

ALTER-Net Summer School
31 August 2006, Peyresq, France



The economics of ecosystem services

Sigrid Stagl

s.stagl@sussex.ac.uk - ++44 (0) 1273-872784

The issue

Biodiversity is declining.

Changes in biodiversity due to human activities were more rapid in the past 50 years than at any time in human history, and the drivers of change that cause biodiversity loss and lead to changes in ecosystem services are either steady, show no evidence of declining over time, or are increasing in intensity.

Biodiversity benefits people through more than just its contribution to material welfare and livelihoods. Biodiversity contributes to security, resiliency, social relations, health, and freedom of choices and actions.

Exciting times ...

- Addressing environmental challenges by social and natural scientists working together
- Expanding the frame of reference by perceiving society and nature as complex systems
- Improving explanatory power by making social and behavioural sciences compatible

Outline

1.0 Ecological economics

- The standard circular flow model
- Economy-environment interdependence
- Stocks and flows

2.0 Environmental valuation and appraisal

- Value-articulating institutions
- Overview of environmental valuation methods
- Examples

Main thoughts on ecological economics

- The **economy** is dependent on a **functioning environment**.
- We need a **framework** for thinking about the interdependence of the economy and the natural environment, and the implications arising for sustainability.
- There are four **classes of services** that the environment provides to the economy - resource inputs, waste sinks, amenities, and life supports.
- If the economy **extracts more** resources from the environment, it necessarily inserts **more wastes** into it.
- **Waste** insertions at high rates have the potential to, and often actually do, **reduce the environment's ability** to provide renewable resource inputs, to provide amenity services, and to provide life support services.

Ecological Economics - 1

The analysis of the **interactions** between economy, society and environment.

It is at this intersection that we realise and increasingly understand the **complexity** of lifestyle, production and policy choices.

To address them ecological economists use **analytical tools** and draw on concepts coming from many **different disciplines** and fields of experience.

Usually the aim is to propose policy measures for sustainable development.

Ecological Economics - 2

'Ecologic' -

- 'eco' - Greek *oikos*, the home or dwelling place, the place where we belong
- 'logic' - Greek *logos*, the wisdom or the word of the *oikos*.

'Economic' -

- 'eco'
- 'nomic' - Greek *nomos*, a system of management or law for dealing with the *oikos*.

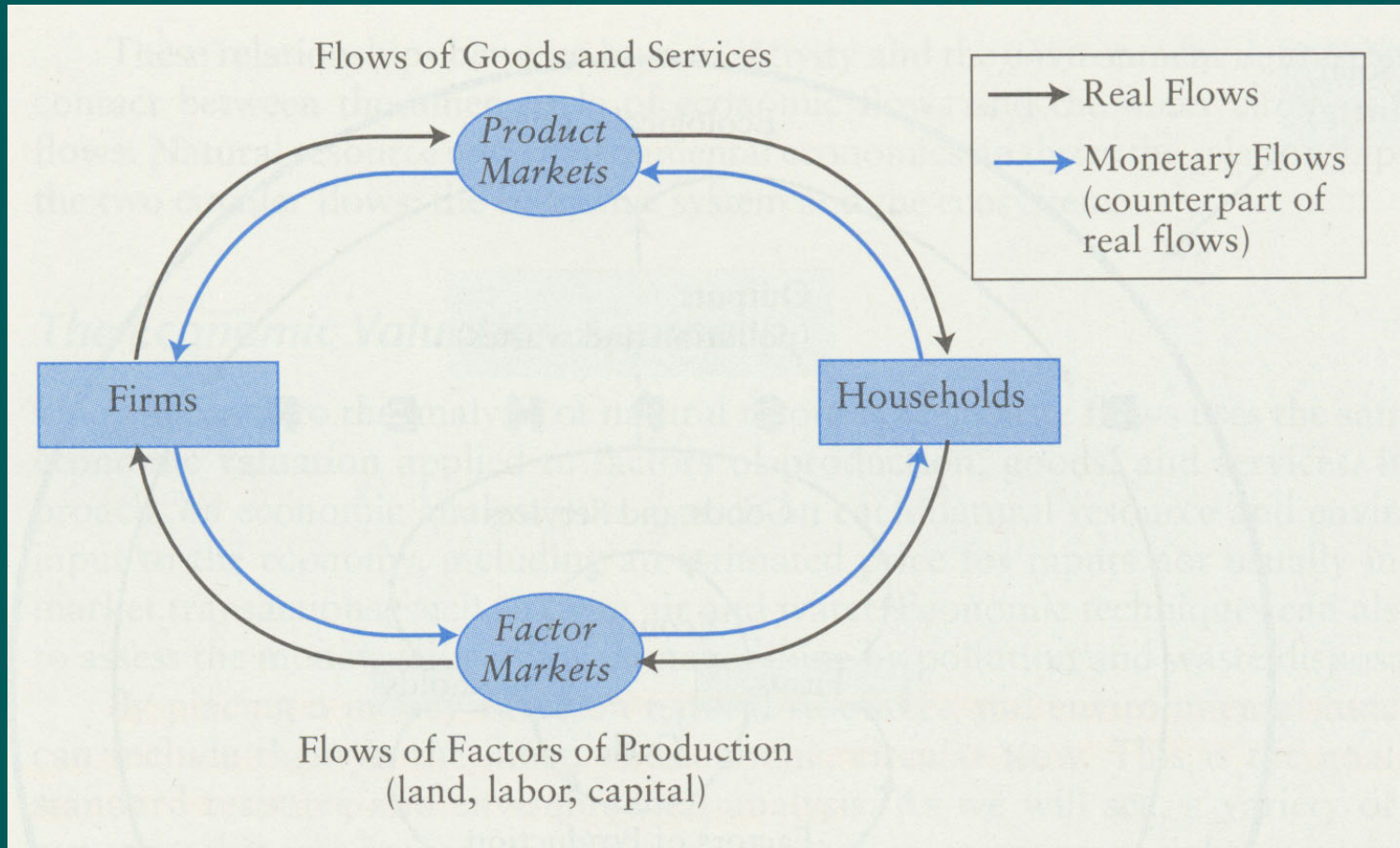
Ecological Economics – 3

Ecology is the study of the relations of animals and plants to their organic and inorganic environments.

Economics is the study of how humans make their living, how they satisfy their needs and desires.

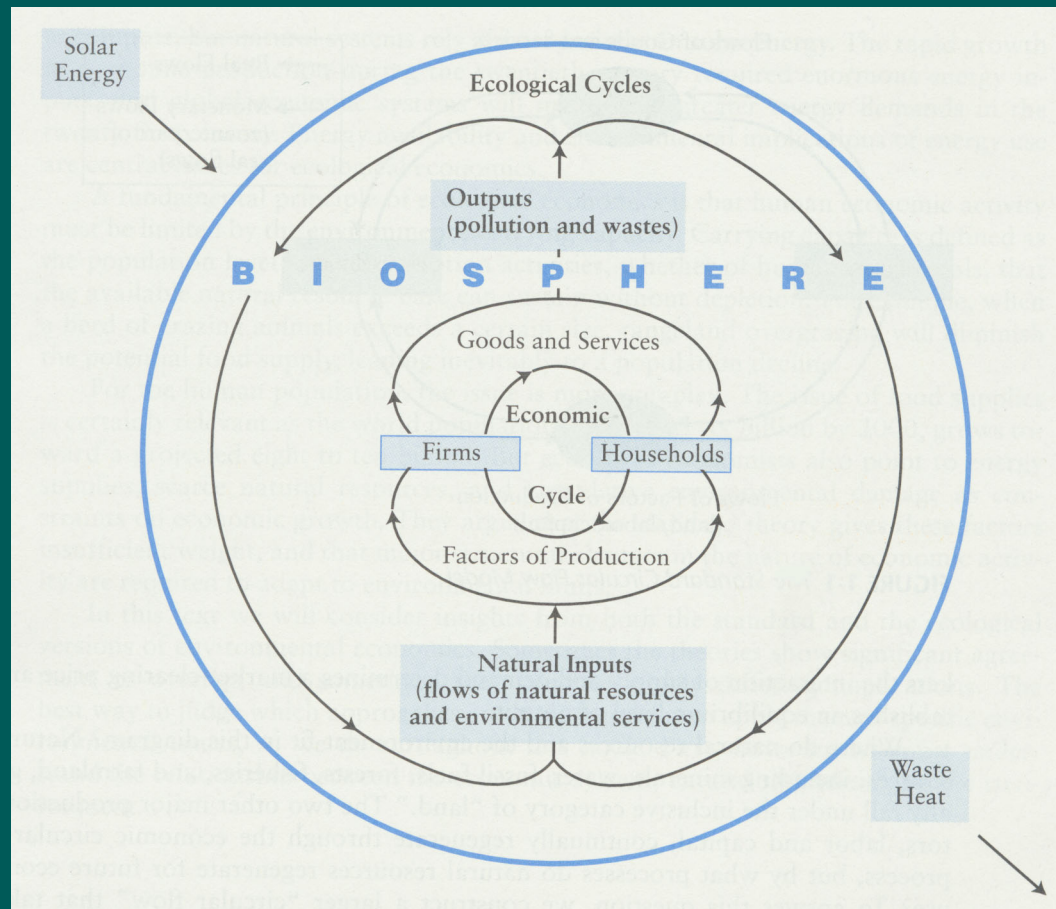
Ecological economics is the study of the relationships between human housekeeping and nature's housekeeping. In other words, it is about the interactions between economic systems and ecological systems.

