Indicators of Ecosystem Services

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Indicators of Ecosystem Services - outline

• Fundamental role of ecosystem functions and services for humans, terminology

• Indication of Ecosystem Services: how and why?
  – Examples from forest ecosystems and soils
  – Connection to indication systems relevant for biodiversity and ALTER-Net (CBD and EU headline indicators, SEBI2010, Millennium Assessment)
  – Towards a common indicator framework?

• Attempts and limitations of (monetary) valuation

• Condensed indication of ecosystem functioning and services by aggregated indices (ALTER-Net project)
A striking example how delicate and vulnerable ecosystem services are: the failed "Biosphere 2" endeavour

- Eight humans enclosed in 3.15 acre closed ecosystem
- With replicas of several key ecosystems
- Investment of over 200 M$
- Proved impossible to supply the essential services to support the eight humans
- Unexpected and unpleasant problems arose instead.
Terminology

• „Ecosystem functions“ (ESF) longer established and in use compared to „Ecosystem services“ (ESS)
• The former refer more to the natural processes and their resilience and integrity, the latter more to the benefits to humans from that.
• No definite and clear distinction since many ecosystem functions directly constitute ecosystem services, e.g., water retention in soils:
  – Water supply to the vegetation as well as water resource provision to humans.
A model of ES function – service

From: NRC (2005)
Fundamental category system for forest ecosystem functions

- **Natural functions**
  - Habitat
    - Support of biological diversity
  - Regulation of energy and matter cycles
    - Soil protection
    - Water storage and peak flow control

- **Cultural functions**
  - Wood production
  - Non-timber products (game, resins, herbs, mushrooms ...)
  - Water resource provision
  - Recreation
  - Education

Beese 1996, and many others
The category system of the Millennium Assessment for ecosystem services (ES)

- "supporting" ecosystem services – i.e., ecosystem functions
- Provisioning ES
- Regulating ES
- Cultural ES
Dimensions of the services obtained through plant use

Species richness: vascular plants ca. 270,000

Utilized by humans > 70,000

- Food plants Ca. 3,000
- Medicinal Ca. 25,000
- Wood and fibre >15,000
- Ornamental > 15,000
- Model plants in science Ca. 2,000

Not utilized < 200,000

- Species protection (CITES) 25,000
- In bio-prospecting > 30,000
- Medicinal plants >20,000
- Food and fibre plants >10,000

Historical excursus ....
Ecosystem functions and services have been used and consumed for a long time ...
However, manifest effects emerged only with the „invention“ of agriculture and large-scale forest clearing.
„Dutchmen Cuttings“
Wood demand of early Industries leads to regional deforestation

From: Klose (1985)
Forest pastoralism
Litter raking and humus layer removal (straw substitute)
Permanent transfer of nutrient capital (forest $\rightarrow$ arable land)

N, P, Ca$^{2+}$, Mg$^{2+}$, K$^+$ ...
Back to indicators ...

- What is an indicator?
  - Until present there is, unfortunately, no rigorous unification of terminology. In the ecological and monitoring communities, however, there is largely agreement that
  - An indicator should be a quantitative variable (metric or ordinal scaled) which gives information on the system's actual status.
  - An index should be a combined or aggregated measure which may integrate over very many such indicator observations.
  - It is important to be aware of this differentiation, because an indicator is unequivocal once its indication function of system status is accepted. For an aggregated index much more scrutiny is required if the mode of aggregation and application seem sensible.

Excerpted from Klok et al. (2006 in progress)
A typical example

Long catalogues of ESS and their pertinent indicators

<table>
<thead>
<tr>
<th>ESF</th>
<th>ESS</th>
<th>Indicator(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net primary production (forest ES)</td>
<td>Wood supply</td>
<td>Wood produced; ratio harvest/actual increment</td>
</tr>
<tr>
<td>Water retention of soils</td>
<td>Flood mitigation</td>
<td>Peak flow attenuation [mm/h]</td>
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<tr>
<td>Water purification</td>
<td>Drinking water resource</td>
<td>Water extracted; stability of stores</td>
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<tr>
<td>Habitat and niche provision</td>
<td>Support of biodiversity</td>
<td>Species diversity and abundance; species population trends</td>
</tr>
<tr>
<td>Emergence of natural structures</td>
<td>Aesthetic appeal</td>
<td>Number of tourists in region</td>
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</tbody>
</table>

