the case when they do not reflect total diversity, the consequences for the ecosystem and society of the discrepancy should be investigated.

2. What should we measure and where? Are there indicators of diversity?

It was thus agreed that we should monitor biodiversity, but clearly we cannot monitor every aspect of biodiversity. What parts of the ecosystems should be monitored? Johanna Wesnigk suggested to start with habitats where the threats were known, and to focus on key organisms. Anda Ikauniece suggested monitoring of key organisms like the bladder wrack (Fucus) as an indicator in shallow areas of the Baltic. There were also further examples of possible habitat forming organisms in the Baltic area and the question of whether monitoring should be restricted to such organisms was raised. However, there was a general perception that determination of species was unavoidable when monitoring diversity. An example where species determination of species, both meio- and macrofauna, is necessary was given by Emil Olafsson with the effect on meiofauna diversity of the macrofauna invader Marenzelleria. There was some discussion about whether or not the diversity of a single organism group could reflect overall biodiversity. Emil Olafsson pointed to the fact that in some areas of the Baltic, the macrofauna was extremely species poor, while meiofauna was rich in species, and suggested further studies of diversity in macro-, meio- and microbial communities using T-RFLP genetic fingerprinting. A message by Jean-Pierre Feral described the work in WP2 of BIOMARE on bioindicators of diversity changes. A detailed account of the bioindicator concept was given and it was proposed to use pressure indicators and response indicators as they stand in the literature and to link them with national and European policies. The efforts were focused on the sorting of state indicators, indices and set of species.

3. What determines the appropriate scale of a monitoring program?

The fact that many marine organisms have good dispersal abilities, and that marine environments have relatively small physical barriers started the basis to discussion of monitoring on a large spatial scale. However, Emil Olafsson pointed out that certain groups of organisms (e.g. free-living marine nematodes) have rather restricted dispersal abilities, and suggested that monitoring only on a large scale could be misleading. In a general message, Jean-Pierre Feral informed us about the BIOMARE concerted action, where a large scale (and long term) approach have been taken to assess changes in biodiversity.

4. How do the target and the environmental pressures determine monitoring?

The question of whether different monitoring approaches should be adopted depending on biodiversity compartment and environmental problem was also raised.

Johanna Wesnigk pointed out that anoxia in the deep Baltic Sea was not a problem for diversity of microbial communities, while it could be a problem for macrofaunal diversity. This illustrates that the same environmental problem may affect target diversity differentially between different organism compartments.

5. How does diversity determine the monitoring approach?

Should we have different approaches for monitoring in high and low diversity systems? There was not really any direct response to this question, however Christian Altaba, in a general response suggested different approaches in the Baltic than in systems with higher diversity.

Session and title of contribution	Contributors
Concluding contributions	
Predictive modelling may improve political relevance	Erik Framstad
Ensuring biodiversity monitoring is policy relevant	Melanie Heath
Overview of biodiversity monitoring	Konstantinos Spanos
Integration of scientific monitoring into conservation policy	Riccardo Simoncini
Political cut-offs and biodiversity monitoring	Ben Delbaere
Monitoring is required for planning and development	Helena Freitas
Improving scientific discourse in biodiversity monitoring	Andreas Troumbis
Developments in monitoring biodiversity	Hermann Ellenberg

Predictive modelling may improve scientific basis as well as political relevance of biodiversity monitoring- Erik Framstad, Norwegian Institute for Nature Research.

SUMMARY: The author discusses the need for harmonisation of monitoring programmes using unifying frameworks represented by generic models.

Biodiversity by its very nature is multi-dimensional and complex, encompassing a multitude of species and complex webs of interactions. To monitor even a small part of this multitude, to discover real changes and to communicate clearly about any such changes, is almost beyond the possible. Nevertheless, if we don't succeed in giving clear messages to society about the changes occurring in biodiversity and about their causes, remedial action will be largely based on trial and error and the current rapid decline in the state of biodiversity can only be expected to accelerate.