The standard circular flow model



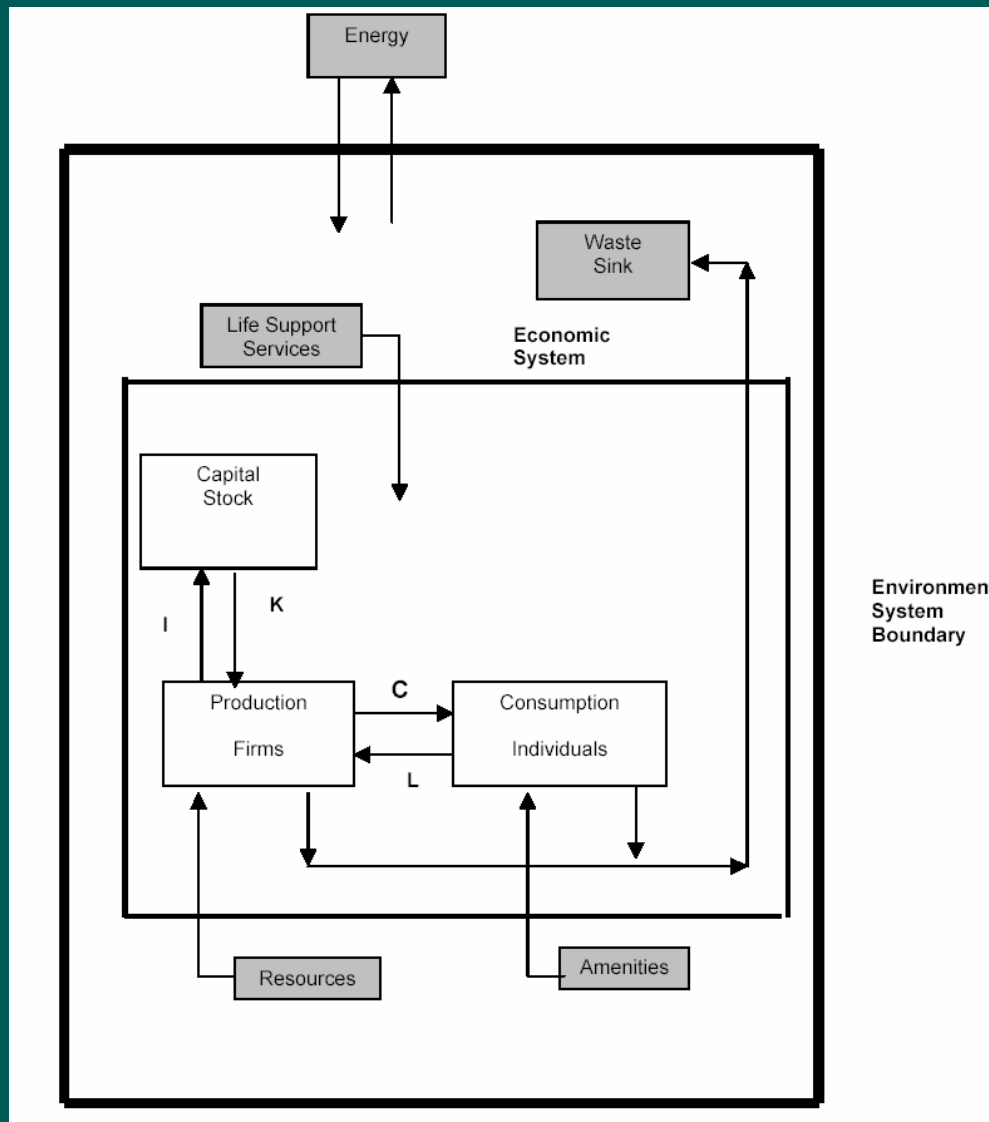
Source: Harris (2002:7).

A Broader Circular Flow Model



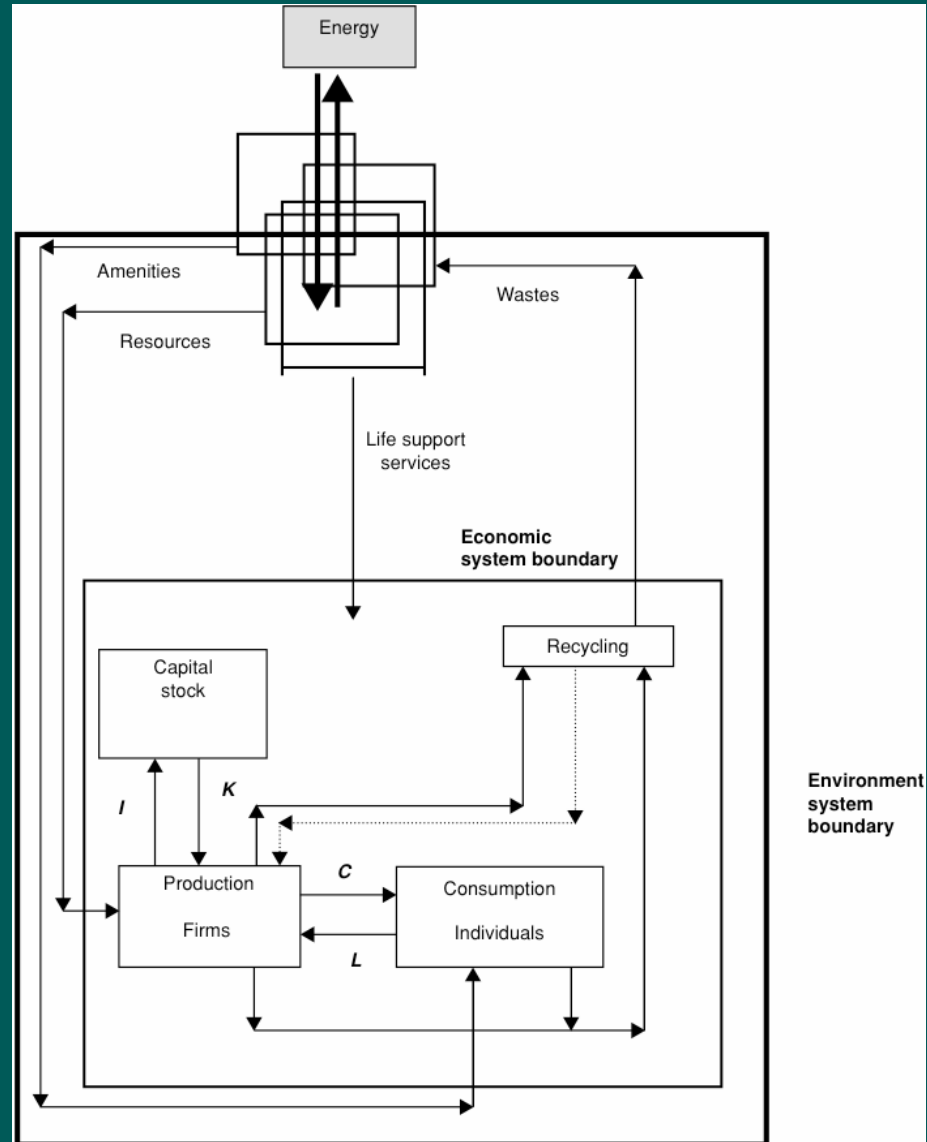
Source: Harris (2002:8) based on Daly (1977).

Economy-environment interdependence

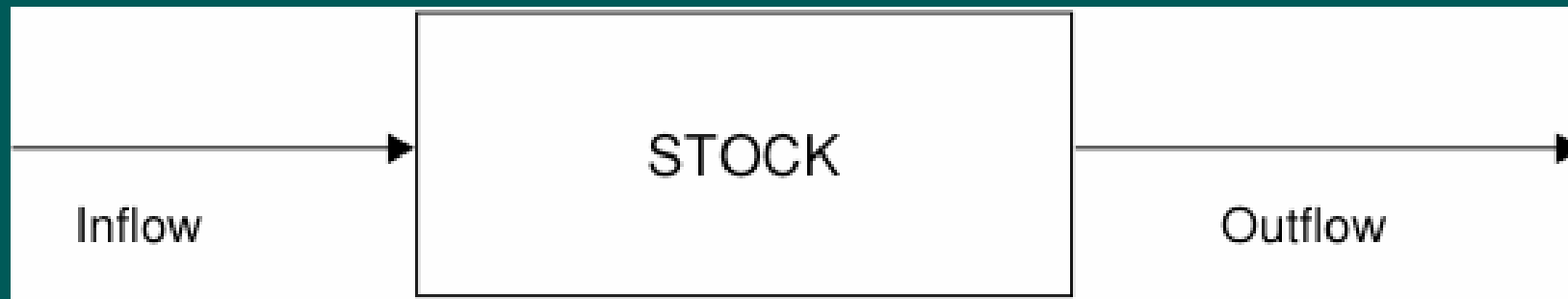


Source:
Common / Stiglitz 2005

Environmental service interactions



Stocks and flows



$$S_1 = S_0 + A_1 - O_1$$

$$S_t = S_{t-1} + A_t - O_t$$

$$S_t = S_{t-1} + G_t - E_t$$

Main thoughts environmental valuation

- Formal and informal **institutions** can **influence and enable actors to form preferences.**
- Environmental valuation methods are **value-articulating institutions** (Vatn).
- In the context of public policy implementation we are concerned about individual and group preferences.
- In the context of public policy making we are concerned about **social preferences.**
- For environmental governance we need institutions that are inclusive and deliberative, allow preferences to form and change, and we need to be reflective about the designs of value-articulating institutions.

Environmental valuation

- The **method / institution of inclusion of environmental resources** and ecosystem services in decision processes **determines how far they are taken into account** with results affecting the quality of our lives and those of future generations.
- Over the last 20 years **alternative** environmental valuation methods have been developed. More recently **novel combinations** of methods (hybrid methods) were developed and used in a number of empirical applications for environmental valuation.

Value articulating institutions

Value articulating institutions (VAI) define -

- Who participates?
 - How and in what capacity (consumer, stakeholder, citizen)
- What counts as data, which form they should take?
- What kind of data handling procedures are used?
 - Processing and aggregation

A VAI defines the **rationality** or logic of a specific choice.

Vatn, A. (2004).
Institutions and the environment.
Cheltenham, Edward Elgar.

Value articulating institutions (cont.)

Different VAls respond to different social contexts and rationalities

→ We must ask:

What characterizes the issues involved?

How would we like specific issues to be evaluated?

Core questions:

- Is the issue or good **individual** or **common**?
- What is the degree of **complexity**?
- Is the issue or good characterized by **one** or **plural value dimensions**? Are **preferences given** or may they change?
- What is a logical **aggregation procedure** given answers to the above?

Value articulating institutions (cont.)

Main VAs:

- Cost-benefit analysis (CBA)
- Multicriteria appraisal (MCA)
- Deliberative institutions (DI)
 - Citizen juries
 - Consensus conferences etc.

Value articulating institutions (cont.)

The neoclassical model (basis for CBA)

- Individualist: Decisions based on individual preferences → **instrumental / strategic action**

The basic assumptions:

- Rationality: **Maximizing individual utility** → one-dimensionality
- **Stable** preferences
- **Unlimited** calculative capacity

Value articulating institutions (cont.)

The institutional economics perspective – both individual and social rationality – 'I' and 'We'

Basic assumptions:

- Which **rationality** pertains depends on **institutional context**
- Uses also the concept of **social rationality**; reciprocity and norms; **communication and cooperation** (→ both self- and other-regarding logics).
- **Preferences** are **socially influenced** – culture
- **Understanding** is largely **social** – language and 'models'
- People are **boundedly rational** – capacity constraints

Weak comparability of values as a foundation for ecological economics

Strong comparability - single comparative term by which all actions can be ranked; implying strong or weak commensurability.

Strong commensurability – a common measure of consequence exists; cardinal comparison.

Weak commensurability – a common measure of consequence exists; ordinal comparison.

Weak comparability – values irreducibly plural and cannot be uniquely ordered along a single scale; implying incommensurability.

