RESPONSIBILITIES OF ENVIRONMENTAL RESEARCH

Proceedings of a Conference at the Royal Netherlands Academy of Arts and Sciences on September 17, 2004, Amsterdam

Royal Netherlands Academy of Arts and Sciences

Responsibilities of Environmental Research

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Amsterdam, 2005

This is a joint publication of the Royal Netherlands Academy of Arts and Sciences and the Netherlands Committee for IUCN.

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ISBN 90-6984-444-3

The paper in this publication meets the requirements of ∞ iso-norm 9706 (1994) for permanence.

Preface

The Science and Ethics Advisory Committee of the Royal Netherlands Academy of Arts and Sciences (KNAW) provides both solicited and unsolicited advice to the board of the KNAW concerning ethical issues of scientific research. The Committee organises conferences focussing on ethical topics either within specific scientific disciplines or of a general nature. The present conference focuses on the field of environmental science.

The main questions the conference dealt with, were:

1 Why does scientific research that claims to show arguments for a change of policy, frequently remains without result? Is that caused by research itself, or by its organization, or by flawed communication either amongst researchers or between researchers and society?
2 How can individual researchers or research teams take responsibility? Who do they address and which interaction is pursued with society?

This publication summarises the lectures and case studies, and the reflections of panel members on the introductions and discussions. We hope it will help stimulating and guiding further discussions among scientists, politicians and the public at large. We are very pleased with the co-operation of the Netherlands Committee for IUCN to actively co-produce and distribute this publication.

Jan H. Koeman,
Chairman Science and Ethics Advisory Committee

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JAN H. KOEMAN, JAN D. SCHIERECK

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Introduction
People depend on the Earth as an ecosystem for their existence. It is the most important supplier of goods and services to satisfy the primary necessities of life ('ecosystem services'). Research into the function of ecosystems (agro-ecosystems as well as 'nature') has underlined this significance. At the same time, the way in which human activity represents a strain on the environment is becoming increasingly evident. This burden is severe and some aspects already seem to be irreversible. As such, it may seriously impede our existence. The term 'environment' refers here to the surroundings determined by nature and culture; 'nature' refers to landscapes or populations that are not, or are only scarcely, influenced by human activity. Human influence on the environment is a topic of political debate and social discussion, where occasionally widely differing standpoints are assumed on the basis of research results or other (ideological or opportunistic) considerations. The role of scientific study in controversies concerning environmental issues is reviewed below.

In ecological terms, the human species has formed an integral part of natural ecosystems for millions of years. However, unlike other species of animals, most human populations evolved culturally. Their position in the ecosystems became more and more dominant leading to marked changes in the ecological structure of their environment, for instance following the rise of agriculture. At first, disturbance by human activity appeared for a long period of time to result in new ecological equilibriums. However, there is overwhelming evidence that the present scale of human impact on the environment far exceeds the levels of tolerance of most ecosystems. In the most extreme cases, human activity may generate conditions that can seriously hamper (human) life on Earth, or even make it impossible. This has already occurred in some places, as the consequence of desertification, for example. This very possibility is sufficient reason to consider whether this represents a serious threat to human welfare or survival. What risks can be identified here? What influence do they exert? What activities foster the materialisation of these threats, within what time parameters, and to what extent?

The Science and Ethics Advisory Committee (Advies Commissie Wetenschap en Ethiek, (ACWE)) of the Royal Netherlands Academy of Arts and Sciences (Koninklijke Nederlandse Akademie van Wetenschappen (KNAW)) has placed the above-mentioned issues on its agenda. This memorandum aims at sparking a discussion on responsibilities of environmental sciences in resolving issues concerning human influence on the environment.

Views and paradigms
Opinions and research results on these matters diverge greatly. On the one hand, some researchers conclude that the natural environment imposes hard limits on the possibilities for survival. If humanity does not take (sufficient) account of these limits, the possibilities for survival are seriously impaired. Here, one can think of harmful consequences such as climatic change, shortages of food and potable water, and the pollution and even toxification of the environment. Moreover, there also are aspects such as inhibition of economic growth (although economic growth is probably not a must for the maintenance of a sustainable society) and possible destabilisation of social order mainly as a consequence of the exhaustion of ecological commodities.

On the other hand, some research communities and individual scientists have concluded that such fears are unfounded. There are enough options to guarantee humanity a future in which 'sustainable' use can be made of natural resources in conjunction with the retention, or perhaps even an expansion, of prosperity. In this approach, there are no *a priori* hard constraints. Constraints arise in practice after a comparison of options and a balancing of considerations. Non-linear relations between causes and effects, and the 'flip-flop behaviour' of transition states and hysteresis contribute to the fact that it is extremely difficult to present any expectations concerning the reaction of ecosystems to external influences. The prevailing view is that extrapolation of research results generally leads to an outcome with little reality value. Moreover, this viewpoint presupposes the positive effects of new technological possibilities.

Society and research
Countless studies and investigations by means of models have been performed since the beginning of the 1970s, with the purpose of analysing future interaction between society and the environment. Three generations can be broadly distinguished here (Opschoor 1999). The first generation contains the reports that were issued under the auspices of the Club of Rome. Making use of system-dynamic models, these reports predicted the advent of serious crises. Some of these have now become visible, such as the decline in population of the larger animal species. Other predictions have not or not yet materialised because new developments have enabled the deployment of alternative materials (such as fibreglass instead of copper). The second generation of reports, including Global 2000 and Our Common Future, drawn up by the World Commission on Environment and Development, tended toward quality and synthesis or integration. The last report led to the UN conference in Rio de Janeiro in 1992. The third generation consists of the model studies that have been published since approximately 1990. In these studies, more emphasis is placed on quantitative analysis than was the case with the previous generation. Reconstruction-based research

from the fields of biology, geology, physics, and physical geography is giving rise to what may be seen as a fourth generation of studies. These integrated assessment models make use of biotic and abiotic data carriers.

The reports that have appeared to date have not been able to settle the academic controversy concerning the existence of hard limits on ecological capacity. This ongoing altercation influences opinions about the urgency of addressing environmental issues and the corresponding political deliberation on problems. It also explains why, from a global point of view, there is insufficient support for policies that are oriented toward the implementation of countermeasures (such as cutting CO_2 emissions, reducing overexploitation of forests and water areas, ensuring a fair division of energy and other natural products, etc.). The enormous problems encountered in attempting to reach consensus at international conferences such as those at Rio de Janeiro (1992), Kyoto (1997), and Johannesburg (2002) illustrate this situation all too well.

Public reactions to environmental studies can be divided into three categories. Firstly, in some situations of overwhelming evidence or alarming calamities society has responded effectively to negative impact on the environment. Examples are the reduction of water and soil pollution, the ban put on a number of persistent chemicals and improvements in waste control in general. In the areas in which improvements have been achieved, measures could be imposed relatively easy. In the case of pollution this was often achieved because of the limited number of sources. Secondly, there are human activities which have a disastrous impact on ecological human life-supporting systems and which are not under control at all. Examples are the process of desertification through irreversible loss of topsoil and drying up of streams and other sources of water and climate change in connection to green house gases and deforestation. These problems affect a large number of countries and they are well recognised by scientists, governments and international organisations. However, results of environmental research have not yet brought about sufficient political determination to impose necessary countermeasures. Thirdly, human influences on the environment have been detected, which may turn out to be disastrous for the biological life support system, although there is no scientific agreement regarding this cause-effect relation. Examples of this kind of controversial themes are loss of biodiversity in connection to a loss of live support functions, irreversible damage to marine resources and shortages of raw materials for the livestock industry.

Social interest in the environment is reflected in the priority that is allocated to the environment, as expressed in governmental policy. Of course, this priority also depends on the value that politics assigns to other matters. The period within which the effects of action and policy become noticeable also plays a role here, as does the complexity of the problem. In Dutch physical planning policy, the ecological capacity of the environment is only taken into account to a limited extent. For example, the conclusions of the Natuurbalans 2002 report by the Dutch National Institute of Public Health and the Environment (Rijksinstituut voor Volksgezondheid en Milieu, (RIVM)) state: ‘Finally, for a successful extension of the policy on nature and the landscape, it is necessary to have a government that pursues a policy in which the departments are mutually well attuned, on the basis of a common vision of the different functions of nature and the landscape, with attention being focused on both the ecological and the socio-economic functions of nature. At this moment, this type of vision seems to be lacking, as well as any fine-tuning between the departments.'[1] This element did not appear in recent electoral programmes of Dutch political parties.

Responsibilities of scientific researchers

It is debatable whether or not the Earth as an ecosystem can absorb the ever-increasing burden of human activities at a global level. This does not alter the fact that, further down the scale, there is already mention of irreversible and unwelcome breaches of normal patterns (temperature, rainfall distribution). However, a multitude of feedback mechanisms and buffers in the ecosystem make categorical explanations very difficult. Nevertheless, it remains a task of scientific researchers to make statements on future developments. Decisions to implement measures should be the topic of political debate. This type of decision-making can only be effective if unambiguous and balanced information is presented. Even then, it must be taken into consideration that knowing and understanding facts, situations or processes does not necessarily generate confidence in any proposals for action. Power politics plays a major role in environmental policy. For such reasons, political and decision-making processes should also be the research objects of environmental sciences.

Scientific researchers should be willing to look beyond the boundaries of specific schools and disciplines. In addition to unequivocal information, social and political priorities are important in decision-making processes. All too often, there appear to be problems in this domain that obstruct an adequate treatment of environmental problems (particularly if these only become manifest and tangible in the long term). Accordingly, discussions between researchers and between various schools can lead to political inertia or to policy that is strongly oriented towards the short term.

By analysing patterns and causal relations on the basis of perceptions and experience, science provides a knowledge base of underlying principles and causes of phenomena. Such knowledge enables us to make meaningful statements about the chances of specific events occurring in the future. A clear indication of the consequences of policy contributes to the careful use of raw materials and the management of the ecosystem. Rational choices have to be made with regard to the dilemmas that arise in this context. Science can contribute here by developing techniques for scenario analysis. In terms of policy, formal positions can be developed that legitimise or enable choices in situations of uncertainty. A good example of this is the precautionary principle[2] that was proposed in Rio de Janeiro (UNCED).

Consideration of individual interests, collective interests, stewardship and the interests of future generations plays a role in the stimulation of possibilities for sustainable action and operations. Evolutionary processes are slow and thus it is easy to express

[1] RIVM. 2002. *Natuurbalans*, p. 164.

[2] In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (*The Rio Declaration*: Principle 15 - the Precautionary Approach; 1992).

meaningful statements about the primary necessities of life. This is not the case with secondary requirements. It is only possible to speculate about the intentions that future generations may have in circumstances that do not yet exist, and the preconditions that could apply to operations and policies. Great caution is demanded from politicians in scientifically sound publications. Authoritative political ideas cannot be championed in this context.

Research into the state of ecosystems and the effects of human action on the equilibrium and buffer capacity of ecosystems is multidisciplinary *par excellence*. Paradoxically, however, the multidisciplinary nature of environmental research may pose a threat to the progress of research and to the development of measures to reverse negative effects on the ecosystem. These problems are substantial and complex, and also involve the aspect of non-linearity, making it difficult to provide a good analysis. Differences between the participating disciplines with regard to basic principles and methodologies tend to have an adverse effect. These problems are part and parcel of scientific activity. Accordingly, researchers should devote their efforts to overcoming these differences in order to reduce these disadvantages for society. The backers of research ought to aim at encouraging a multidisciplinary approach to environmental problems wherever possible.

Debate

The issues presented give rise to topics for debate. Below they are presented in the form of propositions and questions in order to organise a debate aimed at clarifying the influence of scientific research on society and the responsibilities researchers can and should accept in matters of ecological research.

Propositions

- One should not expect uniform reports from scientific research circles in the near future: the problem at issue is too large and too complex. In addition, there is a certain amount of inefficiency in research due to the fact that researchers from various disciplines often have poor contact with one another. Meanwhile, the problem of a complex global ecology and disturbance of natural equilibrium due to human activity persists. Finding solutions to environmental issues is of paramount importance. It is debatable whether or not it is essential to have a straightforward model describing the effect of human activity on the environment.
- In the opinion of some people, this justifies the acceptance of the precautionary principle. Researchers have a duty to highlight this principle and the argumentation that should lead to its acceptance. An inability to take decisions because of a lack of adequate scientifically substantiated knowledge cannot be construed as a reason for doing nothing. A precondition of this is that serious problems or irreversible processes are at stake.[3] Other commentators, however, maintain that it would be unacceptable for researchers to legitimise normative stances such as the acceptance of the precautionary principle. This train of thought contends that the results of

[3] See also WRR, *Naar nieuwe wegen in het milieubeleid*, pp. 129-136.

research should be presented in the shape of 'if-then' propositions on the effects of certain developments or interventions. The consequences of *a priori* choices in policy should be made as visible as possible.
– Communication plays a crucial role in environmental research and the implementation of results and conclusions of this research. Researchers ought to take this into account. Communication on environmental problems is important to balance individual and group interests as a function of time and place. Communication also plays a part in allowing research results to be taken into consideration in political decision-making processes.
– Research into the effects of human activity on the environment is necessary. The Earth as an ecosystem is of crucial importance to humankind. Researchers have a duty to clarify this in order to generate a political support base for the release of sufficient resources for research. The concepts of scarcity of natural resources and sustainable use can fulfil an important role in this field, just as an overview of the problems and issues to be covered by the research.

Questions
The main question is why scientific research that claims to show arguments for a change of policy, remains without result, is that caused by research itself, or by its organisation, or by flawed communication either amongst researchers or between researchers and society? Secondly, how can individual researchers or research teams take responsibility, what issues should they address and what interaction is pursued with society?

With reference to the first question:
– There is reason to believe that the responses to the issues posed here diverge considerably. A great variety of academic disciplines within environmental studies are involved here. Are enough resources being invested in multidisciplinary and interdisciplinary frameworks? Do researchers from disciplines relevant to environmental research make sufficient use of one another's results?
– The unpredictability of ecosystems also plays a part in the evaluation of research results. Non-linearity and hysteresis often give rise to unexpected results, while a total absence of effect may initially even seem to be the case. What is the ideal way to deal with these causes of ecosystem complexity?
– The temporal and spatial scales that are relevant to the influence of human action on the environment are so great that they may exceed one's imaginative powers. Have sufficient instruments and concepts been developed to meet this requirement? What is their effect? Do (local) government and companies invest sufficiently in research whose results can contribute to sustaining ecological capacity for future generations? What can researchers do to influence public and political interest in research agendas? What influence do research results have on the willingness of governments and companies to fund follow-on research?

With reference to the second question:
- Do researchers engaged in environmental studies commit themselves sufficiently to finding the truth? Are the research issues specific enough?
- Consideration of the interests of individuals and groups plays a role in the transition from research results to policy, as does the fact that every country on its own is much too small to achieve any significant effect, even with a very pronounced policy. How can these interests be compared? What does this mean for policy-making?

The statements and questions that are mentioned here were topics for introductions and discussions during a conference held at the premises of the Royal Netherlands Academy of Arts and Sciences. This has led to the conclusions and observations in the next section.

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Conclusions and observations with regard to the main questions of the conference

The main questions were:
- Why does scientific research that claims to show arguments for a change of policy, remains without result?
- Is that caused by research itself, or by its organisation, or by flawed communication either amongst researchers or between researchers and society?
- How can individual researchers or research teams take responsibility, whom should they address and what interaction with society should be pursued?

The following conclusions can be drawn from the presentations and discussions with regard to these questions.

On the role of research and its organisation
- Environmental scientists – like scientists in general – should have a closer involvement with society and a willingness to debunk myths and prevailing public opinion (facts, analysis and opinions versus prejudices and popular beliefs). It is clear that interests or dependencies often determine the opinion of the beholder. These should be made visible and subjected to critique. Scientists have to play a crucial role contributing facts, analysis and clear diagnosis and they should make clear what the consequences of certain political decisions are. Scientists have a clear obligation and a privileged position that should be handled with both responsibility and care.
- Teams of scientists, focusing on basic and applied research but also on facilitation and communication, should invest first in their own *community of scientific practice*, which should be based on appropriate, solid scientific methodology. By focusing on alternative options for action for any given issue, including all economic, ecological and social trade-offs involved when striving for sustainable development, scientists can preserve their independence (and thereby clarify their position in the debate) while providing crucial knowledge.
- The problems that form a large part of environmental issues are seen to call for multidisciplinary and interdisciplinary science where scientists from different disciplines not only need to come together; they need to develop new knowledge in collaboration with social actors.
- Scientists should take time to consider the broader scientific picture before they express their scientific findings to the public. The Netherlands, and the European

Union as well, will benefit from independent organisations that take up the role of organising assessments such as the International Panel on Climate Change (IPCC). The Dutch academy of arts and sciences (KNAW) could play a role here in the same way as the National Academy of Sciences does in the USA. One option is to support assessments such as the ones carried out by the IPCC. In general, academies of science should encourage researchers to overcome disciplinary boundaries and reduce institutional boundaries between disciplines.

On communication between researchers and society

- In general, communication between environmental scientists and society is inadequate. First of all, too many scientists do not make an effort to be advocates for their research and communicate their findings in an accessible way to a wide audience. Second, communication about science and its achievements is frequently ineffective and sometimes even incorrect.
- Traditionally, scientists have felt that good research would find its way on its own merit. This is no longer assured in the information age. Professional communication techniques are needed to reach modern citizens, who are numbed by a continuous avalanche of information. Scientists cannot afford to ignore this if they are serious about their work. It is the responsibility of scientists to provide data and arguments, and also to evaluate the use and abuse of the results and interpretations in the decision-making process. It is not the final decision that should be kept under control of science, but the correct use of scientific arguments in that decision.
- Ecologists often seem to lack firmness when stating conclusions, point to uncertainties rather than certainties, leaving others to freely interpret the data, leaving a lot of leeway for opportunistic short-term decision-making or political inertia. When data are convincingly strong to scientists, they should be firm in their message to the general public. However, they should realise that knowledge is not sufficient to build confidence.
- Alarming messages about environmental degradation are generally counterproductive. Mass media and other publicity interests often comment on rather serious and sober reports on empirical state of affairs in alarmist terms. Scientists should be aware of this. Pointing to positive achievements is crucial to get things done in the future. However, at the other extreme is the position of being over-cautious or conservative, which means that scientists are excessively cautious when drawing conclusions and arguing continuously that sufficient proof of the deterioration of the environment in general is lacking and that one needs more evidence, setting an unreasonably high standard of evidence.

On public perception and/or disregard of science

- Despite the efforts to establish 'sustainable development' as the central developmental objective globally and at the national levels, in day-to-day practice societies and their governments too often still behave as though unqualified economic growth is desirable and possible. In terms of the institutional structures, an increased reliance on free international trade and market mechanism can be observed that is geared more towards unchecked growth than to sustainable development.

- Partly as results of scientific research human activity has had a wide influence on the use human-kind makes of the earth's resources. In a number of cases these impacts have given rise to concerns over the sustainability of this utilisation, e.g. many minerals are extracted from the earth's crust with associated waste flows that often lead to accumulating stocks of wastes.
  At the same time science has also helped to reduce the waste load per product. More generally, science is finding ways to increase the sustainability of production and consumption by reducing the environmental claims per unit of product. In social science instruments have been developed that affect patterns of consumption and production in such a way that they become less unsustainable. Suitable alternative materials have been found or developed aimed at reducing the usage of other resources that are more scarcely available. In science communication both aspects should be brought forward.
  Meanwhile it is an open question whether these efficiency gains can be maintained and augmented in the future and whether they and the policy instruments as proposed thus far, will be sufficient in reducing the over all impacts of economic activity to levels that can be considered environmentally sustainable. Economic growth may outpace efficiency gains. Concerns such as these pose profound challenges to scientists, policy makers and civil society.
- The concept of the 'ecological footprint' has been developed as one of a family of similar concepts to indicate the impact human activities have on the earth and its resources. It is meant to make clear that in the long run human activities that bear on necessarily limited natural resources cannot grow *ad infinitum*.
- The collapse of some of the world's fish populations is largely due to management failures by governments and international bodies like the UN, including the failure to heed the warnings of academic scientists. Certainly, the danger signals had been evident. Regrettably this tragedy is fairly typical of the human exploitation of self-producing natural capital. Although there is considerable variation in detail, there is a remarkable consistency in the history of resource exploitation. Resources are often over-exploited, to the point of collapse or extinction.
- Environmental issues, crises and especially successes should be made part of our historical thinking, our societal identity and our knowledge of chemistry, biology and geography. Our educational system needs radical changes in emphasis and there is an important role here for the (easy access) media. Science in newspapers and in television programmes should not only focus on recent hot topics but also generate historical awareness of environmental issues.
- Aid for third world countries tends to aim primarily at improving economic living standards. This aid or its implications often have negative consequences for the environment, including the availability of natural resources for development in the long run, and biodiversity. Research should aim to further clarify the potential economic wealth of ecological diversity, but biodiversity should be recognised in the economic process as having an intrinsic value in most (if not all) cultures.

