RUBICODE WP4 Workshop
"Assessing and monitoring ecosystems – concepts, policies and indicators"
27th February – 1st March 2007

Minutes

Wokshop location: *Alte Lohnhalle* in Essen/Kray, Germany.

Participants:

1. Francesco de Bello (CNRS, France)
2. Antonio Bispo (Agence de l'Environnement et de la Maîtrise de l'Energie, France)
3. Rob Bugter (ALTERRA Green World Research, the Netherlands)
4. Christian Feld (University of Duisburg-Essen, Germany)
5. Ulf Grandin (Swedish University of Agricultural Sciences)
6. Daniel Hering (University of Duisburg-Essen, Germany)
7. Hanneke Keizer-Vlek (ALTERRA Green World Research, the Netherlands)
8. Pedro Martins (Universidade de Coimbra, Portugal)
9. Meelis Pärtel (University of Tartu, Estonia)
10. Isabel Pardo Gamundi (Univ. Vigo, Campus Lagoas-Marcosende, Spain)
11. Jörg Römbke (ECT Oekotoxikologie GmbH, Germany)
12. Leonard Sandin (Swedish University of Agricultural Sciences)
13. Dirk Schmeller (Université D'Angers, France/Umwelt-forschungszentrum Halle-Leipzig, Germany)
14. Astrid Schmidt-Kloiber (University of Natural Resources and Applied Life Sciences (BOKU), Austria)
15. Frederik Schutyser (European Environmental Agency, Denmark)
16. Paulo Sousa (Universidade de Coimbra, Portugal)
17. Bernd Sures (University of Duisburg-Essen, Germany)
18. Allan Watt (Centre for Ecology and Hydrology, UK)

Workshop structure and major outcome (downloadable files are indicated at the end of a paragraph):

Day 1 – 27th February

- Welcome to the participants (*Christian Feld*)

  Welcome to participants, a short introduction to the region and to the venue, and several domestic announcements were made in this presentation.
  The presentation is not available on the RUBICODE website.

- Presentation of workshop structure, aims and expected outcome (*Paulo Sousa*)

  In this presentation a brief summary of the aims and scope of RUBICODE was given and the workshop was put into context regarding the specific questions to be tackled and the activities to be taken for WP4 (indicators).
  The main objective of the workshop was to generate the discussion about indicators and indication approaches for different ecosystems and different policies, taking the advantage of the critical mass and different expertise of the invited participants. It was stressed that the output of the workshop will be used to elaborate a review paper on these topics, to which the different participants were invited to participate.
  See 00b_Opening_Paulo-Sousa.pdf

Session 1 - Plenary talks on policy requirements (chair: *Paulo Sousa*)

- Overview of SEBI 2010 and the CBD and EU-headline indicators *(Frederik Schutyser)*

  The SEBI 2010 project (Streamlining European Biodiversity Indicators for the 2010 target) works pan-European , with DG ENV and PEBLDS. At the same time, SEBI is connected with BIP 2010 (Biodiversity Indicator Partnership), which works on the CBD indicators at a global level.

  A first set of 26 specific indicators within the 16 European Headline Indicators has been proposed. The indicators will be published in a technical report by the summer of 2007, and the assessment report based on the set of 26 headline indicators is scheduled for spring 2008.

  Issues with the SEBI 2010 indicator set where work can be linked with RUBICODE are:
  – response indicators - no separate category in CBD/SEBI2010;
  – climate change impacts on biodiversity is a area that needs further work
  – ecosystem services - a key area for the planned ecosystem assessment for Europe (2012, focused on policy and scientific challenges.

  See 01_SEBI2010_Frederik-Schutyser.pdf and CBD_and_EU-headline_indicators.xls

- Indication approaches according to the EU Soil Thematic Strategy *(Jörg Römbke)*

  A brief history of soil protection in Europe (with emphasis on soil biodiversity) was made focusing on the Communication of the EU Commission "Towards a Thematic Strategy for Soil Protection" (2002), the first EU activity for soil protection including emphasis on soil biodiversity. In this context the results and recommendations from Task Group 3 on Soil Biodiversity were highlighted.
  The recent EU soil Thematic Strategy (2006) was presented with particular attention to its two major documents (Thematic Strategy for Soil Protection and the proposal for a Soil Framework Directive). The SFD aims at the protection of soil functions (including biodiversity) but, so far, no explicit biodiversity indicators have been mentioned/demanded, despite the several references regarding the threats to soil biodiversity and the relations between soil functions and biodiversity.
  The recommendation for a tiered monitoring of biodiversity (resulting from Task Group 3) was presented, including tier 1 indicators (microbes, earthworms and nematodes) and indication approaches (BISQ, BBSK, assessment via comparison of observed/expected values or via resistence/resilience approaches). Moreover the potential research topics in the area of soil biodiversity (under the 7th FP) were presented; this will help to overcome (the mentioned) lack of knowledge on soil biodiversity and contribute to the adoption of indicators and indication approaches into the SFD.
  See 02_SoilThematicStrategy_Joerg-Roembke.pdf

- Indication approaches according to the EU Water Framework Directive *(Christian Feld)*

  The Water Framework Directive (WFD) was presented focussing on its major demands, in particular those related to sustainable management of water resources and ecosystems and the ecological quality targets. The specific demand for different types of indicators was highlighted, including (1) the primary biological indicators (phytoplankton, benthic algae, macrophytes, benthic macroinvertebrates, fish), (2) the secondary physical-chemical and hydromorphological indicators, (3) the establishment of typologies for rivers and lakes, and (4) the definition of type-specific biotic and abiotic reference conditions. The ecological status classification (high, good, moderate, poor, bad) according to the previous indicators was mentioned.
  The types of biotic and abiotic indicators available, and used under the WFD, as well as their classification, was summed up. Moreover the indication concept behind the WFD (comparison to a reference situation) was explained and the relation between indicators and the indication process to ecosystems services underlined.
  See 03_WFD_Christian-Feld.pdf

