Project no. GOCE-CT-2003-505298
ALTER-Net

A Long-Term Biodiversity, Ecosystem and Awareness Research Network

Indicators as communication tools: an evolution towards composite indicators

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WPR2-2006-D3b

Instrument: Network of Excellence
Thematic Priority: Global Change and Ecosystems (Sub-priority 1.1.6.3, Topic 6.3.III.1.1)
Due date of deliverable: September 2006
Submission date: December 2006
Start date of project: 1st April 2004
Duration: 5 years
Deliverable lead contractor: ECNC – European Centre for Nature Conservation
Revision: 1.0

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CONTENTS

Short summary
This paper provides an overview of various ways of presenting biodiversity information to policymakers and the general public. It focuses on the use of composite indicators. It is an output of the ALTER-net subproject on ‘Aggregating indicators for policy purposes: sense or nonsense?’

This work was supported by ALTER-Net (A Long-term Biodiversity, Ecosystem and Awareness Research Network). ALTER-Net (http://www.alter-net.info/**www.alter-net.info**) is a Network of Excellence funded by the 6th Framework Programme of the European Commission.

1 Introduction

This paper provides a brief description of : i) the communication gap between scientists and policymakers; ii) definition, key elements and different types of indicators; iii) the evolution from simple data towards composite indicators; iv) characteristics and pros and cons of five currently applied composite indicators and v) how they could be communicated.

The paper is prepared as part of ALTER-Net project 'Aggregating biodiversity indicators for policy purpose: sense or nonsense?'and is based on the personal experience of the author. The author has been working in the field of indicators, assessments, communication and policy making since 1982 under the ministries responsible for Nature Conservation, Water Management and Environment (CRM, V&W, LNV, VROM). He participated in a variety of international processes such as UNEP's Global Environmental Outlooks, OECD Strategy and Environment Outlook, CBD's Global Biodiversity Outlook, the Millennium Ecosystem Assessment, the Streamlining European Biodiversity Indicators initiative (since 2005), various OECD expert groups on indicators since 1994; the CBD's expert groups on biodiversity indicators since 1997 leading to a global agreement in COP7 in Kuala Lumpur in 2004, for which he also wrote the CBD paper on suitable 2010-indicators (2003). Various texts from these processes have been used in this paper.

This report by no means intends to be exhaustive and all-covering but has an explorative character, meant for fueling the debate on this interesting topic of indicators as a tool to close the gap between scientists and policymakers.

1.1 Policy and science: different worlds, rules & languages

For years there has been a debate among scientists and policymakers/politicians on the usefulness of aggregating biodiversity parameters and indicators into indices. Scientists are concerned with detail, reliability, replicability, accuracy, etc, whereas high-level politicians are interested in the broad picture, the key message, preferably a value of biodiversity condensed in one figure on a scale from 0 to 10. Curiously these discussions are hardly present in the economic field. Curiously experts in the socioeconomic field have been able to establish these information systems in nearly all countries, while ecologist failed in nearly all countries. To my opinion it is not because economy is less difficult and complex than ecosystems to describe and assess, because it is not. I think economists have a different attitude. While economists and policymakers speak the same language, ecological scientists appear to be in a different world, governed by different rules.

Policy versus	Science
quick	slow & steady
headlines	precise
simplifications	differentaited approach
> 30% accuracy OK	> 95% accuracy OK

Figure 1: Policy and ecological science appear to be two different worlds, governed by different rules

Eventually also ecological scientists should accept that uncertainties are inevitable, and that final answers do not exist. Ecological institutions must base their advice on the current knowledge, instead of complaining on lack of information waiting for another five years for doing research. No policy is also policy.

But even if ecological scientists would behave according to the political rules they would not be understood. They have no language in common. Basic ecological concepts such as ecosystem, ecosystem functioning, goods & services, stability, integrity, baselines, thresholds, ecosystem values, ecosystem health, productivity, biodiversity, evenness, resilience, assessment principles are blurred, badly-defined and heavily discussed, let alone understood by policymakers and the public. This widens the communication gap between ecological scientists and policymakers.

Figure 2: Ecological scientists and policy makers talk different languages. Courtesy: Gary Larson

1.2 Management by accident, or feedback and feed-forward?

As a result of this communication problem calamities are taken over the role of science. “Management by accident” instead of “management by vision”. Numerous examples can be given: emission regulations after lethal poisoning; shipping regulations (MARPOL) after disasters and devastating oil spills; Rhine and North Sea Action Programmes after the occurrence of dead zones; catch regulations after fish stock depletion; and protection plans when the very existence of flagship species is at stake.

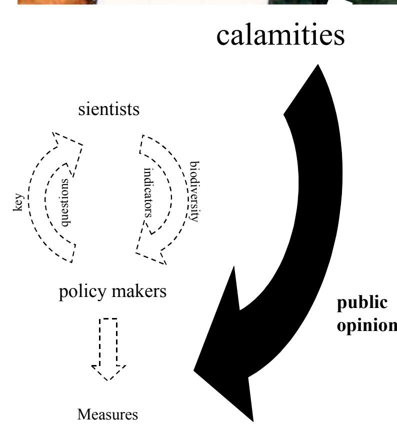


Figure 3: Management by accident. Calamities take over the role of scientists.

A continuous flow of ecological information, similar to that of the annual economic and social figures, is needed. To this end, a convenient number of indicators should be created, which can be used to give regular indication of the state of biodiversity. These indicators should resemble those used for the socio-economic information. As long as the scientific community fails to design and implement suitable biodiversity indicators, any biodiversity target, strategic plan or convention will lack political “teeth” as stated by Calestous Juma, former executive general of the CBD. Consequently, ecological consequences of policy cannot be considered. The Dutch minister of Public Works and Water Management (current Commissioner N. Kroes) was straightforward on this: “no figures, no policy”.

Another major cause is the lack of co-operation between scientists. I experienced different groups working on indicators, monitoring and modelling separately. Next, politicians set targets and measures which did not relate to these tools. This ended –so to speak- in four pieces of four different jig-saw puzzles, never leading to useful information. In a certain way we are data-rich information-poor.

According to the CBD policymakers have the following key questions:

1. What is changing?
2. Why is it changing?
3. Why is it important?
4. What can I do about it?

These key questions directly relates to the policy cycle and the feed-back principle. According to this cost-effective management is only possible in the presence of the following basic elements (Wiener):

1. Verifiable policy targets;
2. Timely and sufficient knowledge about the current and projected state and the progress made towards a target;
3. Possibilities for making corrections.

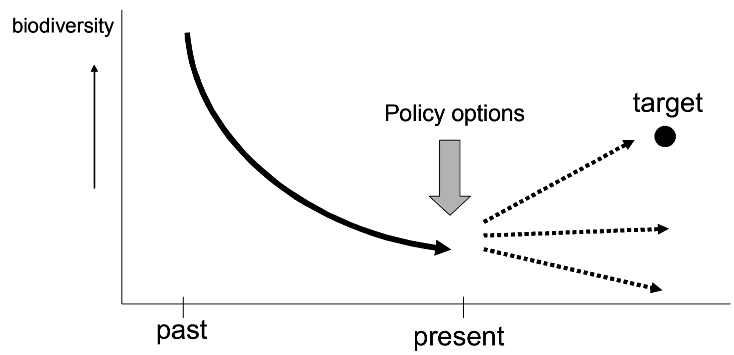


Figure 4: The basic elements of effective management systems consists of i) setting targets; ii) up-to-date monitoring and testing the current state to the target; and iii) availability of measures to make corrections

If only one of the above 3 elements is lacking, rational and effective management is hampered seriously.

2 What is an indicator?

2.1 Basic elements of an indicator

Figure 5 shows the basic elements of the feedback loop projected on an indicator. Developing an effective indicator requires cooperation between scientists, monitoring and policymakers:

Step:

1. they all agree on the indicator definition, because it has to be policy relevant, ecosystem relevant, measurable and susceptible to human measures (modeling).
2. monitoring experts determine current state
3. policymakers chose objectives, measures and baseline (assessment principle)
4. scientists establish models, work out chosen baselines, assess the effects of scenarios and measures

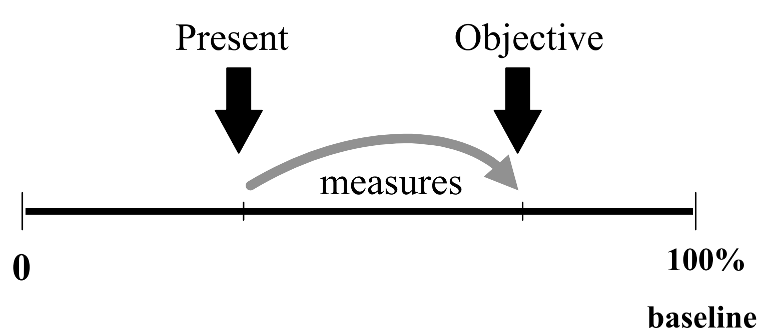


Figure 5: The basic elements of an indicator

In this way indicators will serve as the vehicle of communication aimed at.

2.2 Indicator definitions

Indicators have been defined in many ways (Box 1).

Box 1: Indicator definitions

Biodiversity indicators are information tools. They summarise data on complex and sometimes conflicting environmental issues to indicate the overall status and trends of biodiversity. In the context of implementation reports, they can be used to assess national performance and to signal key issues to be addressed through policy interventions and other actions.

Benchmarks include thresholds, baselines and targets provide reference points to lend political weight to data and are therefore a critical component of indicators. Indicators have been defined as quantitative measures which "imply a metric (i.e. distance from a goal, target, threshold, benchmark, etc.) against which some aspects of policy performance can be measured". It is the use of reference points, such as targets or benchmarks that distinguish indicators from statistics. Use of a reference point allows the reader to gauge the significance of the statistic e.g. "the extent to which an objective is met" (Liaison Group on biodiversity indicators UNEP/CBD/SBSTTA/3/inf/13).

Indicators serve four basic functions: simplification, quantification, standardization and communication. They summarize complex and often disparate sets of data and thereby simplify information. They usually assess trends with respect to policy goals. They should provide a clear message that can be communicated to, and used by, decision makers and the general public (Ad Hoc Expert Group on biodiversity indicators, UNEP/CBD/SBSTTA/9/10).

Indicators are pieces of information that provide insight into matters of larger significant and make perceptible trends that are not immediately detectable (Hammond et al. 1995 in Somé and McSweeny 1995)

Indicators help you understand where you are, which way you are going, and how far you are from where you want to be (Hart 1995, in Somé and McSweeny 1995)

Indicator is a measurement that reflects the status of a system, for example an oil pressure gauge on an engine or the number of owls in a forest (Alexandra et al. 1996)

Indicators are bits of information that highlight what is happening in a large system. They are small windows that provide a glimpse of the "big picture". (Sustainable Seattle 1995)

Indicators generally simplify in order to make complex phenomena quantifiable in such a manner that communication is either enable or promoted (Adriaanse 1993, in MacGillivray and Zadek 1995)

Generally speaking successful indicators[1]:

- quantify information so that its significance is apparent;
- simplify information in order to help communicate complex phenomena;;
- are user-driven (e.g. summarise information of interest to the intended audience); and
- are policy relevant (in that they help guide decision making).
- should be scientifically credible, responsive to changes in time and/or space, and
- be easily understood by the target audience.
- presentation is an important aspect of communication; depending on the type of information to be conveyed, indicators can be represented as numbers within a text or table, as graphics, and as maps.

[1] CBD *Liaison Group on biodiversity indicators UNEP/CBD/SBSTTA/3/inf/13*

2.3 Information pyramid, single and composite indicators

Indicators may contain simple or highly aggregated information.
Figure 6 shows the information pyramid starting with raw field data, which can be processed into statistics, single indicators and finally composite indicators. The level of aggregation depends on the user needs. Raw data are variables measured in the field. Statistics may be aggregations of these data over space and time (e.g. population trends). Single indicators are such statistics related to a reference value (e.g. number of storks compared to viable population). A reference or baseline might be a target, a threshold value, or a reference year. Composite indicators aggregate various single indicators by transforming them into another common unit (like classifying apples and pears as fruit). One way is to transform single indicators into dimensionless indices by dividing them by a reference value (e.g. average population size of 10 species as % of undisturbed state). Another approach is the weighted transformation into a common unit (e.g. methane and CO2 emissions transform into greenhouse gas equivalents). Both calculation procedures aim at data compression and the transformation of data into meaningful information. Site managers are usually interested in statistics and single-indicators, while politicians are mostly interested in composite indicators.