Martinez-Alier J, Munda G, O'Neill J. Weak comparability of values as a foundation for ecological economics. Ecological Economics 1998;26(3):277-286

Challenges environmental valuation

- **Social incommensurability** - derived from the concepts of reflexive complexity and post-normal science; refers to the existence of a multiplicity of legitimate perspectives in society.
- **Technical incommensurability** - evolving complex systems, multidimensional nature of complexity; uncertainty, ambiguity and ignorance; refers to the issue of representation of multiple identities in descriptive models.

Munda, G. (2004).

"Social multi-criteria evaluation: Methodological foundations and operational consequences."

European Journal of Operational Research 158(3): 662-677.

Aims and quality of deliberative processes

Making 'better' decisions. What do we mean by 'better'?

Trouble to evaluate decision outcomes → focus on the decision process.

Key quality criteria for deliberative processes:

- Competence in the process
- Fairness
- Social learning.

Webler, T., H. Kastenholz, et al. (1995).
"Public participation in impact assessment: a social learning perspective."
Environmental Impact Assessment Review 15: 443-463.

Multicriteria appraisal (MCA)

MCA allows to take into account in decisions -

- a large number of data, relations and objectives; facts and values,
- multiple criteria, measured on different scales (€, MT, ha, etc.),
- requires only weak comparability between actions,
- scientific data from various disciplines and different value judgements and interests.

→ MCA enables us to rank a finite number of alternatives, while considering several, in part conflicting criteria.

No solution optimising all criteria; compromise solution has to be found.

Hybrid value articulating institutions

- Methodologies which systematically judge how well different courses of action (options) perform when compared against a set of economic, social, environmental and ethical criteria.
- Value articulation is a process.
- Taking quantitative and qualitative information into account.
- Aim to support robust and accountable decision-making when dealing with complex scientific and technological issues.

Deliberative monetary valuation

Deliberative aspects are introduced in methods for the estimation of environmental monetary values.

(a) Input from focus groups in the design of questionnaires.

(b) Group deliberation for expressing value in monetary terms.

Recent projects:

ADVISOR (EU FP5) – water management

Ettrick Valley forest floodplain restoration - forest management

Deliberative monetary valuation

Selected references:

James, RF and RK Blamey (2004). Deliberation and economic valuation - national park management. Alternatives for environmental valuation. M Getzner, CL Spash and S Stagl. London, Routledge: 225-243.

Kenyon, W and N Hanley (2004). Three approaches to valuing nature - forest floodplain restoration. Alternatives for environmental valuation. M Getzner, CL Spash and S Stagl. London, Routledge: 209-224

Kenyon, W and C Nevin (2001). "The use of economic and participatory approaches to assess forest development: a case study in the Ettrick Valley." Forest Policy and Economics 3: 69–80.

Niemeyer, S and CL Spash (2001). "Environmental valuation analysis, public deliberation, and their pragmatic syntheses: a critical appraisal." Environment and Planning C: Government and Policy 19: 567-585.

Spash, CL (2001). Deliberative Monetary Valuation. 5th Nordic Environmental Research Conference, University of Aarhus, Denmark, 14th - 16th June, 2001.

Social multicriteria evaluation

Multicriteria evaluation (non-utility based) combined with (model-based) integrated assessment of impacts and stakeholder participation. Decision / discussion process about public policy is framed as social learning.

Recent projects:

VALSE (EU FP4) – methodology; water management

EVE (EU FP4) - methodology

MCDA_RES (EU FP5) – renewable energy

MESSINA (Interreg) – mgt of coastal erosion

DIAFIANS (Spanish Env Min) – IA of socio-econ alternatives

ADVISOR (EU FP5) – water management

ARTEMIS (Austrian Science Council) – energy futures

Tyndall Centre – policies for carbon reduction

Social multicriteria evaluation

Selected references:

De Marchi, B, SO Funtowicz, et al. (2000). "Combining participative and institutional approaches with multicriteria evaluation. An empirical study for water issues in Troina, Sicily." Ecological Economics **34**: 267-82.

Munda, G (2004). "Social multi-criteria evaluation: Methodological foundations and operational consequences." European Journal of Operational Research **158**(3): 662-677.

Russi, D, G Munda et al. (2004). "Social multicriteria evaluation of rural electrification: the case of the Montsery Natural Park", ISEE conference, Montreal July 2004.

Madlener, R. and S. Stagl (2005). "Sustainability-guided promotion of renewable electricity generation." Ecological Economics.

Agnolucci, P, K Anderson, et al. (2005). Pathways to a decarbonised UK: achieving a 60% reduction in CO2 emissions by 2050. ESEE conference, Lisbon, June 2005.

Stagl, S, L Bohunovsky, et al. (2005). Participatory MCE of renewable energy technology scenarios on two different scale levels - the case of Austria. ESEE conference, Lisbon, June 2005.

Multicriteria mapping

Multicriteria methodology which emphasises that there is a wide range of perspectives and expertise, and produces an overview that ``maps" the debate. It combines the transparency of numerical approaches with the unconstrained framing of discursive deliberations.

Recent projects:

Rethinking Risk (Unilever) - GMOs

UK Sustainable Hydrogen Energy Consortium – hydrogen futures

PorGrow (EU FP6) – public health (obesity)

Multicriteria mapping

Selected references:

Stirling, A (1997). Multi-criteria mapping. Mitigating the problems of environmental valuation? Valuing Nature? Ethics, economics and the environment. J Foster. London, Routledge.

Stirling, A and S Mayer (2001). "A novel approach to the appraisal of technological risk: a multicriteria mapping study of a genetically modified crop." Environment and Planning C: Government and Policy 19(4): 529-555.

Stirling, A and S Mayer (2004). Confronting risk with precaution: a multi-criteria mapping of a GM crop. Alternatives for Valuing Nature. M Getzner, CL Spash and S Stagl. London, Routledge: 159-184.

Eames, M. and W. McDowall (2005). Towards a Multi-Criteria Sustainability Appraisal of Competing Hydrogen Futures. ESEE conference, Lisbon, June 2005.

Deliberative mapping

MCM + facilitated group discussions. Combination of individual and small group judgements. Specialists and small groups of citizens to follow the same appraisal process.

Recent projects:

Kidney-Gap (Wellcome Trust) – public health

Evaluation of the Deliberative Mapping Pilot (CoRWM) – radioactive waste

(Consultation for Energy White Paper (DTI) – energy policy & sustainability)

Deliberative mapping

Selected references:

Davies, G, J Burgess, M Eames, S Mayer, K Staley, A Stirling, S Williamson (2003). Deliberative mapping: appraising options for addressing 'the kidney gap'. London, Final Report to the Wellcome Trust: 260.

(Stagl, S. (2006). "Multicriteria evaluation and public participation: the case of UK energy policy." Land Use Policy.)

MCA case studies on energy policy issues

- (1) Public Participation on UK National Energy Policy (Energy White Paper 2003)
- (2) Comparison of Energy Scenarios on multiple scales in AT

Methodology

Scenario building

Life-cycle analysis

Multi-criteria appraisal

Expert interviews

Stakeholder interviews

Deliberative processes (stakeholder or citizen workshops)

Case Study 1: Public Participation on UK National Energy Policy

Aim:

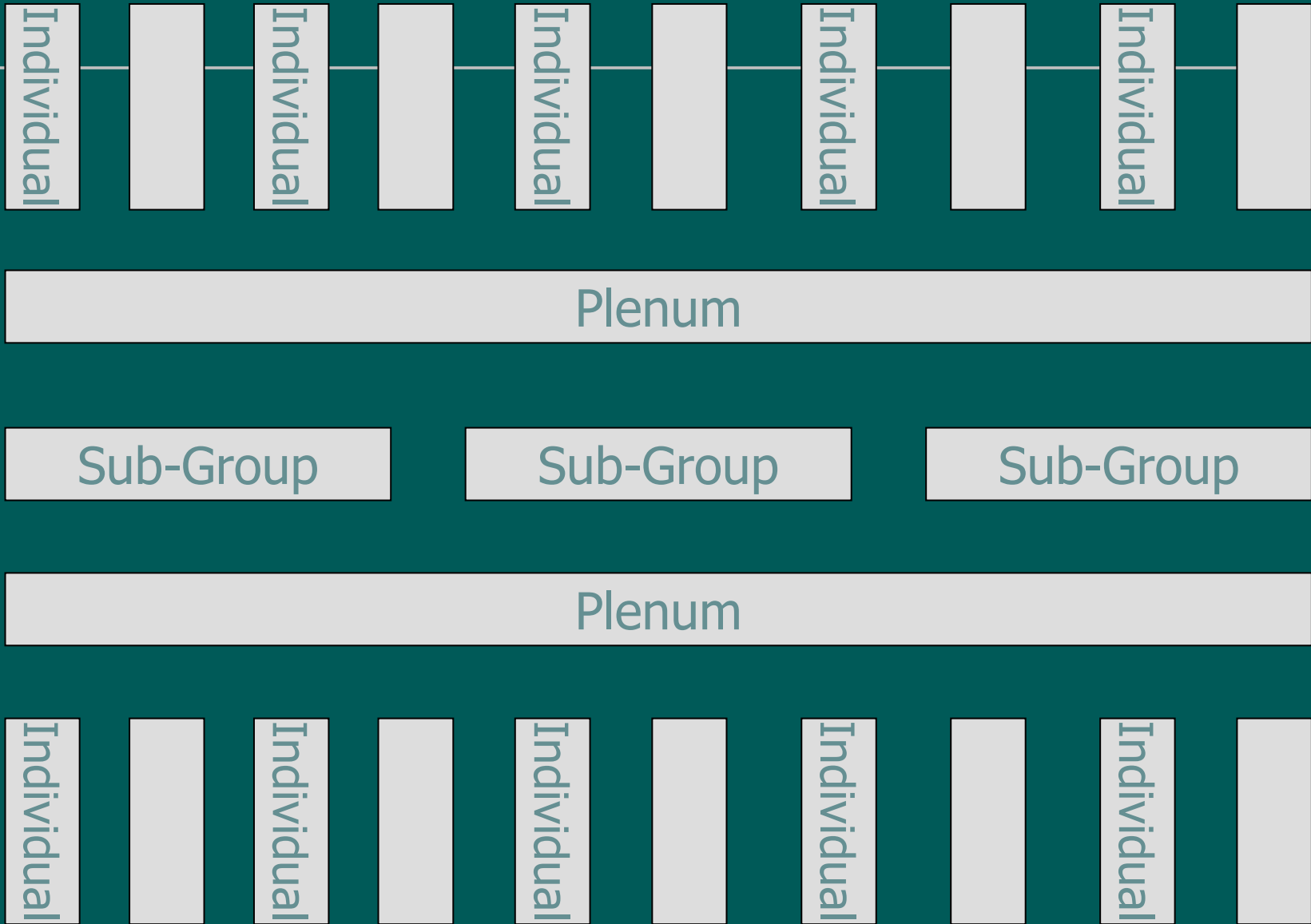
Preparation for UK Energy White Paper (2003)

Elements

- Web-based expert consultation
- Survey-based consultation with stakeholders with special interests
- Focus Groups
- Deliberative Workshops
 - Participants: Citizens from three regions
 - Process: Structuring deliberation
 - Results
 - Forms of learning



Process Design – Part 1



Process Design – Part 2

Recording attitudes
Votes on different scenarios

Developing criteria and weighting

Deliberation and evaluation/MCA

Comparison and reasoning for differences

Votes on different scenarios
Recording attitudes

Deliberative Workshops on UK National Energy Policy - Results

Three options for 2020 explored in groups:

- A – a continuation of current trends
- B – a focus on renewables development and reducing energy use
- C – a focus on UK based sources of energy with a focus on reducing energy use

Individual preferences for policy measures:

- Reducing energy's impact upon climate change
- Increased use of renewable energy
- More efficient use of energy
- Reliability of supply (diversity of technologies)
- Keeping energy costs low
- Helping vulnerable people to afford to keep warm.

