Revista Internacional de
Sostenibilidad,
Tecnología y Humanismo
año 2006 nº 1

Towards integrated long-term scenarios for assessing biodiversity risks.

Joachim H. Spangenberg

UFZ, Helmholtz Centre for Environmental Research, Germany
Workplace: Vorsterstrasse 97-99, D-51103 Cologne, Germany
Joachim.Spangenberg@ufz.de

*This work has been supported by the European Commission FP 6 Integrated Project ALARM (Assessing **LA**rge-scale environmental **R**isks for biodiversity with tested **M**ethods) under grant number GOCE-CT-2003-506675, see www.alarmproject.net*

Abstract

From a policy point of view, the rapid loss of biodiversity (how ever measured) constitutes an urgent need to improve the ability to forecast possible changes in biodiversity. Scenario development and modelling are essential tools for studying changes of biodiversity and their impacts in order to provide well-founded policy options. However, so far no comprehensive model has been developed integrating the diverse relevant ecological, economic, individual and societal processes. Instead socio-economic, climate and biodiversity models exhibit a wide range of assumptions concerning population development, economic growth and the resulting pressures on biodiversity. The paper summarises the efforts undertaken in the framework of the ALARM project by an interdisciplinary team of economists, climatologists, land use experts and modellers. It describes the challenges of such a kind of work, bringing together different world views unavoidably inherent to the different fields of investigation.

Keywords: scenario development, econometrics, narratives, shocks, climate change, biodiversity, social impacts, politics.

1 Introduction

It seems improbable or at least a matter of a distant future that biodiversity will become institutionalised as a policy field in its own right, on at least formally equal footing with fiscal, foreign or agricultural policy. In order to be effective right now, biodiversity protection needs to get out of the preservation policy niche to be effective. Although there is still room for improvement regarding capacity building and education, the key challenge is to integrate biodiversity concerns into the day-to-day working mechanisms of state, business and society. For the safeguarding of biodiversity end-of-the-pipe solutions and compensations like establishing protected areas is simply not enough, as long as the pressures on biodiversity continue unabated.

Consequently, any effective biodiversity protection strategy must be broadly based, addressing production, consumption and administration patterns and attitudes alike, and so must scenarios developed to derive efficient strategies for biodiversity pressure reduction. This requires a paradigm shift – which is the common ground for biodiversity and sustainability policies. However, before promising strategies can be developed and be integrated into the sustainability context, first the relevant pressures have to be identified in order to properly represent them in the scenario narratives and either in the model runs or in their interpretation. Otherwise, the scenarios might be consistent and interesting, but irrelevant (since not permitting relevant conclusions) for biodiversity preservation.

2 Focus on pressures

For effective biodiversity protection policies, pressure reduction must be achieved for all three levels of biodiversity, and thus the relevant pressures have to be identified for each of them (Spangenberg, in press). Combining the three lists results in a *biodiversity pressure inventory*, permitting to identify those pressures which are mentioned more than once as Very Important Pressures (VIPs) and to address them in constructing the scenarios and deriving policy recommendations. Important analytic instruments for this purpose are “scenarios that describe sustainable and unsustainable developments, including unexpected events, changes, and lines of fracture” (Martens, 2006, p. 40).