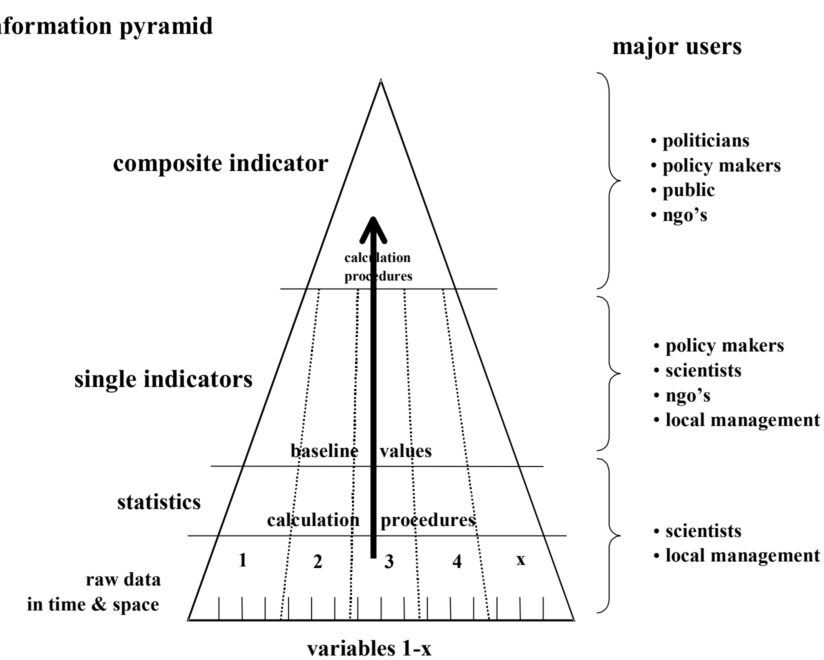


Figure 6: Information pyramid, from raw field data to statistics, single and composite indicators. Level use varies by the audience.

2.4 Assessment principles and baselines

A *baseline* is one of the elements of an indicator. Baselines are "starting points" for measuring change from a certain date or state (

Figure 6). Although they give rise to much discussion and confusion in biodiversity indicator development, they are common practice and broadly accepted in such fields as medical care, economics, abiotic environmental quality, climate change and education. A patient's health is assessed by comparing its actual values, e.g. on blood pressure or blood sugar level, to baseline values corresponding to his/her gender, height, weight and age. In the quality assessment of soil, water and air and on climate change natural background values or pre-industrial values play a prominent role. In all assessments baselines are involved, implicitly or explicitly; consequently indicators -implicitly or explicitly- give a value judgement in relation to these baselines. That is what they are meant to do.

Baselines play a key role in this valuing. They determine the 'point of view' from which biodiversity is assessed: the more species the better; or the more natural the better, or the more productive the better, etc? Baselines transfer data into policy meaningful information. Box 2 and Figure 7 illustrate various assessment principles and corresponding baselines.

Box 2: Baselines and their function in policy making

Biodiversity data as such have no meaning. For example: "**currently 1,000 dolphins** in a particular sea" only have significance in relation to baseline values. Baselines make such statistics meaningful indicators. The type of baseline determines the policy message. Some examples (see also Figure 7):

Baseline type	*Baseline value*[2]	*Meaning of current value of 1,000 dolphins vis-à-vis the baseline*	*Policy signal*
1. Natural state	> 10,000	Currently 10% of original population is left. 90% was destroyed by anthropogenic factors, such as pollution, depletion of major fish stocks and drowning in fishnets.	The population is still heavily impacted. Let's work out further measures and policies to ensure that the populations increase.
2. Specific year 1993: CBD entered into force	500	The current population has been doubled	Policymakers did a very good job. Fishermen speak about a plague. They propose to limit the population to 500. Limitation measures?
3. Genetically Minimum population size	250	The current population is 4 times above the critical level	No need to worry about dolphins.
4. Red list	750	The current population is 33% above red list criterion	Great job done in last years. Dolphins can be removed from the red list. "Let's go back to business".
5. Species richness	2 indivi-duals	Much of the population can still be lost without losing a species. Even if extirpated it would not affect the species- richness. An alien seal species compensates the loss.	1000 dolphins are fine but not interesting. The species richness is only affected when the population is zero. No measures are needed, even if the dolphins were to disappear.
6. None	---	1000 dolphins seems a lot, and the population appears to be growing.	Fishermen say dolphins are becoming a plague and must be limited. Conservationists state that 1000 is not much at all. To restore a healthy marine ecosystem it should increase to several 1000s. A political discussion is needed.

[2] In number of dolphins

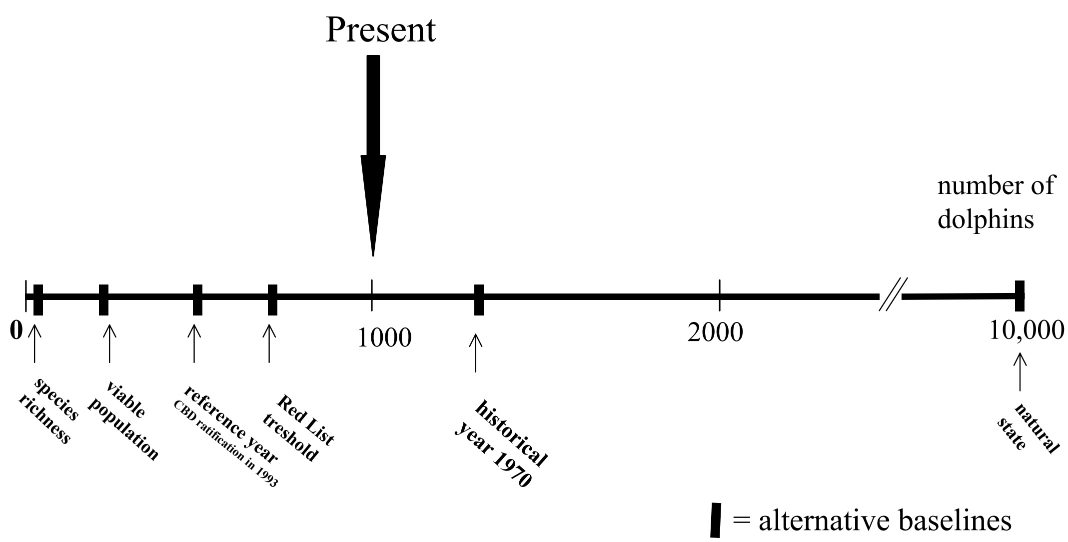


Figure 7: Alternative baselines lead to different judgements of the present state.

Baselines limit the indicator as maximum or minimum. Further, the function of baselines is to:

- give **meaning** to raw data and statistics (see Box 2);
- allow **aggregation** of different indicators into coherent composite indicator[3];
- make biodiversity indicators **comparable** within and between countries[4];
- **simplify communication** with politicians and the public[5;]
- provide a **fair** and common denominator for all countries, being in different stages of economic development.

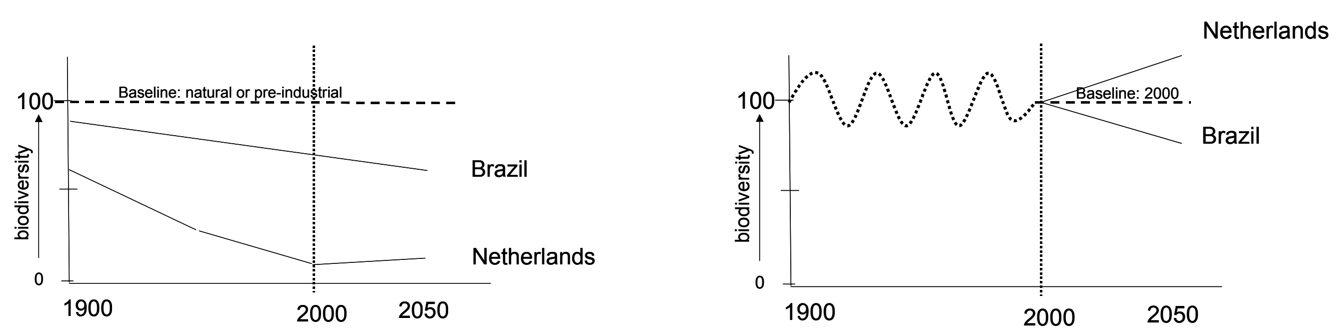


Figure 8: Using a natural baseline (left) and the year 2000 as baseline (right) results in opposite conclusions. The latter does not take historical losses into account.

3 e.g. resulting in an index on ecosystem quality
4 e.g. nature types such as forests, marine ecosystems and grasslands are assessed in a similar way
5 it different baselines and consequently different indicators would be used for the various nature types that would seriously hamper the communication, for their meaning differs. Similarly, "unemployment" is also defined consistently in a country.

It has to be stressed that the baseline is **not** the targeted state. Policymakers choose their ecological targets somewhere on the axis between 0 and 100%, depending on the political balance between social, economic and ecological interests.

Although some indicators are used simply for comparison over time (for example, the Dow Jones Index and the Retail Price Index), biological indicators are far more powerful if they are measured against a specific meaningful baseline. Setting such a baseline is a complex and rather arbitrary process. As shown in Box 2 there are many possible alternative baselines. Each alternative generates a different result and different policy information.

2.5 Solid and hybrid indicators

Solid indicators are composite indicators which compose similar entities. For instance a Species Assemblage Trend Index aggregates species trends only. Hybrid indicators combine different entities into one indicator for example catch per effort, efficiency (progress/cost), and sustainable development (combination of ecological and socioeconomic sustainability).

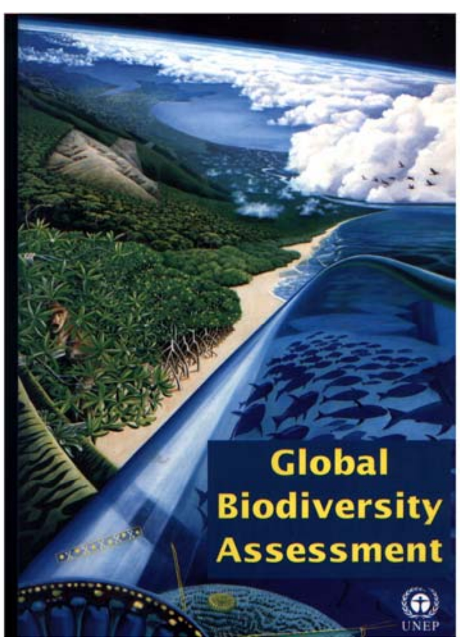
3 Evolution from data towards composite indicators

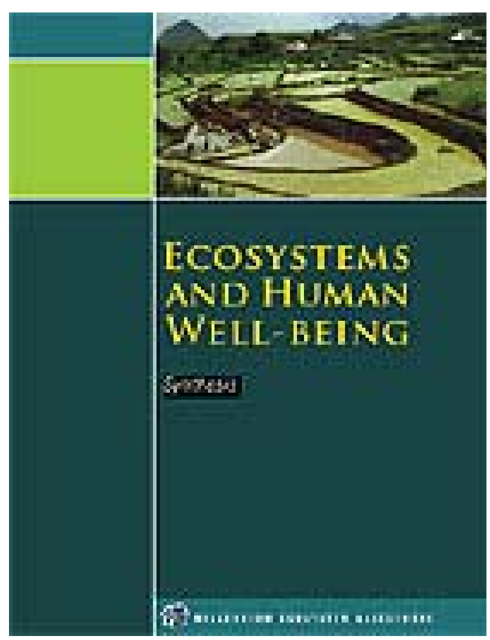
Obviously it is not easy to communicate biodiversity loss, let alone to show the human consequences and possible options and their efficacy. It is a badly-defined concept, it has various levels (genes, species, ecosystems), it has an almost infinite number of components, it has different spatial scales (local, regional, global biodiversity), data and monitoring are scarce, scattered and fragmented, the relation with human activities is complex and only partly understood, and there is no general agreement on baselines and assessment principles. However, policymakers require information **now** to set targets and measures. As stated earlier, no policy is also policy.