Deliberative Workshops on UK National Energy Policy - Learning

Cognitive learning: information, local knowledge, terms

Mutual understanding: values

Learning about behaviour and preferences of others and
behavioural norms: cooperation

Learning about societal needs and institutional change: integrative
thinking, institutional change

Barriers to social learning: time constraint, power, scepticism of
commitment

Conclusions – Case Study 1

MCA and public participation allow participants to deliberate about complex issues in an open but structured way; leading to robust decision making.

Learning processes during the participatory workshops were observed.

MCA seems useful also as a tool not only to rank options (close down), but also to open up a debate.

UK citizens consulted want greener energy policy. In part accounted for in Energy White Paper.

For more information see: Stagl, S. (2006). "Multicriteria evaluation and public participation: the case of UK energy policy." Land Use Policy, 23(1):53-62.

Case Study 2: Energy Policy on multiple scales in AT

Assessment of Renewable Energy Technologies on Multiple Scales (ARTEMIS) - A Participatory Multi-Criteria Approach

Aim: Support discussions / decisions about energy policy on the national and community level in Austria + develop methodology further.

Environmental valuation / integrated appraisal.

Multi-level environmental governance.

Partners: SERI Vienna; CEPE, ETH Zürich and SPRU, University of Sussex, UK.

June 03 – May 06

Funded by the Austrian Science Council.



www.project-artemis.net

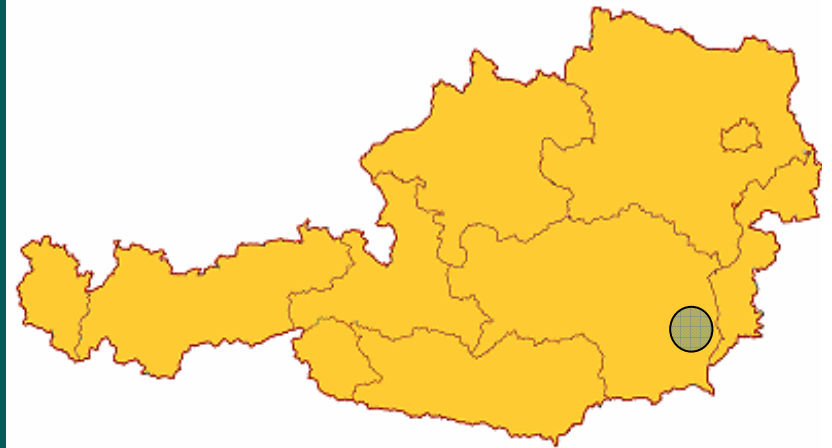
Multi-scale case study

I) Austria

- population: 8.1m
- 1,290 PJ energy demand

II) Lödersdorf & Raabau

- population: 1,290
- 94.9 TJ energy demand



Energy Scenarios

Key parameters:

- (1) demand,
- (2) share of renewables,
- (3) focus on central or decentral energy systems,
- (4) focus on short- or long-term development,
- (5) requirement for institutional change,
- (6) system- or technological efficiency.

Scenario A: „Rapid and familiar“

Description: Focus on technologies that have been applied successfully in the country and where rapid expansion of capacity is possible.

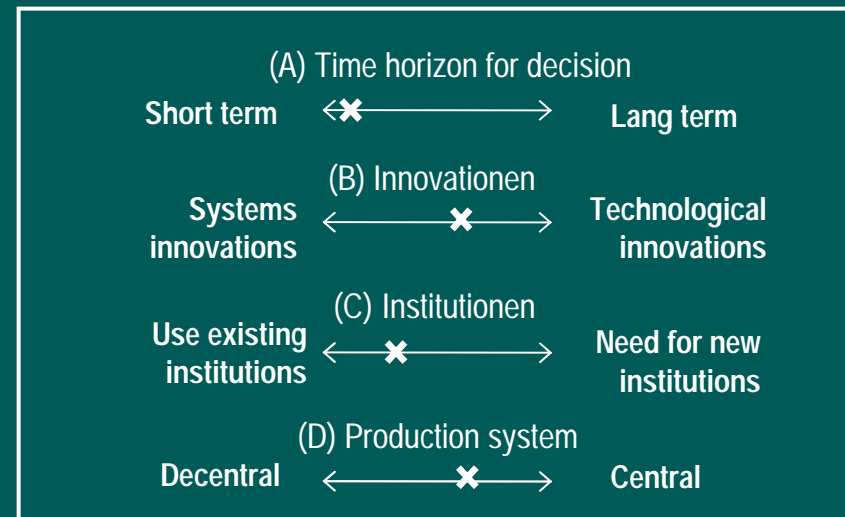
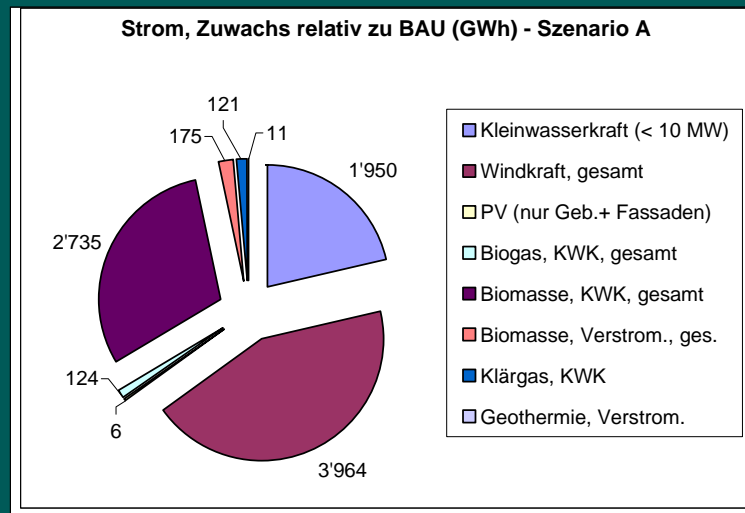
Key technologies: Biomass (heat and CHP), Wind, Solar thermal, biogas

- Increase of renewables compared to 2002:

+80%

- Additional supply from renewables by 2020

electricity **9,086 GWh**
heat **66 PJ**



Scenario B: „Extending competitive advantage“

Description: Focus on technologies that have been exported successfully in the past.

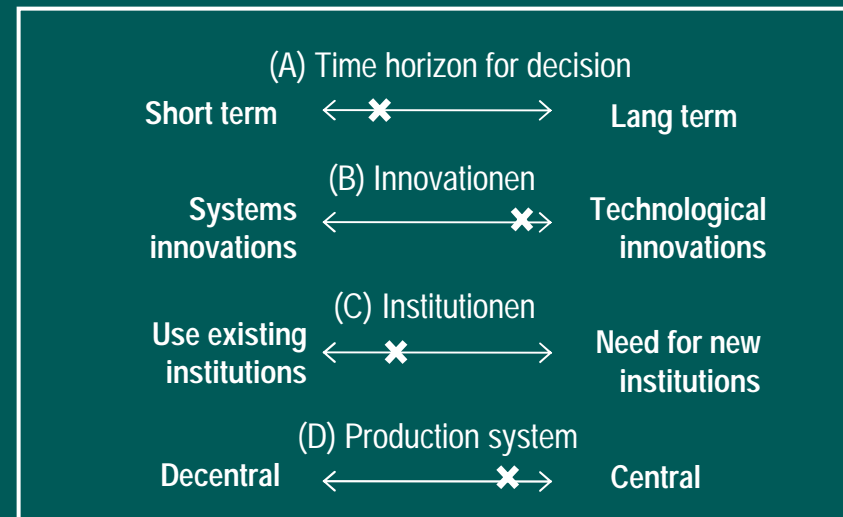
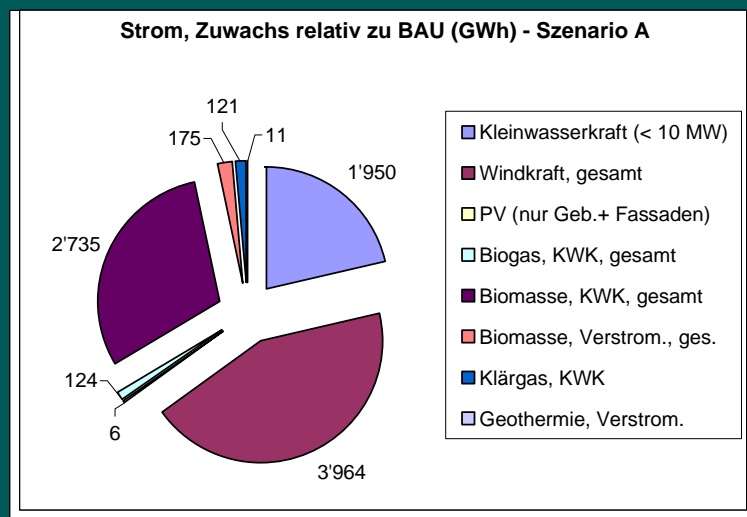
Key technologies: Biomass, communal CHP, Solar thermal, geothermal, small hydro, wind

- Increase of renewables compared to 2002:

+76%

- Additional supply from renewables by 2020

electricity **8,931 GWh**
heat **62 PJ**



Scenario C: „Investing in the future“

Description: Focus on decentral technologies and those that have particularly high potential in the long run, although they may require more support now (e.g. PV).