On the application of the concept of the precautionary principle

- What is new is the scale on which human demands, as a result of technological development and population growth, have ravished the resources of the earth. Scientists need to address the problem of dealing with environmental issues that are often subject to scientific uncertainty, have major social impacts, particularly on the vulnerable segments of society and on ecosystems and species and, hence, are arguably characterised by urgency. What makes this problematic is, that many of these impacts are expected to occur in sometimes fairly distant futures (as seen by decision-makers), which leads to an unwarranted lack of mitigative action. Moreover such action often challenges vested interests of politicians and industrialists.
- Policy makers face problems, in bringing policy into effect that reduces short-term advantages for some, for the benefit of long-term advantages for all. This is where the precautionary and proportionality principles play an important role. The precautionary principle asserts that lack of scientific certainty cannot be used as a reason for not taking appropriate measures to combat a given problem.

Climate change

- Climate trends and emission of CO_2 into the atmosphere have both been well studied. These studies attract public and political interest as they may support the view that a rise of CO_2 concentration due to the use of fossil fuel causes a rise of mean global temperature. It is an established fact that climate information shows a rise in mean global temperature over recent history. There is also evidence that in the period in which the temperature has been rising, the concentration of CO_2 in the atmosphere has risen. The increase in concentration of CO_2 may be related to the use of fossil fuels.
- Amongst researchers it is debatable to what extent these trends are causally related, since the observed changes are small compared to historically visible trends and they may also be caused by various other phenomena or mechanisms. The difficulty in establishing a clear and simple relation between the concentration of CO_2 in the atmosphere and a general rise of mean global temperature, leads to the view that there is only a partial relationship, if any, between CO_2 emissions and the rise in mean global temperature. 'Climate sceptics' favour the view that the mean temperature rise is not proven to be human-induced at all and therefore action to reduce CO_2 emissions is unnecessary.
  However, the correlation between CO_2 concentration in the atmosphere and mean temperature is clearly established and the mechanisms that underlie a supposedly causal relation are also well understood. On the basis of data on mean global temperature and the use of fossil fuels the precautionary principle calls for preventive action.
- There are two ways that decision-makers can respond to the prospect of uncertain environmental effects of novel activities: 'mitigation' and 'adaptation'. Mitigation involves actions that reduce the likelihood of an event or process. Adaptation involves actions that reduce the impact of the event or process without changing the likelihood that it will occur. Mitigation accordingly implies action before the event. Adaptation may involve actions taken before, during or after the event. Adaptation

usually implies actions that reduce the expected damage of an event (such as the adoption of building standards that minimise earthquake damage), but it also includes actions that pool or transfer the risk of an event (such as insurance). The management of environmental risks includes both sets of actions. However, precautionary decision-making is usually associated with mitigation. The time has come that more serious effort at implementing mitigative actions is undertaken – otherwise future generations are most likely to have to face more costly adaptive strategies.

– A general topic for further research and debate may well lie in an assessment of the pros and cons of the existence and effects of myths and the use of metaphors in environmental research and policy. Myths have to be regarded with extreme caution. Metaphors are indispensable, but they should have a proper science base. The ecological footprint is one of the prevailing metaphors, which is appealing because surface area is easily recognisable. However, it is also biased, as it is based on non-justifiable assumptions and because measurements of sustainability are in the end reduced to only one parameter. The idea that the efforts made by the World Wildlife Fund result in an effective conservation of tropical forests seems to be a myth; the same may hold true for the Kyoto protocol. It may turn out that our society will not be able to timely reduce the emission of CO_2, as an effort to abate climate change.

RUDY RABBINGE

(Multi-/inter)disciplinarity and organisation of research

Introduction

In this contribution an overview is given of the way various scientific groups in society have demonstrated their commitment to societal goals and have indicated their willingness to use ethical arguments to determine how their science is being developed and used. Various trends in society are described and it is shown that ethical debates have long been held in a number of professions. The roles of science and scientists in society have evolved. The traditional paradigm for science and scientific research has changed and a new paradigm in which techno-centric, eco-centric, socio-centric and etho-centric considerations are combined is now being adopted more frequently. This can be made operational by the introduction of so-called action perspectives. This is illustrated by the way sustainable development is treated.

Relevant trends in our society

Four dominating relevant trends affect many processes in our society nowadays. The first trend 'globalisation and communication' causes a tremendous increase in the possibilities to communicate and have information from all regions of the world. This globalisation makes the unquestioned position of science a problem. Secondly, the population and economic growth of the last century was largely made possible due to innovations based on science and technology. There was a technology push that amplified the economic potentials and possibilities. A third trend in society is the changed role of consumers and citizens. Chain reversal has generally been adopted and the demand from consumers dictates the characteristics of products and production methods. As citizens, consumers set norms for and constraints on production methods and goals including environmental and animal welfare objectives. The latter is emphasised by the increasing focus on norms and values in the public debate. There are more goals than productive goals and environmental and ethical objectives are increasingly taken into account. There is a shift in general attitude that technocratic ways of operation are less acceptable if they are not well contextualised and if explicit attention to goals and objectives is not taken into consideration.

Ethical debate

The ethical debate at the recent turn of the century is not new. It previously occurred much earlier, when the environmental side-effects of the (over-)use of pesticides became clear and visible in the early sixties of the last century (Carson 1963). The danger of pesticide residues and their effects on human beings and on various other components of the fauna became clear and fuelled the discussion in society on what ethical principles need to be obeyed. This discussion was strengthened by the various Malthusian-based studies in the early seventies and eighties. The bestseller *Limits to growth* (1972) and the books on overpopulation (Ehrlich 1969, Harden 1986), and too much wealth in the West (Commoner 1971) were all pleas for a normative debate to guarantee the interests of those elements of the flora and fauna that cannot defend themselves. They were all based on the same notion: too many people, too much pollution and an inevitable collapse. Achieving a good balance between economic development and ecological and environmental restrictions and constraints became a common notion, but was not made operational in all cases. The realisation that genetic improvement occurred and could have a very detrimental effect on global fauna, but would also narrow the genetic basis for agricultural crops, created a strong movement against some aspects of the green revolutions and got new fuel when GMOs started their exploration of the world's agro-ecosystems.

To preserve natural resources and help to develop the South at the same time was the notion presented in the *Brundtland report* of 1987. This report made a powerful plea for sustainable development, i.e. strong economic development in the South, better allocation and reallocation of natural resources on a global scale, more space for maintaining natural ecosystems and a strategy for global sustainable development that would include a drastic change in policies in the North on behalf of the South.

On the basis of the analysis, a very clear concept has been adopted in the triple P model (people, planet, profit). Mutual interaction and, where the basic conditions and constraints of an environmental and ecological nature have been fulfilled, sustainable development are possible. The balance between these three Ps requires an explicit notion of the interests of future generations, global cohesion and more explicit attention to ways of operating that minimise such effects on the environment. This requires a recoupling of developments and self-correction in the North to enable possibilities in the South; it should connect future generations to the present one and consider the dynamics in societies as an asset and not as a liability. On an abstract level, the world community has accepted, adopted and created the political will for sustainable development. However, in many cases, this has not been operationalised and in many other cases not internalised or accepted.

The role of individuals and humankind

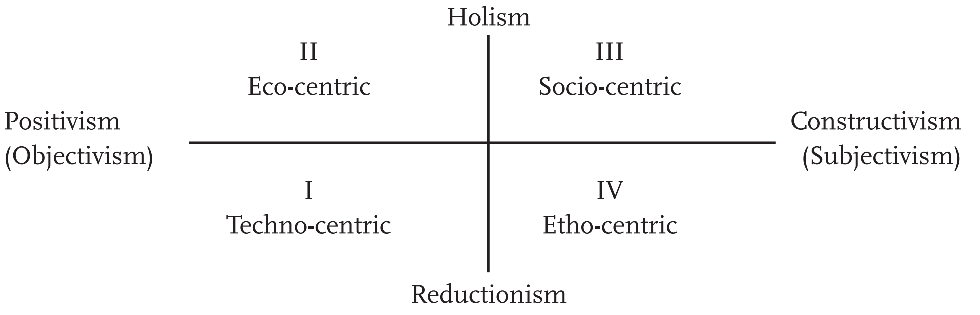
The role of humankind in this debate is in many cases perceived differently. The traditional attitude of humankind dominating nature, managing and exploiting nature and natural resources for its own benefit was very often motivated by religion. Humankind should manage the earth in a way that is in line with its creation by God. The movement in which humankind is part of nature and has to act and react in a responsible manner, in fact a manner that involved well-understood self-interest started with the Darwinian view of nature. The role of humankind may be differently motivated but leads in all cases to responsible conservation and conservative use of resources and a well-defined economic development.

The role of science and scientists

The role of scientists has changed considerably over the last few decades. The position of scientists and science standing above society and generating knowledge, insights and theories, ultimately leading to a better revelation of the truth, has shifted. Scientists are becoming a much more integrated part of society where other sources of knowledge are increasingly accepted. Uncertainties and risks are more accepted as phenomena that have to be accounted for. This affects the role of scientists. They have to make problems explicit for the relevant temporal and spatial scales and have to address the boundaries of systems. They have to account for externalities and make them explicit and identify windows of opportunity. To translate societal problems into scientific questions requires an attitude that is open and sensitive to these problems. It requires a closer involvement with society and a willingness to debunk myths and prevailing public opinion (facts, analysis and opinions versus prejudices and popular beliefs). It should also be clear that in many cases interests or dependencies determine the opinion of the beholder. These should be made transparent, visible and criticised. Scientists have a crucial role to play in contributing facts, analysis and clear diagnosis and should make clear what the consequences of certain political decisions are. They politicise but are not actively as such as policy makers. That is a role a scientist can play as a citizen or even as a political representative, but the role of scientist should be as much as possible and as long as possible without a clear choice for a particular position. This does not mean that science is free of values and norms. On the contrary, it is of utmost importance to make explicit the values or norms that are being adopted and what are the consequences in political choices. Scientists should also contribute to the societal debate and upgrade and update it by making utopia and dystopia visible. Early warnings should be given for various developments in society, for example pesticide use, mineral problems caused by excessive use of fertilisers, climate change etc.

Paradigms

The role of science has also changed as a result of changing paradigms. These paradigms may be represented in a quadrant where the abscissa varies from positivism to constructivism and the ordinate from reductionism to holism. The lower quadrant combines positivism and reductionism. There science will always explain things better by looking at them in more detail. This is the traditional techno-centric attitude. By looking at the cause of problems we will find the appropriate solution. In the second quadrant, upper left, it is clear in many cases that systems are more complex and that a holistic view has to be combined with the reductionist view. In ecology this is widely accepted. This eco-centric paradigm comprises both studies at systems level and study of underlying processes and phenomena that are dictated by the environment. In the upper right quadrant the socio-economic constraints and goals or objectives dictate the way ecosystems are managed. Ultimately, many aspects of sustainable development are social constructs. These objectives are reducible to norms and values and the lower right quadrant therefore exemplifies the ethnocentric paradigm. The combination of the approaches in the quadrant is in fact the basis for a balanced view. No single paradigm should dominate, as a combination is required.



Science and uncrtainties

There are several sources and causes of uncertainties, for example, the complexity of problems, the speed and scale of human influence globally, and the non-linearity of relations between cause and effect. Science and scientists should identify these sources and make them subject of debate and accessible for general discussion in society. This requires an operationalisation of these uncertainties and risks. There are several methods for distinguishing between perceived risks and calculated risks. A well-accepted and extensively documented method is the one proposed by the Netherlands Scientific Council for Government Policy in the report *Sustainable Risks - a lasting phenomenon* (WRR 1995).

In this report a method using action perspectives is introduced that requires an explicit identification of the risks, the way to deal with them, and various approaches in consumption and production to address the problems. This approach is applied in the five major domains where aspects of sustainable development matter: food production and food security (1), energy supply and demand (2), nature conservation and biodiversity (3), water availability and water demand (4), man-made polluting compounds such as chlorates (5). The outcomes of this analysis show that, globally, there are various ways of addressing sustainable development. It also makes clear that the four action perspectives: utilising, managing, saving and preserving, will result in very different ways of tackling the problems in the various domains. It also demonstrates that a consistent action perspective in all domains is impossible. Nature conservation and biodiversity require a large amount of land surface in the preserving action perspective, which conflicts with a similar action perspective in the food production and food security domain. In fact, choices always have to be made and these can only be based on perceived and accepted norms and risks made explicit in action perspectives. Contrary to general belief that a consistent preserving attitude is best for sustainable development and that the precautionary principle is then best served, it appears that a balance in action perspectives in various domains is needed.

Consumption pattern	**Production level**	
	high	low
Adaptation of production methods	utilising	saving
Change of production systems	managing	preserving

Conclusions

To conclude, the ethical debate in environment and sustainable development now addresses more complex problems and scientists are increasingly being held accountable. They are increasingly responsible for updating and upgrading the debate in society. This requires them to be explicit in their normative values and it also makes clear that they can contribute to this debate with facts, insights, scenarios, utopia and dystopia. Scientists should be aware that they have an obligation to contribute to the debate by politicising, but should be careful not to confuse their roles as scientists and citizens. Scientists have a dual responsibility, which is a clear obligation and a privileged position that should be handled with responsibility and care.

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HERMAN D. RIJKSEN

Science and the demise of spectacular wild biodiversity

Introduction

Science combines intellectual and experimental activities to reveal truth, and to seek effective solutions to problems. Nature conservation aims at long-term survival interest for people as a component of the biosphere system. It has a philosophical foundation that is rarely appreciated, partly because it has an impact on land use and socio-economics. Questions that will be addressed here are: first, why does scientific research in wild biological diversity not produce applicable results that are useful for the conservation of even its most spectacular representatives and the rainforest ecosystem of which they form part? And second, what do the scientists involved have to do with such failure, and how can they possibly contribute to assuming responsibility for the survival of wilderness and wildlife?

Why positive results fail to materialise

The answers to the first questions are, stated briefly:

1 Nature conservation is a complex of interventions, based on integrated disciplines of applied science, to help wilderness and wildlife survive under conditions in which biased ethical and banal socio-economic issues dominate.

2 Scientific advice on land use and conservation is rarely welcome in the political world that is focused on consumptive progress (Terborgh et al. 2002).

3 In spite of public support for nature conservation that amply outnumbers any political constituency, the past decades have shown that effective wildlife conservation is being starved of financial support while research on wildlife utilisation is promoted. Thus, politically determined annual financial allocations for biodiversity and rainforest conservation have largely been diverted to international organisations for reasons that have little to do with nature conservation. The effect of selective disbursement of the allocations away from conventional nature conservation has corrupted the very concept of conservation with amazing success – i.e. to keep something, rather than consume or use it so that its integrity is compromised. And, unfortunately, many scientists have played a dubious role in this development.

The last topic deserves some further illustration. For instance, on the authority of the 'scientific conscience' of the international nature conservation movement, represented by the International Union for the Conservation of Nature and Natural Resources[1]

– working in collaboration with the World Wildlife Fund[2] and the UN Environmental Programme (UNEP), the concept of conservation was replaced by sustainable utilisation in the early 1980s (McNeely & Miller 1984). Its utilitarian meaning for people outside the academic world was unmistakable, i.e. nature conservation is *the management of human use of the Biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations* (Allen 1980, p. 2).

The role of governments

The protection of areas and wildlife was soon being labelled as outdated (Allen 1980; Janzen 1994), and the strong directive, which was launched in a worldwide promotional campaign at an incredible cost (for conservation), called for participation by local communities in the sustainable management of protected areas. Many who immediately saw the economic opportunities received its message enthusiastically. In many developing countries the Strategy has effectively made all State forests including protected areas into archaic 'commons' and conjured up a classic 'Tragedy of the Commons' situation. From a traditional focus on wilderness functions and ethical wildlife values, the trend shifted with the support of corruptive financial power from 'development aid' to the alleged sustainability of exploitation under supposed traditional rights (WCED 1978; Min. Buza 1992; Voorlichtingsdienst 1994; Prins et al. 2000). In a number of developing countries it facilitated outright anarchy, violating long-established laws and regulations of land allocation, while making poaching, illegal logging and settlements into a new 'traditional right' for poor subsistence farmers living around State forests and established protected areas. Managers of protected areas, who had struggled to make protective law-enforcement effective, soon lost all national and international support. Corruption and collusion by lower authorities for forestry and nature conservation was thus encouraged. The grip of government authority weakened as law-enforcement became virtually impossible while worldwide demand for timber and non-timber forest products soared.

The few scientists who did look into the matter wondered how rural societies could suddenly claim any traditional rights since they had become modern state citizens and had abandoned the essentials of their formal tribal religion and culture. Moreover, the subsistence patterns of all rural societies in the twentieth century have become far from sustainable in an ecological sense due to the continuous increase in population, the easy availability of modern technology and the demand of the international market for forest products. Again, just a few scientists dared to publish their concerns for fear of losing their positions (but see: Rijksen 1984; Redford & Sanderson 1992).

The mix of expedient political ideology and financial power went even further. In the Netherlands, government subsidies were provided for international conservation bodies subject to the strict conditions of the policy for disbursement that demanded full attention be paid to supposed traditional rights to promote sustainable use (Van

[1] IUCN, now World Conservation Union
[2] WWF, now World Wide Fund for Nature

der Zon 1997; Van de Veen & Dorren 1997). Soon the policy was changed to give so-called poverty alleviation of poor rural stakeholders priority in all project subsidies from government allocations for conservation. Any sort of non-compliance with or challenge to the policy posed a serious risk that scientists involved in nature conservation research would be blacklisted.

Ecological and sociological opinion raises serious doubts about this poverty alleviation policy, while its political justification conveniently leaves the skewed international trade dimension out of the argument (Brandon 1997; Wunder 2000). Empirical impressions corroborate the doubts (Terborgh et al. 2002). Where poverty alleviation projects are being conducted, the ecological integrity of protected areas is declining, and spectacular wildlife faces imminent extinction (Oates 1999; Rijksen & Meijaard 2000). However, the empirical data that disprove the ideological hypothesis underlying the policy have fallen on deaf ears at the level of policy-making and subsidy provisioning. After more than a decade in operation, no serious scientific evaluations were, or could be, made of the ecological effects of this policy. In the Netherlands, an application for such an evaluation was turned down at the Directorate General Development Cooperation in 2000. The curious argument was that a governmental department could not support evaluations of their own policy. Yet, the attention did apparently lead to a commissioned programme evaluation after several months. Typically, the terms of reference for the evaluation stipulated that the focus should be exclusively on administrative affairs and it explicitly excluded any reference to the effects. When such effects were mentioned, however (Arcadis-Euroconsult 2000), the consultant nearly lost his job while both a scientific panel and the bureaucracy challenged his findings on ideological rather than ecological grounds.

The role of Non-Governmental Organisations

It is possible to argue that a considerable number of Non-Governmental Organisations (NGO) for international nature conservation have emerged, who supposedly bring together all expertise in the field, have considerable financial power and allegedly implement conservation measures. Evidently organizations like the World Wildlife Fund, Conservation International and Greenpeace have played important roles in creating widespread public and political awareness of the exponential demolition of global ecological functions. Professional fund-raising propaganda banking on the continuous decline in spectacular wildlife, vanishing holiday destinations and global climate change, has made international conservation NGOs well known and very wealthy indeed. However, the growing wealth and public esteem has infused them with corporate self-indulgence, and somehow caused a gradual divorce from active commitment in the field. If one expects most of the funding to be spent on the survival of wildlife, this expectation is betrayed by reality. Professionalism in moneymaking and politics has superseded the original driving force for professional wildlife conservation. Much of their income is spent on enlarging bureaucratic structures worldwide with local branch offices. Another significant part of their annual income is spent on regular mega-conferences and so-called strategic meetings across the world that claim to influence government policies. However, if policy has been influenced, it has apparently been in a direction that has little bearing on the survival of wildlife. Governments have turned away from any initial commitment to serious wildlife conservation, rather than showing more support. Financial allocations for protection have dried up, and the loss of wilderness and biodiversity has increased.