Over the last decennium a gradual development can be seen to overcome these difficulties:

- **From a scientific to policy-orientation**

The Global Biodiversity Assessment published in 1995 and the Millennium Ecosystem Assessment (2005) are two extremes. Although policymakers were the target-audience for both, the former was actually scientist-oriented and the latter policy-oriented.





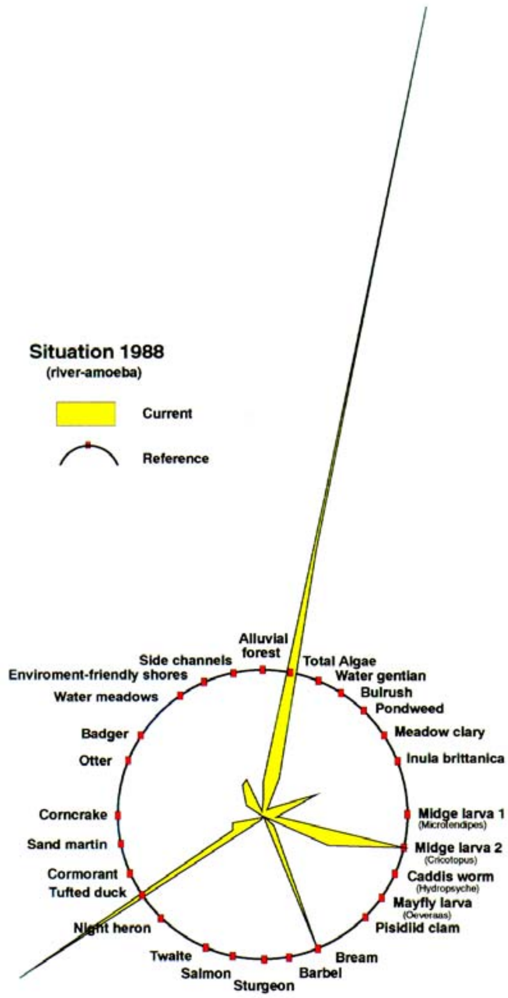
While drafting the former policymakers were hardly involved. It was written in scientific language, consists of article-like chapters with endless data and figures without policy relevance, more then 1100 pages, data-rich but policy information-poor. Although it was scientific sound and cost millions of dollars, it was entirely neglected by politicians.

The Millennium Ecosystem Assessment was set up learning from this experience (Bob Watson chaired both processes). Policymakers were involved from the start as well as well as closely related conventions on biological diversity, wetlands, desertification and migratory species. Summaries for decision makers from all target groups were made and countless presentations given for policymakers and media all over the world. A powerpoint presentation –free available- was released for public use. The MA was intended to be indicator-based, but the subjects -biodiversity and goods & services-appeared too difficult and badly-defined to do so successfully.

- **From ecosystem statistics to indicators**

Table 3. Estimated number of endemic mammal and bird species in the 50 most endemic-rich countries by this measure.

	Endemic mammals		Endemic birds
Australia	210	Australia	351
Indonesia	165	Indonesia	258
Mexico	136	Brazil	191
United States	93	Philippines	172
Philippines	90	Peru	106
Brazil	68	Madagascar	97
Madagascar	67	Mexico	88
China	62	New Zealand	74
[ex-USSR]	55	Colombia	73
Papua New Guinea	49	Solomon Islands	72
Argentina	47	United States	69
Peru	46	India	69
India	38	China	63
Japan	29	Papua New Guinea	54
South Africa	27	Venezuela	45
Ethiopia	26	Ecuador	37
Zaire	25	Ethiopia	26
Colombia	22	French Polynesia	25
Ecuador	21	Fiji	25
Solomon Islands	18	Jamaica	25
Cuba	15	São Tomé and Príncipe	24
Malaysia	14	Zaire	23
Taiwan	13	Cuba	22
Tanzania	12	Argentina	21
Sri Lanka	12	Sri Lanka	20
Panama	11	New Caledonia	20
Venezuela	11	Japan	20
Chile	11	Micronesia, Fed. States	18
Kenya	10	Chile	15
Cameroon	10	Bolivia	15
Myanmar	8	Taiwan	15
Somalia	8	[ex-USSR]	13
Costa Rica	8	Tanzania	13
Sudan	7	Angola	12
Bolivia	7	Viet Nam	12
Mongolia	6	Somalia	11
Morocco	5	Puerto Rico	11
Thailand	5	Cameroon	11
Viet Nam	5	Mauritius	10
Libya	4	Palau	10
Iran	4	Vanuatu	10
Canada	4	Seychelles	9
Egypt	4	Comoros	9
Guatemala	4	Yemen	8
Spain	4	Western Samoa	8
Uganda	4	Cook Islands	7
Angola	4	Kenya	7
Gabon	3	South Africa	7
Zambia	3	Panama	6
Jamaica	3	Spain	6



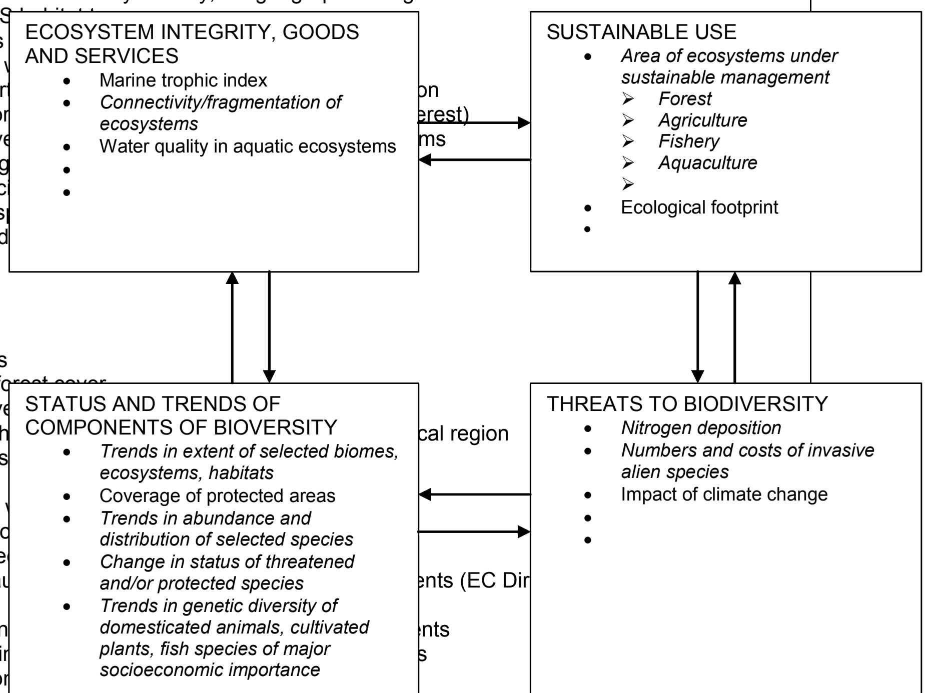
Source: UNEP-WCMC Biodiversity series No. 3; Priorities for Conserving Species Richness and Endemism
Source: Brink, B.J.E. ten, Hosper, S.H., Colijn, F., 1991, A quantitative method for description & assessment of ecosystems: the AMOEBA-approach. Marine Pollution Bulletin 23, pp. 265-270, 1991.

In the ninethy-ninethies, most assessments reported rather biodiversity statistics than indicators of change. It concerned ecosystem features such as on species-richness and number of endemics. Ecosystem features are static in nature similar to the number of engines in a airplane, and do not describe the changes in state of biodiversity as intended. Also statistics on trends were given without reference values. What is the significance of a population declined from 4000 to 3500 individuals? The political value was low. Gradually information was given in context of meaningful reference values, which uplifted data to real indicators. Reference values could be i.e. natural population size or minimum viable population. The amoeba figure (right) shows the populations sizes of a cross-section of marine species relative to their pre-industrial (low impacted) population sizes (circle), providing a clear picture of huge human impact on the Dutch major rivers Rhine and Mease .

- **From a caleidoscopic view to a small set of complementary indicators**

The box below shows the “core set of biodiversity indicators” as proposed by the EEA in 2003. It provides an overwhelming, caleidoscopic and little coherent view on biodiversity. The figure right shows the set of headline indicators as agreed under the CBD (2004) and implemented in Europe (SEBI 2010 programme) a few years later. The latter forms a coherent framework of complementary indicators, providing maximum information with as few as possible indicators and monitoring effort.

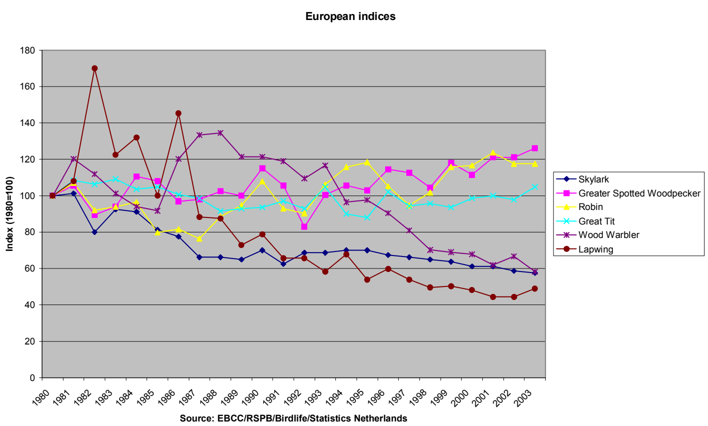
1. State of 10 main EUNIS habitat types
2. Change in State of 10 main EUNIS habitat types
3. Percentage and trends in wilderness areas
4. Naturalness of forests
5. Species-richness in proportion to surface area by country, biogeographical region
6. Species-richness by 10 main EUNIS
7. Tree species composition in forests
8. Changes in species composition in
9. Endemic species richness in propor ... on
10. Trends ofd species groups (carnivor ... erest)
11. Trends of selection of representative ... ms
12. Number of threatened taxa occuring
13. Number of globally threatened spec
14. Percentage of globally threatened s
15. Percentage of European threatened
16. Threatened forest species
17. Forest genetic resources
18. Wild relatives of cultivated plants
19. Crops and breed genetic diversity
20. Threats in and around wetland sites
21. Landscape-level spatial pattern of forest cover
22. Diversity of linear features and doive
23. Percentage of introduced species th ... cal region
24. Spread of invasive selected species
25. Introduces tree species
26. Introduces species in fresh surface
27. Introduces species in marine and co
28. Proportion of globally threatend spe
29. Proportion of globally threatened fa ... ents (EC Dir Convention)
30. Proportion of known species presen ... nts
31. Proportion of species only present i ... s
32. Progress in implementation of actio
33. Funds spent through LIFE Nature projects for species and habitats
34. Total area of wetlands (and other ecosystems types) reclaimed by country, biogeographic region, Europe
35. Cumulated area of sites over time under international conventions and initiatives
36. Cumulated area of sites proposed over time under EU Directives
37. Proportion of sites under EU Directives already protected under national instruments
38. Cumulated area of national designated areas over time in Pan-Europe
39. Species diversity in designated areas
40. Bird species distributions and Special Protection Areas (SPAs) coverage
41. Range of Species of European Interest or Threatened Species present in designated areas
42. Trends of selected species population within and outside designated areas
43. Percentage (in surface area) of Annex I habitat-type included in potential Sites of Community Interest (pSCIs)
44. Change (in surface area) of Annex I habitat-type included in pSCIs
45. Range of Habitats of European Interest present in designated areas
46. Percentage of main activities reported in pSCIs
47. Agricultural land in designated areas
48. Land cover changes in the surroundings of designated areas
49. Deadwood
50. Number of individuals per main fauna species group killed on roads per length per year
51. Number of fauna passages per infrastructure length unit
52. Financial investment for fauna passages

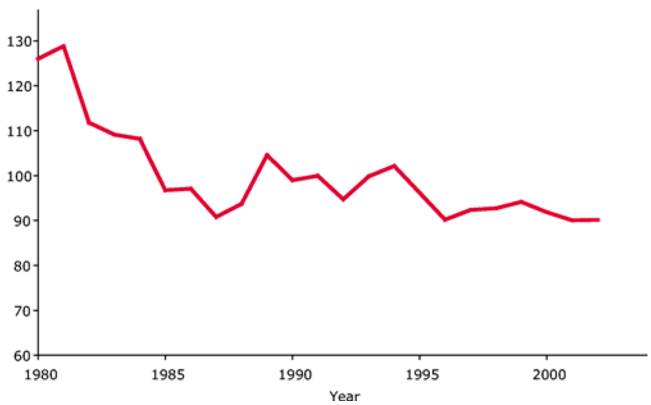


➢ From single towards composite indicators

Biodiversity consists of an infinite number of components. Obviously it does not make sense to communicate these individually to policymakers. Similarly, the minister of economic affairs is not so much interested in individual companies but in sectors and their contribution to GDP. After all, policymakers are not running a company but the country. The left picture shows the trends of eight individual species as an example of to detailed information for our purpose. The right figure shows the average change in farmland birds population in Europe which is far more suitable.