Session 1 (cont.) – Plenary talks on indicator types (chair: *Daniel Hering*)

- Genetic diversity as indicators *(Dirk Schmeller)*

  Genetic diversity and its usefulness for biodiversity assessment was highlighted in this contribution. Genetic diversity can be measured on individual, species and population level and is well defined, basing on a long history of genetic analyses. Among other genetic parameters, heterozygosity, number of alleles and F-statistics can be used as indicators of the ability of a population and species to adapt to changing environmental conditions. Hence, the field of application is mainly connected to the assessment of ecological condition. The relation of genetic parameters to environmental stressors has been proven and the strengths regarding their use were highlighted. Relation to ecosystem services was also presented.

  Several case studies showed the relation between GD indicators and several types of stressors, but also highlighted interpretation traps, given that different genetic markers cover different temporal scales. Measuring genetic diversity is still fairly expensive, originating that only a small subset of biodiversity covered and that the implications to overall biodiversity might be poor.

  See 04_Genetic_Diversity_Dirk-Schmeller.pdf

- Traits of aquatic species as indicators *(Astrid Schmidt-Kloiber)*

  The term "trait" is used for a single feature or measurement of an organism. The spatial scale for application ranges from global to local monitoring of both marine and freshwater ecosystems, and is strongly related to habitat assessment, trend monitoring and restoration purposes. The several advantages and the few disadvantages of using traits as indicators were presented, as well as their relation to policies and ecosystem services.

  Traits related to the different biological indicators (phytoplankton, benthic algae, macrophytes, benthic macroinvertebrates, fish) were highlighted and their application and importance according to stressor types were presented.

  A brief overview of existing trait databases for aquatic organisms was presented including several examples of traits. The database compiled during a couple of EU-funded projects is currently available at www.freshwaterecology.info.

  Finally two case studies using traits as indicators were presented: (1) effects of climate change and the application of the Floodplain index; (2) the use of the Multimetric Index for Austria for indicating general degradation status (relation with the WFD ecological status classification classes).

  See 05_Aquatic_traits_Astrid-Schmidt-Kloiber.pdf

- Traits of terrestrial species as indicators *(Francesco de Bello & Sandra Lavorel)*

  The separation of response and effect traits was outlined and several examples given. The first group is mainly related to adaptation to the environment, whereas the second type is mainly related to ecosystem processes and ecosystem services.

  The concept of functional diversity and its metrics (mean, range), and the way they relate to different ecosystem services, were presented. Several examples about the use of traits and trait composition and the relations between traits and services were presented (particular focus on the ability of certain traits/trait composition to predict ecosystem processes).

  See 06_Terrestrial_traits_Francesco-de-Bello.pdf

- Parasites as indicators across ecosystems (*Bernd Sures*)

  The ecological value of parasites was highlighted in this contribution, especially the use of parasite diversity as a measure of ecosystem health/change and the way parasites can act as a driving force for biodiversity.

  Three main case studies were presented with clear results of the use of parasite diversity and their relation with ecosystem health (analysing different types of stressors): (1) the Prestige oil spill (the ration between monoxenous and heteroxenous parasites was able to separate pre- and post- spilling samples); (2) the opening of the Danube-Main canal that connects the Danube basin with the Rhine basin. Changes in the amphipod fauna in the Rhine system led to changes in the species richness of parasites and in the prevalence of some parasite species of the European eel; and (3) trematode diversity in snails from estuarine habitats (trematode diversity in snails from control sites was higher than in snails from restored sites). Also one example regarding parasites as a driving force for biodiversity was presented. In this case the heavy parasitism of cockles enable them to burrow and results in more cockles lying at the surface, where they are approximately 7 times more likely to be eaten by oystercatchers. Moreover, the effects upon benthic community derived

from this inability to burrow led to an increase of density of several benthic groups and overall species diversity and species richness.
See 07_Parasites_Bernd-Sures.pdf

Session 2 - Breakout groups (including final plenary session to report output of each group)

Breakout Group 1(chair: *Frederik Schutyser;* rapporteur: *Paulo Sousa;* participants: *Rob Bugter, Astrid Schmidt-Kloiber, António Bispo, Leonard Sandin*)

- ***What are criteria for a good indicator?***

  The discussion on the suitability criteria for a good indicator was based on the pre-prepared list of criteria based on a literature review made by Pedro Martins. The group discussed the importance of the several criteria always focusing on a wide range of indicator types.
  The output (table on page 5 below) contains a list of suitability criteria divided into 5 major types (for the order of importance: relevance, accepted methodology, sensitivity, data availability and practicability). The group also ranked the different sub-criteria according to the type and purpose of the indicators, i.e., for 1) biodiversity monitoring, for 2) assessing responses to stressors and for 3) indicating ecosystem services.
  See 08_Breakout_Group_1.pdf

Breakout Group 2 (chair: *Ulf Grandin;* rapporteur: *Christian Feld;* participants: *Meelis Pärtel, Pedro Martins, Francesco de Bello*)