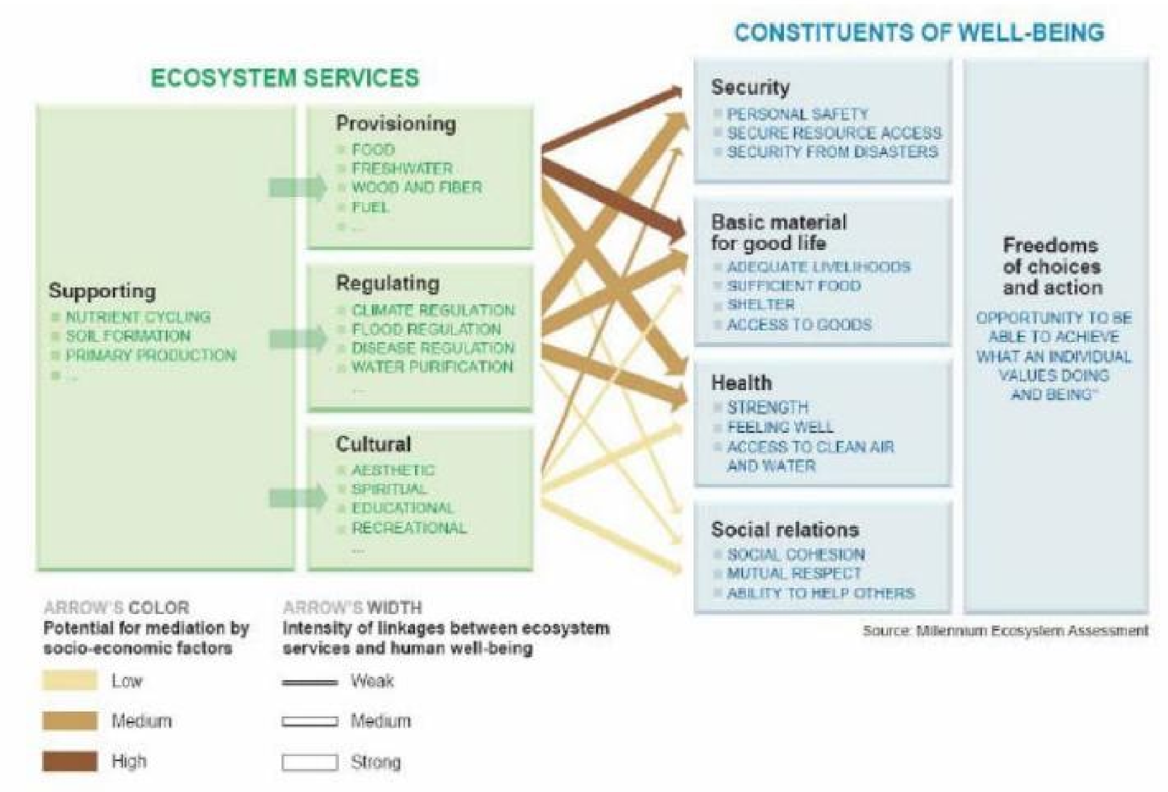
Thus the pressure analysis is but a first step towards policy definition, not yet the solution: for the scenarios, the drivers behind the pressures must be identified and used in the modelling for projections into the future and the analysis of unsustainable trends. This permits to derive priorities for strategic policy action. For Europe, the main anthropogenic disturbance factors (i.e. pressures) have been identified for the three levels of biodiversity (EuroStat, 1999; Spangenberg, 1999; UNEP, 2002; EEA, 2004; EEA, 2005).

In total, the *Very Important Pressures* dominating in a combined inventory are:

- Climate impacts (including hydrological changes);

- Chemicals (pesticides, other persistent organic chemicals, petroleum products, endogenous disruptors, etc);
- Fragmentation (reduction of biotope size and thus of population numbers);
- Biological pollution (deliberately/unconsciously introduced foreign or modified species);
- Overuse/transformation (exploiting biological resources beyond their regeneration capacity).

Each of these pressures is mentioned in at least two of the three lists of key pressures, one for each of the three levels of biodiversity. Reducing them is an obvious priority for biodiversity protection policies.



(Source: MEA, 2005)

Figure 1: The impact of ecosystem services on human well-being

2.1 Demarcation

The generation of such pressures is neither intentional nor incidental, but the result of ongoing socio-economic processes and policies. In the majority of cases, the negative impact on biodiversity has been detected too late (or not at all), and has been dealt with by suggesting additive measures for biodiversity protection instead of questioning the basic drivers causing these pressures. As opposed to a species-centred perspective, the justification of policy measures rests implicitly or explicitly on the functional attributes of the ecosystem level ("ecosystem services"). Their utility can be aesthetic as much as economic, but the general approach is anthropocentric and focussed on the short to medium term availability of such services, as illustrated in figure 1.

According to the Millennium Ecosystem Assessment MEA definition, they "include provisioning services such as food, water, timber, and fibre; regulating services that affect climate, floods, disease, wastes, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling" (Reid, 2002, p. 1-2).