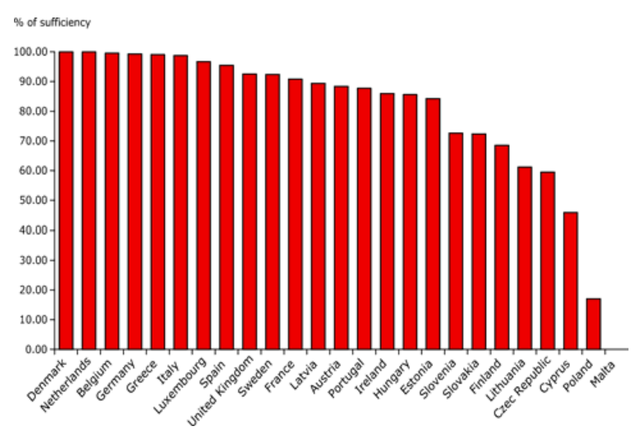
Source: Netherlands Statistics





➢ From pressure & response towards state indicators

The pictures below are a pressure and response indicator (BOD and ammonium concentrations in European rivers (left) and (right) the Sufficiency Index of progress of the Habitat Directive). Such indicators were often used as substitute information for the state, which was not available. Although meant well, the relationship with the state of biodiversity is absent. In case of protected area it appears even to inversely related to the remaining biodiversity.



Source: EEA

The next figure, recently made by the EEA, shows the state of commercial fish stocks in NE Atlantic and Baltic Sea in 2003-2004. It concerns a clear and meaningful picture on the state of an important component of Europe's marine ecosystems, related to the biological safe stock size as baseline. It is a beautiful example of an extremely simple and meaningful indicator. As a result of its bipolar character it loses sensitivity.

Commercial stocks	Baltic Sea	North Sea & Skagerrak / Kattegak & Eastern Channel	West Scotland & Rockall Sea	Irish Sea	West Ireland	Celtic Sea &Western Channel	Bay of Biscay	Iberian Peninsula	Arctic
	ICES: IIIbcd, 22-32	ICES IIIa,IV, VIId	ICES: VI	ICES: VIIa	ICES: VIIb,c, h-k	ICES: VIIf-k, VIIe	ICES: VIIIa,b-d, e	ICES: VIIIc, IX,X	ICES: I, II, Va,b, XII, XIV,
Albacore									
Anchovy									
Anglerfish									
Blue whiting									
Bluefin tuna									
Brill									
Capelin									a
Cod									
Conger									
Chub mackerel									
Dab									
Flounder									
Haddock			b						
Hake									
Greenland Halibut									
Herring									
Horse mackerel.									
Ling									
Mackerel									
Megrim									
Norway pout									
Plaice						c			
Pouting									
Red fish									
Saithe									
Salmon									
Sandeels									
Sardine									
Seabreams									
Sole									
Elasmobranchs									
Sprat						d			
Swordfish									
Turbot									
Whitefish									
Whiting									

Source: EEA

➢ **From various towards a coherent baseline as a common denominator**

Baselines are the most neglected, avoided or discussed issue of indicators. Often baselines are not explicitly mentioned nor substantiated, let alone used consistently over a set of indicators in an assessment report.
The figure below illustrates a fictitious example of different indicators with different baselines. Inconsistency impedes a meaningful assessment of the overall state of biodiversity within or between countries. Under neither the CBD nor the EU an agreement has been reached on a common baseline. This deficiency will become apparent soon after the first indicators are to be produced in order to show the progress towards the 2010-target. To date no examples can be given of reports with explicitly chosen, coherent baselines. However, in i.e. the field of climate change and many other fields a common baseline is common practice. A thorough discussion at the regional and global level is indispensable.

State of the Environment report:

Indicator	value	Assessments principle or baseline
• Forest area:	halved in 20 years	1980
• Crane population:	became viable	viability
• Otter population:	half the target	policy target
• Defoliation:	70% -> 75%	natural state
• Lynx:	vulne-> nearly ext.	extinction risk
• Red dear:	increased	the more indiv. the better
• Species richness:	+ 2%	the more species the better

+

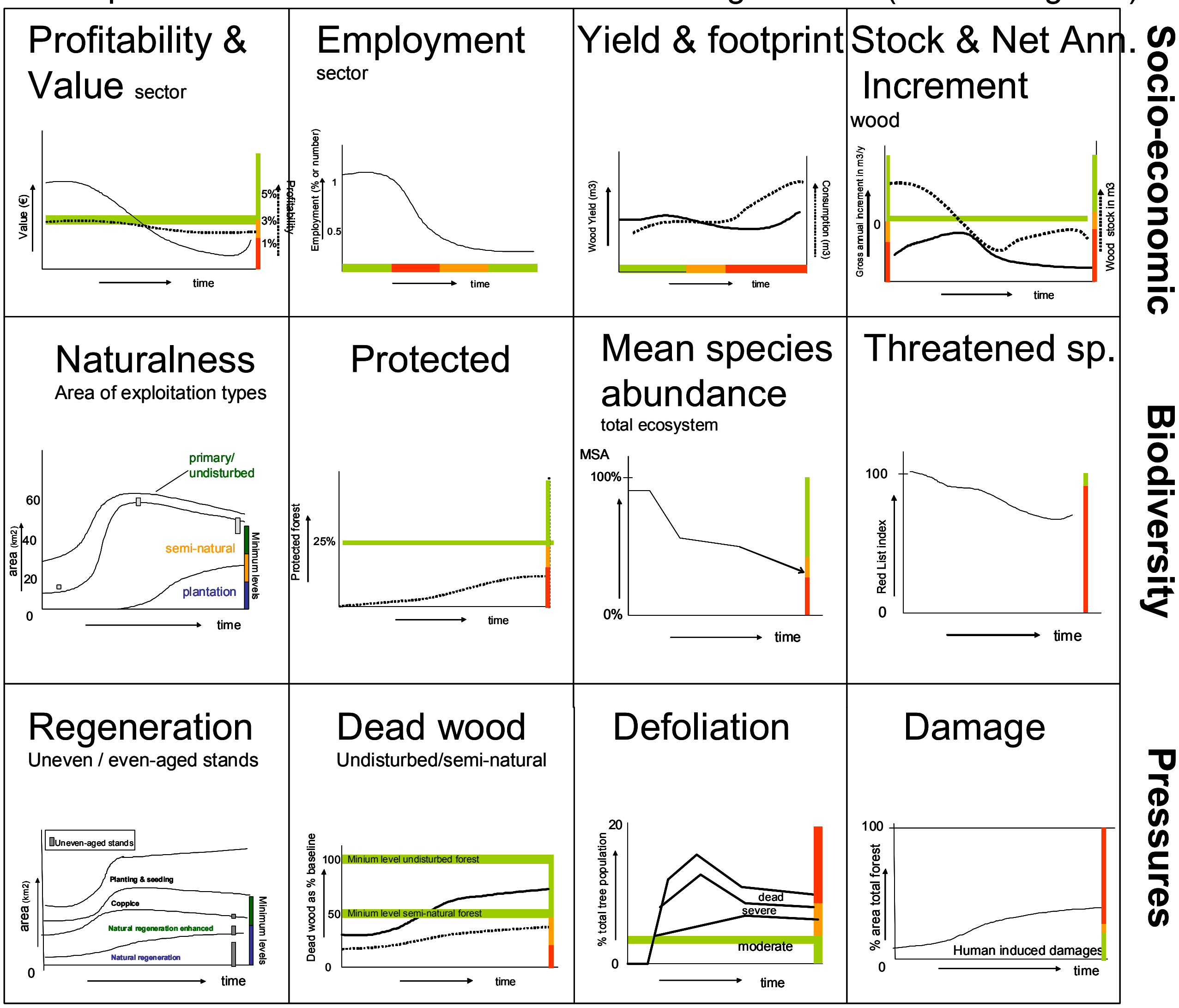
State of country ?

➢ **From voluminous reports towards lean cockpit-views**

It is generally agreed that biodiversity is a multi-dimensional entity. It cannot be simply expressed by one-single indicator. Different aspects need different indicators, comparable with GDP, inflation, growth, balance of payments, employment and income distribution as major macro-socioeconomic indicators.

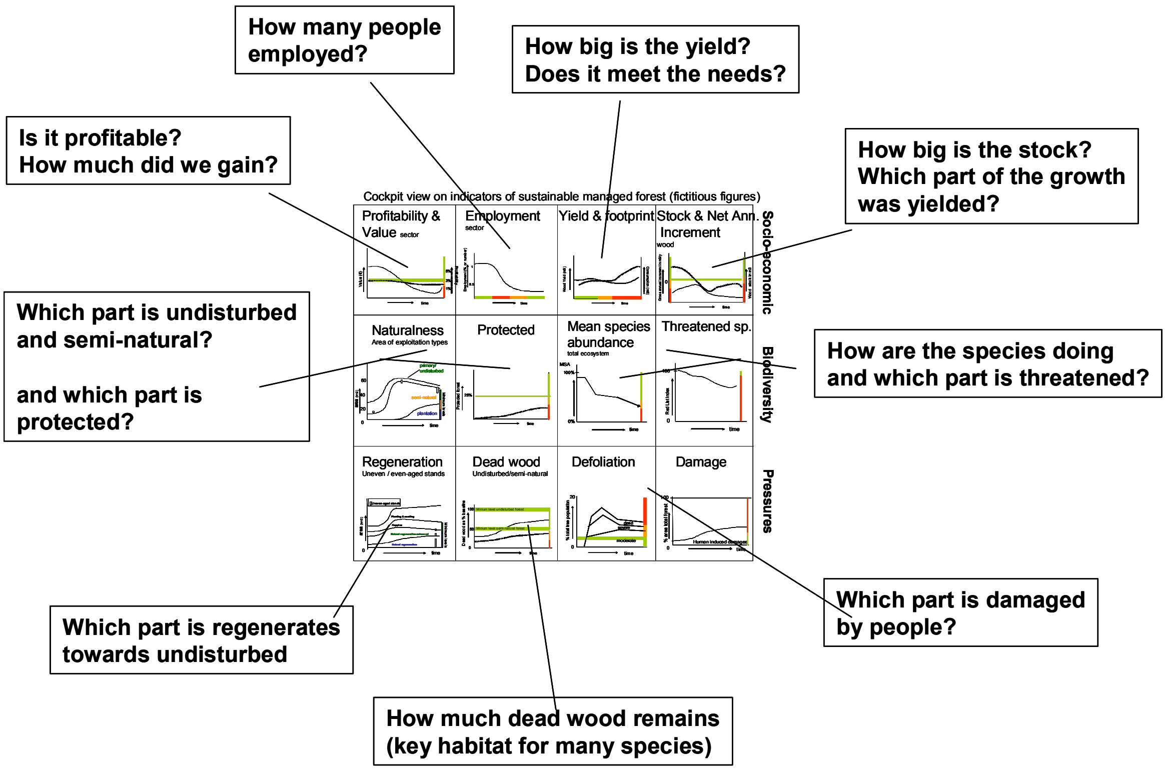
Although the number of the current CBD/EU headline indicators is small in comparison with previous indicator sets, they are still not easy to perceive as a whole. Human physical ability to digest and fully understand different indicators is limited to about 5-10. This also applies for policymakers! It should be noted that it not only concerns values of the present but also of the past and future for various options. Actually the airplane industry dealt with a similar problem how to inform the pilot in the most simple, quick and coherent manner. Life is at stake. Drawing on this various biodiversity cockpits have been designed and –sometimes- implemented. The figure below is designed in the SEBI 2010 inintiative on how the sustainability of the management of forest could be shown in one glance.