- ***Which parameters are suited towards a "typology of indicators"?***

  The discussion on this group was focused on several aspects of an indicator typology: why is a typology needed and the definition of a suited criteria for a typology and their application across ecosystems. During the discussion the group realised the lack of common terminology, particularly between experts from different backgrounds and different ecosystems, and stressed the need to find one.
  Discussions resulted in the definition of an objective for the typology according to (1) the spatial and temporal scales, (2) the application of the indicator/indication approach, (3) the "type" (e.g., structure vs. function = pattern vs. process indicators; or abiotic vs biotic indicators) (5) the organism level (from [genes] species to landscape). Next steps were identified and discussed.
  See 09_Breakout_Group_2.pdf

Breakout Group 3 (chair: *Jörg Römbke;* rapporteur: *Daniel Hering;* participants: *Bernd Sures, Hanneke Keizer-Vlek, Isabel Pardo, Dirk Schmeller*)

- ***Comparison of parameter types against the following questions: (1) Suitability for the detection of stress and stressors; (2) Applicability on different spatial and temporal scales; (3) Suitability for the detection of ecosystem services and SPU; (4) Discrimination between natural and man-made variability***

  The discussion was structured on three major aspects: (1) Delineating groups of indicator types; (2) Classifying groups of stress types, scales, services, variability types; (3) Checking each indicator type against stress types, scales, services, variability and coding each indicator according to its relevance.

  (1) Several indicator types were defined: abiotic; genetic; biochemical (e.g. enzyme activity); morphological / functional / life history (traits) at different levels (species, species group, or community); structural attributes (population, community, e.g. species number, abundance, diversity); processes; landscape features.
  (2) Several stressor types have been identified (focus on anthropogenic stressors): Physical stressors (e.g., landscape and habitat changes, temperature, light, noise…); Chemical stressors (e.g., toxic substances, nutrients, acidification); Biological stressors (e.g., translocations of specimens / release of breed specimens, invasive species, genetically modified organisms)
  (3) The following scale types were identified: Geographical (Global; Regional; Local; Farm scale); Time scale (Early warning; Late warning).

  Regarding the discrimination between natural and man-made variability, the group agreed that almost all indicators are more or less affected by both types of variability, causing "noise" (exception may be some abiotic indicators). Moreover several abiotic parameters are stressor- specific,

while most biotic parameters are not. The output check-up tables of the different indicators against stressor types, scales and protection goals can be seen on pages 6 and 7 below.
See 10_Breakout_Group_3.pdf

Breakout Group 1 Criteria for the selection of bioindicators	Biodiversity monitoring (including policy assessment)	Response to stressors (including policy assessment)	Ecosystem services (including policy assessment)
1st Relevance to the purpose, e.g.: • Representative of total biodiversity (surrogate) • Indicative for anthropogenic stress • Indicative for risk • Representative of a specific service • Relevance to policies • Relevance within a proposed indicator set	(3)	(3)	(3)
2nd Accepted methodology			
Established standardised methods for measuring and validation should be available	(3)	(3)	(3)
Effects of temporal or geographical differences on sampling should be known	Case dependent	(3)	(3)
3th Sensitivity:			
Sensitivity to changes (able to provide early warning or early sign of recovery)	(3)	(3)	(3)
Show a well-defined and unambiguous response to (different intensities of) stressors; stressor specific if possible	(1)	(3)	(2)
Able to differentiate between natural cycles and trends and those produced by anthropogenic stress factor	(2)	(3)	(1)
Able of providing and forecasting the response in a predictable way	(3)	(3)	(3)
4th Data availability:			
Taxonomically well-known, taxonomic expertise readily available	(3)	(3)	(3)
Baseline data on biology (e.g. traits) and ecology available, e.g. related to temporal and spatial variability	(1)	(3)	(3)
Historical/reference data available	(3)	(3)	(3) For reference data
For indicators related to drivers and conditions, information about links with biodiversity need to be clear	(3) Only if conditions are monitored	(3)	(3)
Good data availability across the relevant spatial and temporal scales	(3)	(3)	(3)
5th Practicability:			
Cost (time, funds, equipment personnel) in relation to relevance, cost to establish reference, and to regularly update/assess	(3)	(3)	Case dependent
Ease of use, e.g. easy to sample, sort and identify; easy storage; easy to evaluate	(3)	(3)	(3)
Methodology not limited by small number of experts/equipment	(3)	(3)	(3)
Capable of scaling: possible to be used through different spatial scales	(3) For scale dependent indicators	(3) For scale dependent indicators	(3) For scale dependent indicators
Easy to communicate to the public	(3)	(3)	(3)

Breakout Group 3
Indicator types vs. Stressor types

	Abiotic parameters	Genetic parameters	Biochemical parameters (e.g. enzyme activity)	Morphological and functional parameters (traits)	Structural attributes (population, community)	Processes	Landscape
Landscape and habitat changes	(+)	(0)	(-)	(+)	(+)	(+)	(+)
Temperature	(+)	(-)	(+)	(+)	(+)	(-)	(+)
Light, radiation, noise…	(+)	(0)	(-)	(+)	(+)	(-)	(+)
Toxic substances (pesticides, biocides, heavy metals, POPs, drugs…)	(+)	(+)	(+)	(+)	(+)	(+)	(0)
Nutrients (e.g. eutrophication)	(+)	(+)	(+)	(+)	(+)	(+)	(0)
Acidification	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Translocations of specimens / release of bred specimens	(-)	(+)	(0)	(+)	(+)	(-)	(-)
Invasive species	(-)	(+)	(-)	(+)	(+)	(-)	(0)
Genetically modified organisms	(-)	(+)	(-)	(+)	(+)	(0)	(-)