3 Driving forces: the rationale for socio-economic scenarios

The next step of scenario construction is to make sure that the drivers causing the pressures are adequately reflected in the scenario dynamics. Only then it is possible to compare different scenarios regarding their expected impacts on biodiversity, and to derive suitable policy suggestions. For this behalf, scenarios must not only be relevant from a biodiversity perspective, but also from a policy point of view, i.e. addressing relevant problems with effective means. Otherwise they would miss their explicit objective, improving the effectiveness and efficiency of strategy proposals for making the everyday mechanisms of business and politics better compatible with biodiversity concerns. In other words: the scenarios must be formulated in the language of decision makers at the appropriate level.

Political and administrative decisions, including those on biodiversity pressure management, are taken on the local, regional, national or supranational level, and they apply within political borders, not within ecological boundaries. The challenge is then to find strategies on the institutionally adequate scale, informed by bioscience analysis, helping to steer decision making with a sufficient degree of reliability towards effective biodiversity preservation. Other information is helpful to contextualise the message, but the essence must refer to what the decision makers can influence.

A systematic analysis of driving forces would ideally be conducted as a participative process involving administration and civil society. In the course of such a process, a "Pressure-Policy-Matrix" would be established, a tool which has been suggested to cross the governmental policy domains with identified pressures. The cells of the matrix would contain the relevant policies as driving forces; as far as civil society participates, behavioural routines and preferences could be listed on their part (Spangenberg, 2005). Combining driving force analysis with bottom-up and top-down, forecasting and backcasting scenario techniques, decision support can be provided to all relevant levels of decision making, and for all relevant sectors.

3.1 Status quo and challenges

So far no comprehensive model has been developed integrating the diverse relevant ecological, economic, individual and societal processes linking driving forces, pressures and impacts. This is not only due to the overwhelming complexity such a model would have to accommodate, but also to different system characteristics like system boundaries and time scales, and the lack of knowledge regarding their interactions. Probably, no such integrated model is possible, and what could be achieved at best is a group of separate but coupled models. Amongst these, externally set assumptions would be harmonised and the results of one used as input to the others. For instance, while population development could be based on joint assumptions, growth data from an economic model might be used by land use and climate models, which in a next step would interact (emissions from land use and climate impacts, respectively). Their results would in turn influence the economic modelling exercise by inducing the need for adaptation expenditure or by modifying productivities. Obviously, such a process of model harmonisation must be an iterative one, implying the need for time and other resources.

Unfortunately, the state of the art is rather far away from this optimal situation. Instead socio-economic, climate and biodiversity model exhibit a wide range of assumptions concerning population development, economic growth and the resulting pressures on biodiversity. The IPCC's SRES scenarios do neither include climate protection policies so far, nor their potential effects on economic growth. Consequently, the Millennium Assessment scenarios, which include climate protection policies, expect less and slower climate change than the SRES scenarios (which at the same time are considered rather conservative by other sources). Computable global equilibrium (CGE) models are frequently used for predictions, but they are unable to reflect the structural change which is characteristic to any market economy, in particular in the long run (which may be a rather short term view from a climate research perspective).

Therefore as a first step it is necessary to derive consistent assumptions and scenario interpretations from a comparative analysis of existing models and scenarios from several disciplines. Assessing their overlaps and the possible contradictions between the results of one and the assumptions of other scenarios can help get a better assessment of the relevance of specific scenario results by contextualising them with the outcome of other modelling exercises. Similarities in results can confirm the robustness of the scenarios chosen and that the results are not mere model or data artefacts, but like any sensitivity analysis they can also raise doubt regarding specific outcomes (see e.g. Bockermann et al., 2005). This way, a complementary, cross-disciplinary knowledge base can be developed in order to support effective policy decisions and provide a basis for future modelling exercises on all levels.

4 The ALARM scenarios

Each ALARM scenario consists of a narrative, of which several elements are quantitatively illustrated by different, partly integrated models. The narratives have been drafted by the project team and were discussed for their consistency and plausibility with the external stakeholders constituting the ALARM Consultative Forum. Regarding the bioscience relevance, additional discussions were with the ALARM partners (comprising 67 scientific institutes and about 250 scientists).

