

Auditing the Ark

Science based Monitoring of Biodiversity



Report of a Electronic Conference, September 2002

BIOpatform

EPBRS EUROPEAN PLATFORM FOR BIODIVERSITY RESEARCH STRATEGY



Danish Biodiversity Platform



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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 Feast (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 Hagemeyer, 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 Danish 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 known 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 Muesner (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 programmesⁱ and indigenous knowledgeⁱⁱ.

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. UNFCCC 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
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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^{xxx}, 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.

ⁱ See Richards, Kenward; Ellenberg; Tack, De Blust & 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; Hagemeyer; 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.

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

Session and title of contribution	Contributors
<i>Biodiversity monitoring: Towards a functional approach</i>	Peter Veen
<i>Biodiversity monitoring needs in rivers</i>	Scot Mathieson
<i>Challenges for monitoring biodiversity in the Water Framework Directive</i>	Laurence Carvalho
Session 2. To discuss some existing and planned monitoring programmes and identify their strengths and weaknesses.	
<i>Introduction to the second session</i>	Allan Watt, Chair
<i>Lessons from the French breeding bird monitoring programme</i>	R. Julliard & F. Jiguet
<i>Advantages and challenges arising from amateur monitoring</i>	Caspian Richards
<i>Innovative approaches to monitoring and conserving biodiversity</i>	Robert Kenward
<i>European site-based monitoring: An illustration</i>	Ben Delbaere
<i>The development of biodiversity indicators within the MCPFE</i>	Tor-Bjorn Larsson
<i>Forest biodiversity monitoring under discussion in Finland</i>	L. Saaristo & J. Niemelä
<i>Environmental objectives and indicators- The Swedish example</i>	Thomas Nilsson
<i>Reply to "Environmental objectives and indicators"</i>	Frederic Gosselin
<i>Landscape and biodiversity monitoring in Estonia</i>	K. Sepp & A. Roose
<i>Biodiversity and protected areas in Romania</i>	Simona Mihailescu
<i>Monitoring routes in the Dutch province of Noord-Brabant</i>	Jan Jansen
<i>Methods used in cross-cutting baseline estimates</i>	Alan Feest
<i>Criteria for selecting species-level indicators of biodiversity</i>	Jari Niemelä
<i>Biodiversity indicators of sustainable development in Scotland</i>	J.D. Wilson <i>et al.</i>
<i>The Pan-European bird monitoring scheme</i>	R.D. Gregory & P. Vorisek
<i>Successful workshop in Prague</i>	W. Hagemeyer <i>et al.</i>
<i>The new directive on Strategic Environmental Assessment</i>	Arnau Queralt
Session 3. To identify some developments in monitoring biodiversity and the advantages they offer	
<i>Introduction to the third session</i>	Allan Watt, Chair
<i>Existing forest monitoring programmes- Building on the legacy of the past</i>	R. Bradshaw <i>et al.</i>
<i>FOREST FOCUS, a new European monitoring scheme</i>	Etienne Branquart
<i>Reply to "Forest Focus, a new European monitoring scheme"</i>	Pat Neville
<i>Establishing a common framework of biodiversity monitoring</i>	Alan Feest
<i>Development of biodiversity indicators and monitoring- the MacMan project</i>	Josef Settele

Session and title of contribution	Contributors
<i>Using mound-building ants as a model system</i>	P. Bliss <i>et al.</i>
<i>Auditing the ark- thoughts about terminology</i>	P. Bliss <i>et al.</i>
<i>Innovative approaches to monitoring and conserving biodiversity</i>	Robert Kenward
<i>New developments in biodiversity indicators: The Austrian experience</i>	Norbert Sauberer
<i>Spatial scaling in biodiversity monitoring</i>	Rainer Waldhart
<i>Monitoring biodiversity at the landscape level</i>	Jose Garcia del Barrio
<i>Incorporating functional parameters in soil biodiversity monitoring schemes</i>	P. Sousa & P.V. Morais
<i>Hungarian Biodiversity Monitoring Programme</i>	Katalin Torok
<i>The Swiss Eco-Fauna-Database</i>	T. Walter <i>et al.</i>
<i>A reference based approach to monitoring</i>	R. Ejrnaes & E. Aude
<i>Biodiversity monitoring needs- an international perspective</i>	Tomas Coll
<i>Using a PC software package to collect data</i>	Tomas Coll
<i>Why and what to monitor? Indicators vs. biodiversity</i>	J.M. Lobo & J. Hortal
<i>Monitoring strategies for biodiversity</i>	J.M. Lobo & J. Hortal
<i>An optimal spatio -environmental sampling</i>	J.M. Lobo & J. Hortal
<i>How to monitor biodiversity and communicate results to policy makers</i>	Ben ten Brink
<i>Monitoring of complex systems for policy purposes</i>	Erling Berge
<i>Reflections on session 3</i>	Allan Watt, Chair

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

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

Session and title of contribution	Contributors
<i>Monitoring biodiversity in the Mediterranean region</i>	Emilia Poli
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	
<i>Introduction to the final session</i>	Allan Watt, Chair
<i>Reply to "Introduction to the final session"</i>	Erling Berge
<i>Monitoring biodiversity in rivers</i>	Richard Johnson
<i>Priorities for future research on biodiversity in lakes</i>	S. Declerck & L. De Meester
<i>High Conservation Value Forests (HCFs)</i>	Marco Marchetti
<i>The European Network for Biodiversity Information (ENBI) and biomonitoring</i>	C. Hof <i>et al.</i>
<i>The NBN UK example</i>	J. Munford & L. Way
<i>Research priorities for indicators and monitoring schemes in agroecosystems</i>	Klaus Henle
<i>Value-specific indicators- to meet the needs of stakeholders</i>	P. Duelli & C. Scheidegger
<i>Establishing the biodiversity of a site or region</i>	Alan Feest
<i>Three tasks in a Biodiversity monitoring sandwich</i>	Robert Kenward
<i>Towards biodiversity monitoring at the European scale</i>	Frederic Gosselin
<i>The use of full species lists in biodiversity monitoring</i>	Richard Fischer
<i>The more we speak about monitoring, the less we do it!</i>	Jurgen Tack
<i>Monitoring with pragmatism</i>	Romain Julliard
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Concluding contributions	
<i>Predictive modelling may improve political relevance</i>	Erik Framstad
<i>Ensuring biodiversity monitoring is policy relevant</i>	Melanie Heath
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<i>Political cut-offs and biodiversity monitoring</i>	Ben Delbaere
<i>Monitoring is required for planning and development</i>	Helena Freitas
<i>Improving scientific discourse in biodiversity monitoring</i>	Andreas Troumbis
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