Cockpit view on indicators of sustainable managed forest (fictitious figures)

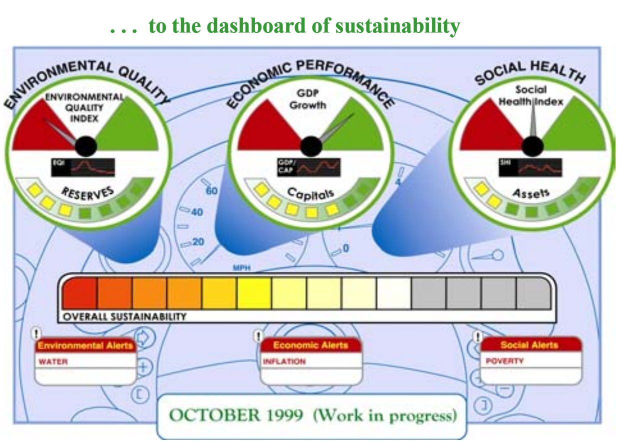


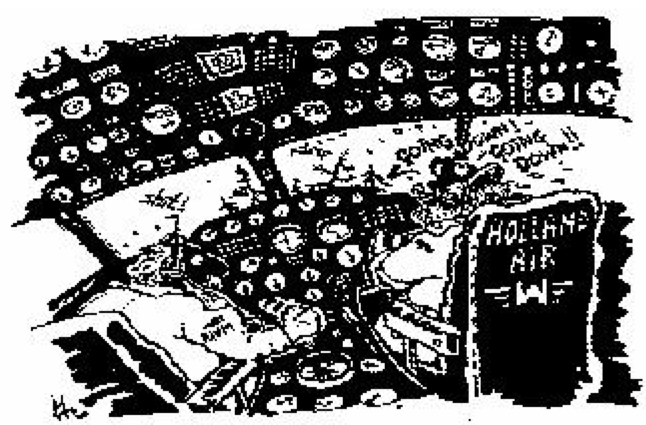
Source: Streamlining European Biodiversity Indicators initiative, Expert Group 6 (EEA, 2006).

The various aspects of sustainably managed forests are ordered, answering on different policy key questions. The indicators clearly relate to critical levels (green, orange and red zone, common practice in cars and airplanes, but also education and health), which makes the message directly clear and eases communication



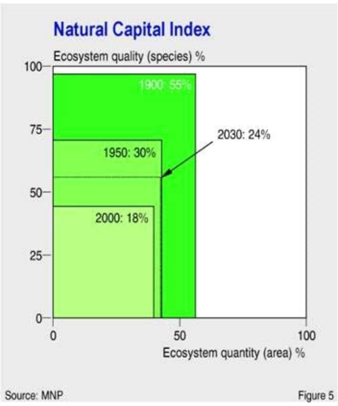
The need for environmental cockpits is felt by many. The cartoons below illustrate this desire. The next page shows The Netherlands reporting to the CBD with a cockpit-like approach.

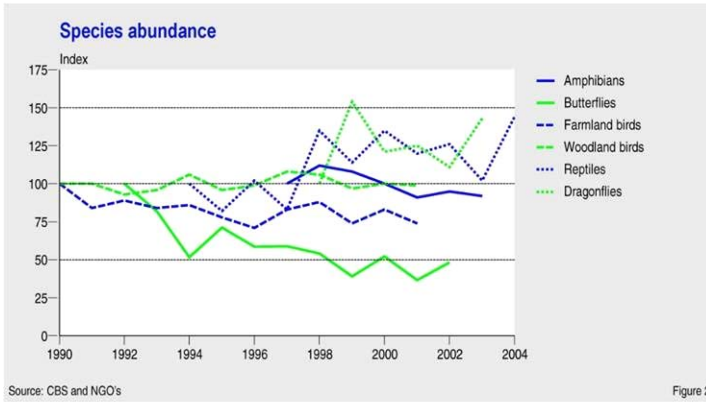


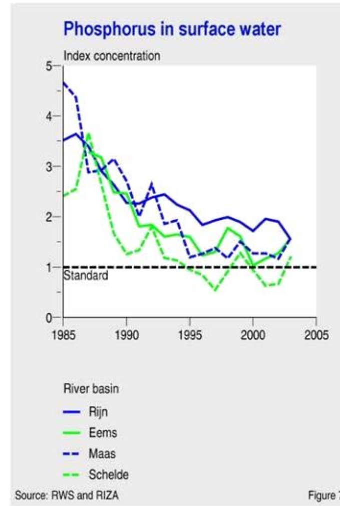


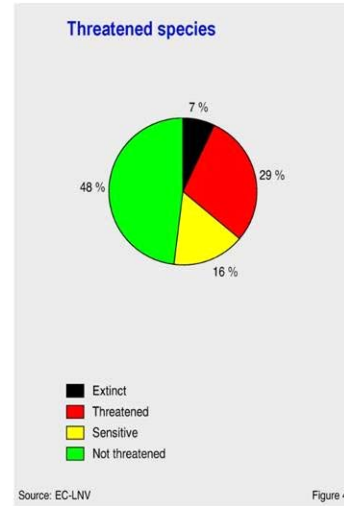
Source: left unknown; right: LT Journaal, Wageningen University Research (1993)

BIODIVERSITY STATUS AND TRENDS IN THE NETHERLANDS (UNEP/CBD/SBSTTA/11/inf/16)