The three scenarios analysed cover a broad range of social, economic, political and geo-biosphere parameters. The BAMBU (**B**usiness **A**s **M**ight **B**e **U**sual) scenario is what the IPCC calls a policy driven one, i.e. a scenario extrapolating the expected trends in EU decision making and assessing their sustainability and biodiversity impacts. It includes climate mitigation and adaptation measures and explicit but not radical biodiversity protection policies.

The two others describe different policy orientations discussed by relevant stakeholders in Europe. GRAS (**GR**owth **A**pplied **S**trategy) is a liberal, free-trade, globalisation and deregulation scenario. Regarding climate change, its focus is on adaptation rather than mitigation, with some limited measures taken to limit climate change. Provisions for biodiversity protection (and other environmental problems) are also limited and will only be taken when the problem emerges. The scenario policies show no interest in social and institutional sustainability; economic sustainability is interpreted mainly as economic growth.

SEDG (**S**ustainable **E**uropean **D**evelopment **G**oal) is a backcasting scenario dedicated to integrated environmental, social, institutional and economic sustainability. Methodologically, it is normative, designed to meet specific goals and deriving the necessary policy measures to achieve them. For illustrating the scenarios in a coherent manner with different simulation models, it is necessary to compare and – where necessary – reconcile the model assumptions.

Amongst the SRES scenarios we haven chosen those particularly fitting to the expected climate development under the three ALARM scenarios, namely A1FI for GRAS, as both are growth scenarios based on a neoliberal policy approach. For both BAMBU and SEDG the choice was less obvious, as both include mitigation measures not foreseen under the SRES scenarios. For BAMBU we have chosen SRES A2, as this seems to match the past developments which – although the emissions in the modelling period will be different – determine the climate trend, due to the time lag between emissions and atmospheric warming. For the SEDG scenario, we have chosen the one SRES scenario leading to a stabilisation at 550 ppm, the B1 scenario. As this is not achieved due to mitigation, but economic problems, the SEDG and the SRES B1 worlds are significantly different, but share the same climate trajectory.

In illustrating the narratives, each of these three climate scenarios was discursively combined with a narrative-specific run of a spatially explicit land use model disaggregated to the NUTS 3 level, and with GINFORS, an econometric input-output model. The latter combines economic data with energy and material flows, and calculates domestic economic development, resource consumption, emissions and employment plus the global trade in some forty categories of goods. Although the models used are global ones, the focus of the analysis is Europe, and how changes there affect the world (and vice versa).

Economic development trends cannot be spatially disaggregated to a sub-national level based on the available data, but for their impacts we have developed rules to spatially differentiate population density, migration, income disparities and income development.

4.1 Preliminary results

The emission trajectories resulting from the econometric model are lower than those assumed in the SRES scenarios. Nonetheless no specific corrective factors for the SRES scenarios can be suggested, as the deviation of the emission paths will lead to changes in climate effects only beyond the scenario perspective: evolving input-output models (unlike Computable Global Equilibrium Models CGE, which however underestimate the structural change occurring in the medium to long run) cannot be usefully run for more than 20 years, so the time horizon is a simulation to 2020 with a projection of some parameters to 2050. However, looking at the SRES narratives, it is obvious that the BAMBU and the SEDG scenarios and the economic and land use model runs used to illustrate them do not describe an A2 or a B1 world, respectively. Developing climate scenarios including adaptation and mitigation, and the socio-economic effects thereof thus should be one priority issue for the future climate research at the IPCC level.