The national branches in developing countries are fully supported with subsidies from their parent body and are manned by local staff that can operate virtually autonomously and free of supervision of their performance in terms of the conservation objective – as the author has experienced in a number of developing countries. What may be meant as supervision often takes the form of a well-organised tourist safari of a more or less high-ranking representative of the parent organisation. This situation is based on anxiety because supervision and evaluation are considered on both sides as neo-colonial distrust, ruining the token partnership. If the question is whether such structural support has been effective for the conservation of biodiversity, the answer is: rarely, if ever.

On both sides of the international economic chain, the occurrence of misery and decline appears to be a project- and job-opportunity. Sustainable misery and recurrent decay can even imply a long-term career. Some twenty years of experience seem to have taught authorities in developing countries that sustained failure of (conservation) projects has generated sustainable financial 'aid', while success makes the financial support dry up. As a wealthy European sponsor of conservation, one might ask: Can we expect a far less wealthy group of local people of an entirely different culture, with a different ethical outlook and a different kind of educational background, to have the same commitment to 'useless' wilderness and nuisance wildlife as an elite minority of our own wealthy constituency at home? What do such people learn from alien sentiments for wildlife that make money flow in their direction? Why cannot those who are concerned about the extinction of wildlife demand successful performance for the money we pay for the conservation of protected areas and wildlife in the tropics, when far less ethical quid pro quo deals are successful in the case of international business relationships concerning land use, labour and resource exploitation? After all, conservation happens to be really beneficial to the long-term interests of the ignorant local people, whereas business for commodities and resource exploitation deals may even be detrimental. As long as investment for conservation is presented as 'aid', support, or a soft loan, it facilitates sabotage, corruption and extortion, exploiting and destroying natural assets, while finding false justification in the fact that active conservation implies unpopular interventions like law-enforcement and protection, often directed against 'poor' people scratching out a living.

Sponsorship for applied research in nature conservation is frequently subject to anxieties related to the prevailing consumption economy and false social concerns (Wunder, op cit.). In these cases, anxiety is the motor of corruption as it seeks to skew public perceptions, as well as application-oriented scientific research. Politicians and authorities often appear to be far more concerned about the presumed sensitivities of their constituency and leadership than they are about the long-term interest of all people. After all, they have a short-term position, and the major desires of their constituency are consumptive, while their knowledge of ecology is negligible. NGOs are subject to very similar anxieties once their organisation grows, and they become subject to corruption if powerful sponsors use their power of selective subsidy to promote a politically or economically attractive ideology. It seems that international conservation bodies are far more anxious about the presumed sensitivities in their constituency of sponsors and their financial position, than about the prime objective of conservation, i.e. to preserve existence. Advice based on applied scientific research is at the bottom of the line of dependency in this field.

Due to their misguided policy of expediency, rich governments in Europe and North America and the unprofessional spending of funds by international conservation NGOs, spectacular biodiversity is declining and protected area conservation has become far less effective than ever. If corruption and collusion are perceived as widening the gap between rich and poor nations, the motor of these vices lies in unrestricted international trade in natural resources, which is in the prime interest of the rich, industrially advanced countries. After all, much poverty in tropical countries is the basis of the wealth in the rich countries of the Northern hemisphere (Wackernagel & Rees 1996), and their occupation of former wilderness habitat for production of export commodities (palm-oil, cotton, coffee, tea, etc.) is supplanting wild biodiversity (Wakker 1999).

Ultimately, from an ecological perspective, the major cause of the demise of spectacular biodiversity and wilderness can be typified as 'overshoot' of the particular carrying capacity of an area, in which the ecological footprint of technologically powerful nations plays the prime role (Wackernagel & Rees, op. cit.). Too many people, with access to too powerful technological facilities, and enslaved in a consumer system of growing demand, are usurping all space and resources on Earth. For instance, Dutch over-population and wealth contribute to tropical poverty and ecological disasters – in spite of a 1% GNP budget for so-called development cooperation. This socio-economic complex, including the development cooperation allocation for rainforest and biodiversity conservation, destroys the conditions that allow wilderness and spectacular wild biodiversity to survive while any conservation-minded counterforce is suppressed or corrupted. The poverty problem cannot be solved by letting poor local subsistence farmers participate in the management of ‘their’ protected areas as the political euphemisms in propaganda documents for ‘poverty alleviation’ and sham conservation claims (Wunder, op. cit.), nor can doling out 'small projects' or 'aid'. Why are the few publications on major cause-effect chains for imminent extinction being neglected? (Bowles et al. 1998; Rijksen & Meijaard 2000). Is it perhaps because they have been overwhelmed by government propaganda or criticised into oblivion with petty arguments by their far more compliant academic colleagues (e.g. Lomborg 2001)?

No doubt the fundamental problem of the failure to conserve wilderness and wild biodiversity appears to be in the prevailing ethics of most modern people in the world (White 1968). Irrespective of one's religious background, fundamental ethic derives from a convenient, quasi-divine command in the originally Judaic book of Genesis 1, 28: ‘And God blessed them, and God said unto them, Be fruitful, and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth’ (King James Version of the Bible). Anthropocentric consumerism has become a universal foundation of ethics, even for non-religious people. Academically trained policymakers apparently lack the ecological insight to recognise that the command is a fatal instruction.

What has been the role of the Dutch granting organization for research (NWO) and the Royal Netherlands Academy of Arts and Sciences (KNAW)? Has the academic elite of Dutch society demonstrated vision in this field? Has it tapped all expertise in the country to come up with visionary policy advice and sponsorship for innovation? Or has it only looked to existing institutions and conventional research lines for support while carefully avoiding challenging the prevailing ideology of the politicians and their government bureaucracy? How could a *Tropenbos* (tropical rainforest) programme, initiated for the conservation of the tropical rainforest, conduct decades of research almost exclusively into exploitative issues and alleged restoration of demolished forests? Has anybody challenged the programme of the Netherlands Development Assistance Research Council (Raad voor het Wetenschappelijk Onderzoek in het kader van Ontwikkelingssamenwerking (RAWOO)) to focus on research into Biodiversity *in damaged ecosystems*? Are these the research programmes that are likely to come up with applicable results for making conservation of wild biodiversity effective? Or have the programmes been designed to justify an accomplished fact, and placate a trendy but unrealistic ideology favoured by politicians?

Future responsibilities

The question is how scientists can possibly contribute to the assumption of responsibility for the survival of wilderness and wildlife. Influential scientific bodies such as the KNAW should be playing an important role in encouraging governments to allocate funds for integrated research into the economic role of a large natural tropical forest area and in regional aspects of the hydrological cycle and carbon sequestration. If the current hypothesis, as emerging from scattered ecological results is correct, and this economic role is as significant as it seems, the outcome may be the saving of much biodiversity, as the few remaining natural forests can become a source of income from non-consumptive functioning. The international research efforts as described in the KNAW publication *Global change research in The Netherlands* are an excellent start. However, conservation of biodiversity will be boosted most if the necessary macro-ecological research could be directly related to a particular area of prime importance for biodiversity, rather than the entire planet Earth. There are still a few areas left where such research could be implemented, e.g. the 27,000 square kilometres Leuser Ecosystem in Northern Sumatra, Indonesia (Rijksen & Griffiths 1995).

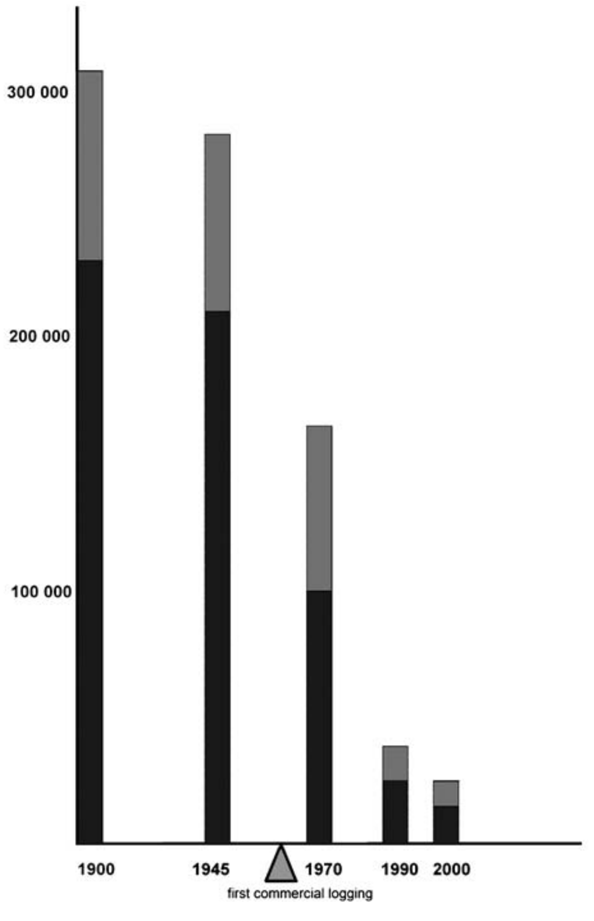

Figure: Decline Oeran Utan population on Borneo.

With scientific backing, the Indonesian Leuser International Foundation, which has the (conservation concession) custodianship over the Leuser Ecosystem, may be able to implement the very first ecologically sound Integrated Conservation and Development Programme, from the expected considerable income from its water and carbon assets. With its annual financial support for sustainable development of the area surrounding the Leuser Ecosystem, it will then also be able, for the very fist time, to effectively conserve the ecological integrity of a representative sample of unique Sundaland biodiversity. This comprises endangered mega-fauna elements such as the Orang-utan, the Tiger, the Sumatran Rhino, and the Sumatran Elephant as well as innumerable endemic plant species. I expect that with applied scientific backing, many more instances of successful biodiversity conservation will follow in due course.

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CHARLES PERRINGS

Environmental risk, uncertainty and the precautionary principle

Abstract

The characteristic feature of many social-environmental systems is that they are complex and 'adaptive'. They can exist in any one of a number of locally stable states, but can switch states – often quite abruptly. The atmosphere, biosphere and hydrosphere are all characterised by the fact that incremental changes can induce a switch from one state into another. This may be irreversible or only slowly reversible, and there is frequently uncertainty about both the magnitude and direction of change. Such systems are also said to be path-dependent. The future depends on the past. Environmental changes feed back into the dynamics of the system through, for example, the price mechanism or institutional responses. The question addressed is how we should make decisions in these circumstances. The two main options of mitigation and adaptation will be considered as responses to uncertainty as regards the long-term implications of human-induced abrupt climate change.

Introduction

The precautionary principle has been widely adopted following its endorsement both in the 1990 Bergen Declaration (signed by 84 countries as a follow-up to the Brundtland Commission report) and the 1992 Rio Summit. But although it is incorporated into the environmental policy of many governments, it is typically applied in a very ad hoc way. A widely held interpretation of the principle is that where the costs of current activities are uncertain but potentially both high and irreversible, a precautionary response requires action before the uncertainty is resolved. That is, it involves action to avoid damage in anticipation of proof of damage. Implicitly, the principle applies where the costs of inaction may exceed the costs of preventative or anticipatory action, but where there is insufficient information to calculate either expected costs or expected benefits (Taylor 1991).[1] Because this involves subjective evaluations of the risks of action versus inaction, it is hardly surprising that the principle has not been applied consistently. Whereas there is international consensus on the banning of the disposal of radioactive wastes and the incineration of toxic wastes at sea, for

[1] Legal liability for environmental damage frequently refers to 'precautionary' activity, but this is quite different from the precautionary principle. For example, fault or negligence based liability allows 'precaution' as a defence, but in this case 'precaution' means compliance with regulations.

example, there is no consensus on the limitation of carbon emissions to the atmosphere.

A number of countries have tried formally to operationalise the principle as it applies to public policy, but there is already a wealth of 'case law' illustrating how the principle is currently being applied to both public and private decisions. One set of applications is theory-based. It concerns the modelled effects of activities that include outcomes which are potentially very severe but which are also fundamentally uncertain. Action by those countries that have acceded to the *Kyoto Protocol* to reduce current carbon emissions falls into this category. The general circulation models have generated climate change scenarios that involve significant future costs. Even though there are no probabilities attached to these scenarios, the signatories to the Protocol have agreed to action now that is thought to reduce the likelihood that the scenarios concerned will be realised later.

A second set of applications is evidence-based. Where experimental research or experience produces a novel effect that involves very high cost, but where there are insufficient observations to calculate a probability density function for that effect, action may be taken to reduce the likelihood that the effect will be repeated while research is undertaken to establish what that likelihood is. Common examples of precautionary action in this case include the removal of consumer items from supermarket shelves in response to experimental evidence showing an item or some constituent of it to have unexpected negative health effects, or the recall of motor vehicles in response to experience of an unexpected mechanical failure. The reason for invoking the precautionary principle in both cases is that the outcomes concerned are thought to be important, but would receive little attention in conventional decision models, like benefit-cost analysis, that are based on some measure of expected net present value.

The problem I want to consider here involves applications of the principle to the potential for sudden changes of state in general circulation systems. In common with all complex adaptive systems, general circulation systems are characterised by the fact that they can exist in multiple states, and that a change from one state to another is frequently quite sudden. I want to consider how the precautionary principle helps us think about one change of state of particular interest to Europe – a change of state in the thermohaline circulation (Figure 1). The features of the thermohaline circulation that matter to local climate are that warm, low-salinity water flows north along the surface of the Atlantic, becoming saltier (indicated by red arrows in Figure 1). Cooling of this water in the North Atlantic produces water of high enough densities to sink and then flow southward in the deep ocean and into other ocean basins (indicated by blue arrows in Figure 1) (National Research Council 2002).

Most of the general circulation models predict a weakening of the Atlantic circulation in response to carbon emissions (Figure 2). Changes in Atlantic circulation in the models are forced by prescribed increases in atmospheric CO_2. In almost all cases the result is a reduction in the thermohaline circulation in response to increasing greenhouse gas forcing (Intergovernmental Panel on Climate Change 2001).

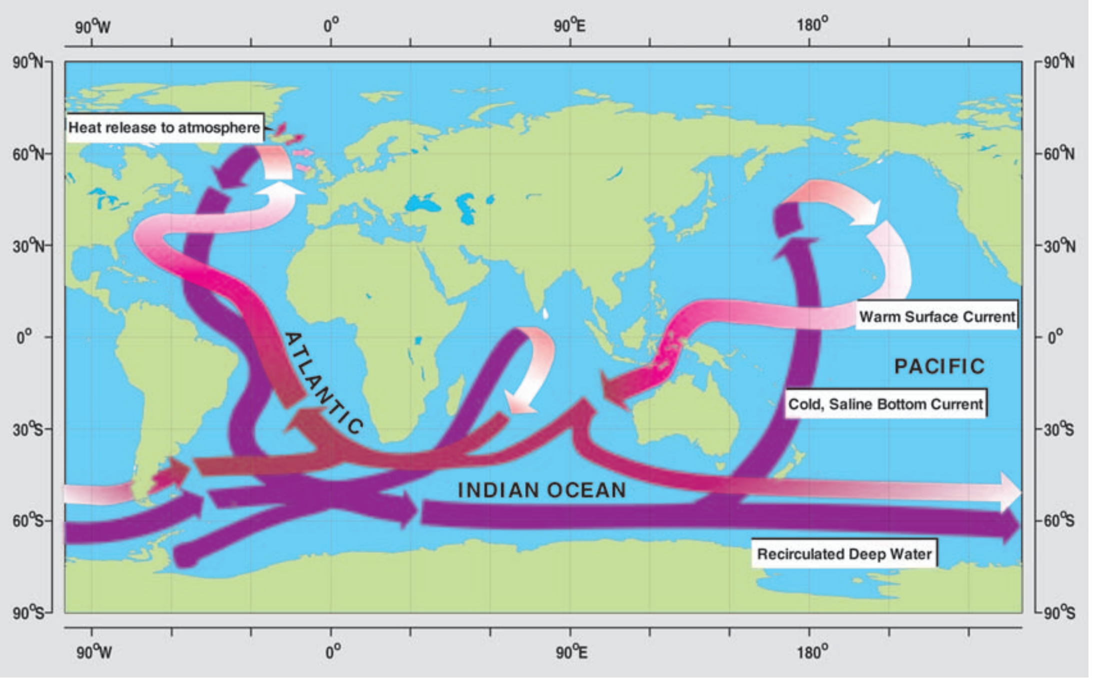

Figure 1: Schematic diagram of the global ocean circulation pathways, the 'conveyer' belt (after W. Broecker, modified by E. Maier-Reimer).
Source: National Research Council (2002).

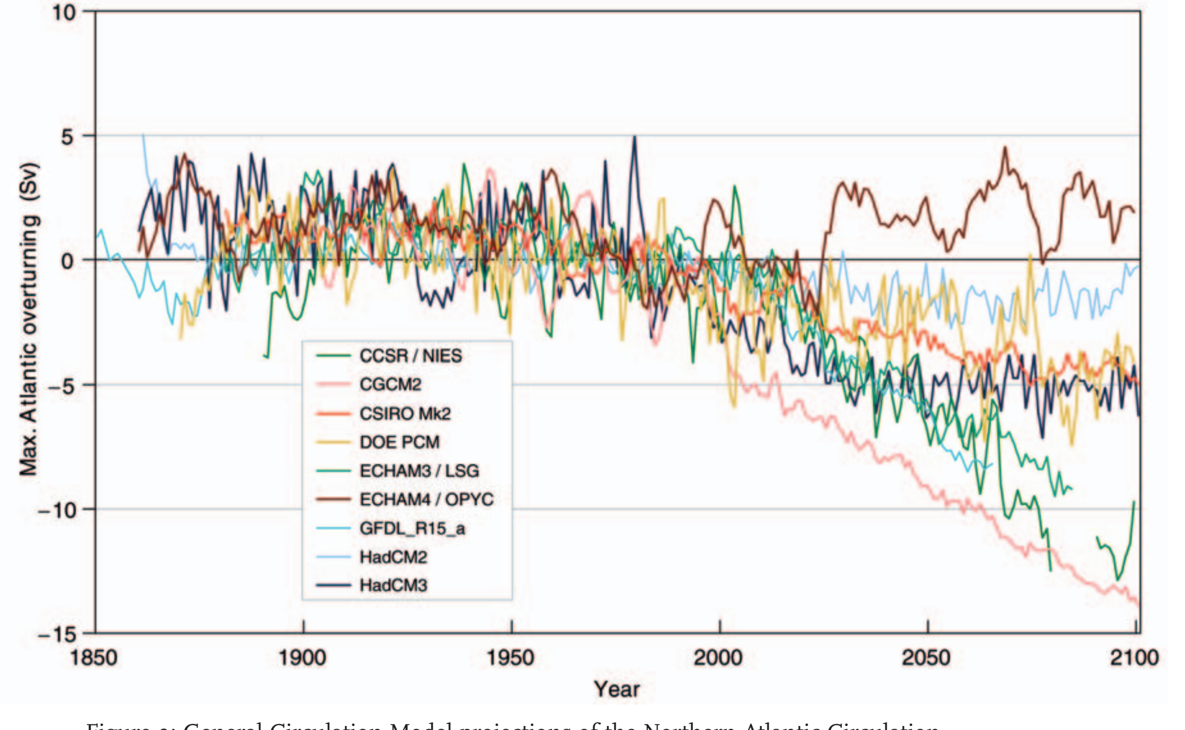

Figure 2: General Circulation Model projections of the Northern Atlantic Circulation
Source: Intergovernmental Panel on Climate Change, 2001.

In some model runs the change in the thermohaline circulation is abrupt, inducing a rapid change in climatic conditions in Northern Europe. Figure 3 shows the outcomes of different models forced in the same way. Specifically, it shows the rate of the ocean overturning when the freshwater forcing flux H is increased and then decreased.