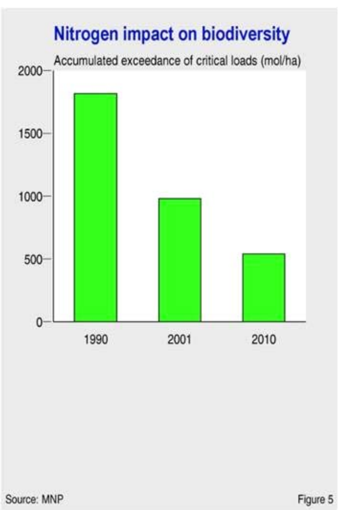




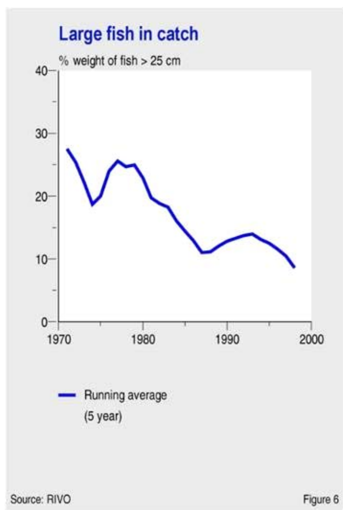


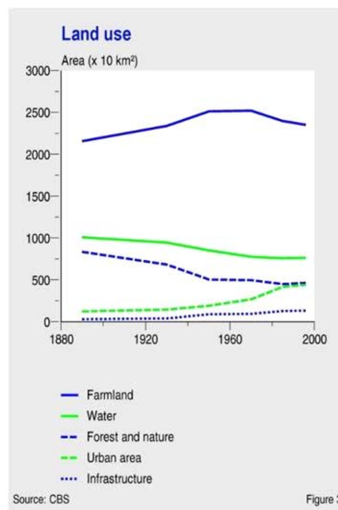


PRESSURES

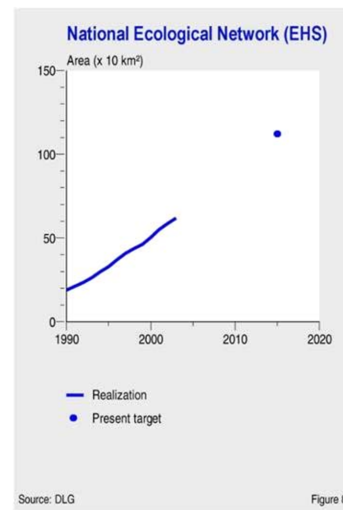


ECOSYSTEM INTEGRITY AND GOODS & SERVICES





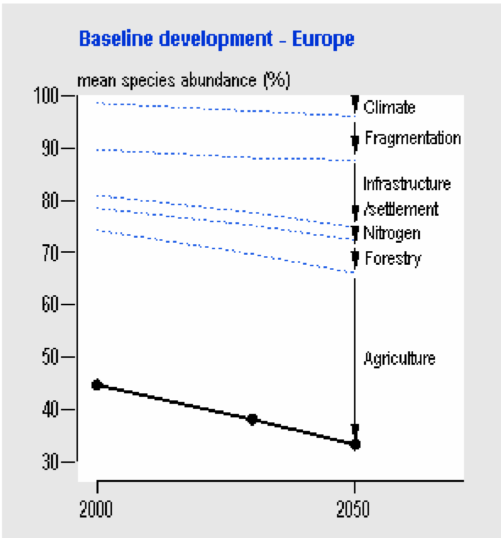
RESPONSE

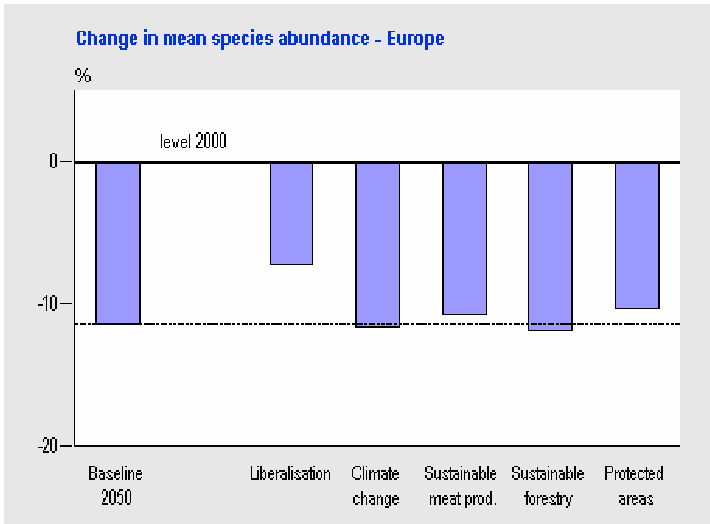


- **From problem-oriented towards solution-oriented indicator use**

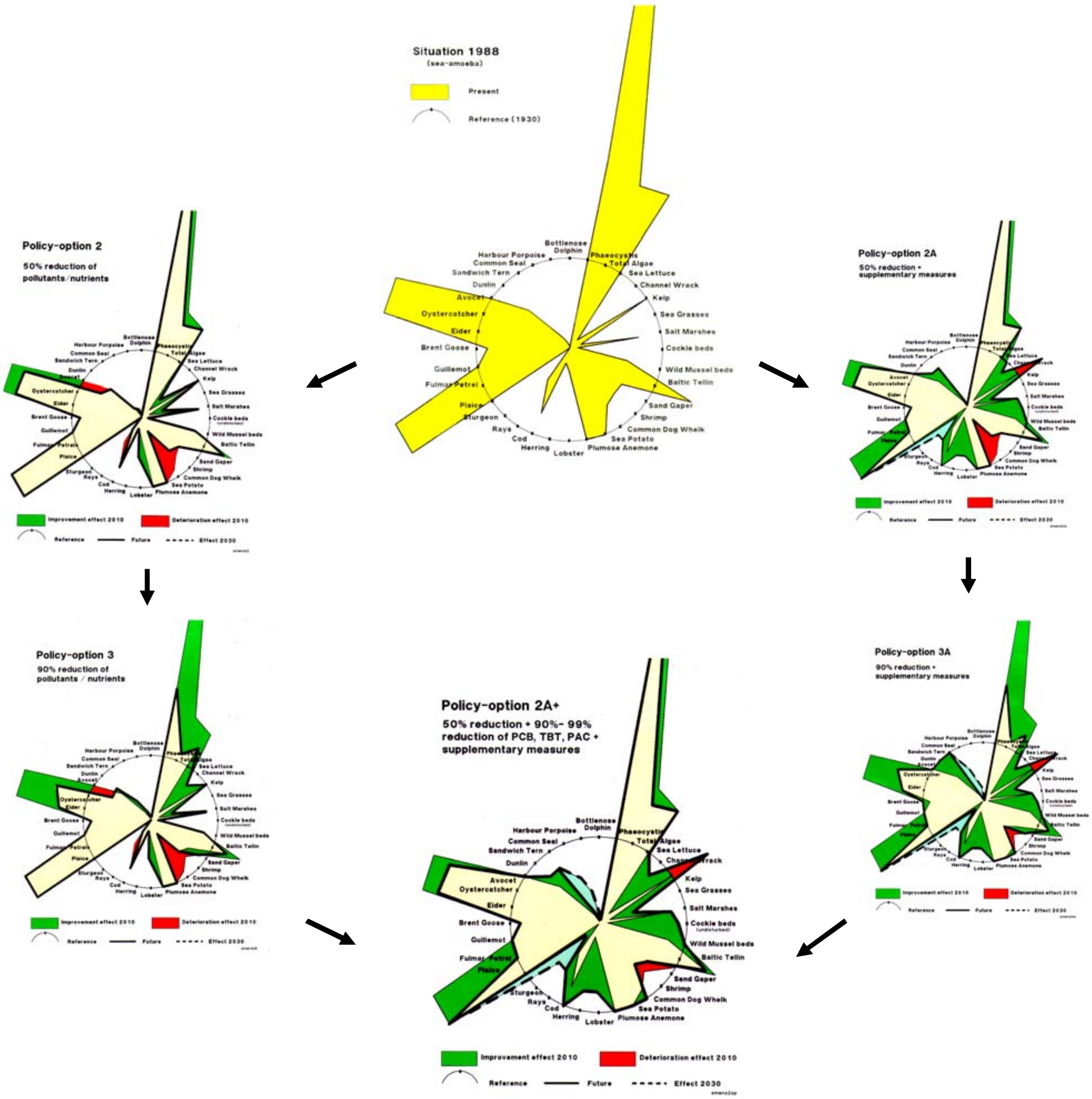
Providing coherent information on the current state is a big step forward. However, information on the future state makes the indicator even more powerful. Below two examples are given. The left picture shows the effect on Europe's biodiversity in a business-as-usual scenario. Also the shares per pressure are shown, making the link with measures. The right picture shows the effect of six policy options compared to the baseline scenario. It shows that Europe will not achieve its goal halting the loss by 2010, but on contrary, probably will continue its loss. Most options (bio fuels for climate mitigation, eating less meat by 5%, wood plantations and 20% protected areas will hardly reduce the loss. Only liberalisation of food trade (WTO) will reduce the loss considerably. However, this is at the expense of biodiversity in South America and Southern Africa converting huge natural areas into agriculture.

Source: MNP (2006)



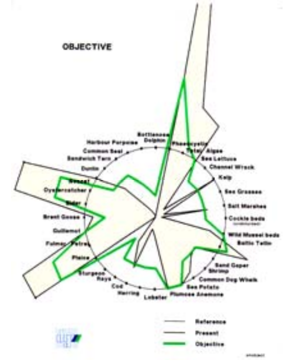


This example shows an assessment of the Dutch part of North Sea, Wadden and Delta ecosystem by a multi-species indicator (amoeba). The amoeba on top shows the current state while the “impact-amoebas” shows the effect of different policy options.



Source: Ten Brink (1990)

Option 2 and 3 (left site) concern the impacts of 50% and 90% reduction of nutrients, heavy metals and organic micro pollutants, respectively. Options 2a and 3a (right site) concern the same options, including various additional measures on habitat restoration, limiting fish catches, and species reintroduction and conservation. Changes in red represent deterioration compared to the natural ecosystem (circle), changes in green improvements. Option 2a (below) provides a mart combination of these options resulting in a low-cost and high-effect.



On basis of these analyses the government set the target for the marine ecosystems at an amoeba between the 75%-200% level. Probably this is one of the first verifiable ecological targets set at the country level.

4 Composite indicators as communication tools

The CBD selected a set of single indicators, but did not agree on composite indicators. However an indicative list of suitable composites was provided as shown in *Box 3*.

*Box 3: Indicative list of suitable composite indicators according to the CBD [6]**

State

- **Natural Capital Index (NCI)** [7]
- **Living Planet Index (LPI)** [8]
- **Species Assemblage Trend Indices (STI)** [9]

Threat

- **Red List Indicators on species groups (RLI)**
- Hot spots

Pressures

- Total Pressure Index (pressure-based NCI)
- Habitat-species Matrix (agricultural practices)
- Climate change
- Acidification
- Eutrophication

Uses

- Sustainability of total use

* in bold the indicators elaborated in this study
Source: UNEP/CBD/SBSTTA/9/Inf/7

In this chapter I will describe six composite indicators which are regularly implemented in official assessment reports; major features, pros and cons are given:

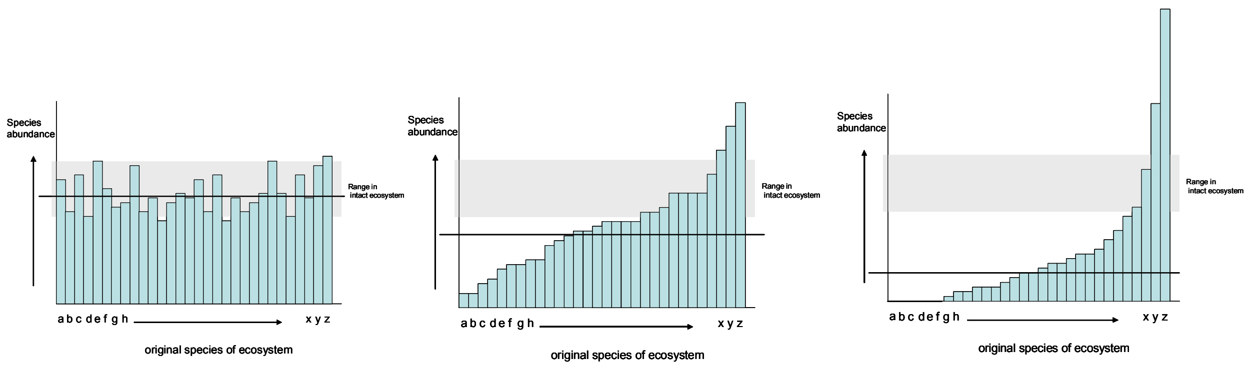
1. Natural Capital Index (NCI),
2. Living Planet Index (LPI),
3. Biodiversity Intactness Index (BII)
4. Mean Species Abundance (MSA)
5. Species Assemblage Trend Index (STI),
6. Red List Index (RLI)

These indicators have in common that they describe the change in species abundance. Change in species abundance (= number of individuals per species) is the key process of biodiversity loss. This process is described in Box 4. Insight in the process is a precondition to assess whether an indicator suits or not.

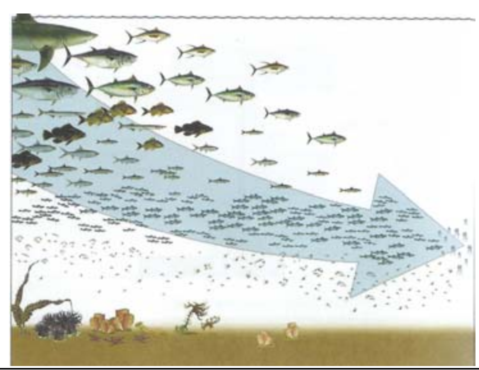
[6] Fact sheets with indicator details are provided in UNEP/CBD/SBSTTA/9/Inf/7 and 9/inf/26.
[7] As described in UNEP/CBD/SBSTTA/3/9 and . UNEP/CBD/SBSTTA/3/Inf.13.
[8] see WWF
[9] Examples of Species Assemblage Trend Indicators are the European Farmland Bird Indicator, or any other species group

Box 4: Biodiversity loss and how it could be measured

Biodiversity is a broad and complex concept that often leads to misunderstandings. According to the CBD, biodiversity encompasses the overall variety found in the living world and includes the variation in genes, species and ecosystems. In this document we will focus on species, considering the variety of plant and animal species in a certain area and their population sizes. Population size is the number of individuals per species, generally expressed as the abundance of a species or briefly “species abundance”. The various nature types or “biomes” in the world vary greatly in the number of species, their species composition and their species abundance. Obviously a tropical rainforest is entirely different from tundra or tidal mudflats. The loss of biodiversity we are facing in modern times is the -unintentional- result of increasing human activities all over the world. The process of biodiversity loss is generally characterised by the decrease in abundance of many original species and the increase in abundance of a few other -opportunistic- species, as a result of human activities. Extinction is just the last step in a long degradation process. Countless local extinction (“extirpation”) precedes the potentially final global extinction. As a result, many different ecosystem types are becoming more and more alike, the so-called homogenisation process (Pauly *et al.*, 1998; Ten Brink, 2000; Meyers and Worm, 2003; Scholes and Biggs, 2005; MEA, 2005). Decreasing populations are as much a signal of biodiversity loss as highly expanding species, which may sometimes even become plagues in terms of invasions and infestations (see the figures showing this process from left to right).

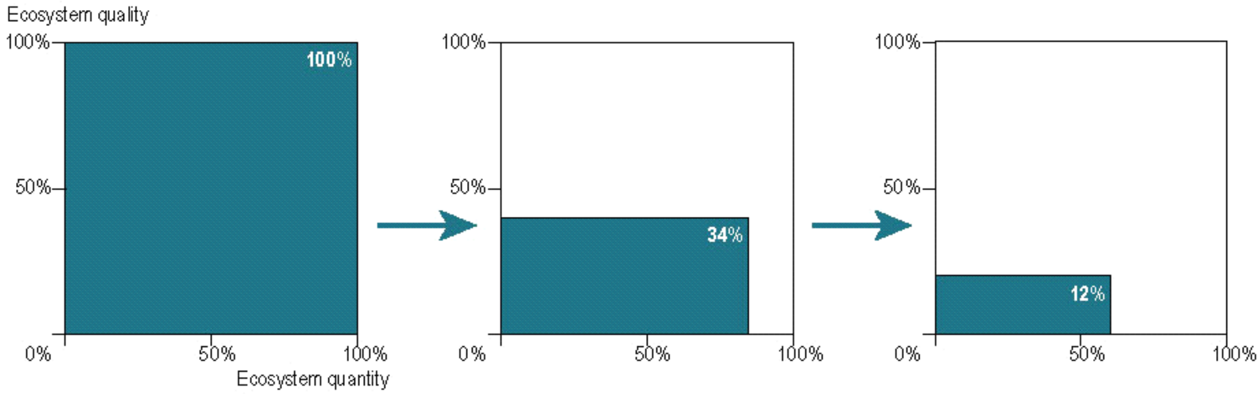


Until recently, it was difficult to measure the process of biodiversity loss. “Species richness” appeared to be an insufficient indicator. First, it is hard to monitor the number of species in an area, but more important it may sometimes increase as original species are gradually replaced by new human-favoured species. Consequently the Convention on Biological Diversity (VII/30) has chosen a limited set of indicators for use, including the “change in abundance of selected species”, to track this degradation process. This indicator has the advantage that it measures this key process and can be measured and modelled with relative ease. A similar process is seen in shopping streets. The number of shops in a street remains the same but become more and more similar (Body shop, KFC, etc). The fishing-down-the-food-web figure (Pauly, 1998) illustrates this process nicely. Similarly we also plough, burn, log, hunt and pollute down terrestrial ecosystems. As a common feature long-lived, large bodied and low productive species are reduced.