Science-based monitoring should rest on two pillars, an underlying understanding of the mechanisms involved in how natural and anthropogenic causes affect biodiversity, and stringent sampling procedures for getting reliable data. We generally lack sufficient understanding of underlying mechanisms. Funding and human resources are also utterly insufficient for reliable monitoring of more than rudiments of biodiversity.

Hence, we need to take an adaptive approach to monitoring, based on combining results and understanding from a range of on-going as well as new programmes. This certainly entails a great need for better harmonisation, but we also need to be able to work with current heterogeneities in coverage and lack of standardised parameters and methods. To do this we need to develop unifying frameworks that may integrate our disparate data and help us develop our understanding. Generic models linking biodiversity to natural and anthropogenic factors that significantly influence changes in biodiversity will represent such an integrative framework. Such models will at first be very crude and provide only the roughest predictions of development in biodiversity. However, by using models as a framework, we will be forced to learn more about the dynamics of the systems involved and to gather relevant and more reliable data to test our model predictions. In so doing, we will also improve our ability to communicate about the development of biodiversity to society.

I would therefore argue strongly for more emphasis on underlying mechanisms in designing monitoring programmes and in interpreting recorded changes in biodiversity. Generic models will be useful tools in developing our understanding about mechanisms, in designing effective monitoring and in communicating the results to the public.

Ensuring biodiversity monitoring is policy relevant- Melanie Heath, BirdLife International.

SUMMARY: The author acknowledges the importance of biodiversity monitoring and its challenges, the need to maximise the usefulness of data generated at different levels, and the Pan- European Bird Monitoring Strategy.

Undoubtedly monitoring biodiversity is essential. We need to understand what is happening to biodiversity and adapt our interventions appropriately. We need to detect and act on threats in good time and assess the effectiveness of conservation efforts being undertaken. There are many policies at national and international levels across Europe which impact biodiversity in both positive and negative ways. We need to understand the impacts of these policies, feed this better understanding into monitoring policy effectiveness and also use this knowledge to further their development. To be most effective we need to simplify the messages coming from monitoring programmes through the development and implementation of simple sets of targeted indicators that demonstrate change.

As has been emphasised several times during this conference comprehensively, monitoring all biodiversity is not an easy task. Also, agreeing a set of indicators which are scalable at national and international levels present some difficulty and much debate, but is essential. We also currently struggle as we are far from having complete monitoring of all biodiversity across Europe - but as we have learnt in this conference there is a great deal of biodiversity monitoring and indicator work going on telling us about the state of bio diversity, the pressures it faces and the responses being undertaken.

Different schemes have varying strengths. It is clearly not sensible or pragmatic to consider combining these numerous efforts into a single scheme. However a challenge must be for managers of monitoring programmes and users of these data to work together to maximise the usefulness of data generated from the different schemes and particularly to 'bridge the gap between those who collect data on biodiversity and those who need information in a format that helps them to make decisions'. Collaboration in the field of indicators and monitoring is increasing and some convergence is evident. Initiatives taking up this challenge to improve collaboration include the European Biodiversity Monitoring and Indicators Framework initiated under the Pan-European Biological and Landscape Diversity Strategy and an informal international working group for coordination and collaboration on biodiversity monitoring and indicators (IWG Bio-MIN) set up by the European Environment Agency.

We should also recognize that as we do not have monitoring data on all elements of biodiversity, monitoring programmes on certain taxa may be used to demonstrate biodiversity change, at least until comprehensive data on all taxa are available. Some seminal work in this area has been carried out on birds. Bird indicators are likely to form an important component of sets of indicators for biodiversity and habitats. BirdLife International is developing a Pan-European Bird Monitoring Strategy which aims to develop good quality Pan-European monitoring and assessment of the state of birds and their critical sites in Europe, the pressures acting upon them and the actions being taken to conserve them. The programme will develop policy relevant bio-indicators for Globally Threatened Birds, Important Bird Areas and the wider European environment as a whole. Indeed this work on common bird monitoring and the development of composite Pan-European bird indicators advanced considerably at a European Bird Census Council/BirdLife International workshop held just this week. A first attempt at generating such indices for individual species and Pan-European multi-species indicators will be published in 2003.