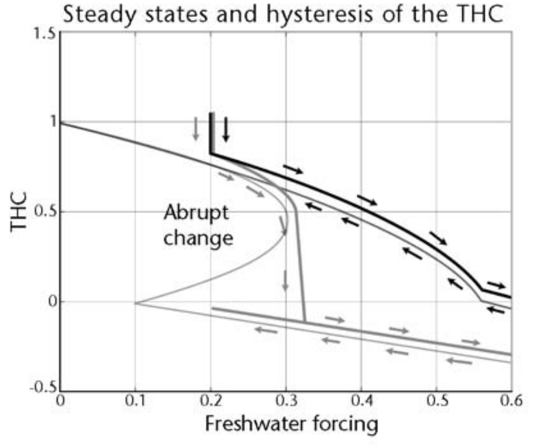

Figure 3: Alternative reactions to freshwater forcing in the North Atlantic
Source: Intergovernmental Panel on Climate Change, 2001.

In the case of weak diffusion (orange) the model generates abrupt change, once a threshold in H is crossed. In the case of strong diffusion (green), at any time, there is a unique equilibrium.

How does the precautionary principle help us to think about a problem of this sort? In what follows I first consider how economists generally approach the problem of decision-making under uncertainty – through expected utility -, and then indicate how that approach has influenced decisions to mitigate or adapt to climate change. Mitigation implies precautionary action. Adaptation does not. Since the precautionary principle requires proportionality between the benefits and costs of precautionary action, I argue that where a simple benefit cost analysis favours adaptation, a precautionary response will only be chosen where societies give a high weight to uncertain costs.

Uncertainty and weighted expected utility

Following Perrings (2003), the feature of environmental 'risks' that poses particular problems for decision-making is novelty. Novel effects imply that there is no history of observations on which to form expectations about those effects. It is not possible to specify a probability density function for the effects, and so to calculate the expected value of the effects. In many cases novel environmental effects follow from a change in the state of nature. In such cases the problems posed by novelty may be compounded by the problems posed by irreversibility. Actions that cause a system to cross a threshold between one state of nature to another may, for example, be either irreversible or only slowly reversible – i.e. subject to hysteresis. If irreversible, no commitment of resources will enable it to return to the original state. If only slowly reversible, the resource cost of returning the system to its original state will be much higher than the resource cost of the action that induced the flip in the first place. But if the degree of irreversibility of the transition to a new state is not known, then so is the resource cost of restoring the status quo.

Economists normally approach the problem of decision-making under uncertainty via the expected utility approach. This approach supposes that individuals evaluate a risky prospect in terms of the expectation of the utility conferred by the prospect. That is, the attractiveness of an action offering outcomes $(q_{1t}, \ldots, q_{nt})$ with probabilities $(p_1, \ldots, p_n)$ is evaluated by the expected utility associated with those outcomes:

$$V(p,q,t) = \sum_{i=1}^{n} p_{it} u(q_{it}),$$

where $u(\cdot)$ is a (Von Neumann-Morgenstern) utility function defined on the outcomes and corresponding probabilities. The approach therefore requires specification of the probabilities attaching to different outcomes. If these probabilities are not known, it is assumed that people form subjective judgements about them, and then maximise expected utility as if they were known.

Take the case where the probabilities are known. Low probability events will attract little attention, even if the value of the outcome is large. Empirically, this has created a problem, in that there is considerable evidence that decision-makers do not treat low probability-high cost outcomes as the decision model predicts. Decision-makers generally underestimate risks from frequent causes and overestimate risks from infrequent causes (Pigeon et al. 1992; Starmer 2000). For example, insurers faced with low probability high loss risks have been shown to systematically quote rates that exceed the expected losses (Katzman 1988).

Where the probabilities are not known, the problem is even less tractable. Savage (1954) argued that decision-makers make subjective judgements about the probability distribution of the outcomes of their actions.[2] The closer they come to complete ignorance, the more equal the probabilities assigned to all outcomes – by the principle of insufficient reason (Arrow & Hurwicz 1972).

The notion of subjective probability implies that decision-makers impose their own judgement on an existing incomplete and possibly incorrect set of estimates. A related approach formalises this idea. The weighted expected utility approach supposes that there exists an estimate of the probability distribution of outcomes that is known to the decision-maker, but that the decision-maker then weights the various outcomes of their actions. This may be because they care more or less about particular outcomes, or about those who are affected by the outcomes. For example, it has been suggested that decision-makers weight outcomes relative to some reference point, such

[2] A number of non-probabilistic decision models suppose that decision-makers do not formally work with estimates of the probability distribution of outcomes, but with the degree of disbelief or potential surprise associated with each outcome (Shackle 1955, 1969; Vickers 1978; Katzner 1989, 1998).

as the status quo, or even to a number of reference points (Starmer 2000). Decision-makers' weighted preferences over outcomes can be represented by the function:

$$V(p,q,\Psi,x,t) = \sum_i p_{it} g(q_{it}, \Psi_t) u(x_{it}),$$

where $g(q_{it}, \Psi_t)$ is the weighting function that depends both on the value of the outcomes, q_{it}, and the state of knowledge at time t, Ψ_t. Consider $g(q_{it})$. If the weights attaching to all outcomes are identical (the decision-maker has no reason to discriminate between outcomes) this reduces to standard expected utility theory. Empirical evidence suggests that the probability of an outcome is weighted more or less depending on the impact of the outcome. Quiggin's (1982) rank dependant expected utility approach weights outcomes with the same probability according to how good or bad the outcome is, low probability outcomes being 'overweighted' and high probability outcomes 'underweighted'.

Now consider the relation $g(\Psi_t)$ It states that the weights attached by decision-makers to the probability estimates reflect the state of technical knowledge – or at least the decision-makers' beliefs about the state of technical knowledge. That is, the weights may depend on the confidence that the decision-maker has in the science behind particular estimates. Since extreme, unique, rare and irreversible events all have few historical precedents, their future occurrence is difficult to predict with confidence. A precautionary approach implies rules for decision-making under uncertainty of this type.

A review of the evidence on the use of the precautionary principle in the management of environmental risks by Harremoës et al. (2001) shows how hard it has been in the past to persuade decision-makers to act on the basis of isolated experiments or experience. In several case studies the review shows how experiments or events that provided early warnings of the existence of effects with serious consequences for society were typically ignored. In all cases, the novelty of the experiments or events meant that they did not provide a basis for estimating a probability distribution of outcomes. In all cases, too, the early warning showed at least the potential for widespread, significant and irreversible consequences.

For three examples – halocarbons, polychlorinated biphenyls (PCBs) and methyl tert-butyl ether (MTBE) – Harremoës et al. (2001) argue that the novelty of their observed effects, taken together with their known persistence in the environment and their dispersion rate should have indicated a potential problem. In the case of PCBs, for example, the results of animal tests showing potentially severe consequences were available as early as 1937, but nothing was done. Evidence from the 1960s that the Great Lakes were contaminated by organochlorine stimulated research on bioaccumulation in birds, and this led to the banning of DDT, but PCBs are still ignored (Gilbertson 2001). In the case of antibiotics, the Swann Committee commented on the development of antibiotic resistance in humans as early as the 1960s, but no follow-up research was undertaken for 30 years. Similarly, early evidence on the potential transmission of bovine spongiform encephalopathy (BSE) to humans was neglected (Harremoës et al. 2001).

The costs and benefits of mitigation

To bring this discussion back to the problem of climate change, there are two ways that decision-makers can respond to the prospect of uncertain environmental effects of novel activities. 'Mitigation' involves actions that reduce the likelihood of an event or process. 'Adaptation' involves actions that reduce the impact of the event or process without changing the likelihood that it will occur. Mitigation accordingly implies action before the event. Adaptation may involve actions taken before, during or after the event. Adaptation usually implies actions that reduce the expected damage of an event (such as the adoption of building standards that minimise earthquake damage), but it also includes actions that pool or transfer the risk of an event (such as insurance). The management of environmental risks includes both sets of actions. However, precautionary decision-making is usually associated with mitigation (Perrings 2003).

Nordhaus and colleagues – in a number of papers – have asked whether mitigation should be undertaken to avert the future effects of climate change (Nordhaus 1977, 1994, 1997; Nordhaus & Yang 1996). He has famously answered: 'not much'. Why? The main reason is that the (certain) costs of mitigation are high and occur now, whereas the (expected) benefits, measured by damage avoided, are low and occur in the future.

There is considerable variation in the estimates of the expected net benefits of mitigation. Indeed, there is not even consensus on whether expected net benefits are positive or negative (Pearce 2003). Two studies of the expected impacts of a 2.5°C rise in mean temperature found a –1.5% (Nordhaus & Boyer 2000) and a +0.1% (Mendelsohn et al 1996) change in world GNP respectively. Clearly, if climate change were expected to confer net gains there would be little point in mitigating it. The estimates also turn out to be highly sensitive to the degree of warming assumed. For example, Tol (2002) found that expected world GNP would increase by 2.3% if mean temperatures were to rise by only 1.0°C. They also differ between the North and the South. The studies by Nordhaus and Boyer, and Mendelsohn et al already referred to found that developing countries are considerably more at risk from climate change than developed countries. Mendelsohn et al (1996) calculated that the expected impact on GNP of a 2.5°C rise in mean temperature varied between +0.03 % in the developed countries and -0.17 % in the developing countries. Nordhaus and Boyer (2000), on the other hand, found that the range of impacts on GNP in the North was from -0.5 to +0.4 %, whereas in the South it was -0.2 to - 4.9 %.

There are two other reasons why some governments have chosen adaptation over mitigation. First, mitigation is a global public good with all that implies for the incentives to free-ride on the efforts of others. Second, since carbon is a stock pollutant it takes considerable time for mitigation to yield benefits, and if these are discounted at positive rates they can be rather small in present value terms. Nordhaus effectively asked whether the future benefits of current action to reduce carbon emissions would pass a benefit-cost test, and was doubtful. These additional features of mitigation merely strengthen the bias in favour of adaptation.

So why does adaptation seem to be the better response to some governments? For one thing, adaptation represents a local response to global change, where global change is itself treated as exogenous to the problem. The benefits of adaptation expenditures are captured almost entirely by the decision-maker. This implies that private individuals or firms have a much stronger incentive to undertake private adaptation actions than they have to undertake private mitigation actions. Further-more, adapting public goods such as sea defences or public health regimes allow free riding by the local population, but do not in general offer significant benefits to the international community. No country has an incentive to free ride on the adaptation expenditures by another country, and all countries are able to capture the benefits of adaptation.

The apparent advantages of adaptation over mitigation notwithstanding, enough countries have now signed the Kyoto Protocol with its (admittedly modest) mitigation targets for it to come into force. In other words, despite the available evidence that adaptation dominates mitigation under a benefit-cost test, a significant number of countries have elected to undertake precautionary cuts in carbon emissions. Implicitly, they are weighting either the probabilities attached to the different outcomes of climate change, or the value of extreme outcomes in such a way that mitigation is seen to be a proportionate response.

Abrupt climate change and precautionary behaviour

The case of abrupt climate change makes it relatively easy to see why. In a simple benefit-cost analysis of mitigation the very low probabilities attaching to an interruption of the thermohaline circulation and its comparatively localised effects mean that it receives very little weight in the analysis. Yet the localised consequences if it does occur are thought to be extremely severe. Most estimates of the climatic consequences indicate a reduction in mean temperatures in Northern Europe of approximately 12oC. There are no good economic projections of the impact that would have on human welfare in the region, but this is likely to be very substantial (NCSR 2002; IPCC 2001). These outcomes provide a reference point (in the sense of McDaniels, Kamlet & Fischer 1992) for decisions about mitigation over adaptation.

At the same time, there is reason to believe that understanding of general circulation systems will improve to the point where it is possible to attach meaningful probabilities to such outcomes. In such circumstances, there is a potential gain to actions that buy time to learn about the system without risking potentially irreversible and costly changes of state. Precautionary mitigation should improve estimates of the probability distribution of environmental outcomes without risking severe and irreversible consequences. In terms of the weighted expected utility function:

$$V(p,q,\Psi,x,t) = \sum_i p_{it} g(q_{it}, \Psi_t) u(x_{it})$$

mitigation is designed both to change the probability distribution of outcomes, p_{ij}, and to improve the confidence that the decision-maker has in the estimates, and hence the weighting function $g(q_{it}, \Psi_t)$.

Since the general circulation models indicate the possibility of outcomes that involve significant irreversible cost under some quite reasonable assumptions about the way that the general system behaves, a precautionary response involves actions that avoid those costs while yielding the data to test the model predictions.

For three reasons, then, the existence of abrupt climate change may be expected to encourage the adoption of a precautionary response. First, abrupt climate change should alter the relative net benefits of mitigation and adaptation in favour of mitigation. Abrupt climate change may be expected to increase the cost of adaptation, precisely because the time available for adaptation is reduced. Second, because it is to all intents and purposes irreversible, the costs of abrupt climate change and hence the benefits of mitigation will be increased. Third, the fundamental uncertainty associated with the change increases the return on precautionary responses that allow learning.

The challenge for science in all of this is to develop predictive models of the natural and social processes at work, and of their interactions over space and time. Of course learning about the impact of outcomes is non-trivial, not just because of the complexity of the problem, but because the fact that the outcomes are a combination of physical and social processes, and we are still very poor at understanding interactions between the two. Harremoës et al. (2001) identify two barriers to learning. Disciplinary barriers exist in many forms. One is due to the fact that certain environmental problems may be 'captured' by particular disciplines, with the result that important aspects of the problem are simply ignored.[3] A second is due to institutional barriers, including departmental and inter-authority rivalries, conflicts between levels of government and so on. National science academies can help address at least some of these institutional barriers, but it remains the case that scientists have first to find the problems interesting. But as long as scientists in any one discipline fail to find the concepts and methods of other disciplines interesting, the barriers will be irrelevant. Scientists simply will not look beyond the boundaries of their own discipline. What the national science academies can and should do is to put interdisciplinary environmental problems of this kind firmly on the research agenda.

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3 For example, they note that asbestos and ionising radiation were both captured by medical clinicians who focused only on the immediate acute effects of exposure.

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PIER VELLINGA

Uncertainty, discontinuity and forecasting – The case of climate change

Activities of the human species affect the global climate in a way likely to be beneficial to some and damaging to many (IPCC 2001a). Physics tells us that an increase of CO_2 in the atmosphere affects the radiation balance in such a way that the earth will become warmer. Paleo-climate analysis illustrates that the release of relatively large amounts of carbon into the atmosphere is likely to trigger major climatic changes similar to what combined geophysical and ecological forcing triggered in the past. Paleoclimatologists, referring to the penultimate interglacial (Eemien) indicate that, beyond a global warming of 2°C, significant non-linear responses in the climate system may occur (Cuffy & Marshall 2000; Renssen et. al. 2004). These may lead to a further rise in global average temperatures of 3°C to 6°C and a rise in sea level of 1 to 3 metres and possibly more in a time frame of 100 to 300 years, with large societal impacts.

The time lag in the climate system is such that early action (in limiting anthropogenic emissions) is much more effective than action later. Early action however requires investments that compete with day-to-day societal needs and preferences.

These findings are shared among climate and earth system scientists with a high degree of confidence (IPCC 2001b). While some political and industrial leaders accept these scientific findings as a clear basis for action, others stress the uncertainties and downplay the potential effects and call for more research instead of early action. The major question at this symposium is: what is the role of science and in particular what is the role of individual scientists?

Given the small part of the (climate) picture that individual scientists are expert in, they tend to limit their presentation of certainties and uncertainties in public to the part of the system they are expert in. In practice the general public reads such a 'scientific' presentation as: if their understanding of the system is so limited, we should not take costly measures before there is more certainty. Individual scientist may not agree with such an interpretation, but do not feel competent to say so in public as it is not their scientific competence to cover the entire natural and social system relevant for determining whether early action is desired.

The alternative approach is the generalist-scientist approach. An approach, in which individual scientists absorb and review scientific information from other disciplines, combines this with their own knowledge and present a 'complete picture' to the broader audience. Obviously there are risks involved in such an approach, as scientists can never fully grasp all systems and uncertainties in the various parts.

To address this issue the World Meteorological Organisation and United Nations

Environment Programme established the Intergovernmental Panel on Climate Change (IPCC) with formal procedures for review and re-review. In the IPCC, over a thousand scientists representing the range of relevant disciplines cooperate in a transparent and open process to regularly assess the understanding of the climate system. A process like the IPCC can effectively limit the risk of misinterpretation.

Assessments such as that carried out by the IPCC can help individual scientists to contribute to an understanding of the broader picture of processes. Moreover, and equally relevant, an IPCC-like assessment procedure can address the potential conflict between new scientific findings.

There will always be uncertainties when it comes to the prediction of the effects of human activities on ecosystems, as ecosystems behave in a non-linear way. When established interested groups, including governments, industrial sectors and NGOs, are confronted with new scientific findings that may have a negative impact on their core activities, they are likely to stress the uncertainties and downplay the effects and usually refer to earlier failures in scientific projections.

In the case of climate change it is clear that power structures, e.g. certain lobby groups representing vested interest in the fossil fuel energy sector, stress uncertainty and purposely mobilise scientists that hold 'outlier' positions favourable to the vested interests and by supporting such 'outlier' positions, create confusion among the wider audience and politicians.

Examples are:

1 More snow will accumulate in Antarctica, so the ocean levels will not rise but fall. In relation to the entire climate system and anthropogenic forcing, this is a minor and temporary effect, compensated by far by the expansion of ocean water as a result of temperature increase, (see IPCC reports);
2 The sea level in the Maldives (Indian Ocean) does not rise but is presently falling, thus the global oceans are not rising. This may be true locally as a result of local geophysical processes, but has nothing to do with global rise of ocean levels as a result of thermal expansion);
3 The recent rise in temperature is mainly an urban heat effect. Many people tend to believe this, but it is extensively explained and countered in IPCC reports.

Global Climate Change and the politics around it are a typical example where established interest groups, especially in the USA, have tried to suppress and discredit extensive scientific analysis.

I would like to mention another case as well: the effects of natural gas recovery in the Wadden Sea. As long as twenty years ago, researchers involved in active ecological and estuary geomorphologic research stated that gas recovery and related subsidence would only have a negligible effect on the quality of the Wadden Sea ecosystem. This message was not welcome in environmental NGO circles, the power structures that had been established since the 1970's in national politics and in the minds of the legal officers of our country. The court, in its decision to forbid exploration activities, was more sensitive to NGO sentiments stressing uncertainty than to scientific analysis, stressing a negligible effect. The Wadden Sea case is typically an example where NGO-power was stressing uncertainty beyond rationality and reasonability.

Conclusions

1 Scientists should take time to consider the broader scientific picture before they express their scientific findings to the broader audience.
2 It is the role of scientists to question 'mainstream thinking' and to present and discuss their findings through scientific publications, peer review, and subsequent public debate.
3 Well-structured assessments such as carried out by the Intergovernmental Panel on Climate Change, make good tools to address the tensions between (new) scientific findings and established interests.
4 The Netherlands, and the European Union as well will benefit from independent organisations organising assessment processes such as the IPCC. The Dutch academy of sciences (KNAW) could play a role here like the National Academy of Sciences does in the USA.

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WILLIAM E. REES

Science, communication and policy with special reference to ecological footprint analysis

Introduction: science and society

In November 1992, some 1,700 of the world's leading scientists, including the majority of Nobel laureates in the sciences, issued the following warning to humanity concerning humankind-environment relationships:

We the undersigned, senior members of the world's scientific community, hereby warn all humanity of what lies ahead. A great change in our stewardship of the earth and the life on it is required if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated (UCS 1992).

Ours is supposedly a knowledge-based society, one that has benefited immeasurably, at least in material terms, from science. Yet, more than a decade after the 'scientists' warning' their message seems to have gone largely unheeded. After years of continuous debate on the need to achieve sustainability, the world is arguably more ecologically degraded, less rich in biodiversity, experiencing more rapid atmospheric and climate change, and increasingly threatened by geopolitical strife (caused, in part, by competition for declining resources) than before. Little has happened to transform the fundamental beliefs, values and assumptions underpinning our ecologically destructive and increasingly global techno-industrial society.

The purpose of this paper is, first, to explain why, with significant exceptions, environmental science has so modest an influence in the policy arena and second, to describe the qualities of ecological footprint analysis, a method that seems to be particularly effective in communicating the ecological crisis to ordinary people and politicians alike. My premise is that industrial society will change. The question is whether it will be forced to do so by catastrophe or will choose to do so deliberately, once relieved of its prevailing illusion of invulnerability.