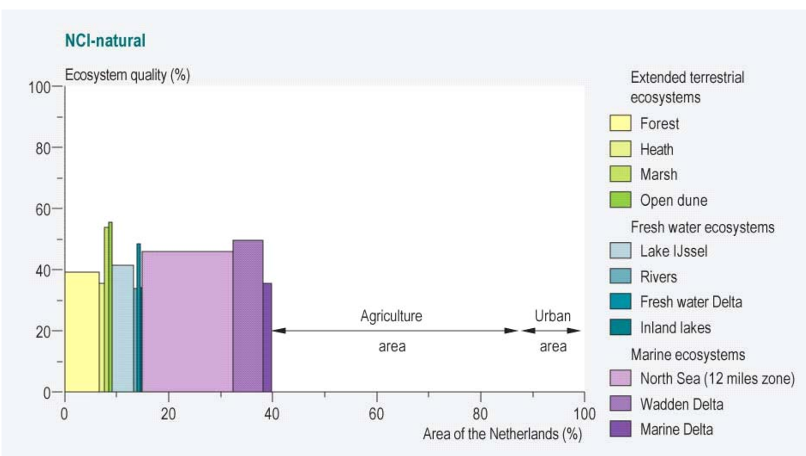
4.1 Natural Capital Index

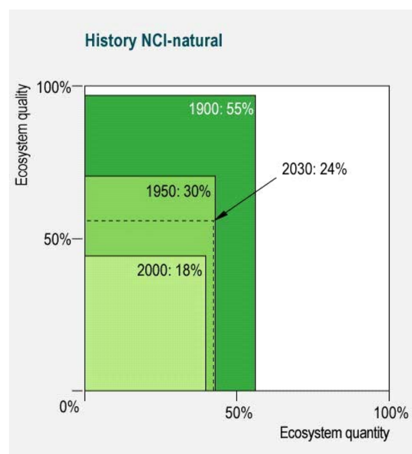
The NCI measures the mean species abundance relative to the low-impacted or pre-industrial state. A distinction is made between the NCI-natural and NCI-agriculture. For NCI-agriculture traditional agriculture is applied as baseline. The mean species abundance is calculated as the product of the remaining ecosystem area (quantity) and the ecosystem quality (mean species abundance in the remaining ecosystem). The distinction between natural (self regenerating) and cultural ecosystems has been made for two reasons. First, traditional landscapes have their own specific biodiversity and cultural-historical features which are often highly valued. Comparing these systems with natural ecosystems would make no sense. They would score low values. Second, ecosystem extent (quantity) is an extremely simple measure to monitor and to model, even for poor countries, which makes it more feasible for global use. In essence NCI measures human impact. The assessment principle is naturalness.

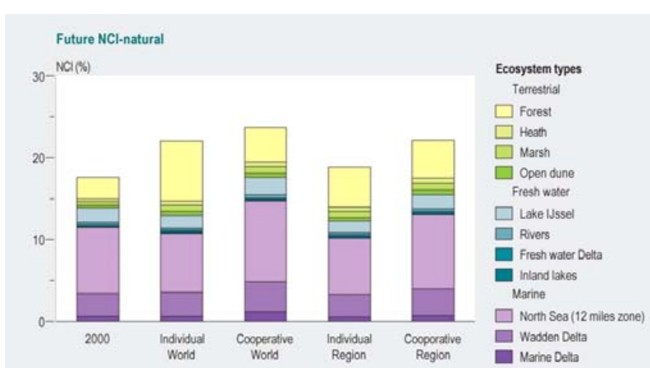


Below (left) the NCI shows the remaining biodiversity in The Netherlands by ecosystem type. The figure on the right shows the decline in NCI in 1900, 1950 and 2000 (55->18%) at the national level and the possible restoration by abatement measures in 2030 (18->23%). For all species (n=980) pre-industrial baselines have been reconstructed. The NCI agriculture (17%) is not included here.

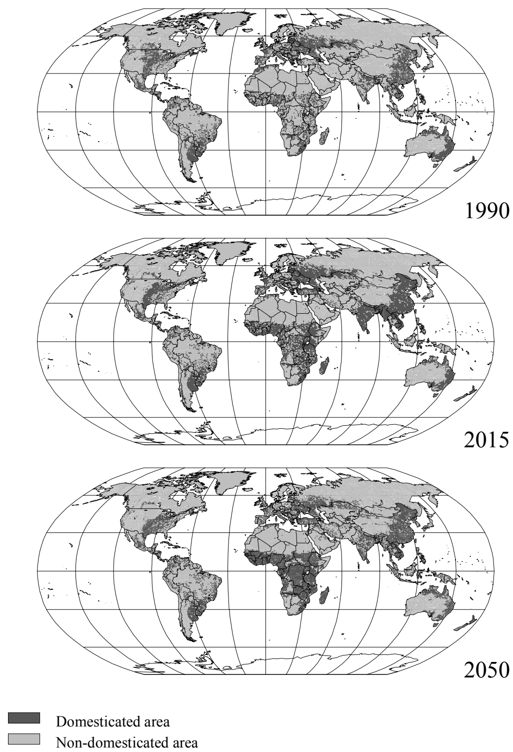
The next figure shows the NCI for different scenarios, including the underlying ecosystem types. The highly aggregated, single figure makes it easier to compare.







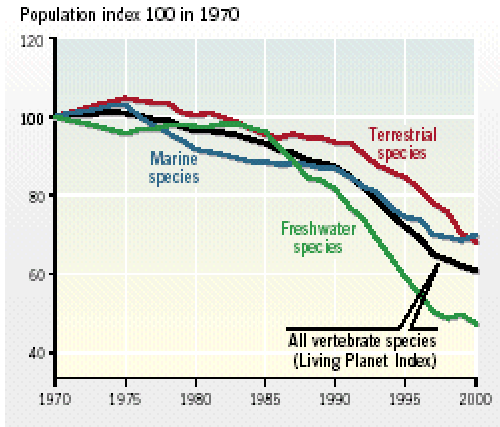
NCI has been used in UNEP's Global Environment Outlook 1 and 3. The ecosystem quantity (extent) is based on land use and land cover monitoring, the ecosystem quality component is based on modelling. The figure below shows the spatial distribution of the natural and agricultural ecosystem types, projected in 1990, 2015 and 2050, and calculated by the IMAGE model in the first Global Environment Outlook (RIVM/UNEP, 1997; UNEP, 1997).



4.2 Living Planet Index

The LPI measures the mean species abundance of ecosystems relative to 1980. The LPI does not distinguish between natural and man-made ecosystems and is entirely calculated on the mean species abundance of a core set of species. For each species the first measurement is used as baseline. This means that there is no one-single baseline but a shifting baseline since 1970, depending on the first measurements of the included species. In essence LPI measures human impact since 1970. The assessment principle is the more individuals per species the better. LPI has been applied in various WWF reports and the 2nd Global Biodiversity Outlook.

FIGURE 2.4 | The Living Planet Index: trends in populations of terrestrial, freshwater, and marine species worldwide



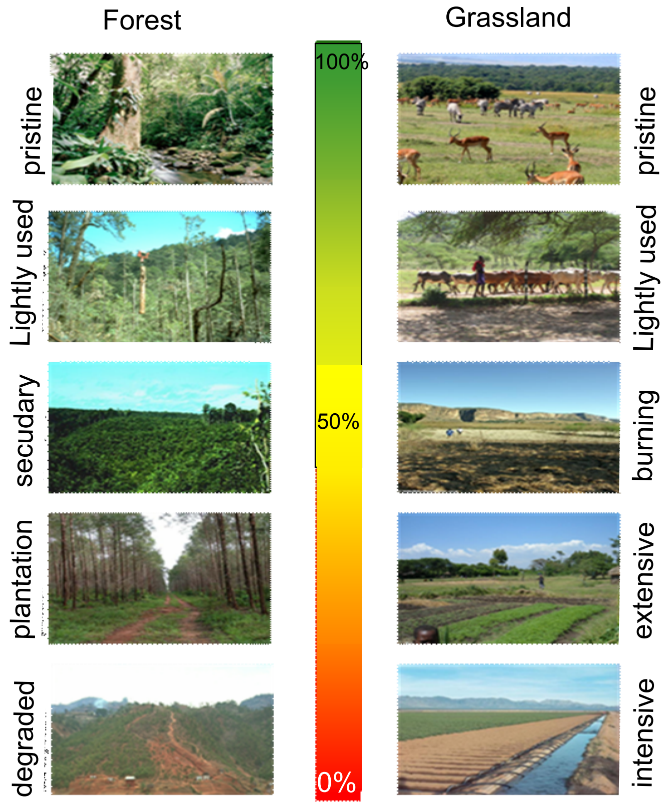
Source: World Wide Fund for Nature and UNEP World Conservation Monitoring Centre

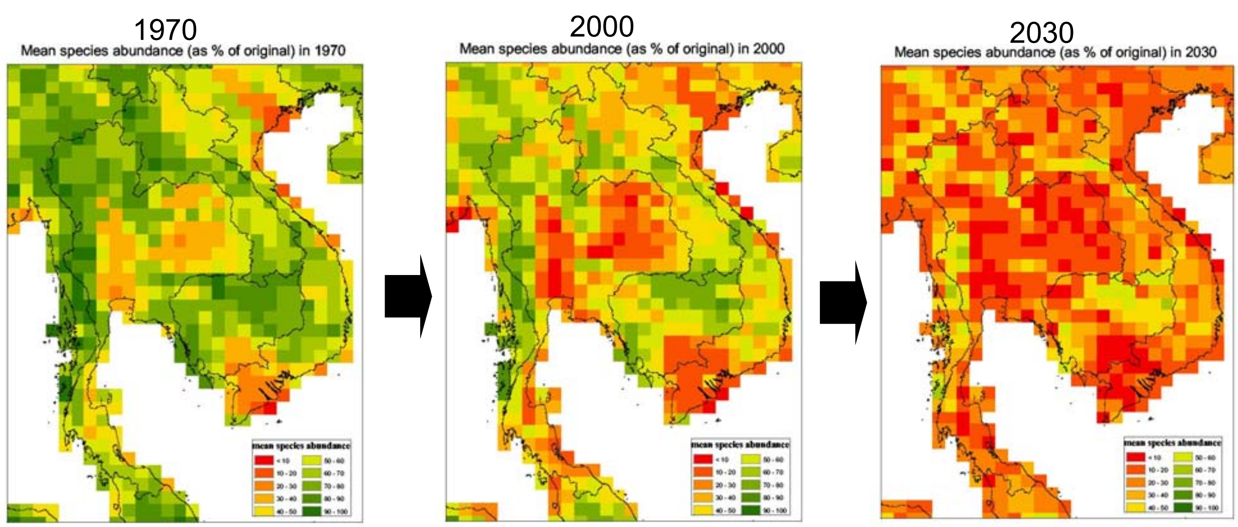
4.3 Biodiversity Intactness Index

The BII measures the mean species abundance relative to the natural or low-impacted state at the ecosystem level. As MSA no distinction is made between the natural and agricultural ecosystems as in NCI. It has been designed for species-data poor regions such as Southern Africa. The BBI is derived and calculated from land-use and land cover data. Each land use category has a fixed biodiversity value. Effects of other pressures like climate change, fragmentation or N-deposition are not taken into account. In essence BII measures human impact by agriculture, extensive grazing and forestry. The assessment principle is naturalness. National parks are used as reference. BBI has been applied in Southern Africa and in the South African assessment of the Millennium Ecosystem Assessment.