It is also important to consider the need for global headline indicators of biodiversity that accompany human and economic indicators to give a clearer picture of whether development is truly sustainable. Three organisations, Oxfam, the New Economics Foundation and BirdLife International launched a report at the recent Earth Summit proposing 10 headline indicators to measure national and international progress towards sustainable development.

Overview of biodiversity monitoring- Konstantinos Spanos, N.AG.RE.F. - Forest Research Institute.

SUMMARY: Most of the contributions on Biodiversity Monitoring E-conference covered in an excellent way the overview of the different topics raised. In this Summary some general hot topics will strengthen the overall overview of monitoring of biodiversity. These important topics are always open for discussion. We have to look for and give scientifically based answers/solutions to these highlighted topics under a sustainable balance between nature and man.

Biodiversity is not a fixed term, it is rather complicated in definition, it is not a standard status but rather a dynamic cluster of components, functions and human life/culture. Biodiversity levels can change periodically (fast/slowly) due to catastrophic natural processes, long-term nature/earth evolution and human activities. Therefore, in many cases it is preferable to talk about biodiversity dynamics and the monitoring should take this dynamic status into account. Monitoring of biological diversity is not only the recording the reduction/increase in rating levels of the study indicators. The dynamic status of biotic and non-biotic components and functions/processes and their relation with human activities (including cultural components) should always be considered. Man has been born in and lived with nature for millions of years, and being a part of nature has developed strong relations with the mother earth (cultural and religious aspects).

An important strategy when monitoring biodiversity is the objective of monitoring. A well-defined monitoring of biodiversity needs a well planned methodology and defined objectives. Why do we monitor biodiversity in natural ecosystems and compare it to agroforestry systems and also to urban environments? Different ecosystems/systems require different monitoring objectives (scientific, environmental, economic). Well defined objectives of biodiversity monitoring will save time, will be relatively cost effective and will give scientifically based answers to policy and decision makers.

Evolutionary factors and processes (gene flow, mutations, immigration, environmental changes, catastrophic events) are in continuous change and can strongly affect biodiversity levels. In the long history of life on Earth, many species have been lost and new species have been developed. Evolutionary factors and processes may increase or decrease biodiversity, and therefore in many cases, loss of biodiversity might be due to such factors/processes. Biodiversity monitoring should always consider the history of the ecosystems/systems and possible future evolution (dynamics, succession, environmental changes, human activities).

Genetic diversity (species, subspecies/races, varieties, genotypes) and genomic diversity (genome) is the material on which all other forms of biological diversity are built. Intra-specific genetic diversity (heterozygosity levels, allele frequencies, relatedness) and the factors/processes affecting it (pollen flow, seed dispersal, reproductive biology including sex ratio, pollination, mating system and incompatibility, inbreeding and genetic drift) are possible to estimate/monitor in natural ecosystems and human made/affected systems. Genetic and gene diversity is not a stable status but rather represents a dynamic status. It is important in monitoring biodiversity always to start from the study/monitoring of genetic diversity. We know that the number of species is an important indicator in evaluating biological biodiversity, but it is important to know the intra-specific genetic variation too. Many subspecies/races, varieties or genotypes locally adapted to different environments, covering a wide range of uses, have been lost or have been substituted by a few commercial varieties or clones (narrow genetic base). It is known that some part of genetic diversity will inevitably be lost, but sustainable management of biological resources with close to nature actions will preserve most of the existing diversity

Biodiversity monitoring is urgently needed in natural/agroforestry/urban environments, which are much affected by human activities (air and water pollution, climatic changes, global warming, including war impacts). In such cases monitoring of biodiversity seems rather easy due to large differences in the indicator-levels. However, it is highly important when these systems are compared (using various indicators- emphasis given on microflora and microfauna) with the close to natural or less affected ecosystems (for monitoring biodiversity levels). Such a well-defined comparison will give scientifically based information on the negative impacts of human activities on biological diversity.