Breakout Group 3
Indicator types vs. Temporal and spatial scales

	Abiotic parameters	Genetic parameters	Biochemical parameters (e.g. enzyme activity)	Morphological and functional parameters (traits)	Structural attributes (population, community)	Processes	Landscape
early warning	(+)	(+)	(+)	(+)	(+)	(0)	(-)
late warning	(+)	(-)	(0)	(+)	(+)	(+)	(+)
global scale	(+)	(-)	(-)	(+)	(+)	(+)	(+)
regional scale	(+)	(0)	(-)	(+)	(+)	(+)	(+)
local scale	(+)	(+)	(0)	(+)	(+)	(+)	(0)
"farm scale"	(+)	(+)	(+)	(+)	(0)	(+)	(-)

Breakout Group 3
Indicator types vs. Protection goals

	Abiotic parameters	Genetic parameters	Biochemical parameters (e.g. enzyme activity)	Morphological and functional parameters (traits)	Structural attributes (population, community)	Processes	Landscape
Biodiversity	(-)	(+)	(+)	(+)	(+)	(+)	(+)
Provisioning services	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Regulatory services	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Supporting services	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Cultural services	(-)	(-)	(-)	(-)	(+)	(0)	(+)

Day 2 – 28th February

Session 3 - Plenary talks on indication approaches in different ecosystem types (chair: *Christian Feld*)

- Review of indication of forest ecosystems (*Ulf Grandin*)

  In this contribution the natural factors affecting biodiversity as well as the impact of the major forestry actions on biodiversity were presented. Based on the Noss diagram (Noss, 1990)[1] the structural and composition key factors of biodiversity were presented, as well as the major functional key factors influencing forest biodiversity.

  Several types of indicators in use were presented as well as their pros and cons: (1) taxon-based indicators (presence/absence of single indicator species, species lists, guilds); (2) structural indicators (stand complexity, plant composition, presence/distribution of key ecosystems, connectivity between ecosystem patches; spatial complexity, heterogeneity over range of spatial scales).

  Examples of the several indicators and the indication approach (comparison to a reference situation) used in the Swedish environmental quality criteria for forests were presented

  See 11_Forests_Ulf-Grandin.pdf

- Review of indication of grassland ecosystems (*Meelis Pärtel*)

  Generally, there is a very high diversity detectable in grasslands, however, grasslands represent semi-natural ecosystems and need permanent management to maintain its character and biodiversity. Grasslands also regulate and support several services, including the provision of cultural services. Major threats are species (biodiversity) loss mainly caused by intensification (cultivation) or abandonment (stop of management) and fragmentation.

  The types of indicators used in grasslands (selected taxa, Red List species, plant traits, landscape features and environmental parameters) and the scales they are used were presented. The reasons behind indication (e.g., monitoring, restoration, conservation) were also addressed. The need for validation criteria and uniform sampling methods was also addressed.

  See 12_Grasslands_Meelis-Paertel.pdf

- Review of indication of shrub and heath ecosystems (*Francesco de Bello*, *Sandra Lavorel*)

  An outlook of the type of ecosystems in question was made, with special reference to the fact that these are semi-natural ecosystem maintained with a low intensity management, namely grazing and wood control via fire. The major threats have been identified and they can be divided in two opposite directions: intensification or abandonment.

  Policy demands regarding these ecosystems were mentioned, namely the need to know of (1) the traditional and expected services and effects of threats upon them, and of (2) "status" and "ecosystem functioning" indicators at different spatial scales. Several examples were presented.

  See 13_Shrub_heath_Francesco-de-Bello.pdf

- Review of indication of soil: soil classification systems (*Jörg Römbke*, *Pedro Martins & Paulo Sousa*)

  A definition of soil quality, mainly related to the ability to serve as an habitat for soil organisms and plants (habitat function), was given. The link between preserving the habitat function and several regulating and supporting ecosystem services was stressed.

  The different indication approaches used to protect the soil habitat function were analysed in detail: (1) approaches based on single organism groups (e.g., diversity of earthworm, Collembola, etc); (2) approaches based on the whole community (synthetic approaches like the IBSQ or biological classification systems like the BBSK or the BISQ); (3) "quality" indices based on morphological traits (QBS index). Several examples were used to illustrate the pros and cons of each approach.

  Sampling standard ISO methods are now available for several soil organism groups (earthworms, Collembola, mites) and several are under discussion (enchytraeids, Nematoda, macrofauna). The need for a soil biological classification system at European level, based on evaluating the diversity of soil organisms and comparing to reference conditions, was stressed. To overcome the huge dif-

[1] Noss, R.F. (1990) Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology, 4(4), 355-364.

ferences of soil types and soil-uses in Europe, a soil typology is needed, as well as the definition of the class-specific reference conditions as a basis for assessment.
See 14_Soils_Joerg-Roembke.pdf

- Review of indication of soil: results of the ENVASSO project (*Antonio Bispo*)