.... and so forth and forth ...
The challenge is to develop agreed and common indicator frameworks

- Identify a key set of indicators to address (an) issue(s) adequately
- Harmonized approach across different regions and countries
  - Considering, of course, the differentiation of ecosystems, and
  - Eco-regional differentiation (e.g., forest in sub-continental vs. atlantic climate)
- Including identification of suitable proxies and surrogates
Indication systems: The EU headline biodiversity indicators

**Level 1. Structural Indicator for Biodiversity.**
- The function of this indicator is to inform politics and the public at a very generic way on the condition of biodiversity in Europe. This indicator should place biodiversity alongside economic growth and social development.

**Level 2. Headline Indicators for Biodiversity.**
- A small set of indicators that give high-level messages on trends of various aspects of biodiversity. Politicians and the public are the target group again but the information has a broader coverage. This level should complement other environment, economic and social indicators and together they present a picture of sustainable development in Europe.

**Level 3. Indicators linked to policy sectors.**
- Indicators designed for communication with key stakeholders in each sector, so that stakeholders get an impression of how their actions impact on biodiversity. Organisation of indicators around recognised key stakeholder/policy themes is the main issues at this level.
EU headline BD indicators by focal areas: 1 – components of BD

• 1: *Status and trends of the components of biological diversity*
  
  – Trends in extent of selected biomes, ecosystems and habitats
  – Trends in abundance and distribution of selected species
  – Change in status of threatened and/or protected species
  – Trends in genetic diversity of domesticated animals, cultivated plants, and fish species of major socioeconomic importance
  – Coverage of protected areas
EU headline BD indicators by focal areas: 2 – use and threats

• **2: Sustainable use of BD and threats**
  
  – Area of forest, agricultural land, fishery and aquaculture ecosystems under sustainable management
  
  – Nitrogen deposition (CL exceedance)
  
  – Numbers and costs of invasive alien species
  
  – Impact of climate change on biodiversity
EU headline BD indicators by focal areas: 3 – integrity and services

• 3: *ES Integrity, goods and services, resources allocated*
  
  – Marine Trophic Index
  – Connectivity/fragmentation of ecosystems
  – Water quality in aquatic ecosystems
  – Patents (to be developed)
  – Funding to biodiversity
  – (Public awareness and participation; added in SEBI 2010)
A common framework for BD and ES indication?!

Frameworks like EU headline and SEBI have

- **Merits**
  - Reduction of number of indicators to an operational amount
  - Harmonized selection for reporting over large spatial scales (e.g., EU or Pan-Europe)
  - Reflect state-of-the-art assessment of many experts

- **...and pitfalls**
  - Some relevant indicators may drop from the set
  - Fixed selection may not appropriately reflect the needs of particular regions or countries
  - May become outdated but not adapted
Examples of aggregated indicators

ALTER-Net project „aggregating indicators for policy purposes – sense or nonsense?“
The aggregated species trend indicator (STI) of EEA/RIVM

Terms of Reference

**purpose:** to show the long-term trends in species populations

**function:** evaluation progress towards 2010 target

**target audience:** high-level policy makers and the general public

**focus:** Pan-Europe, major habitat types

**principles:** following CBD

Mireille de Heer, ALTER-Net RA2 Hamburg Workshop, 2005
## Methodology

Each cell: set of representative species, with their population trend of the set of species

Habitat total: index = area-weighted mean of the country indices

Overall: index = non-weighted mean of the habitat indices

<table>
<thead>
<tr>
<th>Pan-European aggregated STI</th>
<th>Coastal habitats</th>
<th>Freshwater</th>
<th>Forest and woodland</th>
<th>Mires, bogs and fens</th>
<th>Heathland, scrub &amp; tundra</th>
<th>Un-vegetated habitats</th>
<th>Farmland</th>
<th>All natural habitats</th>
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<tbody>
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<td>Albania</td>
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</table>
## Data Providing Organisations