From the practical, scientific and realistic point of view, biodiversity monitoring should be well planned and be applied to specific sites/ecosystems defined by the objectives of monitoring. It is not possible to monitor all natural ecosystems/habitats and all agroforestry and urban systems. It is more advisable to establish a net of experimental plots representing different cases. A well-defined strategy, planning and methodology with widespread experimental plots, statistically designed and determined, will be much more useful and cost effective. Additionally, such a strategy of monitoring will be much easier passed to the policy and decision makers.

It is the duty of scientists working on biodiversity to highlight and pass their knowledge and scientific conclusions to the responsible policy makers and politicians (at the national and international level). We know that for policy and decision makers it is worthy to relate biodiversity with human activities and man. Monitoring of biodiversity should always be based on sustainable development, giving the priority to human life.

Integration of scientific bio-monitoring into development of biodiversity conservation policy- Riccardo Simoncini, University of Florence.

SUMMARY: The author argues for the integration of scientific research and biodiversity conservation policy making. He suggests four major steps towards integration: improved communication, appropriate indicators, ecological baselines and integration of biodiversity functioning.

Abruptly speaking, two overall scopes can be identified in bio-monitoring. One is to increase scientific knowledge through the assessment of the status and trend of biodiversity and the analysis of the functioning of ecosystems complexities. This scope is the domain of scientists.

The other scope is to provide useful information and guidance to policy aimed at conserving biodiversity, through the assessment of impacts (positive and negative) exerted by socio-economics sectors activities (i.e. pressures) and of environmental policy on biodiversity conservation. This scope sees the involvement of different stakeholders such as resource users and managers, politicians, general public and scientists.

The two scopes are obviously not separated seeing as the first is supposed to supply information to the second and the second to provide feedback to the first (e.g. promoting scientific research on understanding the impacts of a certain agricultural practice on the status and trend of biodiversity).

In order to develop a core programme of monitoring, more attention should be addressed to the integrate the first scope of bio-monitoring (i.e. scientific research) and the second scope (i.e. biodiversity conservation policy).

Amongst the aspects to be considered at least 4 seem very important:

- Pointing out the usefulness of conserving biodiversity and therefore of monitoring it; relevant stakeholders need clear explanations as to why monitoring has to be carried out. Resource users and politicians use an anthropocentric and utilitarian paradigm to look at the world. Communication from scientists to stakeholders has to be done in the language spoken by these actors for it to be understandable. Associating bio-monitoring to ecosystems components and functions which directly or indirectly provide environmental goods and services to humans, can be a useful step in this direction also putting into consideration (and stressing) the complexities of biodiversity to stakeholders.
- The indicators used in bio-monitoring have to be feasible (manageable, cost-effective, responsive, sensitive to the relevant scale of analysis, etc.) to be used in assessing biodiversity status and trend, implementing policies and evaluating their effectiveness. This implies that stakeholders have to be provided with some bio-monitoring tools that are within their understanding and implementation capability whilst at the same time maintaining the scientific soundness of bio-monitoring. As difficult as this may be, it is probably the right

approach to allow monitoring activities to be carried out, (at least partially) by those who are responsible for using biodiversity (e.g. farmers and administrators) and to create an environmental culture amongst these stakeholders.
- Ecological objectives and targets (i.e. baselines), against which impacts and environmental policy effectiveness have to be assessed. These also have to be clear and transparent for bio-monitoring to be useful. Given the lack of scientific knowledge for many ecological aspects it is understandable that scientists are very cautious to indicate these, however it is important to be aware that without proposing at least indicative baselines (applying the precautionary principle) for monitoring biodiversity conservation, it is very likely that policies on the use of natural resources would fix very general and evasive ones or not fix baselines at all.
- Co-ordination of bio-monitoring activities and integration of results has to be carried out to better understand inter-relationships among different scales of analysis, different ecosystems and different socio-economic sectors, in order to formulate appropriate biodiversity conservation policy and to indicate where further scientific research is needed. An example maybe that, for instance, by monitoring impacts exerted by local agricultural activities on biodiversity of an agro-ecosystem which is surrounded by wetlands, we could determine the areas that are on an important migration route for birds coming from a different part of the world. Following this example, bio-monitoring in this case has to be developed in relation to local agro-environmental policy and multilateral international agreements on wetlands.