Socio-cultural context and human nature

Wooden-headedness plays a large role in government … acting according to wish while not allowing oneself to be deflected by facts (Tuchman 1984).

There are many reasons for the apparent disconnect between the scientists' historic warning and political action. The usual explanations include the following:

- Ignorance and lack of interest among ordinary citizens.
- Poor scientific understanding and inadequate data.
- People's natural 'time preference' for short-term gratification and their tendency to discount the future.

– Competing worldviews and differing interpretations of countless bits of data, that make it possible to construct many alternative plausible pictures of the world. This leads to the spectacle of 'duelling expert witnesses'.
– The power of vested interests to influence policy to maintain the status quo in the face of uncertainty.

One consequence of these conditions is that the general public remains confused or conflicted about the meaning and role of science, which contributes to a general loss of confidence in science and scientists. This, in turn, makes it easy for politicians not to act or to call for more research. In the end, politicians tend to select the science that supports their objectives (this becomes 'good' science ... or 'the best available science') and reject any contrary evidence as 'bad' science. As if in confirmation of this view, a recent editorial in the New York Times (14 September 2004) declared:

The Bush administration has from time to time found it convenient to distort science to serve political ends. The result is a purposeful confusion of scientific protocols in which 'sound science' becomes whatever the administration says it is. In the short run, this is a tactic to override basic environmental protections in favor of industry. In the long run, it undermines the authority of science itself ...

While the political manipulation of science makes matters difficult enough, the situation is actually more complicated than it appears. The English poet W.H. Auden captured matters concisely when he wrote, 'We are lived by forces we scarcely understand'. Human socio-political behaviour is to some extent governed by innate predispositions that operate below the horizon of human consciousness.

Indeed, I have previously argued that *humankind* possesses certain genetic predispositions that were once adaptive but that have become self-destructive in modern times (Rees 2002). For example, like all species, humans express an inherent propensity to expand to fill all the ecological space (niche space) available to them. (This is the Malthusian curse). Uniquely however, human cultural evolution strives to remove the negative feedback on *humankind* that serves to inhibit continuous growth in most other species (disease, starvation, etc.). Once unleashed, humanity's power of expansion remains unchecked by environmental consequences – we have evolved no general inhibitions against the destruction of our own habitats.

Humanity's natural expansionist tendencies are further reinforced by a second ancient tendency, this time a bio-social one: humans have an inordinate capacity for self-delusion including cultural myth-making. If my suggesting that myth still has power in our 'enlightened' age seems to be stretching a point, consider Colin Grant's description of myths 'not as mistaken views but as comprehensive visions that give shape and direction to life'. Seen this way, myths 'move from being dispensable misunderstandings to essential categories that we all take for granted' (Grant 1998). Grant (1998) argues that myth making is a universal property of human societies and plays a vital role in every culture including our own. Certainly in recent years the governing elites of the market democracies have persuaded or cajoled virtually the entire world to adopt a common myth of uncommon power. All major national governments and mainstream international agencies are united in a vision of global development and poverty alleviation centred on unlimited economic expansion fuelled by open markets and more liberalised trade (Rees 2002).

In further support of this myth, many economists and technological optimists believe that human ingenuity has essentially freed humankind from dependence on nature. They cite advances in technological efficiency (and reduced energy and material use per unit GDP in some countries) to argue that the human economy is 'dematerialising' or 'decoupling from nature.' There can be little question that the power of the growth-bound market myth does a great deal to override the contrary evidence of natural science. As McMurtry (1989) observes, '...the deep causal structure at work in the cumulative environmental catastrophe of our era is the deciding values of the global market economy itself'.

Clearly, there are situations in which humanity's capacity for self-delusion can become perversely dangerous. People commonly descend into deep denial when confronted with uncomfortable truths or with data hostile to cherished beliefs and values. Keen observers of human nature have long acknowledged this kind of behaviour. As Gustave le Bon wrote in 1896:

> *The masses have never thirsted after truth. They turn aside from evidence that is not to their taste, preferring to deify error, if error seduce[s] them. Whoever can supply them with illusions is easily their master; whoever attempts to destroy their illusions is always their victim.*

A century later, Derrick Jensen (2000) makes much the same point:

> *For us to maintain our way of living, we must ... tell lies to each other, and especially to ourselves ... The lies act as barriers to truth. The barriers ... are necessary because without them many deplorable acts would become impossibilities.*

Here, then, is perhaps the most powerful explanation of environmental science's failure significantly to influence the dynamics of the global growth myth. While we would prefer to believe that environment and development policy are based on sound science, management decisions in fact tend to favour existing institutions, entrenched interests and established government policy. More and better data on ecological decline, therefore, do not necessarily lead to better environmental policy and decision-making – the expansionist techno-industrial paradigm acts as an effective barrier against the onslaught of contrary information (see Box 1). This is why '... those who covet leadership and political prestige ... act as if unaware of the avalanche of data signalling ecospheric distress' (Morrison 1999).

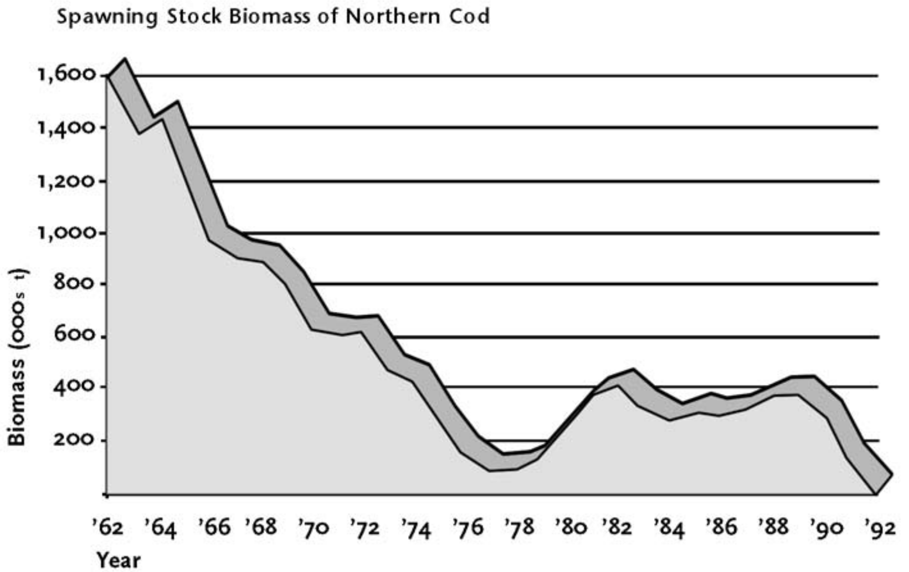

Figure 1: A classic example of politics trumping science. The collapse of Newfoundland's Northern Cod stocks in the early 1990s was due largely to Canadian government management failures, including the failure to heed the warnings of both government and academic scientists. Certainly, the danger signals had been evident in the stock statistics for decades.

Ecological footprint analysis: communicating the anthropogenic 'load' on the earth

When enough people insist upon change to embolden the politicians to break away from the short-term perspective ... the political system will fall over itself to respond ... (Gore 1992).

I developed ecological footprint analysis (EFA) explicitly to counter the belief that the modern economy is decoupling from nature (the 'dematerialization' myth) (Rees 1992, 1996; Rees & Wackernagel 1994; Wackernagel & Rees 1996). I believe that while people tend to conservative social behaviour in defence of the *status quo*, they are also intelligent beings capable of responding rationally to new knowledge and data, particularly knowledge that can be shown to be directly relevant to their own circumstances. EFA is one such method. It is a quantitative technique that both personalizes ecological change and enables whole populations to determine whether they are living within their ecological means. A time-series of EFA studies will tell a subject population whether its lifestyles are really becoming less material-intensive and ecological damaging.

EFA starts from a series of simple premises:

– Human beings are integral components of the ecosystems that sustain us. (Indeed, we are the dominant macro-consumer organisms on the planet.)
– We can therefore best assess ecological sustainability using biophysical data that refer directly to ecosystems, not abstract economic (monetary) measures.

– Most human impacts on ecosystems are associated with conversion of energy and material extraction and consumption.
– Most measurable energy and material flows can be converted to a corresponding productive or assimilative ecosystems area.
– There is a measurable, finite area of productive land and water ecosystems on Earth.

It follows that every human population imposes an 'ecological footprint' on Earth equivalent to the amount of the planet's productive capacity required to supply that population with resources and certain natural waste assimilation services. We therefore formally define the ecological footprint of a specified population as *the area of land and water ecosystems required on a continuous basis to produce the resources that the population consumes, and to assimilate (some of) the wastes that the population produces, wherever on Earth the relevant land/water may be located (Rees 2001).*

Population eco-footprints are based on final demand for goods and services. Thus, the first step in calculating the ecological footprint of a study population is to compile, item by item, the total annualized consumption of each significant commodity or consumer good used by that population. Data are obtained from national production and trade statistics and other sources such as various United Nations statistical publications. For accuracy, consumption data should be trade-corrected. Thus a population's consumption of wheat can be represented as follows:

$$\text{consumption}_{\text{wheat}} = \text{production}_{\text{wheat}} + \text{imports}_{\text{wheat}} - \text{exports}_{\text{wheat}}$$

The second step is to convert consumption of each item into the land/water area required to produce that item (or to assimilate the wastes generated in the production of that item) by dividing total consumption by land productivity or yield. This gives us the ecological footprint of the individual item. We then estimate the total ecological footprint of the population by summing the footprints for all individual items. Finally, we can obtain the *per capita* ecological footprint of the study population obtained by dividing the total population footprint by population size.

For some wastes such as carbon dioxide emissions, or nutrients such as phosphates and nitrates, it is also possible to calculate the exclusive land/aquatic ecosystem area required for sustainable assimilation and recycling. (Carbon sinks constitute most of the eco-footprint area associated with fossil fuels themselves.) In all such cases, the assimilation rate per hectare and year is substituted for yield in the calculations described above.

For basic population ecological footprints (e.g., for whole regions or countries) we usually use world average yields/assimilation rates for all major land categories (cropland, pasture, forest land, productive marine area, etc.). This simplifies calculations since we do not have to trace all the sources of trade goods and waste sinks, or determine the productivity and assimilative capacities of the corresponding production/assimilation areas.

To facilitate comparisons among countries and to estimate national ecological deficits (surpluses), analysts further adjust the basic footprint calculations to a common scale. For example, if country 'A' uses a great deal of relatively unproductive pasture land per capita compared to another country, 'B', that uses more highly productive cropland, then country 'A's eco-footprint will seem disproportionately large compared to country 'B's. To provide a more balanced comparison, we covert each land-type component of basic eco-footprints into its equivalent area in terms of 'global hectares,' where a global hectare is a standardized hectare (ha) of world average biomass productivity (see WWF 2002). Thus, if county 'A' uses the equivalent of two ha of average pasture *per capita*, and average pasture is half as productive as the world's average productive area, then the representation of pasture in country 'A's eco-footprint is scaled down to only one global hectare per capita (2 ha x $.5_{equiv}$). For fuller details of the method see Rees 2001, WWF 2002.

Scientific strengths of EFA

Ecological footprint analysis has gained considerable momentum around the world as both heuristic device and practical method for assessing sustainability. This success derives in part from several methodological strengths of EFA that reflect biophysical reality. EFA:

- Recognises that humans are ecological entities and that the economy is a fully contained, growing, dependent, sub-system of the non-growing ecosphere.
- Reflects the crucial role of natural capital (biophysical stocks and flows) in economic development and sustainability.
- Recognises the second law of thermodynamics as the ultimate governor of material transformations and economic activity (Georgescu-Roegen 1971, Daly 1991).
- Accounts for the effects of trade and technology, two factors generally assumed to free local populations from ecological constraints.
- Is closely related conceptually to the embodied energy (emergy) analyses of Howard Odum (see Hall 1995) and the 'environmental space' concept of the Sustainable Europe Campaign (Carley and Spapens 1998).
- Corresponds closely to and incorporates all the factors in Ehrlich's and Holdren's (1971) well-known definition of human impact on the environment: I = P x A x T, where 'I' is impact, 'P' is population, 'A' is affluence, and 'T' is technology.
- Accounts for both population size and resource consumption. It therefore provides a measure of human 'load' as defined by William Catton (1980), the larger the footprint, the greater the load.

Popular acceptance of EFA

The eco-footprint concept also seems to resonate better with the public than do more abstract and impersonal sustainability indicators that cannot be compared to self-evident limits. Some of the communicative strengths of EFA are as follows:

- The method is conceptually simple and intuitively appealing. Everyone recognises that she or he has a positive ecological footprint.
- EFA further personalizes sustainability by focusing on consumption. Everyone is a consumer and must ultimately take responsibility for his/her own 'load' on the planet.
- EFA consolidates all measurable energy and material flows into a single concrete variable, a corresponding appropriated land/water (ecosystem) area.

– Land itself is a powerful indicator. Everyone understands 'land.' (Popular understanding of the ecological crisis is prerequisite to any politically viable solution.)
– Eco-footprint estimates can be compared to finite local and global supplies of land and aquatic ecosystems (i.e., people and populations can compare their demands to available bio-capacity).
– The 'ecological deficit' – the difference between domestic bio-capacity and a larger eco-footprint – requires little explanation and many people see it as more critical than the fiscal deficit!
– EFA appeals to both the ecologically conscious and those with a social conscience. For example, it reveals gross economic inequity but also shows that *growth is in the end not an option to relieve it*.
– Perhaps as important as any other factor, 'Ecological footprint' is a powerfully evocative metaphor – would people's interest be as stimulated had the measure been called the 'human impact index'?

Epilogue

This paper has highlighted the strengths of EFA in order to explain its communicative power. However, because not everyone agrees with all the methodological premises of EFA, and because its findings directly confront the perpetual growth ethic, EFA has generated unusual debate and conflict among analysts and agencies concerned with sustainability. Fortunately, the main effect of the conceptual debate has been to stimulate improvements in the method and to highlight its basic message – many countries are running massive 'ecological deficits' with the rest of the earth and the human enterprise as a whole has overshot the long-term human carrying capacity of the planet. (Isn't this also what accelerating global change is telling those willing to listen?)

Thus, whatever the warts and blemishes of EFA are, the concept of the 'human ecological footprint' has taken hold and its message is getting through. Ecological footprint analysis is being used and adapted by NGOs, scientists, and governments at various levels around the world both as a tool for teaching sustainability and in practical assessments of the actual sustainability of various sustainable development initiatives. In addition, the World Wide Fund for Nature now uses EFA to show how the decline in the Fund's aggregate indicator of nature's well-being, the 'Living Planet Index,' is negatively correlated with the steady increase in the aggregate human ecological footprint (WWF 2000, 2002). The eco-footprint idea is known well enough – and sufficiently controversial – to merit a special issue of the journal *Ecological Economics* dedicated to putting the concept under the microscope. Meanwhile, a small industry of consulting firms has sprung up to promote and commercialise various products based on the eco-footprint concept. Rare for a scientific model, the 'ecological footprint' has even become table talk, a familiar part of everyday language. (Indeed, it has recently been admitted to the *Oxford Dictionary of the English Language*.)

All this is all to the good as each new application of EF analysis stirs up dissent, leads to methodological improvements, or generates novel insights into humanity's ecological condition. The main point is to communicate and raise to popular consciousness the biophysical basis for the sustainability conundrum. As US Senator Al Gore (1992) pointed out, when enough ordinary people are aware enough of their dilemma to break from comforting myth and the short-term perspective, '... *the political system will fall over itself to respond.*

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KAREL KNIP

Science communication: the role of the media

The subject today is why scientific concerns about the environment and proposals for policy change so often fail to produce results. I will examine the role of communication: the relationship between scientists, the press and policymakers. I will focus on the way scientific concerns about climate-change have been put across to policymakers and politicians. This may seem to be a wrong example initially, because concerns about climate change in the end did lead to some policy changes, in spite of international unwillingness and even resistance. As an example, the greenhouse debate shows us how easily the communication between science and the media can change as the years go by.

The interesting thing in the Dutch greenhouse debate is that the role of the press has been so modest. In the first few years of the greenhouse debate scientists had no problems whatsoever reaching politicians and policymakers. There was no dispute about their authority and integrity. The media chose to follow the debate instead of leading it. Their main trouble seems to have been: getting used to the idea that the climate was getting warmer instead of colder. But this situation, in which scientists may completely ignore journalists, can change fast and easily. It is not hard to see the bad omens in the United States already.

The Dutch parliament started debating the dangers of the greenhouse effect in 1978. This was ten years before the greenhouse commotion would hit the United States. The Netherlands, of course, feared the effect of the rising sea level most of all. Already in 1983 the Health Council of the Netherlands (Gezondheidsraad) called the greenhouse effect ‘a very serious problem’. Shortly after that a Climate Commission was established which was eventually attached to the Royal Netherlands Academy of Arts and Sciences (KNAW). Two already existing government institutes, the Royal Netherlands Meteorological Institute (KNMI) and the National Institute for Public Health and the Environment (RIVM), were ready to act as mediators between science and policymakers. One can assume that the policymakers (that is: the civil servants in the departments involved) had their policy determined by those institutes in the first place. It remains to be seen whether this also goes for the politicians.

In 1988, which brought a very hot summer in America, the United Nations established the Intergovernmental Panel on Climate Change (IPCC). From now on that panel would publish a kind of consensus reports about climate change and its possible effects. And it would make proposals for mitigating measures. The IPCC is not an institute but a scientific review process for existing literature.

With hindsight, one might call this a very strange period. Nobody doubted that the climate was changing and that it was important to limit the emissions of carbon dioxide and other gases. And that didn't seem very difficult. But the IPCC itself was very cautious. The unequivocal detection of the greenhouse effect is not likely to be made for a decade or more, it said. One year later the Dutch government published its own climate report. It was the first one and it reached predictable conclusions. The Dutch journalists very patiently wrote it all down. They stuck to their role as reporters: the retailers of scientific news. Notwithstanding the doubts of the IPCC the Dutch government had developed an ambitious greenhouse policy, based on the 'precautionary principle'. And now things started to change. Within a few years the press developed a critical attitude. Not towards the IPCC but towards the feasibility of the policy targets. Meanwhile, the environmental movement predicted disaster after disaster. But the greater part of industry did not expect any problems with greenhouse gases.

At the start of 1996 the IPCC published its second assessment with the surprising conclusion that, after all, it might already have been proven that mankind is changing the climate. The consequences, on the other hand, could be less serious than previously described. Within a few months, the Dutch scientific climate commission published its own assessment. It added nothing to the IPCC report and the media concluded that the commission just found it useful to show that it recognised the authority and conclusions of the IPCC.

In the summer of 1996, one year and a half before the famous Kyoto negotiations, the Dutch parliament organised a series of public hearings about climate change. Dutch scientists could directly communicate with politicians, without any go-betweens. These hearings were reported by Dutch journalists, sitting on the sideline. A remarkable thing was that a large part of the industry suddenly accepted the IPCC conclusions, with Shell and BP as splendid examples. But many other companies, American ones in the first place, did not stop their opposition. In the wake of those companies we notice the appearance of scientists and other scholars who tried to demonstrate with a kind of scientific means that the findings of the IPCC are totally wrong. They examined the literature that the IPCC already reviewed so carefully and believed they had discovered many flaws.

Although some of the 'climate sceptics' (as they prefer to be called) surely have honest intentions, their motives are not always clear. They are characterised by the use of ever-changing arguments. They publish very complicated and very detailed articles, filled with pseudo-science and cherry-picked or manipulated data. They have their own websites and their own magazines with their own peer review. They need to, of course. Their aim is to prevent the implementation of any greenhouse policy. The method they use is to discredit the IPCC. They describe the IPCC as an institute instead of a process. They underline again and again that policymakers may influence the summaries of the IPCC assessments. They claim that the IPCC refuses to admit sceptics into their review teams. They love omitting differences between the science of the IPCC and the politics of the despised *Kyoto protocol*.

If you keep doing it for long enough it works. In May 2001 the sceptics got unexpected support from the Bush administration, which openly questioned the integrity of the IPCC. Just a few months after the publication of the third IPCC assessment the Bush administration requested the National Academy of Sciences once again 'to identify areas in the science of climate change where there are the greatest certainties and uncertainties'.[1] Explicitly, the administration asked whether there were 'any substantive differences' between IPCC reports and their summaries. But the National Academy defended the IPCC and pleaded for the process to continue. The academy expressed concern about the possibility that 'the scientific process would be viewed as too heavily influenced by governments'. It is doubtful whether this is enough to repair the damage.