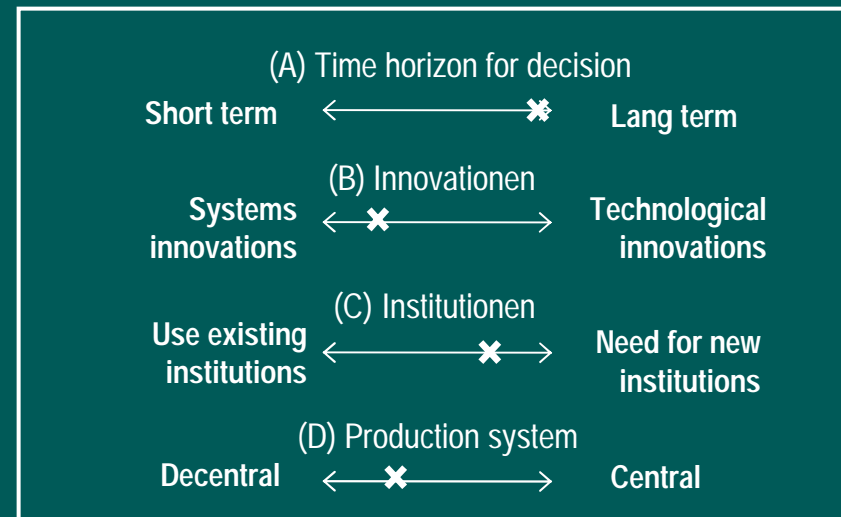
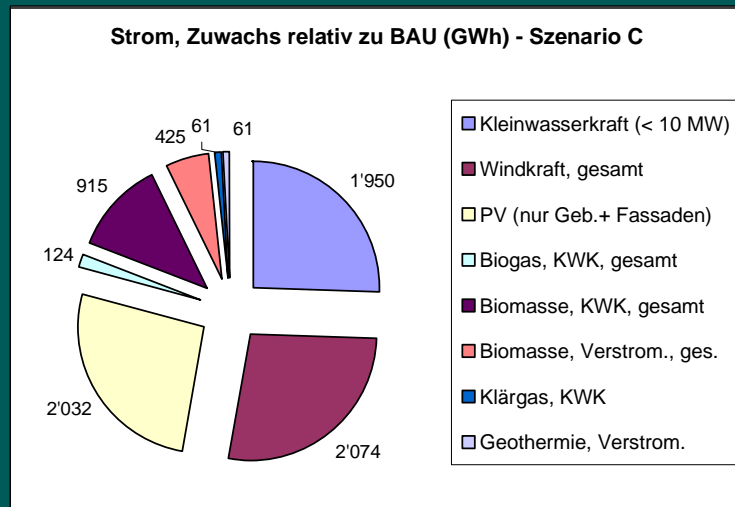
Key technologies: PV (esp. on roofs and in facades of buildings), multifunctional energy centres, biogas-feed-in, geothermal

- Increase of renewables compared to 2002:

+50%

- Additional supply from renewables by 2020

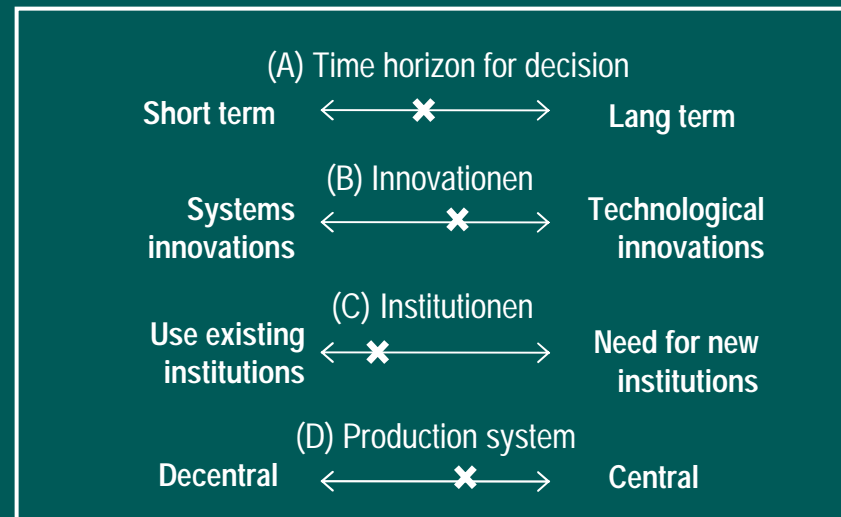
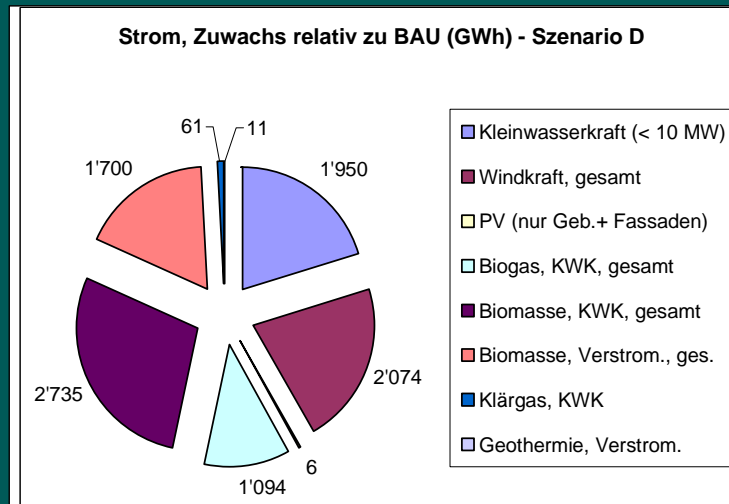
electricity **7,642 GWh**
heat **34 PJ**



Scenario D: „Biomass en gros“

Description: Focus on biomass technologies of different kinds, incl. planting of new energy crops.
Key technologies: Biomass, biogas (electricity, heat and CHP), solar thermal

- Increase of renewables compared to 2002: **+102%**
- Additional supply from renewables by 2020
 electricity **9,631 GWh**
 heat **93 PJ**



Scenario E: „Big on small units“

Description: Focus on technologies for local energy supply from individual and communal production units.

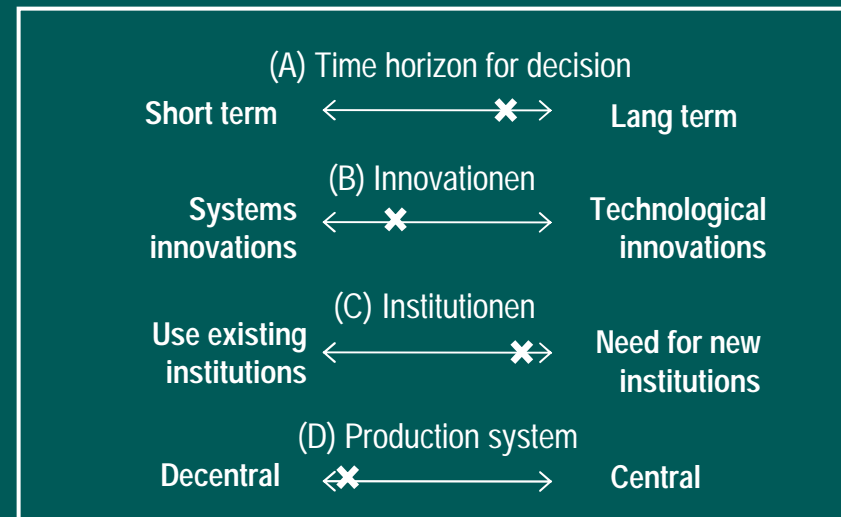
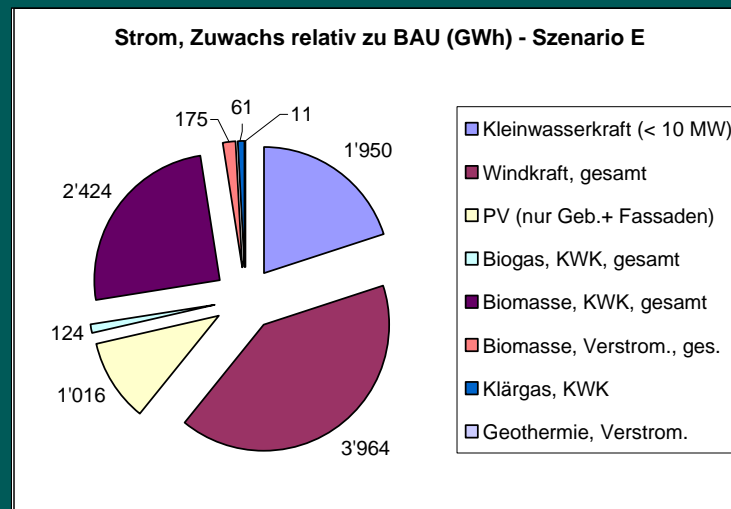
Key technologies: Biomass (indiv and communal CHP), biogas, heat pumps, wind, solar thermal, PV

- Increase of renewables compared to 2002:

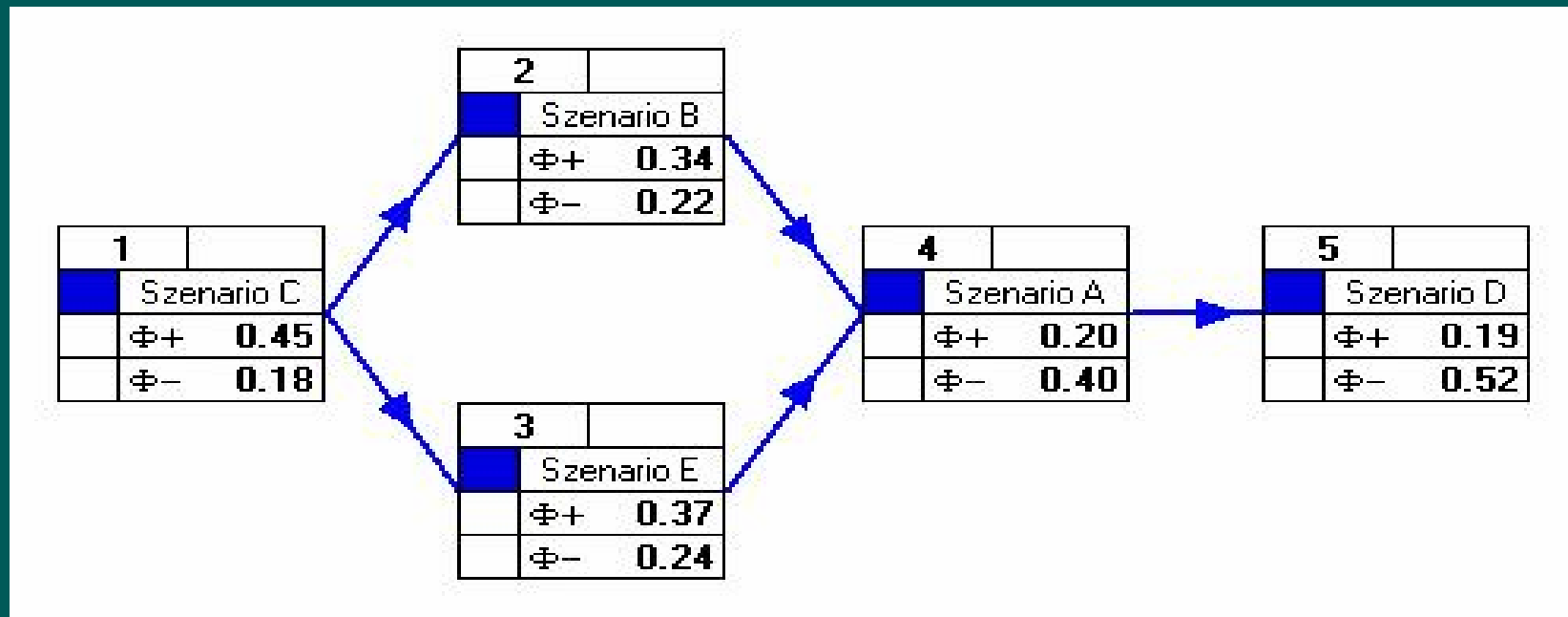
+71%

- Additional supply from renewables by 2020

electricity **9,725 GWh**
heat **53 PJ**



Exemplary ranking of scenarios



Social Learning ...