Political cut-offs and biodiversity monitoring- Ben Delbaere, European Centre for Nature Conservation.

SUMMARY: This contribution looks at the importance of political decisions as regards the desired state of biodiversity and its relation to implementing biodiversity monitoring programmes.

This e-conference looks at science-based monitoring, as indicated in the title of the conference. Numerous contributions have stressed the importance of targets and objectives, including from policy, when developing monitoring programmes. Looking at the European level, one should therefore start from the objectives as laid down in the international policy instruments of relevance to biodiversity conservation, even if their reporting obligations don't require information on trends in biodiversity per se (cf. Smith & Newton). These objectives will form the basis for identifying the level of biodiversity that you compare your monitoring results with (referred to as baselines, targets or reference level in the current e-conference).

When taking the example of the EU Strategy for Sustainable Development, one of the objectives is 'to halt the loss of biodiversity by 2010'. If we were to translate this into a measurable target, this means that the level of biodiversity in 2010 is the reference value, the point in the curve where the downward trend in Europe's biodiversity is turned into an upward trend. Apart from the question whether this means that one accepts further loss of biodiversity (extinction of species, loss of habitats, loss of genes) in the coming eight years, it is clear from the contributions that no simple method exists to date that will allow us to identify this turning point.

One could also argue that the year of adopting the Sustainable Development Strategy, 2001, is to be regarded as the reference to which you compare further trends until 2010 and beyond. Comparing the annual state with the value in 2001 would provide a powerful tool for policymakers to assess whether their objectives will be met in time.

Whichever year is selected as a reference (I do not want to open the baseline discussion here), the point is that political cut-offs are used as a basis for interpreting monitoring results. This is in line with the need for thresholds and the need for interpretation and context information, as stressed by Rainer Muessner. Indeed, this requires political decisions and involvement of a wider range of stakeholders representing a variety of societal interests. Also, it is likely not to be accepted by the scientific or conservationist communities. However, we must urgently provide decision makers with answers to their questions if we don't want them to lose interest in biodiversity conservation. Therefore, using one of the statements at last week's IWG Bio-MIN meeting (cf. Richard & Condé and my previous contribution), we should have the guts to test an aggregated and simple indicator, such as the Natural Capital Index as proposed by ten Brink, and use the bottom-up data flow from local data collectors to international reporting while at the same time providing scientifically sound interpretation of results presented with a convincing and simple message to the decision makers. Meanwhile, nobody will stop us from improving indicators and monitoring programmes on a scientific basis.

Inventory report on biodiversity indicators and (soon) on monitoring networks on:
http://nature.eionet.eu.int/activities/products/indicators/

Monitoring is required for planning and management- Helena Freitas, University of Coimbra.
SUMMARY: We need a European core programme for monitoring biodiversity, as well as a set of indicators clearly assumed in the European Biodiversity Strategy. The programme should include regional and local monitoring schemes, scientifically driven but designed at the appropriate scale, easily interpreted by local and regional planning and management.

This exceptionally lively e-conference showed well the importance of the topics that have been covered. We all experience the need to promptly set up improved tools to preserve biodiversity and we all agree that the development of monitoring programmes to show the status and trends of biodiversity conservation in Europe are urgently needed.