Then the attitude of the media started to change again. Actually, the media were fed up with climate change and bad news about the environment already. This follows clearly from the remarkable interest in, and appreciation of, the book 'The sceptical environmentalist' that the Danish political scientist Bjorn Lomborg published in 2001. The book accuses the environmental movement of making false claims about the real state of the environment and gives some good examples, e.g. forests did not die from acid rain, the loss of ozone in the ozone layer did not pose such a great danger as was presumed. The American and British media were deeply impressed. The American press, already confused by the sceptics, thinks it is now more than ever its duty to develop a critical attitude towards the IPCC. After all the IPCC and the environmental movement come to the same conclusions about the climate. Guilt by association is the name of the game.

A few months ago the American political scientist Maxwell Boykoff published a study on Global Environmental Change called 'Balance as bias'.[2] It describes how American quality papers (New York Times, Washington Post, etc.) keep a careful balance between news that confirms and news that disputes the greenhouse effect and possible climate change. Exactly 50% pro and 50% con. As if they are describing a moral issue. By giving equal time to opposing views, the newspapers significantly downplayed scientific understanding of the role humans play in global warming, Boykoff says. Science historian Naomi Oreskes recently asked for attention to be paid to the same phenomenon in an essay in Science.[3]

The situation in the Netherlands is not as bad as in the United States, but this could change. The Netherlands has its own noisy group of 'climate sceptics' and the group uses exactly the same methods as the American and British sceptics. Up to now the Dutch press did not loose its head, but the last couple of years the Dutch media – after some political incidents – came under heavy pressure. They have been accused of being politically biased. More than ever before the Dutch press feels the obligation of 'balanced reporting'. And it's easy to exploit that feeling.

For some time now the Dutch press has been hesitating to decline printing letters from sceptics and publishes their editorial articles unabridged, hoping that its audience can tell the difference between science and nonsense, but fearing the worst. This

[1] 'Letter from the White House' in *Climate Change Science - An Analysis of Some Key Questions.* Washington: National Academic Press, 2001.
[2] Boykoff, M.T., J.M. Boykoff. 2004. Balance as Bias - Global Warming and the US Prestige Press. *Global Environmental Change* 14: 125-136.
[3] Oreskes, N. 2004. Beyond the Ivory Tower: The Scientific Consensus on Climate Change. *Science,* Vol 306, Issue 5702, 1686.

seems to be the strange fate of the greenhouse effect: the media appeared to be convinced when science still had its doubts. But the growing scientific consensus makes them nervous.

JOHAN BOUMA

Agenda for future research

Abstract
Insufficient use is being made of the results of scientific research as society wrestles with environmental issues. This may be due to environmental science not being in tune with our modern network society where problems are most effectively approached through *Communities of practice* involving various stakeholders and policymakers. Rather than trying to improve relations between scientists, stakeholders and policymakers separately, disturbed relations between stakeholders and policymakers (or broader: between citizens and their government) should be improved using knowledge as a tool, acting as facilitator and mediator. Teams of scientists, focusing on basic and applied research but also on facilitation and communication, should first invest in their own *community of scientific practice* based on solid scientific methodology. By focusing on alternative options for action for any given issue, including all economic, ecological and social trade-offs involved when striving for sustainable development, scientists can preserve their independence (and thereby clarify their position in the debate) while providing crucial knowledge.

Introduction
The central question of this conference is why scientific research, which claims to produce arguments for policy change, has not produced satisfactory results. When directed towards environmental research this question is certainly relevant: even though serious effects of environmental change on society have been well documented, the environment does not figure prominently in the policy debate.

When discussing an agenda for future research, we will therefore not focus on environmental issues as such but, rather, on the research process and its relation with society. Current research priorities are well summarised in the *Milieubalans* (National Institute of Public Health and the Environment (RIVM), 2004). Interestingly, when asked in a recent interview about Dutch environmental priorities for the period July 2004 to January 2005 in which the Netherlands chairs the European Union, the State Secretary for environment policy, Mr. Van Geel, first mentioned the challenge to show that environmental rules and regulations should not be seen as threats but, rather, as opportunities. The communication process, or modern packaging of a message, is clearly seen as very important. In fact, many technological solutions for environmental problems are available but implementation is hampered by lack of political action, poor communication or both.

In discussing an agenda for future research, attention will be paid to: (i) the special character of environmental research; (ii) the changing role of research in a network society; (iii) the implications for environmental research, and (iv) the need to establish *Communities of Scientific Practice*.

The special character of environmental research

Every citizen is directly and continuously confronted with his or her environment. This defines the special character of environmental research, which is very much people-oriented. The first generation of environmental problems, such as water, soil and air pollution, was often local in nature and the effects of pollution could usually be perceived directly. The need for corrective measures was widely supported in society and corresponding rules and regulations were appreciated and well accepted. This was the era of the seventies and eighties of the last century, when environmental policies were popular and effective ('the low-hanging fruit could be picked rather easily'). The second generation of ('wicked') problems is quite different (see WRR 2003). The sensory perception is often only indirect. These problems advance slowly but persistently and transcend national boundaries. Their ultimate effects may or may not become clear within a lifetime or on the spot where they originate. Arbitrary examples of second-generation environmental problems ('the fruit at the top of the trees') are e.g. effects of global climate change, of micro chemicals and of biodiversity loss. The public perception that many of the first-generation problems have been solved echoes into the present and makes it more difficult to recognise the second-generation problems, which are more abstract. This raises concern because public opinion and the policy arena are difficult to mobilise when other pressing societal issues such as health care, employment and immigration continuously cry out for attention.

Disasters may be needed, or so it seems, to mobilise public opinion. The Dutch 'Delta Plan', for example, only materialised following the devastating floods in the Southwest of the Netherlands in 1953. The basic question raised in this symposium can therefore be modified to read: *How can environmental research be executed and communicated in such a way that the effects of future environmental problems can be minimized by timely adoption of corrective measures?* Or, in other words, how can we realize Delta Plans without first having to have devastating floods? WRR (2003) calls this: 'the policy of learning before mistakes are being made'. This illustrates the complicated character of environmental problems that do not only involve environmental quality but also economic and social factors as these problems affect everybody's daily lives. As such, environmental studies provide excellent frameworks for studying sustainable development but this statement does not make the problems at hand any simpler.

The changing role of research in a network society

The relationship between a government and its citizens is becoming rather cumbersome. Van den Brink (2002) pointed out for the Netherlands that at least two groups of citizens can be distinguished. Active and sceptical citizens with a good education who have to be convinced that actions by governmental agencies make sense and a large majority of less educated and less wealthy citizens who cannot or do not wish to follow the political debate and are clearly alienated. The latter feel threatened and do not trust the government while, at the same time, needing its help. The big challenge for any democracy at this time is to find ways to defuse the alienation process and involve citizens in formulating solutions for societal problems that are acceptable to all, however grudgingly this may come about. One approach is to follow the unwritten rules of a network society (Castells 2000) in which groups of engaged citizens work together with various stakeholders, researchers and governmental and non-governmental agencies (NGOs) to solve problems by means of interactive, participatory processes.

But what is the role of science and research in all of this? It would be naive to assume that major changes in society would not affect the role of research and that research can continue to operate as it always has. Perhaps one reason why research results are not adopted by policymakers and society as well as they might be is that research has not found effective ways of responding to the dramatic changes in society that have occurred in recent decades. In fact, I fear this is the case, because the old linear, hierarchical model of knowledge transfer is still rather prominent in scientific circles. This model implies that research is done on certain topics that are deemed to be important, followed by the publication of results. What happens next is another matter. Traditionally, extension services would use research results to educate citizens but this model is breaking down, if only because extension services are privatised. We need to find better ways to define the function of science in a network society. Bouma (2001) analysed some implications for soil science, which have a much wider significance. Wenger (1998) and Wenger et al. (2002) have proposed the formation of *Communities of practice* within the context of a network society. By now, there is a widely held feeling that interdisciplinary rather than mutually unrelated disciplinary research and interaction with stakeholders is needed to effectively address society's problems (see e.g. IAC 2004). Still, it is largely unclear what this means in practice, particularly for science and research. The scientific community would be well advised to address these issues hands-on because purely conceptual and theoretical intentions, without real-world applications, may lead to many interesting conferences that change nothing. A certain uneasiness in scientific circles has already translated itself into rather extreme reactions by some: either stakeholders are embraced and glorified beyond what can reasonably be expected from them, or scientists retreat into their own ivory domain. Alternative intermediate approaches need to be explored and we will therefore argue in the following sections that the science community should first get its own act together, by forming *Communities of scientific practice*.

The implications for environmental research

First, we will consider the core of scientific research, which should be upheld under all circumstances. Next we will explore what this could mean in practice when scientists take part in Communities of practice as discussed above.

The core of scientific research

The independence of scientists is still the basic justification for the public funding of researchers at universities and research institutes, implying an insurance policy for society that, ideally, our best minds can freely explore current and future developments in the broadest sense. And this is to everyone's benefit. Of course, the commercialisation of science is a potential threat, as scientists may become 'their master's voice'. It is therefore increasingly important to formulate the boundaries of our scientific activity, which is the very justification for scientists' independent position in society. Real science yields results that are: (i) reproducible, (ii) based on quantitative experiments (for 'hard' and 'soft' sciences alike) and (iii) tested for statistical significance. This may appear straightforward but it is not. Diverse opinions exist about research and its methodologies and this is often quite confusing to outsiders. Discussions about scientific research, as initiated by Popper amongst many others, not only need to be continued but should also be focused on a specific expression that can be recognised by outsiders.

In any case, uncertainty and risk are crucial research issues to be addressed in our 'risk society' (Beck 1986; RMNO 2004). Van Asselt (2000) distinguishes seven categories of uncertainty of which four are *reducible* and three are *structural*. Science can best focus on the *reducible* types of uncertainty and the distinction between the two categories is helpful when analysing problems: the message is that science has its limits. The *precautionary principle* is of particular interest in this context. It implies that lack of scientific certainty may never be used as a reason for not taking corrective measures to combat a given problem. This principle, formulated in a highly complicated manner with three negative sub statements, is often interpreted to mean: 'When in doubt, don't do anything', but this is not correct. In fact, as scientific research is always associated with uncertainty, this could imply that no research could ever be done. This certainly will appeal to some type of activists but it is deadly to science. A good example of applying the *precautionary principle* was the banning of chlorofluocarbons (CFCs) after indications were found that they destroyed the ozone layer in the atmosphere. There certainly was no scientific certainty but measures were taken and rightly so, as became obvious many years later.

Functioning in communities of practice

Communities of practice, focusing on environmental issues, are already operating for different issues. Arbitrary examples are the *Land care* programme in Australia (Campbell 1994), the Intergovern-mental Panel on Climate Change (IPCC) and the ICES-KIS 3 (Bsik) programme of the Dutch Government in 2003 in which 800 million euros were made available for the knowledge infrastructure in the Netherlands through *communities of practice* involving researchers and representatives from industry and government.

Without suggesting a complete analysis, some observations can be made about the role of scientists in issue groups with various stakeholders, non-governmental organisations and policymakers:

1 Scientists are members of a team that they do not necessarily lead. Their role, aside from presenting relevant data and information, often includes the facilitation of interaction processes and mediation between conflicting members, using scientific expertise as a tool. They find this role difficult, as they have not been trained to do so.
2 Stakeholders often have important tacit knowledge, based on experience. This should be valued highly, but not glorified. Also, *tacit* knowledge should be tested by

scientific methods. Sometimes, stakeholders simply cannot know certain facts and it is unfair to them to have unrealistic expectations.

3 Policymakers or governmental agencies follow a policy cycle, where highlighting of potential problems is followed by designing of appropriate measures and by implementation of rules and regulations. If scientists ignore this cycle their activities may not match with policy demands, thereby creating unnecessary friction (e.g. WRR 2003; Bouma 2003).

4 Scientists are most effective in this context when they have empathy, which is the ability to put oneself in the position of others. But they should not operate as if they were stakeholders or policymakers themselves, making final choices and decisions. They are not. But how then, can they be most effective within the *community of practice*? In their study: *Duurzame risico's, een blijvend gegeven* the Netherlands Scientific Council for Government Policy (WRR) (1994) has convincingly made the point that there exist no unique solutions to environmental problems. Many scientists and citizens may still feel deep down that such unique solutions do exist in a classic linear mode of the form a + b = c. In contrast, there is not a single magic solution but there are a lot of options, each with characteristic trade-offs between environmental, economic and social approaches, following different norms and values of society. The latter are, ideally, the basis for programmes of different political parties, which partake in the arenas in democracies where decisions are made. The WRR explored potential scenarios for utilisation, saving, managing and safeguarding when analysing environmental issues such as the world food supply, energy supply, nature conservation, use of natural resources, and water supply. The idea is not to point fingers in the tradition of: 'Thou shalt ...' or: 'Thou shalt not ...', but to show that any decision has to take into account all associated side-effects. Not only looking at ecological interests, as some ecologists are doing, but at economic and societal interests as well, and not only looking at economic interests, as some economists are doing, but also considering ecological and societal interests, etc. Anything is possible but always at a price. The scientist is in a unique, independent position to show how high that price is. Policymakers and stakeholders then decide what price they are willing to pay for their ideals and scientists can help to facilitate such discussions.
Does this mean that scientists cannot have an opinion of their own? Certainly they can. WRR (1994) in the end presents the opinion of their group of scientists on a number of issues, but this fits in with the range of options defined above. A different group of scientists would probably have had a different opinion.

5 Communication of scientific results is sometimes 'hijacked' by interest groups highlighting only that part of the results which supports their point of view. Scientists have a responsibility here to make sure that all research results receive due attention in the debate. Traditionally, scientists have felt that good research would find its way on its own merit. This is no longer assured in the information age. Professional communication techniques are needed to reach the modern citizen who is numbed by a continuous avalanche of information. Scientists cannot afford to ignore this any longer if they are serious about their work.

6 The need for interdisciplinarity and a systems approach when studying environmental problems is by now widely acknowledged. So is the need for interaction with stakeholders and policymakers (e.g. IAC 2004). Scientists in communities of practice run the risk of getting out of touch with their professional colleagues as they may become 'jacks-of-all-trades, but masters-of-none'. This would make them uninteresting and thereby ineffective in the community. Aside from remaining a specialist in a given field, they may be well advised to also specialise in systems analysis or communication science.

Communities of scientific practice

There is no agreement within the scientific community as to how scientists should perform in a network society. Some of those in favour of excellence are concerned that too much interaction with stakeholders and policymakers will weaken science and will be a devastating challenge to its independence. They also tend to see basic or fundamental science as the real science and applied research as being inferior by nature. Also, visions within the 'hard' sciences tend to differ from those in the 'soft' sciences. Some more applied scientists, on the contrary, cannot appreciate what they see as irrelevant so-called fundamental research. Communication is generally not perceived as being a structural part of scientific activities. As a result of this diversity, different groups of scientists have different contacts with stakeholder groups or policymakers. We envisage separate discourses on what it takes to interact well with these two quite diverse groups.

The real problem in the democratic world is, however, neither the relationship between science and society nor the relationship between science and government but the relationship between society and its government. Some modesty on the part of science would be well advised here. Science can, however, play a very important role in facilitating the relationship between society and its government by taking part in *communities of practice*, focused on environmental issues.

I propose that it is now time to look into our scientific community and get our act together by establishing a true Community of scientific practice for environmental science. This Community should (i) be unified by scientific methodology to be applied by all, and (ii) recognise the crucial role of 'free' basic and fundamental research to move the field forward and recognise the need for applied research, which also has the function of identifying areas where basic research is needed most. This can be achieved by building knowledge chains connecting basic and applied research at different spatial levels, ranging from fields to regions to continents (Bouma 1997). Communities of scientific practice should consider communication as a key area of its mandate and take part in communities of practice that address environmental issues by focusing on defining options for action, each representing a reflection of norms and values and all trade-offs involved between economic, ecological and social requirements. Finally, they should establish an educational system that allows different lines of activity, reflecting the five elements of the community of scientific practice mentioned above.

There is in a community of scientific practice not a single type of scientist but a close, interacting team in which some do fundamental or applied work, others participate in communities of practice and others focus on communication and education. The Royal Netherlands Academy of Arts and Sciences can, perhaps, play a role in establishing communities of scientific practice for some key problem areas. The Young Academy, an initiative of the Royal Netherlands Academy of Arts and Sciences to bring together 40 bright young scientists with experience in interdisciplinary work and with a feel for the needs of society, could perhaps play a role here after its establishment in early 2005.

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JELTE VAN ANDEL AND JAC.A.A. SWART

At the interface between science and politics – The case of cockle fishery in the Wadden Sea

Introduction

What are the responsibilities of scientists whose research takes place in a societal or even political context, as is often the case? Do they differ from the responsibilities of those scientists who find themselves in an ivory tower? We will discuss this matter with reference to recent debates among scientists about the results from research on the cockle fishery in the Wadden Sea.

The case

Cockle fishing in the Wadden Sea has been practised for at least a century, but since 1970 it has developed from fine-scale collecting by hand to coarse-scale hydraulic dredging. The latter technique implied such a crucial change in terms of ecological impact – not only on the soil structure and the soil organisms, but also on the predators of these organisms including large numbers of shorebirds – that criticism from private nature conservation organisations increased. The Ministry of Agriculture, Nature and Food Quality (LNV) initiated an ecological evaluation study, carried out by three research institutes.[1] The initial phase of the studies covered the period 1997-1998 (EVA-I), followed by a second phase, 1999-2003 (EVA-II). This resulted in 22 scientific reports and 10 technical appendices, summarised and interpreted in a so-called public version[2], presented by the Minister to the Dutch Parliament in December 2003. The final scientific report was published in August 2004.[3]

The Wadden Sea Advisory Committee has used the results from the EVA-II study in a wider political context. This committee was set up by the Dutch government to pave the way towards an integral policy plan, not only covering the problems related to shell fisheries (cockles and mussels), but also to the long-lasting debate on the exploitation of gas from the Wadden Sea area. The Committee's final report was presented[4] in March 2004.

1 Alterra (Wageningen UR), the Netherlands Institute of Fishery Research (RIVO, Wageningen UR), and the Netherlands Institute of Coast and Sea Research (RIKZ).
2 Ministerie van Landbouw, Natuur en Voedselkwalitieit. *Resultaten wetenschappelijk onderzoek EVA-II* - Publieksversie. 's-Gravenhage, December 2003.
3 Ens, B.J., Smaal, A.C. & De Vlas, J. 2004. *The effects of shellfish fishery on the ecosystems of the Dutch Wadden Sea and Oosterschelde*. Alterra, RIVO & RIKZ, Wageningen.
4 Meijer, W., Lodders-Elfferich, P.C. & Hermans, L.M.L.H.A. 2004. [Adviesgroep Waddenzeebeleid, Commissie Meijer]. *Ruimte voor de Wadden. Eindrapport*. 's-Gravenhage, March 2004.

Public debates among scientists

Here, we confine ourselves to the debate about the cockle fishery, in which we have been involved.

On the results from EVA-II

The research institute Centre for Ecological and Evolutionary Studies (CEES) of the University of Groningen, took the initiative to organise a one-day scientific symposium to evaluate the results from scientific research on ecological effects of shellfisheries in the Wadden Sea. The meeting was meant to enable an open discussion among scientists who had been working under contract with the Ministry of LNV, and several other scientists who had a long record of Wadden Sea research, mainly from the University of Groningen and the Royal Netherlands Institute for Sea Research (NIOZ). The first author of the present paper chaired the organising committee. In agreement with the researchers of the EVA-II team, a date was fixed for 16 October 2003, just one day after the Minister was supposed to present the report to Parliament. Almost 200 people registered to attend the meeting, including scientists, politicians, nature managers, fishermen and journalists. Less than a week before the conference, the project leader at the Ministry of LNV announced that the Minister had decided to postpone the presentation to Parliament, because the EVA-II researchers had not finished their reports in time. According to their contract, members of the EVA-II team were not allowed to speak in public until such time as the Audit Committee (scientific quality control) and the Steering Committee (control of procedures) had had an opportunity to finish their tasks.[5] As a consequence, the symposium organisers had no choice but to inform those who had registered that they had to cancel the symposium because of this political intervention. The Minister presented a public version of the EVA-II reports to the Parliament on 11 December 2004, and the symposium was organised once again, on 29 January 2004. Over 250 people attended this meeting. Two conclusions from this symposium are worth mentioning:

1 It was agreed that mechanical cockle dredging had caused ecological damage, both to the soil ecosystem and to the shorebirds. However, it remained unclear whether the damage was irreversible[6], depending on the time required for recovery and on the criteria for return to the original state.
2 The public version of the EVA-II reports was not considered sufficiently representative of the overall results as it remained without quality assessment and did not refer to international literature.