ENVASSO (ENVironmental ASsessment of SOil for Monitoring) is a project funded under the 6th Framework Programme of the EU and encompasses a total of 40 partners. ENVASSO deals with the definition of common criteria and indicators for the characterisation of soils and the evaluation of soil quality in order to develop common monitoring strategies and validation procedures aiming at comparable data that will facilitate the implementation of soil protection measures all over Europe.
ENVASSO's WP1 and WP2 were presented in details. Their tasks are based on the major soil threats identified by the EU document "Towards a Thematic Strategy for Soil Protection" (i.e., soil erosion, loss of organic matter, contamination, soil compaction, salinisation, decline in biodiversity, sealing, flooding and land slides). WP1 aims at identifying suitability criteria and indicators for each one of them, and WP2 aims at review the existing soil monitoring networks and monitored parameters.
Regarding the *Decline of Soil Biodiversity* (defined by ENVASSO as the "Reduction of forms of life living in soils, both in terms of quantity and variety, and of related functions"), after a extensive literature search and definition of the suitability criteria, structural (species diversity) and functional indicators were selected.
A tiered structure for bioindication was proposed. The "top 3 indicators" (level 1- all monitoring sites) define the minimum set of indicators, embracing both structural and functional aspects: (1) Earthworms diversity and biomass (or Enchytraeid diversity); (2) Collembola diversity; (3) Microbial respiration. At levels 2 and 3 more structural and functional indicators are proposed for a more detailed assessment of biodiversity decline.
The indication approach proposed is based on comparison with a reference situation (in space or time), by defining the baseline values for each indicators for each soil class (the need for a soil typology at European level was stressed) and also by defining the threshold values (defined by a significant or unacceptable deviation from the baseline or from the reference situation).
The top 3 indicators were chosen not only because they fulfil the suitability criteria, but also because several datasets at European level do exist, allowing a better definition of the baseline and threshold values. This approach is going to be validated within ENVASSO WP5.
See 15_Soils-ENVASSO_Antonio-Bispo.pdf

- Review of indication of rivers (*Daniel Hering*)

Different indication approaches for river assessment were presented: (1) Direct measurements (e.g., measurements of pollutant concentration and comparison with threshold values), (2) Indication systems (aiming mainly at detecting effects of organic pollution and acidification) (e.g., saprobic systems, indices for acidification and salinization levels); (3) Measurement of Ecological Quality (as a response to several types of stressors (using ecological quality elements: periphyton, macroinvertebrates, macrophyte, fish).
Based on this last indication approach, the assessment of rivers according to the WFD was highlighted and the results of the STAR project were presented (www.eu-star.at). In this project 230 streams were sampled all over Europe, covering different regions and also different stress types (e.g., eutrophication, land-use, hydromorphology and micro-habitats). Several metrics (traits) were used based on the four ecological elements and correlated to each stressor intensity. The final output was a proposal for the potential bioindication ability of each organism group.
See 16_Rivers_Daniel-Hering.pdf

- Review of indication of lakes (*Leonard Sandin*)

A review on what is indicated and the type of indicators used to assess lakes was presented. Assessing lakes includes to evaluate effects of (1) Eutrophication/nutrient enrichment, (2) Acidification, (3) Hydromorphological change, (4) Toxic substances.
Over 100 indicators are available: (1) indices which incorporate several indicator levels, such as periphyton and invertebrates, into a composite community assessment (e.g. the Saprobic index), (2) indices based on single indicator group (e.g., macroinvertebrates) but incorporating information on species diversity and ecological tolerance of indicator taxa, (3) indices based on taxa richness, evenness and abundance.

WFD lake indicators were presented. They are divided into (1) measurement of the four biological elements (periphyton, macroinvertebrates, aquatic flora, fish), (2) measurements of lake hydrological regime and morphological condition, (3) measurement of several physical and chemical parameters.
An example of the Swedish lake assessment system, based on the biological elements, was presented. For each one the several metrics (including multimetric indices) were presented and related to several stressors. Biodiversity is not a target in this assessment, although a strong relationships were found between ecological assessment and taxon richness for most of the metrics (except the acidification index).
The importance of an intercalibration exercise and the sources of variation in the different metrics and its influence on the final outcome of the ecological assessment were stressed.
See 17_Lakes_Leonard-Sandin.pdf

Session 4 - Breakout groups (including final plenary session to report output of each group)

Questions addressed by each group

- What are the differences between ecosystem types?
- What is the rationale behind these differences?
- Do the indicators fulfil the criteria of indicators defined in session 2?
- What parameters are suited to indicate the services of the ecosystems?
- Gaps?

Breakout Group 1 (chair: *Allan Watt;* rapporteur: *Paulo Sousa;* participants: *António Bispo, Francesco de Bello, Ulf Grandin, Isabel Pardo, Astrid Schmidt-Kloiber, Leonard Sandin, Christian Feld*)

- ***What are the differences between ecosystem types?***
- ***What is the rationale behind these differences?***

Based on the several indicators mentioned in the plenary talks on the different ecosystem types, the group created a double entrance table focusing on these two questions (see table on next page). Generally, most indicators in the selected ecosystem indicate biodiversity, effects of stressors and some of them also indicate services. The several policy drivers for indication were identified (WFD, CBD, SFD, etc).
The process and the rationale behind each indication approach for each ecosystem was also identified and compared: (1) indicators for rivers and lakes are strongly based on specific indicator taxa, compositional aspects and traits and the rationale is based on comparison with reference condition minimally disturbed; (2) indicator for soils are based on species groups and community composition, and the rationale is based on the comparison with "reference" condition (the best possible within a certain land-use type); (3) for forests, shrub and heathlands, indicators are more related at looking at the presence/abundance of specific indicator species (related with their requirements) and looking at traits; the rationale is based on comparison with pristine conditions (for forest systems) or with a “reference” condition under an optimal sustainable management containing the highest biodiversity (in the case of grasslands).
The geographical scale indicated and the geographical scale of application of each indicator was also discussed.
Output table from this group regarding the above mentioned questions can be seen in page 11 below.
See 18_Breakout_Groups_2.pdf