... encompasses a dimension of changes in values, norms, frameworks and skills that transcend the sphere of explicit cognitive knowledge; enhancing opportunities for mutual understanding, joint action and institutional change.

Main hypotheses

Hypothesis 1: There is a change in knowledge within an existing frame of reference, which involves the adoption of new facts (**single-loop learning**).

Hypothesis 2: There is a change in the evaluation of facts on the basis of modified values and assumptions (**double-loop learning**).

Hypothesis 3: People find new ways to deal with complex and conflict-ridden issue in a constructive way (incl. joint action) and contemplate to transfer this knowledge to other settings (**triple-loop learning**).

Data collection and analysis

- Closed-ended **questionnaires** based on Likert scale responses
- Completed at the beginning of the first and at the end of each of the following workshops
- Statistical analyses to study the significance of observed changes (non-parametric tests)
- Personal **interviews** (analysis ongoing)

Results

Single-loop learning - Participants ...

were more familiar with the different renewable energy sources
have learned to compare different energy mixes and about their relative contributions to sustainability

Double-loop learning - Participants ...

modified their assumptions (give more relevance to social parameters and values in the conflict)
did not change their perception about complexity or uncertainty; perception of the role of future generations remained high
remained at the same level of mutual understanding

Triple loop learning - Participants ...

saw participatory processes as a basis for constructive discussion after the workshop
were optimistic about the possibility for joint action
considered transferring IA and stakeholder participation to other settings

Conclusions

- Participatory approaches with the help of scenario techniques and MCA can -
 - be a useful element of a reflexive governance approach,
 - foster SL processes that go beyond the acquisition of facts and information.
- Renn suggested that social learning should be a quality criterion for participatory processes; we think now that this criterion can be operationalised.

Biodiversity – general (background info)

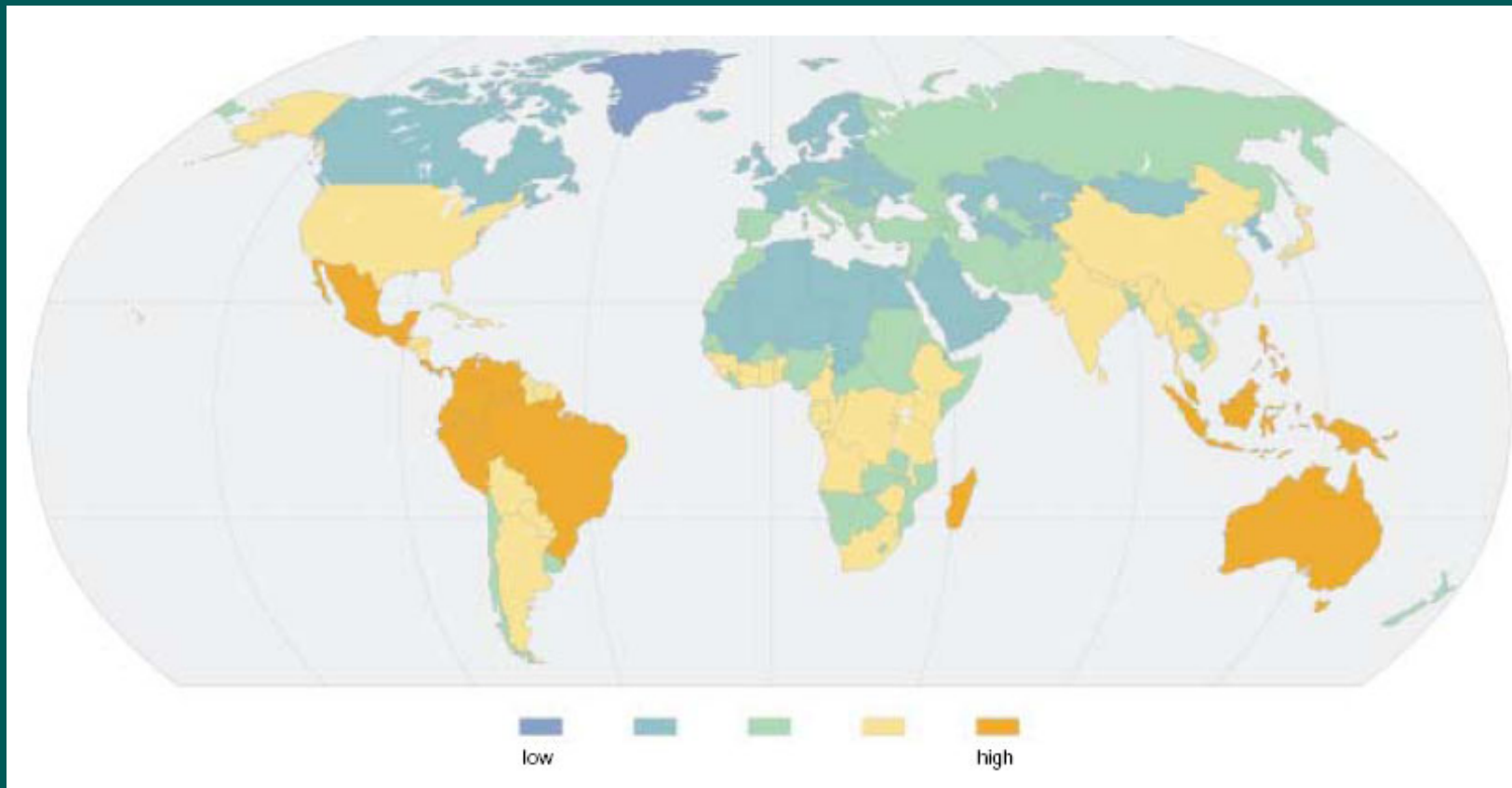
Introduction

- **Biodiversity** is the diversity of living organisms, the genes that they contain and the ecosystems in which they exist. Genes determine the potentialities of individual organisms. A population is a group of individuals which are involved in reproduction, and a species is a collection of individuals that could be involved in reproduction. Populations are reproductively isolated sub-groups of a species.
- There is **genetic diversity within a population and within a species**. Individuals from different species differ genetically from one another more than do individuals from different populations of the same species.
- Most work on genetic diversity takes the **species** as the unit of account – **biodiversity is said to be lost when a species goes extinct**.
- Extinction is a 'natural' event, but subject to severe fluctuations and influenced by human action.

Why does biodiversity loss matter?

- Production
- Consumption
- Functioning of ecosystems

Biodiversity at country level



Source: UNEP-WCMC National Biodiversity Index

Number of species described and estimated, 2002

<i>Kingdom</i>	<i>Described</i>	<i>Estimated number</i>
Bacteria	4,000 (0.4%)	1,000,000
Protoctists (Algae, Protozoa, etc.)	80,000 (13%)	600,000
Fungi	70,000 (5%)	1,500,000
Plants	270,000 (90%)	300,000
Animals	1,320,000 (12%)	10,600,000
Total	1,744,000 (13%)	14,000,000

Note: () gives Described as % of Estimated

Source: Table 1.1 *Global biodiversity outlook* at <http://www.biodiv.org>

Trends

- Fossil records - on average, species have come into existence at a higher rate than they have gone extinct → biodiversity increased over time
- Five brief periods in the history of the earth during which the extinction rate was very high
- 65 million years ago -10% of terrestrial species, incl. the dinosaurs, and –15% of marine species
- Cause: climate change, possibly associated with an asteroid impact
- 250 million years ago -90% of marine animals
- Cause: extreme climate change.
- Every species will become extinct at some point; virtually all species that have existed are extinct.

Trends (Source: MA)