<table>
<thead>
<tr>
<th>Category</th>
<th>Organisations</th>
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<tbody>
<tr>
<td>breeding birds</td>
<td>• BirdLife International</td>
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<td></td>
<td>• European Bird Census Council</td>
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<tr>
<td></td>
<td>• Wetlands International</td>
</tr>
<tr>
<td>butterflies</td>
<td>• Butterfly Conservation</td>
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<tr>
<td>large mammals</td>
<td>• Large Carnivore Initiative Europe</td>
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<tr>
<td></td>
<td>• Large Herbivore Foundation</td>
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<tr>
<td>vascular plants</td>
<td>• Planta Europa</td>
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</tbody>
</table>
Characteristics of the Data

- wide variety of collection methods: total population estimates, monitoring schemes, atlasses, expert judgement
- data available at country-level
- 1970 starting year
- trends often expressed in broad classes
- birds and butterflies: ALL species in ALL countries
# The Data

<table>
<thead>
<tr>
<th>species group</th>
<th>no. of species</th>
<th>no. of time series</th>
</tr>
</thead>
<tbody>
<tr>
<td>butterflies</td>
<td>119</td>
<td>1359</td>
</tr>
<tr>
<td>birds</td>
<td>142</td>
<td>1389</td>
</tr>
<tr>
<td>mammals</td>
<td>5</td>
<td>35</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>266</strong></td>
<td><strong>2783</strong></td>
</tr>
</tbody>
</table>

43 countries
Species Trends per Habitat (all groups)

-50 -40 -30 -20 -10 0 10 20

average % change in population size since 1970

farmland (855)

coastal areas (135)
freshwater (251)
mires, bogs and fens (8)
woodland and forest (743)
heathland, scrub and tundra (94)
unvegetated areas (51)
Species Trends in Europe

Pan-European aggregated STI

natural habitats
(1282)

farmland
(855)

average % change in population size since 1970
Direction of Change in Time Series

- Stable (40%)
- Decrease (40%)
- Increase (19%)
- (Locally) Extinct (1%)
Species Trends in Farmland

Pan-European aggregated STI

EU15 (428)
Acceded (149)
non EU (278)

% change in population size since 1970
Conclusions

• The indicator is potentially feasible and meaningful for monitoring progress towards 2010 in Europe

• Potentially applicable in other regions

• (Harmonised) Monitoring is essential for timely and reliable update

• Tools and organisation for assembling and processing data are also needed
Natural Capital Index (NCI)

- focuses on *both* the species- and the ecosystems and habitat level
  - the terms "ecosystem" and "habitat" are used more or less synonymously
- combines qualitative and quantitative information
  - computing a 2-dimensional product (habitat quality * quantity)
- has been developed to evaluate whether or not progress is being made towards conservation of biodiversity
- results of different countries or eco-regions are mutually comparable
Mode of computation

\[ NCI = \text{ecosystem quantity} \times \text{ecosystem quality} \]

De Heer et al. (2005)
Example of application

Current NCI-natural

Ecosystem types
- Terrestrial
  - Forest
  - Heath
  - Marsh
  - Open dune
  - Fresh water
  - Lake IJssel
  - Rivers
  - Fresh water Delta
  - Inland lakes
  - Marine
- North Sea (12 miles zone)
- Wadden Delta
- Marine Delta

De Heer et al. (2005)
Advantages and benefits

- computation of NCI is simple and straightforward
- the two-dimensional concept (habitat quantity x quality) is appealing
- index can be clearly communicated, even to non-scientific audiences
- Graphical representations can be done in an instructive way
  - both in the form of spatially explicit maps at different grain resolution (depending on the resolution of input data) and of summary graphics
deficits and limitations

• NCI shares with many indicators and indices the problem of the appropriate baseline.
  – baseline reference values usually remain a guess, and even if that is a "best educated guess"
• very small values for NCI may result from computation of the index for single habitats, which may lead to an erroneous impression when viewed in isolation.
• It is „data-hungry“!
Some brief conclusions
…after a long morning talk

• Ecosystem services are vital and have been so throughout the development of our species (historical dimension!).

• A multitude of indicators and indication systems are available for ESS.
  – reduce number in appropriate and sensitive indication systems, integrated under a logical framework

• Conclusive indices (aggregated indicators) should be developed further.
Thank you so much for your attention!

... and for inviting me to come here!!