The econometric model does not directly take into account the effects of climate change, but is the basis for assessing the relevance of the potentially affected regions and sectors. The discussion (part of the narrative) confirms the limited economic impacts of climate change in the observation period under the BAMBU scenario. This suits well with other sources expecting between 0 and 3% loss of GDP growth over a 50 years period, i.e. the equivalent of 0 to 8 month growth (for an overview see the Stern Review, 2006). Affected sectors include forestry (in Europe less agriculture), tourism (more structural change than growth impediment) and to some degree the construction sector. The impact on biodiversity is mixed: some drivers continue to increase (e.g. transport), while others become less severe (e.g. agriculture). In the growth scenario, as expected, most drivers become more serious, emissions rise and climate change is accelerated. The income distribution becomes more uneven, and salaries stagnate, but unemployment goes down more rapidly than in the other scenarios (a general decline is the result of demographic trends). The sustainable development scenario SEDG demonstrates that even a radical mitigation policy in Europe will result in nothing more than a delay in global warming of a few years, unless other parts of the world follow suit (most important: the USA and the BRICS countries, Brasil, Russia, India, China, South Africa).

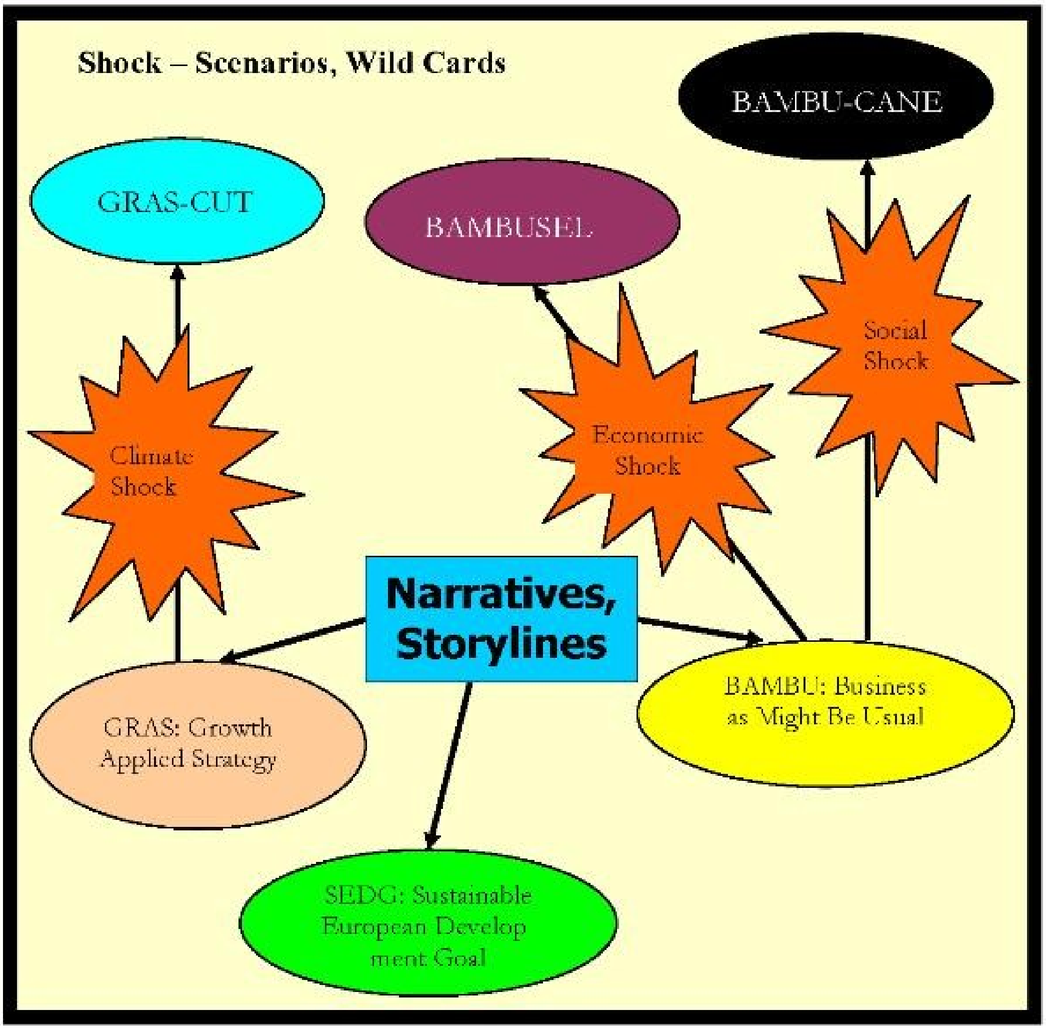
The conclusion for climate policy is that as the impacts e.g. on biodiversity, but also on the living conditions in the South are serious, action must be taken and Europe is well advised to be a frontrunner. However, international cooperation must make sure that other parts of the world follow suit in the post-Kyoto phase, maybe first the Like Minded Countries group of the renewable energy coalition launched in Johannesburg 2002. A second conclusion is that it is in vain to hope that due to cost reasons the market or the business sector would be forced to act on their own behalf; instead dedicated political decisions are needed to set the framework right for climate mitigation. Adaptation will happen rather easily in the business sector, as the speed of change in the economic system is so much higher than in the bio-geosphere that it can easily accommodate these changes of the environment. However, in the infrastructure, changes are much slower and political intervention (regulations, incentives) will be needed.