Several e-participants also brought up the need to expand the current international frameworks, and include not only principles and aims but also evaluation processes. Likewise, we obviously need to solve the problems of scale of monitoring and to develop the proper set of indicators for different scales, but one thing is positive: while we argue between - using Thomas Nilsson words – “the complexity of nature emphasized by the scientists and the simplicity/overview emphasized by the policy-makers and politicians”, we are loosing European biodiversity and we don’t even know how many species or habitats and at what rate (not to mention aspects like functional implications or population viability).

Unfortunately, in many Natura 2000 Sites, somehow representing the EU biodiversity hotspots, habitats are being degraded or eliminated, and populations are increasingly fragmented and threatened due to the lack of monitoring (or its application) in the very basic and local management plans. In these sites, for which management plans will probably be developed by local administrative authorities of the different countries, the conditions to keep the “favourable status of conservation” as requested by the Habitats Directive (whatever this means), are yet to be defined and they cannot be done without specific monitoring programmes.

In my opinion, we do need a European core programme for monitoring biodiversity, as well as a set of indicators clearly assumed in the European Biodiversity Strategy, but it should be open enough as to include the development of regional and local monitoring schemes, scientifically driven but defined at the appropriate scale to be used by local and regional planners and managers. The description of such schemes should be easily interpreted by local and regional planning. This is crucial to preserve biodiversity.

Improving scientific discourse in biodiversity monitoring- Andreas Troumbis, University of the Aegean.
SUMMARY: The author discusses some potential weaknesses of the biodiversity monitoring argument and proposes some key points that might increase the robustness of the scientific discourse regarding biodiversity monitoring.

The debate during this E-Conference has offered a multitude of evidence and arguments that support the need for sustained effort in biodiversity monitoring across spatial and temporal scales of biodiversity components and across the various levels of biological organization and taxonomic groups. Furthermore, it has been pointed out that monitoring should extend over natural and man-made or –driven ecosystems. Sampling, organizational and collaborative aspects to create a future large scale and coordinated scientifically efficient and policy relevant biodiversity monitoring plan have also been discussed.

The core argument of most contributors is that monitoring is "essential to identify priorities for action, define the actions and carry them out" (e.g. see P. Rose's contribution). I want to elaborate on this, identify some potential weaknesses –to my understanding- of the argument and propose some key points that might increase the robustness of the scientific discourse regarding biodiversity monitoring.

* Epistemic niche: the argument describes what can be called a 'conservation chain', linking theory to observation and measurement, to planning, to implementation, to alternative dispute resolution. The knowledge of the current status and the trends of biodiversity is indeed a prerequisite for both theory testing (at the one end of the chain) and management (at the other). In that sense, it occupies a central niche in this epistemic process. Furthermore, monitoring is necessary to control the efficiency of management plans and conservation policies. However, one can see (or misinterpret) in some parts of the debate, a vision of monitoring as a self-defined and ultimate scientific process that has the potential to address the entire 'chain'. I concur with the arguments developed by E. Berge, in other words that a successful, large-scale monitoring scheme should clearly state its epistemic limits and its interdependencies to the other components of the 'chain'.

* Scientific method: by definition, monitoring, no matter what the complexity of sampling techniques and strategy, is an a posteriori 'measurement' of state variables of the biotic environment. As a descriptive method, it fails to comply with the scientific process of falsification (i.e. theory testing, hypothesis, experiment, confirmation or rejection) upon which natural science is founded. However, to reach its primary policy-relevant goal (i.e. to relate change of biodiversity to man-generated changes in use and quality of the abiotic environment), monitoring has to establish a clear scientific method, where causation should follow from the confrontation of data and a range of alternative models/hypotheses: the selection of the 'best' model may lead to the building of an explanatory scheme, necessary for policy-making. I maintain that monitoring should explore all the hidden potential of Bayesian statistics in order to define the clear path connecting observation/measurement to mechanism(s), and therefore to conservation planning and strategies.