	Do they indicate Biodiversity?	Do they indicate Stressors?	Do they indicate Services?	Indicators are outcome of policy drivers?	Process behind indication	Spatial scale indicated	Spatial scale of application	Relation to services	Rationale	Typologies available
Forests	3	1,2	3	Yes (CBD, Natura 2000)	Scientific (e.g., looking at indicator species and their requirements)	Local to landscape	All	Yes (provisioning, regulating, supporting, cultural)	Classification based on pristine conditions	Several
Grasslands / Shrubs & Heaths	3	3	3	Yes potentially (CBD, Natura) but…	Scientific (e.g., looking at indicator species and their requirements; understanding species traits)	Local to regional	All	Yes (provisioning, regulating, supporting, cultural)	Optimal management sustaining high biodiversity	Yes
Soils	3	3	3	SFD (expected)	Scientific (more at community/species groups level)	Local to landscape	All	Yes (mainly regulating, supporting, cultural(?))	Comparison with "reference" condition (the best possible within a certain land-use type)	No
Rivers	3	3	2	WFD, Habitats, Natura 2000, CBD	Scientific (specific indicator taxa, compositional aspects, traits)	Local to regional	All	Yes (provisioning, regulating, supporting, cultural)	Comparison with a reference minimally dusturbed	Yes
Lakes	3	3	2	WFD, Habitats, Natura 2000, CBD	Scientific (specific indicator taxa, compositional aspects, traits)	Local to regional	All	Yes (provisioning, regulating, supporting, cultural)	Comparison with a reference minimally dusturbed	Yes

Note: Scale from 1 to 3 where 3 indicates a stronger response than 1

- ***Do the indicators fulfil the criteria of indicators defined in session 2?***
  The top indicators for each ecosystem type were identified and ranked according to the five major suitability criteria (and sub-criteria) discussed by breakout group 1 in session 2. The summary of the outcome is:

Criteria / Indicators	Forest indicators	Grasslands / Shrubs & Heaths	Soil	Rivers	Lakes
	List of indicator species	*Plant species richness per area*	*Species richness of meso or macrofauna groups*	*Sensitive indicator macroinvertebrate taxa*	*Sensitive indicator phytoplankton taxa*
1st Relevance to the purpose	**(3 for biodiv)**	**(3 for biodiv)**	**(3 for biodiv)**	**(3 for stressors)**	**(3 for stressors)**
2nd Accepted methodology					
Established standardised methods for measuring and validation should be available	**(3)**	**(2)**	**(3)**	**(3)**	**(3)**
Effects of temporal or geographical differences on sampling should be known	**(3)**	**(2)**	**(2-3)**	**(2-3)**	**(2)**
3th Sensitivity:					
Sensitivity to changes (effect size) - able to provide early warning or early sign of recovery	**(2-3)**	**(3)**	**(2-3)**	**(3)**	**(3)**
Show a well-defined and unambiguous response to (different intensities of) stressors, stressor specific if possible	**(2)**	**(3)**	**(2-3)**	**(3)**	**(2)**
Able to differentiate between natural cycles and trends and those produced by anthropogenic stress factor	**(2)**	**(2)**	**(2)**	**(3)**	**(2)**
Able of providing and forecasting the response in a predictable way	**(2)**	**(2)**	**(1-2)**	**(1-2)**	**(1-2)**
4th Data availability:					
Taxonomically well-known, taxonomic expertise readily available	**(3)**	**(3)**	**(3)**	**(2)**	**(2-3)**
Baseline data on biology (e.g. traits) and ecology available (e.g. related to temporal and spatial variability)	**(3)**	**(2)**	**(1-2)**	**(2)**	**(2)**
Historical/reference data available	**(2-3)**	**(2)**	**(1-2)**	**(2)**	**(2)**
For indicators related to drivers and conditions, information about links with biodiversity need to be clear	**(2)**	**(2)**	**(1-2)**	**(3)**	**(3)**
Good data availability across the relevant spatial and temporal scales	**(2-3)**	**(2-3)**	**(1)**	**(3)**	**(1-2)**
5th Practicability:					
Cost (time, funds, equipment personnel) in relation to relevance, cost to establish reference, and to regularly update/assess	**(2-3)**	**(2)**	**(1-2)**	**(2)**	**(2)**
Ease of use (e.g. easy to sample, sort and identify); easy storage; easy to evaluate	**(2-3)**	**(2-3)**	**(2)**	**(2)**	**(1-2)**
Methodology not limited by small number of experts/equipment	**(2-3)**	**(3)**	**(2-3)**	**(2)**	**(1-2)**
Capable of scaling: possible to be used through different spatial scales	**(1-2)**	**(3)**	**(2-3)**	**(3)**	**(2)**
Easy to communicate to the public	**(3)**	**(3)**	**(1-2)**	**(2)**	**(2)**

- ***What parameters are suited to indicate the services of the ecosystems?***
  The discussion was structured in finding easily indicators of ecosystem services for important service types of each major category (provisioning, regulating, supporting, cultural). The outcome is as follows:

Ecosystem type	Ecosytem category	Type of service	Indicator
Forest	Provisioning	Fibre	Plant height and diameter
		Food	Biomass of game
	Regulating	Microclimate	Storm damages
	Supporting	Photosynthesis	Leaf area index
	Cultural	Recreation	Biomass of game
Grassland	Provisioning	Food	Live stock intensity
	Regulating	Erosion	Vegetation cover
	Supporting	Decomposition	Leaf N content
	Cultural	Recreational	Plant diversity
Soils	Provisioning	Habitat	Biogenic structures
	Regulating	Erosion	Soil fauna activity
	Supporting	Soil formation	Ecosystem engineers (species richness)
		Decomposition	Species richness of mesofauna+worms & decomposition
Rivers	Provisioning	Power supply	Reservoir capacity
	Regulating	Self-purification	Saprobic index
	Supporting	Nutrient cycling	Assimilation rate by the system
	Cultural	Recreation	Fish licences
Lakes	Provisioning	Food	Fish biomass
	Regulating	Decomposition	Leaf litter breakdown
	Supporting	Photosynthesis	Chlorophyl A concent.
	Cultural	Sports	Nº beaches