4.2 Beyond extrapolation: shock scenarios

Besides improving scenarios and solidifying their results by comparative analysis, the limits inherent to all these modelling exercises must be assessed. The most important ones result from the gradualism, i.e. the internal dynamics of models based on marginal, linear changes, typical for simulation exercises. To be policy relevant, however, scenarios have to take the effects of non-linear developments into account, in particular if they are singular events with widespread consequences, severe enough to change the development trajectory.

One way to deal with them is to develop a variety of shock scenarios against the backdrop of linear simulation runs, to illustrate how future developments can be different from any extrapolation of past trends.

The real future will most probably include such shocks, although by their very character we cannot predict them, neither which ones will occur nor when this will be the case (nonetheless vulnerabilities can be assessed, and precautionary measures can be taken, reducing a probability which is not quantifiable). Such shocks could include economic crises, reducing the future rate of economic growth as well as the level of economic activity from which the growth is supposed to start, social crises like wars, environmental catastrophes (the 2005 tsunami and hurricanes are just a point in case), technological breakthroughs with positive or negative effects, and other non-predictable events like natural disasters. Thus three additional hazard driven shock scenarios were developed as deviations from the core scenarios (see figure 2), combining a narrative characterised by the deviation from one of the core scenarios by one disturbance event with long-term and large-scale impacts. They could only be partly simulated; partly they were developed as model-supported semi-quantitative narratives. The three shocks include an environmental (THC collapse), an economic (peak oil) and a societal one (pandemia). All these events are possible, plausible, but improbable at any given point of time.



(Source: graph by the author)

Figure 2: Scenarios and shocks in ALARM

5 Discussion

For the THC collapse, since the warming was of limited economic effect, so is the interim cooling (if it materialises after 2050 – nowadays the shock would be significant, but this is not a plausible scenario).

The quadrupling of the oil price first sounds like a safe receipt for an economic disaster, and so it is (minus a fifth of the GDP) – for less than five years. Then the economic growth (not the GDP) bounces back to the old level (or possibly even more), since due to international trade the money that has flown out of the importing countries comes back in form of product orders. As a result, the economic damage is limited, but since a high bill has to be paid for imports, the social impact is serious, resembling the wave of poverty resulting from the East Asian economic crisis a few years ago. What would be the most plausible policy response? For Europe, most probably a massive investment in biofuels (they can be on the market within a year, faster than most alternatives, they provide fluid fuel, and the strategy is already in place). The expected result is a massive pressure on agricultural and forest land, leading to significant losses of biodiversity (as a deviation from BAMBU, mainly focussed on domestic biofuel production, the pressure is on the European landscape; as a deviation from GRAS, demand would be covered by massive expansion of ethanol and palm oil from Brasil and South East Asia, with dangerous impacts on the their biodiversity). So what looked like an economic crisis turns out to be a social one, and the policies to mitigate it will most probably create an environmental disaster (even if they may reduce GHG emissions).

The pandemia is either an economic transformation with some sectors loosing and others winning (like health care, pharmaceuticals etc.), with an overall reduction of GDP below 10% and an early rebound, or leads to the total collapse of the economy. The latter would be the case if about 20% of the population would drop off the production process – some dead or on sick leave, but more trying to escape infection by avoiding to all occasions where many people meet, i.e. work places, shopping centres, cultural events – or even the cities as such (as observed in the bird flue epidemic in China).