* Integration: it has been said eloquently that the strategic axes for biodiversity science are: 1) to catalogue life, 2) to monitor change and 3) to study the functional role of biodiversity. Monitoring is not only about change. It is also about cataloguing the biotic richness in an area, in the sense that it offers the link between the taxonomic investigation and the understanding of the ecological structure –and function- of higher levels of biological organization. This implies that monitoring should address both infra- and supra- species level entities, and should develop 'units' or 'indices' that integrate the environmental 'context', the biotic 'content' and the functional 'structure' of biodiversity.

* The framework: the design and operation of a core international monitoring scheme in Europe should take into account 4 key determinants of success:

1. Opportunities, resulting from societal and governmental commitment to biodiversity conservation
2. Constraints, arising from administrative incompatibilities and physical and cultural variation among individual countries
3. Facilitators, produced by existing scientific excellence and infrastructure capacity
4. Barriers generated by the still persisting mismatch between science emphasis and policy needs.

Developments in monitoring biodiversity- Hermann Ellenberg, Federal Research Centre for Forestry and Forest Products.

SUMMARY: According to the definition of bioindication and biomonitoring, co-ordination of efforts (time, space), standardisation of methods, and calibration of results are required. On this basis, interpolations and some extrapolations are possible from defined reference conditions. This needs continuous scientific support. Monitoring cannot predict changes, only

sensitive observation of possibly sensitive species or populations can. Also EU-scale monitoring at the end needs stratification. Can we measure trends in species density by looking at the travel distances in order to find a given set of species a hundred years ago or today? Could we make the land users themselves take responsibility for monitoring diversity on their land?

Bioindicators are organisms or other living systems that – by their simple presence and/or their easily observable behaviour (reaction) - provide opportunities to "detect" the status and/or trend of parameters in their environment. The presence and/or reaction have to be correlated closely enough for these parameters to make them suitable as "pointers" (indicators). As such, they are triggered by a variety of parameters. The "close-enough" correlation, therefore, has to be proved explicitly before using a bioindicator.

Biomonitoring means the systematic use of bioindicators for documentation of spatial and/or temporal trends in their presence and/or behaviour. This requires the co-ordination of efforts (in similar conditions, simultaneously at many places), the standardization of methods and the calibration of results by means of an independent measure (or definition).

So, bioindication provides possibilities to express hypotheses about "background" parameters and their intensity; biomonitoring is for interpolation and extrapolation (but not too distant!) over otherwise measured or defined information networks, may it be only in order to detect that something goes wrong – or cannot be explained. In this case, research efforts are to follow, focussed on detecting the causes and distinguish them from natural "noise". Think of the many years of research necessary to understand the pesticide syndrome in raptors. The most suitable, cheap and available indicator here proved to be eggshell thickness – but only in a gradient of measured loads of chlorinated hydrocarbons could it be interpreted as not being a normal reaction to specific food shortages. Similar reasoning is true with the bioindication and biomonitoring of "forest decline" since the 80s by looking at leaf or needle losses and discolorations.

What do we want to monitor – from a political point of view ?

If we want to monitor the impacts of "global warming" on biodiversity and the efficiency of political activities for its mitigation, then we have to take care that political activities really had a (physically) measurable effect – as well as check that the presence or disappearance "movements" of sensitive species are not caused by other reasons. The same reasoning exists for acidification or eutrophication.

- What does an indicator of biodiversity really indicate? Plants at ground level in forests react to light availability, soil disturbance and soil compaction due to forestry activities. Does that mean that forestry is triggering a higher diversity? At the same time, the obvious disappearance of dead wood at large scale – as triggered by effective forestry - causes the disappearance of many fungi and insects. This easily measurable "indicator" nevertheless has to be "calibrated".

Monitoring cannot predict changes in parameters. Only sensitive observation of well-known populations that probably are exposed to expectable changes can.

EU-scale monitoring is good to consider, but at the end stratification is inevitable, as the main feature of biodiversity is its difference under different living conditions in northern, southern, western or central Europe.