Breakout Group 2 (chair: *Bernd Sures;* rapporteur: *Daniel Hering;* participants: *Jörg Römbke, Pedro Martins, Dirk Schmeller, Meelis Pärtel, Rob Bugter, Hanneke Keizer-Vlek*)

- ***Do the indicators fulfil the criteria of indicators defined in session 2?***

  Breakout group 2 adopted two different strategies to tackle this question. The first was to select 4 examples of indicator types (1 per ecosystem type) and rank them ([-] not suitable, [0]neutral and [+] suitable) according to each one of the suitability criteria agreed by BG1 on session 2. The outcome was:

	Grasslands	Soil	Rivers	Rivers
	Selected taxa (vascular plants)	Individual groups (species richness)	Saprobic indices (Zelinka and Marvan)	Ellenberg N-number
1st Relevance to the purpose, e.g.:				
2nd Accepted methodology				
Established standardised methods for measuring and validation should be available	(0)	(+)	(0)	(+)
Effects of temporal or geographical differences on sampling should be known	(0)	(0)	(+)	(0)
3th Sensitivity:				
Sensitivity to changes (effect size) - able to provide early warning or early sign of recovery	(0)	(+)	(+)	(0)
Show a well-defined and unambiguous response to (different intensities of) stressors, stressor specific if possible	(+)	(0)	(+)	(+)
Able to differentiate between natural cycles and trends and those produced by anthropogenic stress factor	(0)	(0)	(+)	(0)
Able of providing or forecasting the response in a predictable way	(-)	(-)	(+)	(+)
4th Data availability:				
Taxonomically well-known, taxonomic expertise readily available	(+)	(+)	(+)	(+)
Baseline data on biology (e.g. traits) and ecology available, e.g. related to temporal and spatial variability	(+)	(0)	(+)	(+)
Historical/reference data available	(+)	(-)	(+)	(+)
For indicators related to drivers and conditions, information about links with biodiversity need to be clear	(0)	n.a.	n.a.	(+)
Good data availability across the relevant spatial and temporal scales	(+)	(0)	(+)	(+)
5th Practicability:				
Cost (time, funds, equipment personnel) in relation to relevance, cost to establish reference, and to regularly update/assess	(+)	(0)	(-)	(+)
Ease of use, e.g. easy to sample, sort and identify; easy storage; easy to evaluate	(+)	(0)	(0)	(+)
Methodology not limited by small number of experts/equipment	(+)	(+)	(+)	(+)
Capable of scaling: possible to be used through different spatial scales	(+)	(+)	(+)	(+)
Easy to communicate	(+)	(+)	(+)	(+)

  The second strategy was to compare the indicator types agreed by BG3 on session 2 (several indicator types on different ecosystem types), and to rank them ([-] not suitable, [0] neutral and [+] suitable) against the major suitability criteria groups agreed by BG1 on session 2. The outcome is in the following page.

- ***What parameters are suited to indicate the services of the ecosystems?***

  The discussion around this question was tackled by using the several indicator types adopted by BG3 on session 2, and ranking them ([-] not suitable, [0] neutral and [+] suitable) against their suitability to indicate several services (using the major MEA groups of services: provisioning, regulating, supporting and cultural services) Output on page 15.

		Established standardised methods for measuring and validation should be available	Sensitivity to changes (effect size) - able to provide early warning or early sign of recovery	Good data availability across the relevant spatial and temporal scales	Cost (time, funds, equipment personnel) in relation to relevance, cost to establish reference, and to regularly update/assess	Easy to communicate
Grasslan	Abiotic parameters	(+)	(+)	(+)	(0)	(+)
	Genetic parameters	(0)	(+)	(+)	(-)	(0)
	Biochemical parameters	(-)	(+)	(+)	(0)	(-)
	Morphological and functional parameters (traits)	(+)	(0)	(+)	(+)	(0)
	Structural attributes (population, community)	(0)	(0)	(+)	(+)	(+)
	Processes	(+)	(0)	(+)	(-)	(+)
	Landscape	(0)	(-)	(+)	(+)	(+)
Soil	Abiotic parameters	(+)	(+)	(+)	(0)	(+)
	Genetic parameters	(0)	(+)	(0)	(-)	(0)
	Biochemical parameters	(+)	(+)	(+)	(0)	(-)
	Morphological and functional parameters (traits)	(0)	(0)	(0)	(0)	(0)
	Structural attributes (population, community)	(0)	(+)	(0)	(0)	(+)
	Processes	(+)	(+)	(+)	(0)	(+)
	Landscape	(0)	(-)	(-)	(+)	(0)
Rivers	Abiotic parameters	(+)	(+)	(+)	(+)	(+)
	Genetic parameters	(0)	(+)	(0)	(-)	(0)
	Biochemical parameters	(+)	(+)	(+)	(0)	(0)
	Morphological and functional parameters (traits)	(+)	(+)	(+)	(0)	(0)
	Structural attributes (population, community)	(+)	(+)	(+)	(0)	(+)
	Processes	(0)	(+)	(+)	(0)	(+)
	Landscape	(+)	(-)	(+)	(+)	(+)