6 Outlook

According to our experience, with the help of the comparative analysis of different scenarios and the illustration of some of their aspects by different models, and by using shock scenarios extending the range of potentially possible futures taken into account regardless of their probability, the validity of future projections and the range of future options assessed can be significantly enhanced. At the same time, the analysis provides input for future modelling exercises, by creating a shared interdisciplinary knowledge based which can be used in future scenario development.

In the political domain, this allows to develop strategies and test them regarding their robustness in a wide number of possible futures (strategies which prove effective under a variety of different futures can be considered robust and if successful, a good choice for sustainability and biodiversity strategies). Such “safe bet” or “no regret” policies are the first choice in situations of enduring uncertainty (which in policy making is more often the case than not, in particular with respect to long term objectives).

In the scientific domain, such an analysis provides input for future modelling exercises, by creating a shared interdisciplinary knowledge based which can be used in future scenario development. It helps to assess the relevance of feedback loops and the robustness of scenario-based expectations and recommendations.

Bibliographic references

Bockermann, A.; Meyer, B.; Omann, I.; Spangenberg, J.H. (2005). “Modelling sustainability. Comparing an econometric (PANTA RHEI) and a systems dynamics model (SuE)", *Journal of Policy Modelling,* 27**,** pp. 189-210

CBD Convention on Biological Diversity (2003a). "Integration of outcome-oriented targets into the programmes of work of the convention, taking into account the 2010 biodiversity target, the Global Strategy for plant Conservation, and relevant targets set by the World Summit for Sustainable Development", in CBD Secretariat *(ed.). CDB Documents* Decision IX/13. Montreal: CBD

CBD Convention on Biological Diversity (2003b). "Proposed indicators relevant to the 2010 target", in CBD Secretariat *(ed.). CBD Document UNEP/CBD/SBSTTA/9/inf/26. Montreal: CBD*

EuroStat European Statistical Office (1999), The Environmental Pressure Index Programme. Luxembourg: Office for Official Publications of the European Communities

Martens, P. (2006). "Sustainability: Science or Fiction?", *Sustainability: Science, Practice & Policy,* 2(1), pp. 36-41

MEA Millennium Ecosystem Assessment (2005). Ecosystems and Human Well-being: Biodiversity Synthesis, Washington: World Resources Instit

Reid, W.V. Director, Millennium Ecosystem Assessment (2002). "Now comes the hard part….", *Millennium Ecosystem Assessment Newsletter,* 2002 (April), pp. 1-2

Settele, J.; Hammen, V.; Hulme, P.; Karlson, U.; Klotz, S.; Kotarac, M.; Kunin, W.,; Marion, G.; O'Connor, M.; Petanidou, T.; Peterson, K.; Potts, S.; Pritchard, H.; Pysek, P.; Rounsevell, M.; Spangenberg, J.H.; Steffan-Dewenter, I.; Sykes, M.; Vighi, M.; Zobel, M.; Kühn, I. (2005). "ALARM: Assessing LArge-scale environmental Risks for biodiversity with tested Methods", *GAIA,* 14(1), pp. 69-72

Spangenberg, J.H. (in press). "Biodiversity pressures and the driving forces behind", *Ecological Economics*

Spangenberg, J.H. (2005). "Structural Indicators – Towards Systemic Structures as the Basis for future EU Policies", in CEIES (ed.). *Expert Meeting Statistics, 29th CEIES Seminar, Alpbach, Austria.* Luxembourg: Office for Official Publications of the European Communities, pp. 143-163

Spangenberg, J.H. (1999). "Indikatoren für biologische Vielfalt", in Görg, C.; Hertler, C.; Schramm, E.; Weingarten, M. (eds.). *Zugänge zur Biodiversität - Disziplinäre Thematisierungen und Möglichkeiten integrierender Ansätze,* Marburg: Metropolis Verlag**,** pp**.** 215 - 236

Stern Review (2006). Stern Review on the Economics of Climate Change, http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm > [accessed 22/12/2006]

UNEP United Nations Environment Programme (2002). GEO-3 Global Environmental Outlook. London: Earthscan