Many specialized and dedicated societies exist for ornithology, botany, lepidoptera, molluscs etc. Most of them have detailed knowledge on distribution and trends of their subjects. Plenty of individual publications exist on the presence of biota in given landscapes over time. How should we use them? An indicator could be the travel distance to find a defined number of species at a given time: most "old" researchers were capable of finding the species at walking distance from their homes or by riding a bicycle. Today we need a car to reach the few dispersed sites where these species still occur.

We could think of giving the "responsibility" for monitoring to the land users, foresters or farmers associations. Many dedicated person exist here, and they are by their activities triggering most of the biodiversity present in their areas. In case they require subsidies for better land use, they have to prove the effectiveness of their management to “better” biodiversity. They should need the help of trained biologists to select the species and methods and also to supervise the monitoring.

Any of us working on biological systems (in the field or in the lab) is capable of interpreting observable “reactions” of his/her system in the context of the environmental conditions and to derive hypotheses about possible causes for the “reaction”, that have to be checked … we are even capable of predicting many reactions from the knowledge of a certain context. But we are also aware of the fact that similar or equivalent reactions may be a consequence of quite different causes such as the needle losses in conifers that may be related to deficient water supply or to “acid rain” or to eutrophication via the air or to insect/fungi attack, and all these causes may be interconnected somehow. That’s why, besides definition, co-ordination and standardisation of bioindication and monitoring – calibration is necessary. I like the “nested approach” with plots of high scientific inputs – as suggested by some of the participants to this e-conference.

Monitoring Biodiversity: a social scientist’s point of view - Jacques Weber, Institut Français de la Biodiversité (IFB).

SUMMARY: This E-conference is very rich and has been a good university for the social scientist trying to understand biodiversity issues in an interdisciplinary process. I would like to focus on policy makers and scientists regarding the question of monitoring.

Let’s start with Thomas Nilsson’s contribution: «scientists on the one hand emphasize the complexity of nature and scientific uncertainty, and the policy makers and the politicians on the other hand emphasize simplicity and overview». As soon as we consider the two approaches as legitimate, it becomes possible to explore some «lateral thinking» ways for monitoring biodiversity. No doubt the scientists need complex sets of data, exhaustive if possible. The contributors to the E-conference provided a lot of information and analytic views regarding monitoring. Some emphasised the monitoring lato sensu, others pointed out the need and the difficulty to monitor interactions and dynamics, considered to be the core issue of biodiversity monitoring. The policy maker and the politician deal with another set of complexity and uncertainty, as illustrated by the geopolitical situation since September 11. Their challenge consists in managing the long term on a short-term basis: it is all but simple. Biodiversity is one issue amongst many to be taken into account in public decision-making. It is clear that the need, here, is for «simplicity and overview», although the policy maker is aware of the complexity of nature.

Assuming the legitimacy of both constraints and needs, we have to conclude that

1. Scientists need the monitoring of (i) species; (ii) landscapes and land use, including agroecosystems; (iii) other data
2. Scientists need to build a set of indicators to follow, indirectly measure, and compare, (i) dynamics of interactions between species over space; (ii) dynamics of interactions between biodiversity and the impacts of human decisions.
3. Policy makers need a core set of indicators that provides an overview of the trends in biodiversity and its potential economic and social consequences.

I suggest creating working groups made up of scientists, policy makers, specialists of monitoring from environmental agencies, members of Civil Society, in order to design socially accepted indicators of biodiversity situation and trends. By «socially accepted» I mean a set of indicators, which could not be relevant from a scientific point a view but which may constitute a common reference for evaluating the trends. An example is the Prices Index. It has a very weak relevance from an economic science point of view; but it works as a common reference for decision making (minimal guaranteed salary etc.). This system of core indicators can be documented by the network of scientific monitoring, and cannot replace the scientific system of indicators. But it may help to fund the scientific monitoring.

A question came to me: it has been shown that specific public or private decisions, like a fiscal incitation, may have dramatic consequences on biodiversity (like pioneer fronts).

Can we consider monitoring of biodiversity separately? And if we must take such decisions into account, « how to monitor » becomes a little more complex!

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