On the report of the Advisory Committee

Two months after this symposium, the Wadden Sea Advisory Committee stated that current mechanical cockle fishery is not compatible with respecting the natural value

[5] Veerman, C. Brief aan de voorzitter van de Tweede Kamer der Staten-Generaal. TRC 2003/7766. 's-Gravenhage, October 2003.
[6] E.g. Versteegh, M., Pietsma Th. & Olff, H. 2004. Biodiversiteit in de Waddenzee: mogelijke implicaties van de verwaarlozing van kennis over zeebodemverstoring. *De Levende Natuur* 105: 6-8.

of the Wadden Sea (in agreement with the results from EVA-II). Nevertheless, the committee advised allowing the cockle fisheries to continue for another seven years, subject to the condition that a sustainable exploitation of the cockle fishery would be developed and that the ecological limits set by the evaluation study were respected in the meantime. The first author of the present paper (former chairman of the CEES-symposium) decided to send an open letter[7] to the EVA-II research managers, asking them to reply to two main questions:

1 How does the EVA-II team evaluate the way the research results have been used by the Advisory Committee?
2 Are the EVA-II project leaders willing to organise a workshop to discuss to what extent the currently available scientific insights can be used to predict the chances for sustainable cockle fishery, rather than to see forward to another scientific evaluation period?

In their reply[8] the project leaders of EVA-II considered this open letter not adequately addressed, because it would not be the task of researchers to set the conditions for political decisions. Furthermore, there would be a risk of science no longer being considered independent, thus diminishing the impact science should have on the policy-making process.[9]

Having seen that the EVA-II managers did not play their part, the majority of scientists who had attended the CEES-symposium felt responsible to act directly toward the government. In June 2004, a group of over 100 Dutch scientists wrote an open letter[10] to the Minister of LNV and to the relevant parliamentary commissions, stating that current scientific insights are sufficiently valid to conclude that another seven years of cockle fisheries as proposed by the Advisory Committee, will not result in sustainable use of the Wadden Sea. The Minister was asked to take the available scientific knowledge seriously into account.

A framework for analysis of the debate

To understand this complex case we have to recognise that societal interests and scientific uncertainty generate different contexts in which science functions.[11] When interests are low we may speak of autonomous science. This is irrespective of the scientific uncertainty that is involved since uncertainty and competing scientific insights are key characteristics of a flourishing scientific practice. Autonomous science often occurs in academic settings, is curiosity-driven and is often internally funded. In the case of well-established scientific insights, research often aims to develop new

7 Jelte van Andel. 2004. Open letter to the EVA-II team: Kokkelvisserij. Bionieuws 14 (8): 13. Utrecht, 23 April 2004.
8 Bruno Ens. 2004. On behalf of the research management of EVA-II. Reactie. *Bionieuws* 14 (8): 13. Utrecht, 23 April 2004
9 See also Han Lindeboom. 2004. Kokkels. *Bionieuws* 14 (11): 2. Utrecht, 4 June 2004.
10 Gibbons, M. et al. 1994. *The New Production of Knowledge: the Dynamics of Science and Research in Contemporary Societies*. Sage, London.
11 Gibbons, M. et al. 1994. *The New Production of Knowledge: the Dynamics of Science and Research in Contemporary Societies*. Sage, London.

applications. This means that scientific claims will be more strongly assessed for their practical use or impact. We may refer to this as applied science, which is often carried out in non-academic institutions.

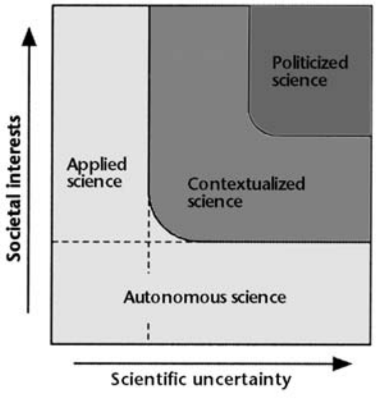

Figure 1: Different modes of scientific research, used as a framework for the analysis of the debate among scientists at the interface between science and politics.

However, if social interests and disputes in economic, ethical, and political senses increase, science becomes societal contextualised and issue-driven. We have coined this 'contextualised science'. Scientific claims are in that case also interpreted and understood from a societal point of view. When scientific uncertainties and societal interests are both heavily involved, we may even speak of politicised science. In the latter case, scientific claims are mainly assessed and questioned from societal points of view and performing science is vulnerable to societal intervention. It may even lead to pleas for moratoria as happened in the fields of biotechnology and human cloning research. The boundaries of these types of science, schematically represented in figure 1, are of course not hard and fast.

Reflection on the debate

The 'ideal' picture of scientific integrity according to Merton[12] applies to the area of autonomous science. However, in our times we often meet more contextualised situations.[13] The EVA-II research is an example of such a contextualised and sometimes politicised mode of science. Indeed, according to a signed contract, members of the EVA-II team were not allowed to speak in public until the Steering Committee and the Audit Committee had agreed on their reports.[14] In reply to the open letter, the

[12] Merton, R.K. 1973. The normative structure of science. *The Sociology of Science* (R.K. Merton, ed.), pp. 267-278. The University of Chicago Press, Chicago.
[13] See e.g. Laeyendekker, L. 1995. Wetenschap en ethiek: een moeilijke verhouding. *Wetenschap en Ethiek* (eds. P.J.D. Drenth et al.). KNAW Mededelingen van de Afdeling Letterkunde, 58 (6): 171-203. Amsterdam: KNAW.
[14] For comments, see J.A.A. Swart. 2004. Onderzoek naar de effecten van de kokkelvisserij: de verweving van politiek en wetenschap. *De Levende Natuur* 105: 3-5.

EVA-II managers retreated to the supposed safety of autonomous science, thus denying that they unavoidably had to do their research in a contextualised or even politicised setting (represented by the Steering Committee). In our view, the responsibility of scientist is not only to provide data and arguments, but also to evaluate the use and abuse of the results and interpretations in the decision-making process. It is not the final decision that should be kept under control of science, but the correct use of scientific arguments in that decision. The open letter to the government by over 100 scientists was meant to underline the importance of the scientific arguments, not to claim the primacy of politics for science.

There is no need to avoid contextualised or politicised science, but rather to cope with the associated problems. What are the codes of conduct for dealing with contextualised science? Several aspects should be acknowledged simultaneously, in addition to the Mertonian criteria:

1 Recognise the context of science in different modes of research.
2 Consider the ivory tower an opportunity rather than a constraint.
3 Evaluate the correct scientific application of the results; this can even be included in the contract.
4 Apply the procedure for scientific quality control to public versions of scientific reports as well.
5 Consider open scientific debate essential; make this explicit in the contract, the more so as public resources are involved.
6 Train students in the methodology and ethics of contextualised science.

Epilogue

The Dutch parliament decided, on 9 November 2004, in line with the decision taken by the government earlier this year, to stop the cockle fishery in the Wadden Sea from 2005 onwards, in view of the impossibility of developing a sustainable fishery within seven years.[15]

[15] *Handelingen Tweede Kamer* TK 23-1377. Den Haag. Published 16 November 2004.

N.D. VAN EGMOND

Comments on responsibilities of environmental research

The limits of science for policy

The following arguments limit the use of science in policy-making. Policy is not only based on scientific arguments but also on values. As such, policy has a mandate to be 'irrational'. Etienne Vermeersch discerns rationality on both ends and means. 'Ends rationality' implies that a government formulates explicit ends, which to a large extent are value-oriented. Subsequently, the ends are achieved by rational means, i.e. by means of scientific methods: 'means rationality'. This contrast is illustrated by the classic trade-off between efficiency and equity, which is not scientific in nature. Science only comes into play when a political choice is made between measures of efficiency versus equity. In today's society the ends rationality is far from explicit. Ends and means are often implicitly interchanged and this interchange is irrational, as the (ultimate) ends are never achieved if the means are confused with the ends. In the end, bigger cars do not contribute to 'self-realisation'. If everybody stands on their toes, nobody can see better than the others. Advertisement is often an example of structural attempts to put means before the ends. A political example is the EU Lisbon strategy in which Europe wants to become the most competitive economy in the world. It remains unclear (implicit) what the associated ends are. It seems that the means of a competitive economy have become an end in themselves.

I want to make a distinction between 'strong' and 'weak' science. Science that is derived from repeatable, controlled experiments is called 'strong'; the empirical basis allows both the generalisation into theories and the subsequent testing of these theories (with independent data sets). Much environmental science is weak in the sense that a repeatable, controlled experiment is essentially impossible; for example it is impossible to perform global scale climate change experiments (except the current real time single 'experiment' we are being part of). Weak science contains inherent and inevitable uncertainties.

There exists a paradox in science policy: strong science is generally irrelevant to policy and science that is relevant to policy is generally weak. However, weak science can hardly be of help to policymakers and the gap has to be filled with the 'precautionary principle'. Denial of the inherent uncertainties in various environmental issues (as a result of the 'weak science character') with the purpose of presenting science to public and policymakers as simply as possible is unscientific. Especially in cases of higher uncertainty, scientists have an obligation to be alert and sensitive to falsification of existing (weak) knowledge and the formulation of competing theories.

In the case of weak science, the value-laden part of the line of reasoning is substantial and leaves room for optimistic or pessimistic interpretations. For example, it is possible to make optimistic as well as pessimistic judgements or extrapolations of the current technology status into future technology expectations. Science can only make the assumptions explicit and show how 'heroic' these assumptions are in the context of earlier, empirical valid trends. For example, the future capacity of an airport within the (politically chosen) environmental noise limits depends proportionally on expectations about future aircraft technology in terms of noise production. The more realistic these expectations are, the more flights can be accommodated in the future.

Communication of science

In practice it is difficult to communicate even strong science in case of negative societal and individual consequences. Herein also the prisoner's dilemma plays a role: 'I will only accept the facts if my neighbour does the same'. Apart from this argument the complexity of the underlying science might be too large. In this case, metaphors such as Rees' ecological footprint can be very effective. History so far has shown that environmental problems are only accepted when the impacts have already been experienced or demonstrated to some extent, a 'small catastrophe'. To a large extent, environmental awareness in the 1980s and 1990s was based on the 1986 Chernobyl nuclear reactor accident with Europe-wide implications such as obviously contaminated food products, lakes, etc. Willingness to consider the climate change issue in the US increased during extreme dry summers in the Mid-West (dust-bowl). The almost weekly frequency of hurricanes over Florida in the summer of 2004 will probably change the public opinion on the climate change issue.

The independence of scientists and formal assessment organisations form an obvious prerequisite for a properly functioning science policy interface. Total transparency can, to a large degree, guarantee this independence. Transparency can be organised by involving many institutions in the scientific core of the work, for example universities, (other) governmental institutes, international organisations, etc.

Science in the network society

The current society structure has become less hierarchical and is increasingly assuming the character of a 'network society' (Castells). Herein many actors are involved in the overall decision-making process, including the government, the market and civil society. The role of the government has diminished and sometimes these three actors are even considered to be equal. As a consequence the role of the environment as a common good is also weakened and shifted to a market good. Subsequently it is subject to negotiation between stakeholding parties. In a negotiation context, predictable outcomes tend to mean values. The role of science is being complicated by a market-oriented negotiation debate, resulting in scientific advocacy and, implicitly, the further conflation of science with values. Principles tend to be suspect in this mechanism; everything can be negotiated. This is far away of the above-mentioned ends and means rationality as stated by Vermeersch[1] where a rational government formulates its ends explicitly, especially when collective goods are involved. Clearly, the role of science in this case is to support rational methods to achieve the chosen ends.

[1] E. Vermeersch. 1990. Dutch Away from the Science Technology Capital-complex. In: *CLTM: Views on the 21st Century*. Kerkebosch, Zeist.

JOYEETA GUPTA

Environmental research – peripheral or cutting edge

Introduction

Resource-related problems are not new. History shows that from time immemorial humans have tried to come to terms with their natural surroundings while exploiting the resources for their private and social goals. Humans have fought over access to land, water and the resources to be found in both. Chanakya's Arthashastra written in about the first century A.D. describes how the core of politics focuses on access to resources. The side-effects of pollution have also been recorded in Biblical documents that discuss waste management in the ancient city of Ur or in the Laws of Manu which describe the laws applicable in ancient Vedic times.

What is new is the scale at which human demands, as a result of technological development and population growth, have plundered the earth's resources. How does one deal with environmental issues that are often subject to scientific uncertainty; have major social impacts in particular on the vulnerable segments of society and on ecosystems and species and, hence, are arguably characterised by urgency; and often challenge the vested interests of politicians and industrialists and therefore have high stakes? Such post-normal problems are seen to call for post-normal science à la Ravetz and Functovicz (1992) where scientists from different disciplines not only need to come together, they need to develop new knowledge in collaboration with social actors. Shiva and Bandyopadhyay (1986) go a step further by arguing that the legitimacy of science-based solutions crafted to deal with such problems depends on how well the views of those affected are taken into account, and not simply on the basis of whose stake is the highest in economic terms. So we need inter- and trans-disciplinary research frameworks.

This is not simply a theoretical conclusion; it has reached the portals of politics. The climate change regime is supported by the efforts of the epistemic community in developing such science through the establishment of the Intergovernmental Panel on Climate Change, which is now preparing the fourth of its five yearly assessments of the state of the art of climate science. Much inspired by the success of this experiment, the Millennium Ecosystem Assessment was launched to also examine the science in the area of ecosystems. Participating in both endeavours, I can assure you that both are major learning experiences for all scientists as one is forced to think in new paradigms and challenged to think 'outside the box', while still basing one's findings on peer-reviewed and/or scientific literature.

The question that this essay then focuses on is: Is such inter- and trans-disciplinary environmental research peripheral to mainstream academic work or is it cutting-edge research that is both highly relevant to society and yields insights for basic research?

Does environmental research make one so superficial in trying to understand and combine elements from different disciplines that one becomes a Jack-of-all-trades and master of none? Does undertaking environmental research make one irrelevant within one's own discipline, and hence unfit for employment in a mono-disciplinary faculty? If one begins university life as a jurist, and evolves into an environmental academic, is one no longer a jurist?

These are the types of questions that I have been mulling over in the weeks following the KNAW conference on Responsibilities for Environmental Research. The workshop was most stimulating in that the particularities of the environmental problem were explored in the context of normative considerations as well as in terms of discussions on holism versus reductionism; constructivism versus positivistic approaches.

Academic challenges

From my perspective, there are five academic challenges to the project of sustainability or environmental science. The first challenge is the way we experiment with and develop means of combining qualitative with quantitative analysis. The humanities, law, legal philosophy, philosophy and history tend to record how societies have developed over the past and, inter alia, identify principles for creating order in society. They focus on dense descriptions and positivistic approaches. The social sciences combine both qualitative and quantitative approaches but not always in the same endeavour. Economics focuses much more on quantitative analysis while politics may focus more on narrative. The natural sciences are far better suited to quantitative approaches. In my experience, quantitative scientists see the work of qualitative scientists as 'blah blah', and qualitative scientists are very suspicious of the black box outputs of the quantitative scientists. This also implies that engaging in such a collaborative endeavour is a much more taxing and risky effort than writing within the boundaries of one's own discipline and publishing in the top mono-disciplinary journals. The justified fear of qualitative scientists is that their input will be reduced to a footnote in the effort to find appealing quantitative solutions.

Beyond the qualitative and quantitative challenge are other challenges. One is the need to develop theoretical insights that are valid in all contexts – leading to institutional and technological design prescriptions; and the other is the recognition that since all contexts are different, the insights may not be equally valid and that both institutional and technological design must take the local context into account if they are to be sustainable. But this brings one to the classic dilemma of theory development versus applied science. The former has a much higher status in the halls of scientific fame; the latter is more relevant for addressing social and environmental problems. One of the ways to merge the two is to develop inductive reasoning based on case studies, but the challenges in practice remain heavy.

A third challenge is that to science's core ethic of neutrality. First, most disciplines have different normative frameworks; law focuses on rights while economics focuses on efficiency. Integrating the different normative frameworks is often very challenging. Furthermore, in the social sciences and humanities, but also in the natural sciences we are discovering that these sciences are unable to provide certain answers (e.g. Does cigarette smoking cause cancer?); and because much of the new science raises ethical questions (e.g. Is bio-technology a risk to society?). How can one assume that the normative framework underlying one's theoretical hypotheses is universally applicable in a globalising world where we have common or similar physical problems that are defined differently in different contexts? If mainstream science has an implicit normative framework and claims to be objective in its results, and if environmental science that focuses on global or globally recurring problems calls for universally applicable results, then how do we deal with the competing normative frameworks? Will such competition be left to the domain of power politics; or will power politics intrude in the domain of science through funding mechanisms and exclusionary practices (Gupta 2001)? For example, if we accept the argument that most global environmental problems are wicked unstructured malign problems that call for the co-production of knowledge on risks and uncertainties then where is the scope for co-production of knowledge with people from other countries? Let us take the issue of what is dangerous climate change. A cost-benefit analytical framework that looks at the costs and benefits for the developed countries is a very limited perspective. Are the lives of people in developing countries of less value because the economic cost of their life is lower (Gupta 1997; 2001b)? Many of these models do not even take into account the political feedback effects of policies based on limited science at the global level.

A fourth challenge is that stakeholder analysis in research and stakeholder participation in policymaking are emerging as key elements of any complete analysis of how environmental management is to be undertaken. Yet, after years of stakeholder research, questions concerning the reproducibility and robustness of the results remain. In participatory integrated assessments, how does one deal with the power of vested interests in influencing outcomes and is there not a fear that we replace democracy with a stakeholdercracy (Gupta 2003)? How does one deal with the creeping problem of stakeholder fatigue? This is not to deny the importance of tacit knowledge, but to acknowledge that there still remain many critical challenges in the path of developing this as a strong methodological framework.

A fifth challenge is that, ultimately, if science is to be relevant, it has to be usable. If mainstream science tends to take a highly technocratic, reductionist approach, and if environmentalists argue that a more holistic perspective is needed, whether eco-centric or socio-centric, this raises new questions. How does one cope with the new complexity and reduce it into usable science and policy advice without being again overly reductionist in one's approach?

Conclusion

Let me return to the questions raised earlier. In a discussion some weeks ago with the law faculty, I realised how much of a pariah one becomes when one engages in what one thinks is cutting-edge research on how actual, complex, potentially devastating environmental problems should be addressed by writing both academic papers and by influencing the ongoing negotiations. If one begins life in the humanities and then through the learning process starts to develop a new vocabulary influenced by social and natural scientists, most lawyers don't understand one any more. Not only does one's vocabulary change, but also one's methodological approach and academic inclinations undergo a metamorphosis. If one believes in what one does, which I think is essential for every person, academic or otherwise, it becomes difficult to remain enchanted with theoretical problems with no immediate significance for addressing global and globally recurring problems. The challenge then to the researcher is whether one then limits oneself and one's newly gained knowledge and experience to still try and publish in the top disciplinary journals, or whether one risks one's credibility as a scientist in one's own field by following the path less travelled. Some hypothesise that one needs to be essentially of top quality in one's own field before one can venture on the inter-disciplinary path. That sounds good, but the risk is that one is locked into one's own paradigm and only ventures to make small contributions to sustainability science. The mental make-up for give and take is missing. Some argue that the environmental issue has been so incorporated within the tenets of their own discipline that environment as a discipline is outmoded. It has served its purpose. Those who continue to work within the environmental framework will gradually be marginalized as the mono-disciplinary faculties develop their own skills in this area.

However, I would argue that environmental issues, development and sustainable development and institutional change are critical to the survival and well being of humanity and other species and there is need for new ways to deal with this – whether under the umbrella of the International Human Dimensions Programme of Global Environmental Change or more broadly - Sustainability Science. The ultimate challenge for all of us engaged in this endeavour is to ensure that we remain cutting-edge science with scientific, social and political relevance and not just peripheral or marginal to mono-disciplinary science.