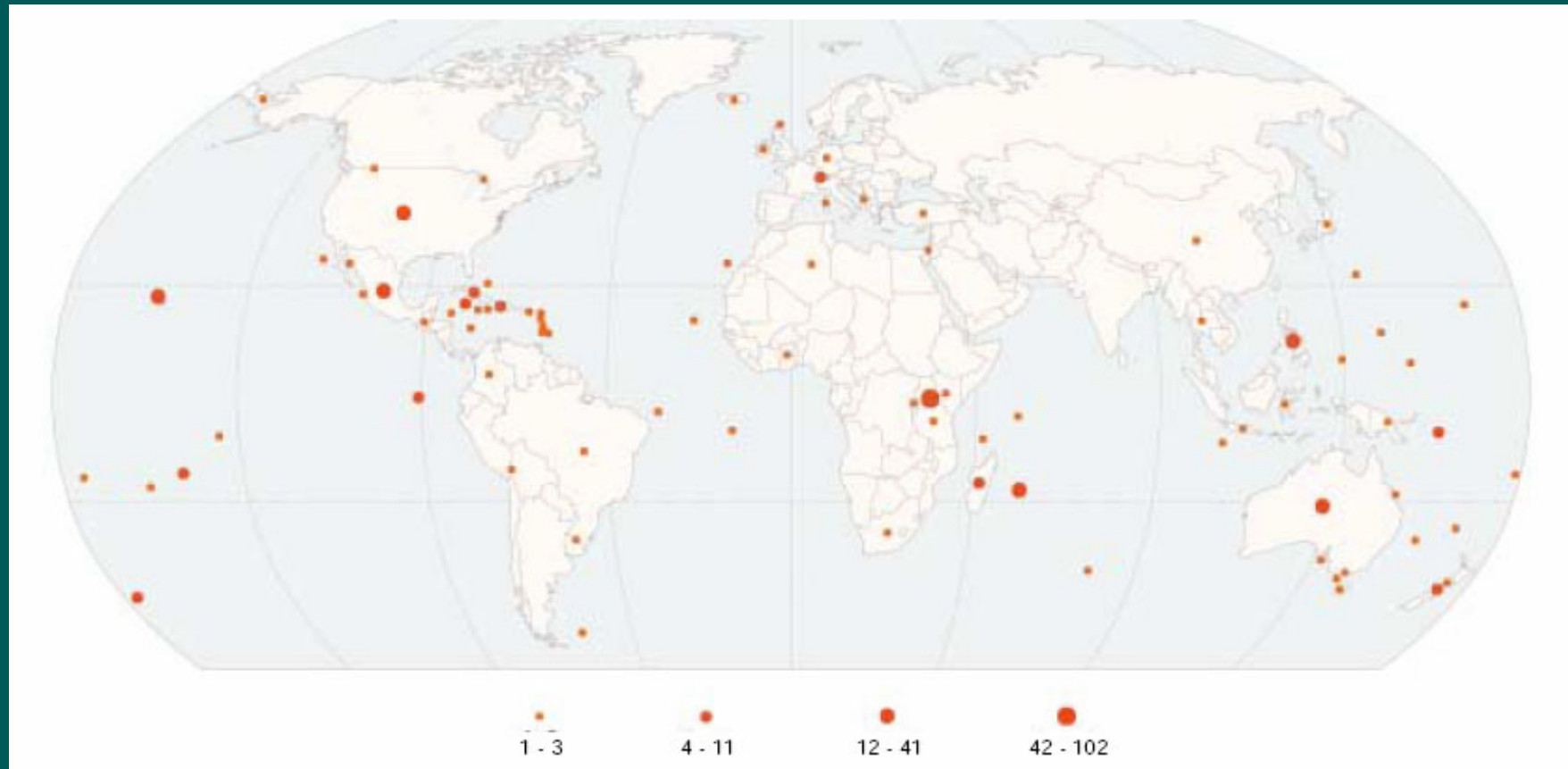
- Virtually all of Earth's ecosystems have now been dramatically transformed through human actions.
- Globally, the net rate of conversion of some ecosystems has begun to slow, although in some instances this is because little habitat remains for further conversion.
- Across a range of taxonomic groups, the population size or range (or both) of the majority of species is declining.
- Over the past few hundred years, humans have increased species extinction rates by as much as 1,000 times background rates that were typical over Earth's history.
- The distribution of species on Earth is becoming more homogenous.
- Between 10% and 50% of well-studied higher taxonomic groups (mammals, birds, amphibians, conifers, and cycads) are currently threatened with extinction, based on IUCN–World Conservation Union criteria for threats of extinction.
- Genetic diversity has declined globally, particularly among domesticated species.
- All scenarios explored in the Millennium Ecosystem Assessment project continuing rapid conversion of ecosystems in the first half of the 21st century.

Species extinctions since 1600

<i>Kingdom</i>	<i>Extinct Species</i>
Vertebrates	337
Mammals	87
Birds	131
Reptiles	22
Amphibians	5
Fishes	92
Invertebrates	389
Insects	73
Molluscs	303
Crustaceans	9
Others	4
Plants	90
Mosses	3
Conifers, cycads, etc.	1
Flowering Plants	86

Source: *Global biodiversity outlook*, Table 1.4 at <http://www.biodiv.org>

Vertebrates extinct since 1600 AD



Source: Global Biodiversity Outlook
<http://www.biodiv.org/gbo/>

Comparison of actual recent extinction rates with “normal” extinction rates

- Background rate: “normal” extinctions per century seen in the fossil record
- Birds - in the last 400 years: 128 times the background rate
- Mammals: 176 times the background rate

Caution!

These are very rough-and-ready calculations. The general message is more important than the specific numbers.

- In recent time, the **known rate of extinction among mammals and birds is far higher than the estimated average rate through geological time.**
- It is possible to **estimate the relative risk of extinction** among recent species on the basis of demography and distribution.
- Mammals and birds have been assessed for extinction risk: 24% of mammals and 12% of birds were considered globally threatened in 2000.

Threatened species - IUCN Red List

<i>Kingdom</i>	<i>Described species</i>	<i>Species evaluated 2003</i>	<i>Species threatened 2003</i>	<i>Percentage of described threatened</i>	<i>Percentage of evaluated threatened</i>
Vertebrates	56,586	17,127	3,524	6%	21%
Mammals	4,842	4,789	1,130	23%	24%
Birds	9,932	9,932	1194	12%	12%
Reptiles	8,134	473	293	4%	62%
Amphibians	5,578	401	157	3%	39%
Fishes	28,100	1,532	750	3%	49%
Invertebrates	1,190,200	3,382	1,959	0.2%	58%
Insects	950,000	768	553	0.06%	72%
Molluscs	70,000	2,098	967	1%	46%
Crustaceans	40,000	461	409	1%	89%
Others	130,200	55	30	0.02%	55%
Plants	297,655	9,708	6,776	2%	70%
Mosses	15,000	93	80	0.5%	86%
Ferns	13,025	180	111	1%	62%
Gymnosperms	980	907	304	31%	34%
Dicotyledons	199,350	7,734	5,768	3%	75%
Monocotyledons	59,300	792	511	1%	65%
Lichens	10,000	2	2	0.02%	100%

Source: Summary Statistics, from the IUCN Red List of Threatened Species, Table 1, accessed at <http://www.redlist.org> on 03/04/2004.

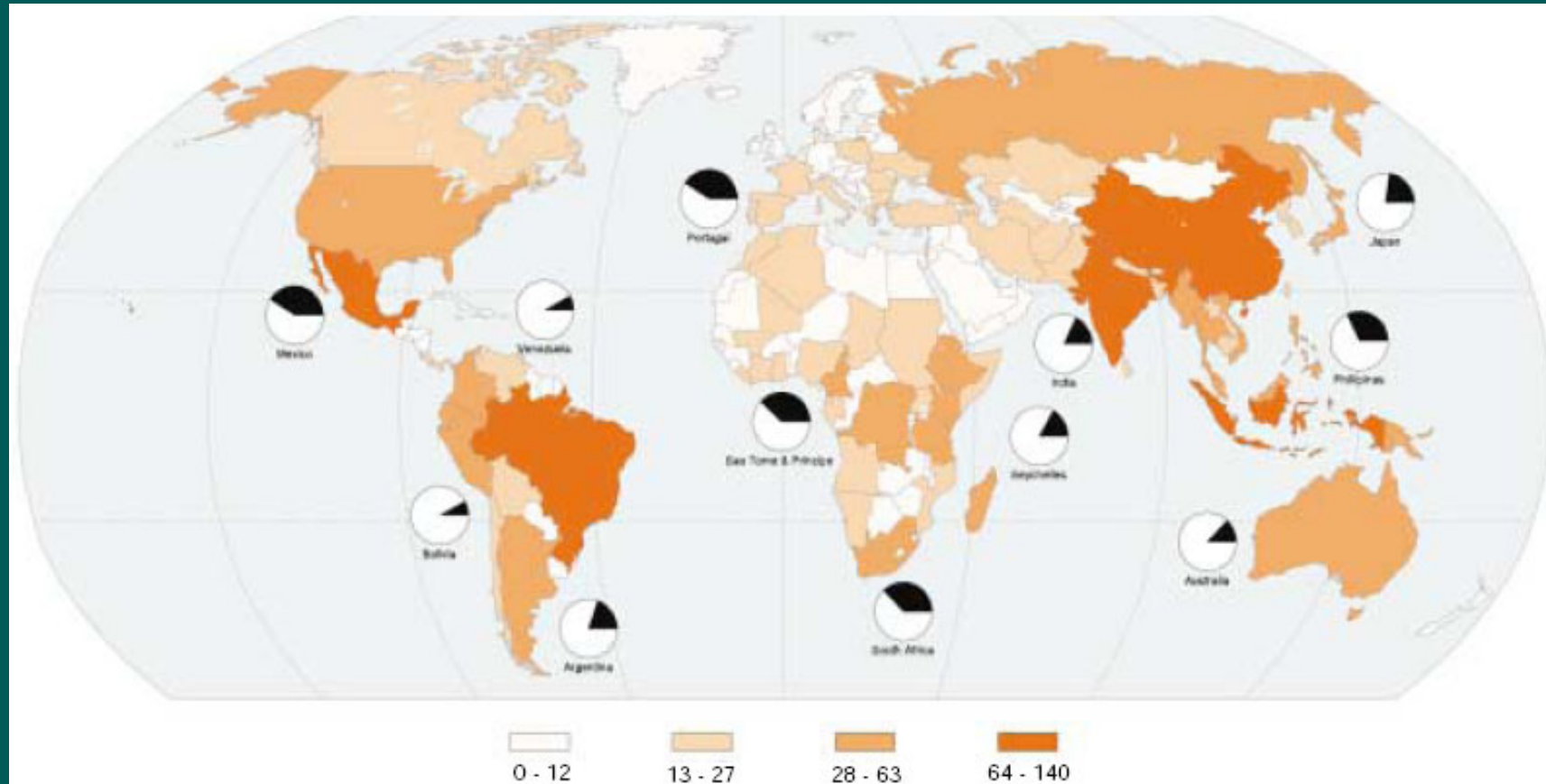
Threatened birds at global and country level



Source: Global Biodiversity Outlook; global data from 2000 IUCN Red List of Threatened Species, country data from selection of national Red Data Books