4.4 Mean Species Abundance

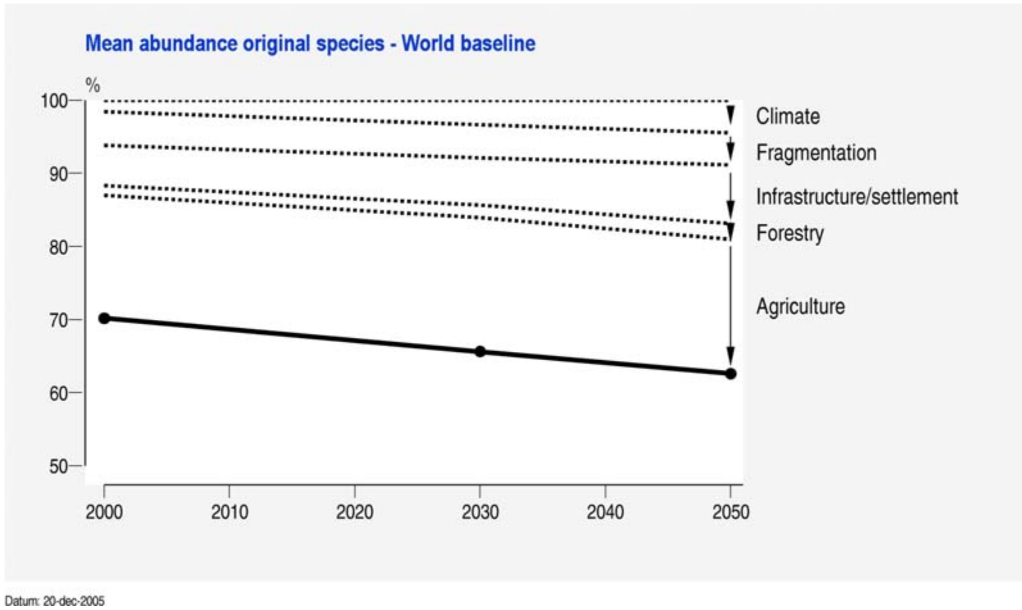
MSA measures the mean species abundance relative to the natural or low-impacted state at the ecosystem level. No distinction is made between the natural and man-made ecosystems as in NCI. It has been designed for global and regional assessments in which models calculate the past, present, and future for different scenarios. Linkages with socioeconomic activities are easy to make as well as calculating the share per pressure or sector. In essence MSA measures human impact. The assessment principle is naturalness. MSA has been applied in the 2nd Global Biodiversity Outlook, regional assessments of UNEP (Fall of the Water, the Desert Outlook, Greater Mekong Biodiversity Corridor Initiative), the FAO agricultural assessment, OECD's Environment Strategy and Outlook and UNEP's fourth Global Environment Outlook. Examples are shown below. The three maps below show the loss of biodiversity in MSA terms in the Greater Mekong Subregion between 1970-2030. The series of pictures and color code have been added to visualize this change into something tangible.





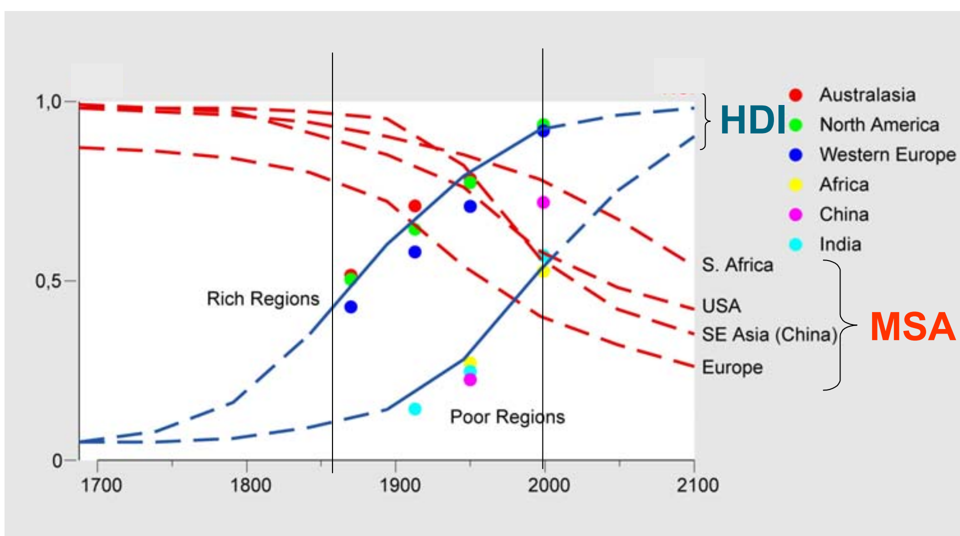
Source: MNP, UNEP-WCMC, UNEP-GA (2006)

The picture below shows the global biodiversity loss in the coming 50 years in a business as usual scenario in MSA terms, including the shares per pressure.



Source: MNP, UNEP-WCMC, UNEP-GA (2006)

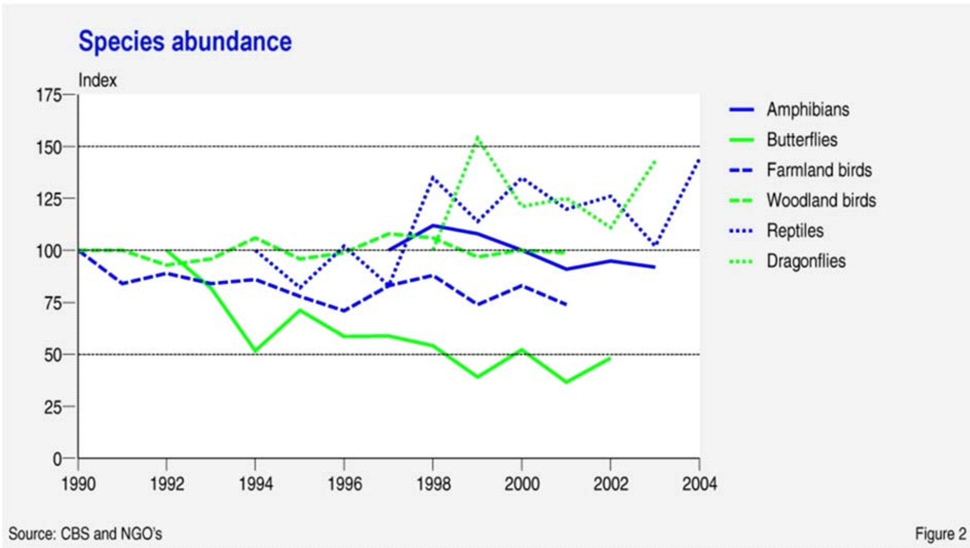
This picture below shows two top-level composite indicators, the Human Development Index as a hybrid composite of health, education and income on the one hand, and the Mean Species Abundance on the other. They have been calculated for poor and rich regions between 1700-2000 and projected towards 2100. The relation between human development and biodiversity seams to be inversely related over time. The poor countries show a similar development pattern on HDI and MSA, however 100 years lagging behind. China makes a short cut, on both indices.



Source: F. Langeweg, MNP (2006)

4.5 Species Assemblage Trend Index

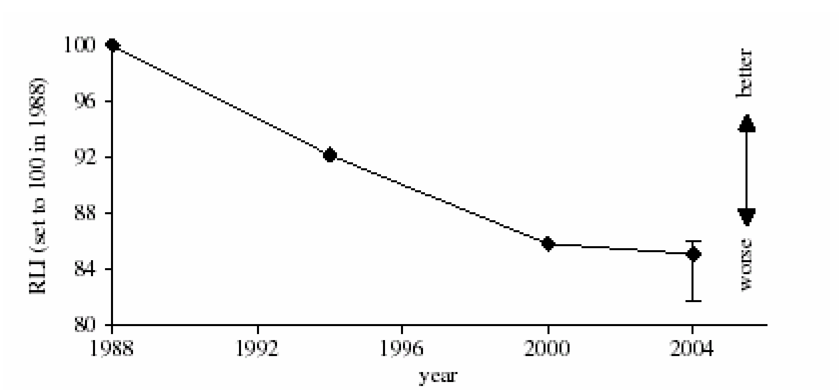
STI is the mean species abundance of a species group compared to a reference year (i.e. 1980). These could be taxonomic groups, species of cultural interest, endemic species, migratory species, threatened species, etc. In essence STI measures human impact on a species group since the reference year. The assessment principle is the more individuals per species the better. STI has been applied in various national and European reports. Examples are the European farmland bird and the butterfly indices. In The Netherlands, the UK and various other countries STIs has been made for i.e. birds, butterflies, large mammals, reptiles and sometimes other groups.



Source: Netherlands Statistics

4.6 Red List Index

The RLI measures species abundance by weighting the extinction-risk of all species of a particular taxonomic group. In the figure below RLI is calculated for all birds, over 1988–2004. In essence RLI measures human impact -in terms of risk at extinction- per species group since a certain year. The assessment principle is the lower the extinction-risk the better. Several varieties of RLI have been used all over the world. The RLI variety as shown below is designed so complex that it is difficult to understand its meaning. The message from picture is that it is getting worse, but the meaning of the change from 100-85 in terms of how many birds are at risk and at what risk level stays unclear. Currently the RLI is redesigned to improve understandability.



Source: Butchard et. al. (2005).

5 Differences and similarities

Although all the indicators are composites, they are all different (Table 1).

- NCI, LPI, BII and MSA are *ecosystem-level* indicators based on species abundance. However, they have different *assessment principles*:
  - MSA and BII are measuring naturalness or human impact.
  - NCI slightly differs by measuring human impact since industrialisation started. Only NCI assesses agri-ecosystems separately by using traditional agricultural ecosystems as baseline.
  - LPI measures human impact since 1970. In absence of a meaningful baseline an increase in the abundance of any species (also introduced or invasive) is perceived as good, and vice versa (the more individuals the better).
- STI and RLI are *species-level* indicators based on species abundance within a species group.
  They have different *assessment principles*:
  - STI is measuring change compared to a reference year (the more individuals the better).
  - RLI is measuring the level of extinction risk. In the example above 1988 is set as baseline year. The various RLI varieties have different calculation procedures such as species selection, the use of a baseline year, including or excluding the rate of change in abundance, and others.
- All indicators differ in calculation procedures such as averaging method, truncating, species selection, dealing with exotic species, whether individual species or species groups are weighted equaly and whether species or units area are the basic building bricks of the composite indicator (species-richness weighing or not).
- There are also differences in the way they are produced.
  - MSA and NCI-model-based are calculated by modelling land use, sea use and a set of other pressures (regional, global, suitable in data-poor regions). Both are used for projections in the future.
  - NCI-monitor-based have been calculated on monitoring a sample set of species (national, suitable in data-rich countries and regions). NCI has been used for projections.
  - BII is calculated by modelling land use (regional, suitable in data-poor regions). BII is suitable for projections.
  - LPI has been calculated on monitoring a sample set of species (three biomes, suitable in data-rich biomes). LPI has not yet been used for projections, but in principle can.
  - STI has been calculated on monitoring a sample set of species (suitable in data-rich regions). STI has not yet been used for projections but in principle can.
  - RLI has been calculated on both monitoring and expert judgement of a sample set of species (suitable in data-rich regions). RLI is difficult to model. to make projections.

Table 1: Comparison between six composites on 5 features and meaning

Indicators	species/ ecosystem	baseline	Assessment principle	Species/area weighted	Truncate	Meaning
NCI	ecosystem	pre-industrial	more natural the better	area	100%	change in naturalness since industrialisation
LPI	ecosystem	1970 - ~	more indiv. the better	species	1%? 10,000%?	change in species abundance since 1970
BII	ecosystem	natural	more natural the better	species	probable 100%	change in naturalness
MSA	ecosystem	natural	more natural the better	area	100%	change in naturalness
STI	species	1980	more indiv. the better	species	1% 10,000%	change in species abundance of group
RLI	species	extinction risk	less risk the better	species	n.a.	change in extinction risk of group

It makes no sense to declare one indicator better or worse. After all, suitability can only be determined in the context of the key questions of the target-audience. However, some generic pros and cons can be made:

NCI:
meaningful, easy to understand, takes specific values of agri-biodiversity into account, can be modeled, but the monitoring of the set of species and determination of their baseline values is costly.

LPI:
moderately meaningful and easy to understand because of baseline (change since 1970, what does that mean?), can be modeled in principle, the monitoring of the set of species is costly, but the determination of their baseline values is easy by using just the first measurement.

BII:
meaningful, easy to understand, but underestimates loss, can be modeled, monitoring of land use changes is cheap and determination of the baseline values is cheap based on comparison with protected areas by expert judgment.

MSA:
meaningful, easy to understand, but underestimates loss although less than BII, is already modeled, the monitoring of the land uses and other pressures is cheap, as is the determination of the baseline values based on literature.

STI:
Moderately meaningful and easy to understand because of baseline (change since 1980?), can in principle be modeled, the monitoring of the set of species is costly, and the determination of the baseline values by 1980 can cost some money if not measured.

RLI:
In the above form not meaningful and not easy to understand because of unclear baseline and calculation procedure, cannot be modeled, the monitoring of the set of species is moderately costly partly thanks to expert judgment, but determination of their baseline is easy and cheap by standardised IUCN procedures.

Last but not least it has to be noted that indicators alone are not enough to communicate your message and convince your target-audience. In every case they should be accompanied by a strong and appealing narrative...