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MICHIEL KORTHALS

Between alarmist and over-cautious, arrogant and isolationist positions and private and public interests – Responsibilities of environmental scientists

Introduction

Traditionally, scientists are seen as amateurs, dedicated to the truth, harming no-one and in the end, almost unintentionally, providing society with the benefits of their work. Ethics comes up, when money is distorting scientific research, when scientists do not comply with their duty to publish and share their findings with others, and when they are doing dangerous types of work, e.g. experimenting with human subjects. The role of ethicists, as a kind of lawgiver, is to correct certain mistakes or even criminal acts committed by scientists in advance.

Nowadays, the situation for life and environmental scientists is totally different from this traditional perspective. Life and environmental sciences are largely paid for by private companies (Brown 2002; Etzkowitz 2002; Torreele 2000) or by private-public partnerships. Publications are not always necessary and databases not always accessible to everyone. Thirdly, many feel that life, nature and environment are becoming more and more jeopardised and may even be destroyed, partly due to previous scientific and technology-led interventions. In particular, structural and almost unintentional activities seem to determine this. Ethics assumes a different role in this situation. Because of the complexity of the relationship between science and society, and the uncertainty of many recipes, ethicists cannot act as police officers precisely because there are no offenders to identify. They cannot act as lawgivers either, because the given principles or laws do not give sufficient assistance in complex or new cases.

So, what principles can guide us, and who decides on these principles and their application? As a preliminary answer I will propose a structure of the landscape life scientists are moving in; I can try to sketch out a map, with the main roads and their relative advantages and disadvantages. To continue the metaphor a little further, on this map there are at least three roads that intersect at a number of junctions, even merging on occasion. One of these roads leads you from alarmist polluted and depleted landscapes to optimistic, bright, diverse and happy landscapes; so this road brings you to the state nature and life are in. The second one allows you to take in internalists' spots with lots of ivory towers and ends up at externalists' positions where anything goes. So this road gives you a ride along the various ways scientific knowledge is seen. The third road takes you from the casinos of private research to the more sober private public partnerships and finally the frugal public research institutes and all kinds of buildings in between.

Scientists are somewhere on all these roads simultaneously, and perform quite a lot of balancing acts at the intersections of these roads. In this short paper I will delineate the main ethical issues involved in steering a middle way between the extremes of these roads. Subsequently, I will discuss the responsibility of scientists between an alarmist and over-cautious position with respect to the environment; the responsibility of scientists between an arrogant expert attitude and an ivory tower attitude; and finally the responsibility of scientists between private and public interests. On all these roads and their intermediate crossings we can discuss cognitive and normative tasks, which means that one can look for theoretical structures and empirical facts and for normative values like communicating and participating in societal debates.

Responsibility of scientists between an alarmist and over-cautious position

A good example of alarmism is the message from scientists in the seventies and eighties that acid rain would destroy the forests and rural areas. The phenomenon to be declared was a considerable loss of foliage, and the hype started with German forest scientists that acid rain was the cause. Although the huge amount of studies did produce useful data, they also as a whole gave the impression that something was seriously wrong and something had to be done about it urgently (Lomborg 2001).

Sounding the alarm that the environment is going havoc has the consequence that psychologically people feel more uncertain. Politically, a strong case is made for changing research and policy priorities towards analysing and controlling alarming phenomena. However, the intention to be alarmist ('scare them to death') it is not always necessary to still give the impression that one is an alarmist. The mass media and other publicity interests often give rather serious and sober reports on an empirical state of affairs an alarmist slant; so scientists should be careful not to fall into this trap and to take their measures and be prepared. One reason is often that scientist publish their results on very specific relationships (like the ecological relation between the demise of a marine species and the increase of fishing industry) without taking into account other disciplinary perspectives (e.g. other biological and sociological perspectives; more examples in Korthals 2005).

However, at the other extreme is the position of being over-cautious or conservative: which means that scientists are excessively cautious when drawing conclusions and continuously arguing that there is not sufficient proof of the deterioration of the environment in general and that one needs more evidence, which makes for a very high standard of evidence. This position is often taken after the experience that one was indeed in an earlier phase of one's development alarmist and the rather understandable reaction is then to refrain from political and social communication altogether. Very often controversies and possible antagonistic reactions by colleagues or funding agencies can also compel one to take an over-cautious stance. The environmental scientist Schneider explains this dilemma in an interview with Discover from 1980: 'On the one hand we, as scientists we are ethically bound to the scientific method, in effect promising to tell the truth, the whole truth and nothing but – which means that we must include all the doubts, the caveats ... On the other hand (...) we have to offer up scary scenarios, make simplified, dramatic statements, and make little mention of any doubts we might have. This 'double ethical bind' we frequently find ourselves in

…' (cited in Schneider 2002). However, controversies are not a reason for doing nothing. However understandable this reaction may be, if there is sufficient reason to communicate to the public that certain states of affairs are really worrying, scientists should do this.

Responsibility of scientists between arrogant expert and ivory tower attitude
The Ivory Tower or isolationist attitude is one that was cherished in particular during the heyday of the amateur scientist, in the eighteenth, nineteenth and early twentieth century. This kind of aristocratic conception of the scientists stimulated the building of high walls between science and society, in the public interest, so that science could flourish as much as possible, as in the Humboldt ideal of the universal scientist. Only in the long run, according to the isolationist position, will society harvest the good fruits of science. The other extreme, the ideal of the arrogant or all-knowing expert who decides on the facts, and leaves the decisions to the politicians, is emphasising that society should start this harvest in the short run; the arrogant expert is convinced that society should take the data and theories seriously with immediate effect. This position became dominant in the fifties and sixties of the last century. The public was conceived to be irrational and totally lacking in expertise.

Responsibility between private and public interests
One rather new phenomenon for the life and environmental sciences is the huge cooperation between private and public organisations in funding and prioritising research and development studies. The numbers of scientists working for the life science industry is still rising (Brown 2000). In life sciences other than the environmental sciences, such as the medical and food sciences, the influence of private industry is already considerable (Korthals 2004b; Etzkowitz 2002). As is clear from several contributions in this volume (Knip, Van Andel, Bouma) environmental scientists are very often caught up in public/private conflicts of interests. Environmental scientists working for private companies (like Alterra in the Netherlands) or for NGOs (like the Waddenvereniging or Greenpeace) are supposed to act from different interest positions than scientists working in public services, but sometimes have problems with these situations. Although the rise in new private/public partnerships has not advanced that much in the environmental sciences, it can be predicted that with the emergence of new biotechnologies in saving the environment the number of those partnerships will increase, because they have lots of advantages, and many governmental funding agencies are encouraging this cooperation though co-matching. One of the advantages for the environmental and life sciences is direct reciprocal learning between scientists, engineers, and industrial professionals. However, there are also disadvantages, in particular if the differences between the private interests of the companies or NGOs and the public interests are not taken into consideration and the individual scientist has to bear the burden. Public interests are articulated on the basis of accepted standards of justice and widely shared social values, whereas private interests mirror partially shared values.

Avoiding extremes and still being a good environmentalist

The three roads with their conflicting start and end points represent three different types of dilemmas: the one between alarmism and over-cautiousness, between arrogant expertise and ivory tower and between private and public interests, do require different attitudes (values) and competencies. There is no general recipe for travelling these roads, although the rather obvious advice of the Greek philosopher Aristotle to try to stay away from extremes still holds true. However, environmental scientists are not in a double bind, as Schneider suggests. There are some ethical guidelines that have value in finding an ethically acceptable way down the three roads. With respect to the first road, one should avoid the alarmist position, as being against the value of speaking the truth, but also over-cautiousness as a result of interdisciplinary laziness should be prevented. One could very much improve the insight that something in the environment is deteriorating in one way or another, by expanding one's disciplinary research to include that of other disciplines, because multiple confirmations always deliver more validity epistemologically than a single methodological proof. So, one should proactively look for interdisciplinary evidence.

The dominant value to tackle the second dilemma is that of modesty: on the one hand scientists should take into account that because of the priority given to their research (and not to others), and the fundamental values underlying research, their research projects are not value free, and in that sense cannot claim to be based solely on facts. Different priorities and fundamental underlying values, give different types of research output. On the other hand, should scientists stand up and be counted when they perceive something to be wrong or interesting in society, on the basis of their critical evaluation of facts produced by themselves and others? A cognitive aspect of this virtue is critical truth-seeking and the normative component is a continuing effort to communicate with the public, without disrespecting it as irrational, emotional or ignorant (Valenti 1995).

The virtues that enable us to tackle the third kind of dilemmas concern primarily being integer and transparent on one's interest and performing scientific activities in an accountable way (Kitcher 2001). It should become standard practice for scientists in publications to make public their sponsors and the financial transactions that are relevant to the project, and that they can be held accountable for potential risks. Moreover, we need institutions that identify and oversee the main disturbing conflicts of interests and conflicts of commitments (Bulger 2002).

In schematic form, the various dilemmas and the ethical competencies (Korthals 2004a,b) that they require both from the cognitive and the normative point of view, look like this:

Dilemma *Normative orientation*	Alarmist/ over-cautious	Expert/ ivory tower	Private/public
Cognitive	Interdisciplinary conscious	Modesty; truth seeking	Integrity; sharing results
Normative	Contributing to research priorities	Communication with public	Transparency on conflicts of interests; accountabili- ty

Cognitive and normative virtues on the three intersecting main roads of modern science

Conclusion

Environmental scientists are often confronted with several types of dilemmas. On the one hand, they are often overwhelmed by evidence that parts of the environment are deteriorating, but on the other hand they are conscious of the fact that the relationships between deterioration and its causes are incredibly complex. So they are torn by alarmism or over-cautious; they are often confronted with an ignorant public or a public that only pays attention to existing environmental problems, which can elicit an elitist or ivory tower response. Thirdly, huge interest positions are at stake in doing environmental research, and this can give rise to conflicts of interests for the scientists working in the field. In this article I have pleaded for scientists to adopt an interdisciplinary, modest, integer, participating, transparent and responsible attitude when tackling these ethical dilemmas.

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LOUISE E.M. VET

Science in society: how to improve environmental awareness

Introduction

The central question of the conference was why policy-relevant research in the environmental sciences has so little influence at the level of political decision-making. The speakers approached the topic from diverse perspectives. In my opinion many of the issues discussed point to a central problem: inadequate communication between scientists and society. First of all, too many scientists do not make the effort to be advocates for their research, and to communicate their findings in an accessible way to a wide audience. Second, communication about science and its achievements is utterly insufficient, sometimes incorrect and frequently ineffective.

Insufficient communication: unknown, unloved

'It takes a village to raise a child', so if we want to see environmental awareness at the policy-making level we first need an environmentally, scientifically literate society. We have failed to achieve this in the Netherlands. The low level of societal interest in the natural environment, and science in general, has its roots in our educational system. At primary school, students aged eight to twelve, are taught no more than 75 minutes of science per week (i.e. biology, physics, chemistry, and technology) (Biologische Raad 2003). What is worse is that the teachers themselves, at the teachers' training college, are deprived of any significant factual knowledge about science and nature. How then can we expect these teachers to inspire and convince our children that science is fun and necessary and that our natural environment is valuable and in need of protection? Science, in general, should not only be taught through knowledge dissemination but also through action and experience. 'Outside' experience is crucial for enlightening a nature-loving mentality. Unknown, unloved. Children need to experiment and explore to embrace scientific thinking. At present, our educational system is failing to reach them, or action is taken too late. And beyond primary education, at high school, for most teenagers identity issues and hormones are more important than a healthy environment. I regard the failure of our education system to raise interest in matters of nature and science as the major structural reason for a general lack of scientific interest in our society.

We are totally neglecting an even larger future problem: through increasing urbanisation and computer and television dominance the present 'back seat generation' no longer grows up with any kind of 'green' experience and is thus further losing touch with nature. Present-day children have little real understanding of what 'nature' is or what biodiversity means (Verboom et al 2004). British primary school children were shown to know more about various ‘species’ of Pokémon characters than about plants and animals (Balmford et al 2002). Yet from their ranks must come the future environmental policymakers and nature conservationists! It will become a lonely profession, a voice crying in the wilderness (if there still is any). Hence, there is an even greater need and urgency for scientists to reach today’s teenagers, with their own world and values, than to reach their baby-boomer parents who are now dominating the world of research and politics but that still grew up in a relatively nature-loving world.

Incorrect communication: firm statements need firm science

Scientific research provides the basis for understanding processes and their underlying mechanisms. Science is responsible for unequivocal information. Yet any data set is subject to a certain degree of differential interpretation, especially when taken out of its wider context. Conclusions can emphasize certainties or uncertainties, the glass is half full or half empty, whatever suits the user. Scientists must therefore feel responsible for the interpretation of their data and not refrain from taking a firm stand when all point in a certain direction. Of course firm statements must be based on firm science. Several of the speakers (e.g. Perrings) emphasised the risk of applying the so-called precautionary principle to protect the environment. I agree that it can only pay off in the long run when it is carefully applied, constantly re-evaluated and updated with additional research on how to mitigate. Information to the public should be free of exaggeration and based on state-of-the-art-knowledge. But ecologists – unlike economists – often seem to lack firmness in their conclusions, point to uncertainties rather than certainties, leaving others to freely interpret the data, leaving a lot of leeway for opportunistic short-term decision-making or political inertia. When data are convincingly strong to the scientists, scientists should be firm in their message to the general public. The Dutch cockle fishery case, where more than 100 biologists joined forces to tell policymakers to end this most disastrous practice in the Wadden Sea (see Van Andel) is a good example of clear and unequivocal information that is appreciated and acknowledged by the public (excluding the cockle fishers…).

Ineffective communication: why laymen love Lomborg

Everyone loves positivism. Defeatists are a burden. Being aware of this common human trait, scientists must make an all-out effort to emphasise the positive achievements of environmental research and policy-making even when the facts are serious and embittering. Unfortunately, to the public the ‘grey literature’, (mis)used by an optimist (and in my eyes unimportant scientist) like Bjorn Lomborg, is worth as much as the many and solid *Nature* papers by excellent scientists. The media endorse specific views by giving undue attention to sceptics and by ignoring the views of serious scientist (see Monbiot 2004 who explains exactly why this is so).

But we can learn something from Lomborg’s psychological impact. Pointing to positive achievements is crucial to get things done in the future. It will stimulate positive awareness, additional action, creative solutions and multiple approaches, see e.g. partnerships as a tool for conserving biodiversity, advocated by Wilson (2002). It will arouse political involvement (you can score with successes) and stimulate technical solutions where possible. It facilitates the achievement of consumer-driven demands that are very powerful in persuading or forcing industries to take their responsibilities, of course critically followed by our valuable NGOs. We will always need our nit-picking NGOs and environmental protection agencies to point to the many serious shortcomings and the need for future action. Without them, major accomplishments in the past would not have been achieved.

Epilogue

Environmental issues, crises and especially successes should be made part of our historical thinking, our societal identity and our chemistry, biology and geography knowledge. Our educational system needs radical changes in emphasis and there is an important role here for the (easy access) media. Science in newspapers and in television programmes should not only focus on recent hot topics but also generate historical awareness of environmental issues. Knowledge of successes entails positive messages that taste like more. I am convinced we will need these successes sooner than most people think.

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International Union for the Conservation of Nature (IUCN)

IUCN and the scientific community

IUCN, the World Conservation Union, was founded in 1948. Its mission is 'to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable.' IUCNs members, coming from some 140 countries, include 77 states, 114 government agencies, and more than 1,000 NGOs. More than 10,000 internationally recognised scientists and experts from more than 180 countries volunteer their services to its six global commissions. Its 1000 staff members in offices around the world are working on some 500 projects. For more than 50 years this 'Green Web' of partnerships has generated environmental conventions, global standards, scientific knowledge and innovative leadership. IUCN builds bridges between governments and NGOs, science and society, local action and global policy. It considers itself a world force for environmental governance. IUCN is known for its 'Red List of Threatened Species' as well as the worldwide known 'Categories for Protected Areas'.

From the days of its foundation IUCN has been focussed on informing decision makers and exchanging information within the scientific community nationally and internationally on the importance of biodiversity and ecosystem conservation. IUCN works on translating scientific information on conservation matters into policy advice, both for the public and private sector. At the same time it carries out projects in these fields and aims to provide relevant and scientifically correct information to the public.

Europe and the World Ecology

The IUCN Netherlands Committee (IUCN NL) is the platform organization in the Netherlands of the members of the IUCN. Apart form executing ecosystem based small grants programmes, IUCN NL carries out the programmes 'the Netherlands and the World Ecology' (NEW) and 'Europe and the World Ecology' (EWE). These programmes conduct research on the consequences of economic activities on global biodiversity as well as communicating the findings to relevant actors.

In 1980, the World Conservation Strategy (WCS), a joint initiative by IUCN and World Wildlife Fund was released. The WCS was a call for developing ideas and activities to establish responsible management of our earth's natural resources. The program: 'Netherlands and the World Ecology' (NWE) resulted from the Dutch version of the WCS made by IUCN NL. By addressing the impact of economic activities on biodiversity the NWE-program contributes to raising environmental awareness at governmental and corporate level.

Over the years the IUCN NL has produced several publications concerning the ecological effects of the Dutch and European economy:

- A first report *Netherlands and the World Ecology* was published in 1988 and was substantially revised in 1994 and accompanied by a map.
- Mining and the Mineral Industry in Tropical Regions, a map showing impacts on rainforest and mangrove areas and their connections with the Dutch economy, was published in 1995.
- Mining in Tropical Regions, a book concerning Dutch involvement in the mining sector and the environmental effects, was published in 1996.
- The Netherlands and the World Ecology, a map assessing the seizure of land used internationally in connection with the needs of the Dutch economy was published in 1996. In this map differences in impacts and ecosystems were taken into account.
- The Dutch, Nature & Tourism, a map that gives insight into the relation between outbound tourism from the Netherlands and the effect it has on nature and culture at the destinations that are visited (published in 2003).
- Soy and Oil Palm, a map focussing on the Dutch imports of soy and oil palm products. The responsibility of The Netherlands in role of one of the world's major importers of soy and oil palm products different impacts on ecosystems in the producing countries are covered (published in 2004).
- The European Union & the World Ecology, a map assessing the numerous connections of the EU with the rest of the world through the import of commodities. The varying impact of the production and transportation of these goods on ecosystems worldwide is discussed on the map (published in 2004).

The European Union (EU) is the world's largest economic entity. It has many links to many other parts of the world through trade, investments, development co-operation programmes and tourism. Through Europe's import of a wide range of materials, a very considerable European impact exists on biodiversity worldwide. Europe's total ecological footprint is second only to that of North America. If all people on earth would use the same level of resources as Europeans do, we would need 3 planets to sustain our needs.

Recently IUCN NL produced the map: European Union and the World Ecology. The focus of the map is on the environmental impact on countries in Southeast Asia, Africa, and South America, as they possess rich and diverse ecosystems. The map aims to raise awareness of particularly those actors inside the EU that can make a difference in changing our unsustainable practices. If one considers Europe's relatively high standard of living, Europe is well placed to work on reversing the current crisis our global ecosystems are confronted with.

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Abbreviations

BSE	bovine spongiform encephalopathy
EFA	ecological footprint analysis
GMO	genetically modified organism
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature (now: World Conservation Union)
KNAW	Royal Netherlands Academy of Arts and Sciences
KNMI	Royal Netherlands Meteorological Institute
MTBE	methyl tert-butyl ether
NWO	Dutch Granting Organization for Research
PCBs	polychlorinated biphenyls
RAWOO	Netherlands Development Assistance Research Council (Raad voor het Wetenschappelijk Onderzoek in het kader van Ontwikkelingssamenwerking)
RIVM	Dutch National Institute of Public Health and the Environment (Rijksinstituut voor Volksgezondheid en Milieu)
RMNO	Advisory Council for Research on Spatial Planning, Nature and the Environment (Raad voor Milieu en Natuuronderzoek)
UNCED	United Nations Conference on Environment and Development (UNCED),Rio de Janeiro, 3-14 June 1992
UNEP	United Nations Environment Programme
WCED	World Commission on Environment and Development
WMO	World Meteorological Organisation
WRR	Netherlands scientific council for government policy (Wetenschappelijke Raad voor het Regeringsbeleid)
WWF	World Wide Fund for Nature