		Abiotic parameters	Genetic parameters	Biochemical parameters (e.g. enzyme activity)	Morphological and functional parameters (traits)	Structural attributes (population, community)	Processes	Landscape
Grasslands	Provisioning services	(0)	(+)	(+)	(+)	(+)	(+)	(+)
	Regulatory services	(+)	(+)	(+)	(+)	(+)	(+)	(+)
	Supporting services	(+)	(0)	(+)	(+)	(+)	(+)	(+)
	Cultural services	(-)	(-)	(-)	(-)	(+)	(0)	(+)
Soil	Provisioning services	(+)	(+)	(+)	(+)	(+)	(+)	(+)
	Regulatory services	(+)	(+)	(+)	(+)	(+)	(+)	(+)
	Supporting services	(+)	(0)	(+)	(+)	(+)	(+)	(+)
	Cultural services	(-)	(-)	(-)	(-)	(0)	(0)	(+)
Rivers	Provisioning services	(+)	(+)	(+)	(+)	(+)	(+)	(+)
	Regulatory services	(+)	(+)	(+)	(+)	(+)	(+)	(+)
	Supporting services	(+)	(0)	(+)	(+)	(+)	(+)	(+)
	Cultural services	(+)	(-)	(-)	(-)	(+)	(0)	(+)

- ***Gaps?***

  Breakout group 2 identified gaps at two levels: (1) gaps to be filled up for the review paper, and (2) gaps in the development of indicators in the different ecosystem types.

  Regarding the first point, the group thinks that it is essential to homogenise the terms and definitions to be used in the paper, since experts from different ecosystem types use different terms and definitions for similar concepts. There is also the need to establish a decision tree to help on the definition of the best suited indicator for the different ecosystem services at each ecosystem type. Last, better examples are needed to illustrate the several indicator types on the different ecosystems.

  Regarding the research gaps for indicator development, the need of reference data to established baseline values for the different type of land-use is necessary for soils. Moreover, the development and/or adoption of standardized methods are necessary over a range of indicator types in different ecosystem types, as one of the most important suitability criteria and an essential condition for the adoption and acceptance of the indicator type. Last, the group has identified that a more intensive communication between experts from different ecosystem types is essential for the exchange of information and expertise, improving the ability to define common indication approaches across ecosystems.

Day 3 – 1th March

Session 5 – Summary of the workshop and next steps of WP4 (chair: *Daniel Hering*)

- Summary of the workshop’s major results (*Leonard Sandin*)

  The major outcome of the discussions from the two breakout groups sessions were summarized by Leonard Sandin. General agreement that fruitful discussions were achieved, but the outcome of the groups needs further thinking.

  See 21_Workshop_Summary_and_Outcome.pdf

- Structure of the review paper, which will be the outcome of the workshop (*Christian Feld*)

  For the review paper, the following structure proposed by the WP4 leaders was presented:
  (1) Introduction (containing (i) Aims, (ii) Terms and definitions and (iii) Policy demands); (2) Criteria for a good indicator; (3) Typology of indicators; (4) Comparison of ecosystem types (including (i) Indication approaches, (ii) Relation to services and (iii) Relation to suitability criteria)

  For the publication of the paper, three journals, capable of accepting a comprehensive review, were proposed:
  1st - Annual Review of Ecology and Systematics (an invitation to publish is needed, but may be arranged by Bernd Sures);
  2nd - Journal of Applied Ecology
  3th - Ecological Indicators

  It was agreed that this review paper is a multi-author paper. The responsibility to write the manuscript belongs to the WP leaders. The participants of the workshop will contribute with key examples from the respective ecosystems. Some participants agreed to act as “ecosystem leaders” coordinating the compilation of the information of the respective ecosystems. The “ecosystem leaders” are: Forests (Ulf Grandin), Grassland (Meelis Pärtel), Shrubs (Francesco de Bello), Soil (Jörg Römbke), Agro-ecosystems (Rob Bugter), Rivers (Christian Feld), Lakes (Leonard Sandin), Wetlands (Isabel Pardo), Floodplains (Klement Tockner), Landscape (across ecosystems) (Allan Watt)

  To allow the easy collection of information, the work is going to be stratified by ecosystem type. The selection of the outcome of the breakout groups will be revised by the WP leaders, including the definition of indicator types and an updated list of terms to be defined.
  Update of indicator forms (database) including (1) Criteria for “good indicators”, (2) Criteria for typology, (3) Criteria for indication of services and (4) The, will also be done by the WP leaders and distributed to “ecosystem leaders” for completion.

In this revision and completion process, it was agreed that, with some important exception, ecosystem leaders will be restricted to references mentioned in the Web of Science during the last 10 years.

In order to cope with the deadline established in RUBICODE, it was agreed that after re-distribution of the data base with the indicator forms among the “ecosystem leaders”, these have 6 weeks to return them completed to the WP leaders. The aim is to submit the manuscript before the summer break.
See 20_Structure_review_paper.pdf

- Further data evaluation meetings within WP4 (indicators) of RUBICODE (time, data requirements, participants) (*Daniel Hering*)

  The purpose of the data evaluation meetings (to compare and test indicators and indication approaches among the different ecosystems) proposed in the WP4 was explained. Three meetings were scheduled (until now without definitive dates or locations). The first could take place in June-July 2007; the second on October-November 2007 and the third on March 2008. Leonard offered to host the first meeting in June in Uppsala, Sweden.
  Several themes were suggested; these will be analysed by the WP leaders before a decision is taken.
  See 19_Gaps_and_Data-evaluation-meetings.pdf

Paulo Sousa, Christian Feld, Daniel Hering & Pedro Martins
04.2007