<http://www.biodiv.org/gbo/>

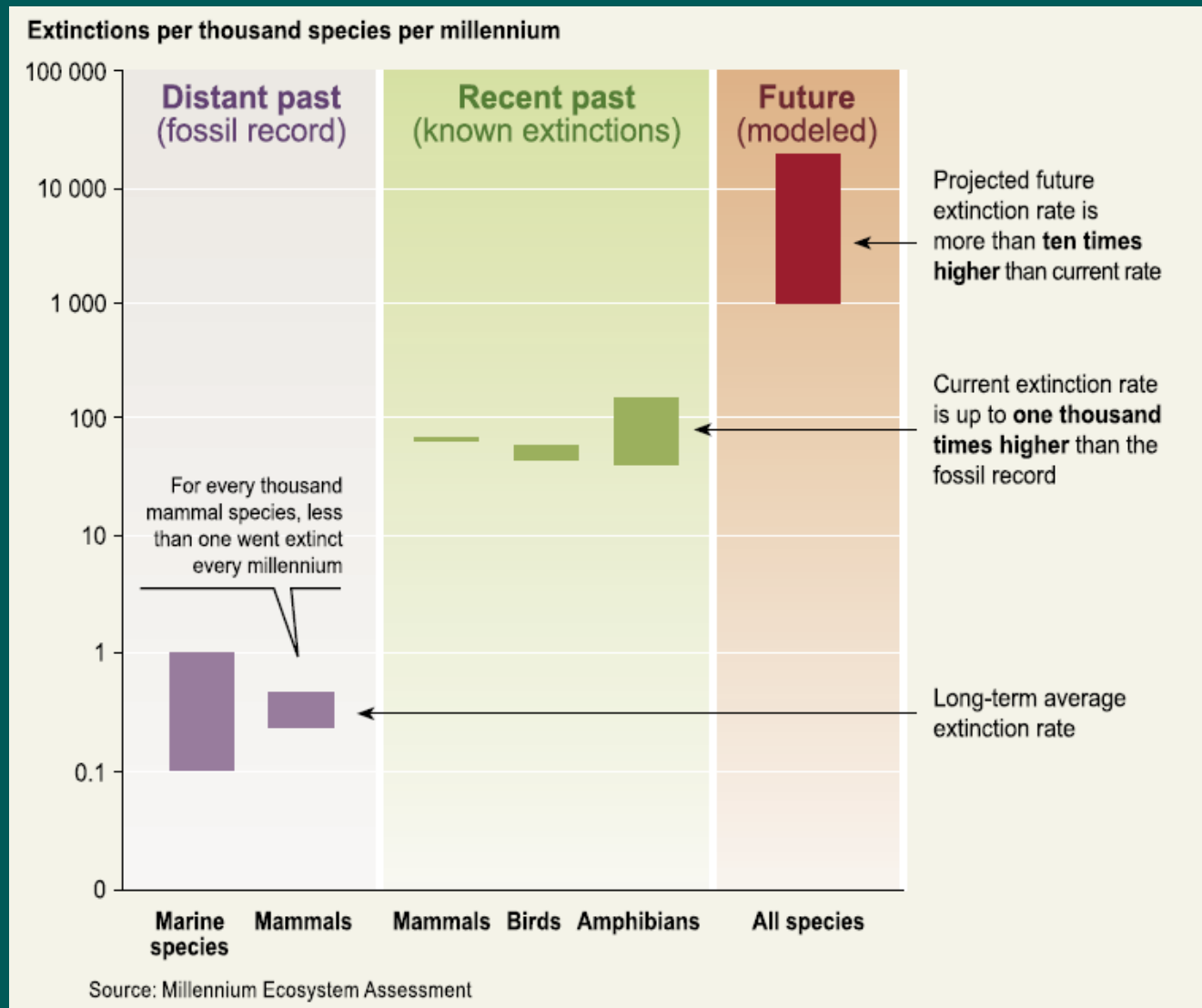
Threatened mammals at global and country level



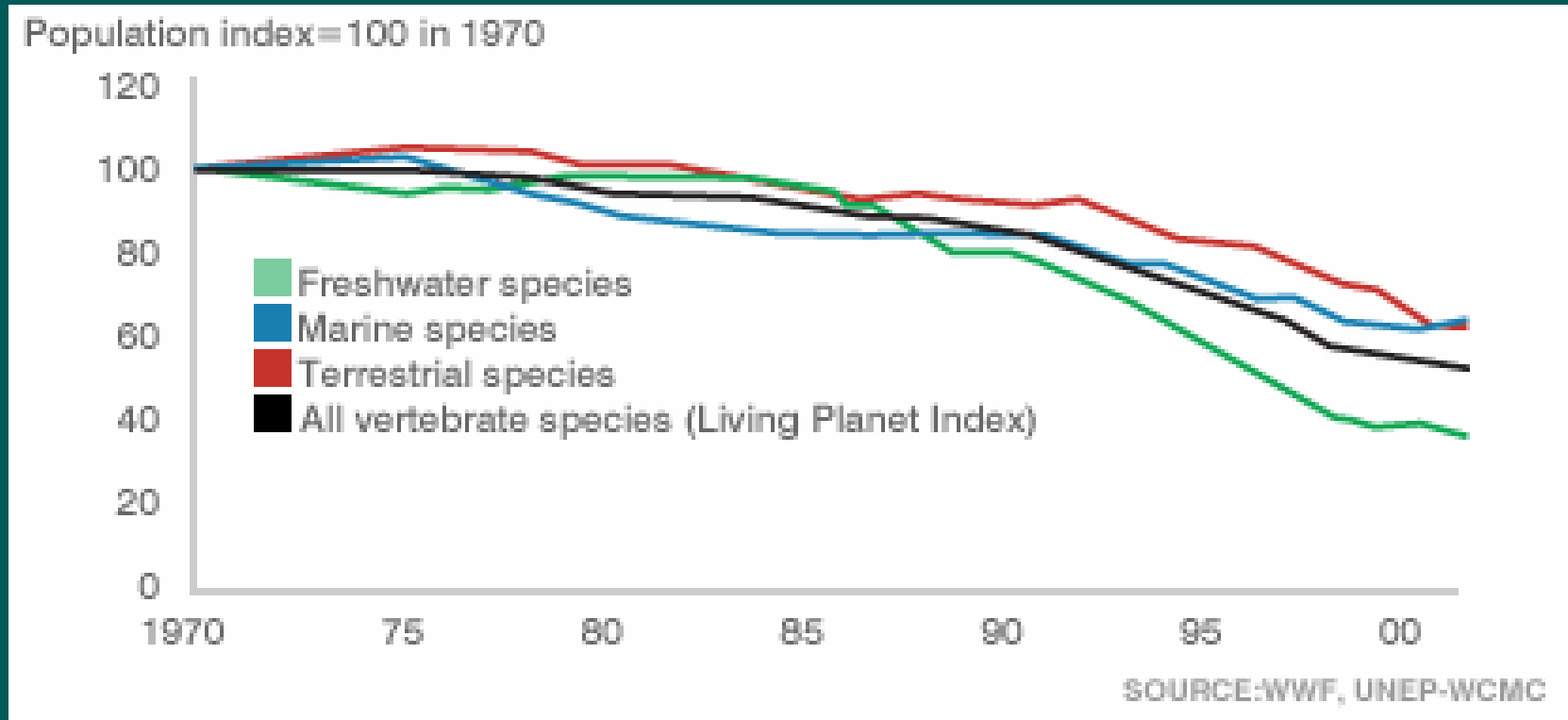
Source: Global Biodiversity Outlook; global data from 2000 IUCN Red List of Threatened Species, country data from selection of national Red Data Books

<http://www.biodiv.org/gbo/>

Species extinction rates



Living Planet Index



Measures trends of vertebrate populations in terrestrial, freshwater and marine environments.

Millennium Ecosystem Assessment – Biodiversity Synthesis

- The last 50 years have seen the biggest biodiversity upheaval in human history
- Over half the world's biomes (vegetation types) have experienced about 20-50% conversion to human use
- The rates of change have been greatest in tropical and sub-tropical dry forests
- Some 35% of mangroves and about 20% of corals have gone
- Across a range of taxonomic groups, species are in decline

Why is biodiversity loss so difficult to address?

- biodiversity is a global public good
- reduce the current rate of biodiversity loss involves both intertemporal and intratemporal equity issues
- while
- its broad features are reasonably well understood, there is much uncertainty about particulars

Causes for biodiversity loss

Proximate causes:

- Habitat change (degradation, destruction and fragmentation)
- Overharvesting of targeted renewable resource species, and by-catches (secondary catches) of non-targeted species
- Pollution and global climate change
- Invasive alien species

Most important underlying causes:

- human population growth
- growth in per capita energy and materials consumption
- institutional failures

Causes – Global climate change

- Directly affects species through changes in phenology (e.g., earlier flowering of trees and egg-laying in birds), lengthening of the growing season, and changes in distribution (e.g. pole-ward and altitudinal shifts in insect ranges).
- Climate change is an additional stress on ecosystems and species that are, often, already under stress from other pressures such as: habitat change resulting from land-use change; overharvesting; pollution; and the effects of invasive species. Such pressures thus make biodiversity more vulnerable to climate change. For example -
 - habitat fragmentation poses **barriers to dispersal**, thereby reducing the possibility that species can adapt by moving as the climate changes;
 - ecosystem degradation, which may result from unsustainable use of ecosystem components, pollution, pest outbreaks, or changes in fire regimes, can **decrease the resilience** of ecosystems to climate change.

The expected result of these interactions is that **climate change will lead to reduced biological diversity.**

Interrelations of global environmental problems

The impact of climate change on biological diversity is expected to be **non-linear**. The impact may be particularly severe when certain critical thresholds are crossed. **Ecosystem** types that are **vulnerable** to such thresholds include:

- Wetlands overlying permafrost
- Coral reefs

Climate change may also increase threats from **invasive alien species**:

- Climate change may result in extension or changes in the ranges suitable to certain invasive species. An example may be the increased prevalence of vector-borne infectious diseases transmitted by blood-feeding mosquitoes and ticks;
- Environments may become more favourable to weedy species because of climate change induced ecosystem disruptions.

Interrelations with global social problems

Millennium Ecosystem Assessment:

If we continue with current rates of species extinction, it becomes very difficult to roll back poverty and the lives of all humans will be diminished. The world's poor are often the most vulnerable to ecosystem degradation.

What needs to be done?

Millennium Ecosystem Assessment:

- “An unprecedented effort would be needed to achieve by 2010 a significant reduction in the rate of biodiversity loss at all levels.
- Short-term goals and targets are not sufficient for the conservation and sustainable use of biodiversity and ecosystems. Given the characteristic response times for political, socioeconomic, and ecological systems, longer-term goals and targets (such as for 2050) are needed to guide policy and actions.
- Improved capability to predict the consequences of changes in drivers for biodiversity, ecosystem functioning, and ecosystem services, together with improved measures of biodiversity, would aid decision-making at all levels.”

Conservation policy

- What is the aim? *In situ conservation* is the preservation of species in their natural habitats, in the wild. *Ex situ conservation*: conservation of biodiversity in facilities constructed by humans.
- Which species to preserve?
- Habitat preservation and protected areas
- Agreements:
 - [Convention on Biological Diversity](#)
 - Other relevant international conventions (the United Nations Convention to Combat Desertification, the Ramsar Convention on Wetlands, and the Convention on Migratory Species)
 - The European Biodiversity Conservation Strategy



Convention on Biological Diversity

- CBD was opened for signing at UNCED in Rio de Janeiro in June 1992. It was signed by 156 countries, and came into force in December 1993, 90 days after the 30th signatory had ratified it. There are now over 180 parties to the CBD -- most of the world's nations. The USA signed in 1993, but has not yet (October 2005) ratified the CBD.
- The **objectives**, stated in Article 1, are:
“the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.”
- **Precautionary Principle** endorsed
- Main approach: ‘**in situ conservation** of ecosystems and natural habitats’.

