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# VALUATION OF ECOSYSTEM BENEFITS FROM AIR POLLUTION ABATEMENT

Summary report of the workshop by its Chairman
in collaboration with the secretariat

## Introduction

1. The Netherlands Ministry of Housing, Spatial Planning and the Environment organized and hosted the second workshop of the Network of Experts on Benefits and Economic Instruments (NEBEI). The workshop on the valuation of ecosystem benefits from air pollution abatement was held on 2 and 3 October 2002 in Scheveningen (Netherlands). The papers and presentations can be found on the Internet at http://www.unece.org/env/nebei.

2. The workshop was the second NEBEI workshop following the one held on 19-20 February 2001 in London, which had focused on the health effects of air pollution. NEBEI aims at developing further the economic work on benefits undertaken by the former Task Force on Economic Aspects of Abatement Strategies. An economic benefit assessment had been prepared in support of the negotiations of the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. This work had been summarized by the Task Force



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(EB.AIR/WG.5/1999/15); the complete background report is available at http://www.unece.org/env/tfeaas. Effects on natural ecosystems had not been included in the assessment because there was insufficient information on their valuation. The objective of this workshop was, therefore, to fill one of the gaps in the previous work.

3. The main purpose of the workshop was to identify: (a) the state of play in ecosystem valuation; (b) the degree of credibility of existing benefit estimates; and (c) the remaining research challenges.

4. Experts from Canada, Croatia, Czech Republic, Denmark, Estonia, France, Georgia, Germany, Latvia, Lithuania, Netherlands, Norway, Republic of Moldova, Slovenia, Sweden, Switzerland, United Kingdom, United States, and the European Community, as well as from the European Chemical Industry Council (CEFIC), the Oil Companies' European Organization for Environment, Health and Safety (CONCAWE), the World Conservation Union (IUCN) attended the workshop. The Coordination Center for Effects, the EMEP Centre for Integrated Assessment Modelling (CIAM), the Programme Centre of the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation) and the secretariat also participated.

5. In the absence of Prof. D.W. PEARCE (United Kingdom), rapporteur of NEBEI, due to health problems, Mr. J. SLIGGERS (Netherlands) chaired the workshop.

## I. ROLE OF BENEFIT ESTIMATION IN THE WORK UNDER THE CONVENTION[1]

6. The negotiations of the effects-based emission ceilings in the protocols under the Convention, most recently the Gothenburg Protocol, are based on calculations of integrated assessment models. The models calculate abatement strategies on the European scale that essentially minimize the overall cost of abatement for given levels of health and ecosystem protection. Protection levels are not pre-established, but are effectively determined when the trade-off between cost and protection is made clear through the analysis of various scenarios. Ecosystem protection is measured in terms of the ecosystem areas that do not exceed critical loads or levels, i.e. depositions or concentrations at which no significant ecosystem damage is expected. The long-term objective is to reduce pollution so that critical loads and levels are not exceeded anywhere. Negotiators make a judgement about the 'affordability' of the varying degrees of ecosystem protection. Whatever the level of protection corresponding to the chosen trade-off, abatement costs are, by and large, minimized through explicit modelling, which allocates emission reduction efforts according to Parties' varying abatement costs. Negotiators do therefore make some sort of

1 This section and the introductory paragraphs of the following sections are based on an introductory note prepared by Prof. D.W. Pearce for the workshop.

trade-off between costs and benefits. However, in the absence of an explicit cost-benefit analysis covering natural ecosystems in which the monetary value of benefits is compared to the cost levels in question, the work cannot go beyond cost-effectiveness analysis.

7. That cost-effectiveness should play a central role in the work is a great achievement and positively contrasts to other internationally negotiated agreements that are not cost-effective. However, it has always been recognized that the process of trading off costs and effectiveness would be better informed if there was some idea of the monetized value of the ecosystem benefits. The efforts made so far in this respect have focused on human health effects – the subject of the first NEBEI workshop – and other impacts (e.g. impacts on materials and buildings and on crop loss) where monetization was thought to be credible. Non-agricultural ecosystem effects have been regarded as fairly speculative, although some estimates have been made. Health effects have dominated the cost-benefit studies made and there tends to be a systematic outcome that benefits exceed costs, although health benefit estimation remains uncertain.

## II. APPROACHES TO ECOSYSTEM VALUATION

8. Most approaches to ecosystem valuation see any given ecosystem as a multi-product asset. Any system produces many services, and those services all have economic value in so far as they affect human well-being in one way or another. This suggests that the approach to valuation first involves a production function linking ecosystem outputs to inputs, where inputs are often stocks of interconnecting assets. Perturbations to the system, e.g. through pollution, should then be capable of being modelled via the production function analysis. Individuals' valuations of the changes in the services resulting from the perturbation should then be elicited by the 'usual' means – revealed and stated preference analyses.

9. Such a concise statement of what is needed conceals many pitfalls. First, the valuations in question must relate to a clearly identified baseline – i.e. what would happen if the perturbation had not occurred. Given that ecosystems are not static entities, defining the baseline is not necessarily straightforward. Second, the nature of the change that individuals value must itself be identifiable and understood. Examples of changes that may be ecologically significant but which often do not show up in human perception include things like small changes in river flow. What may be important here is identification of the threshold level of change at which humans do 'take notice' - what may be called the 'just noticeable difference' in ecosystem performance. Third, the production function procedure yields a set of apparently additive values with the total being the total economic value of the ecosystem. But there are several well-known problems. The first is the risk of overestimating total economic value when there are substitutes and income constraints, i.e. there is a risk of double counting. The second is a risk of undervaluation if there is a sense in which the 'whole' of the ecosystem is more than the sum of its parts. The third problem arises from the valuation techniques themselves: some of them measure use values only, and it is not

always clear what is being valued by some of those use value techniques, e.g. the property price approach. These problems of aggregation perhaps explain the bias shown by economists in using stated preference techniques to derive ecosystem values. But these techniques have their own problems and perhaps a major one in the context of ecosystem valuation is the issue of 'cognitive load', i.e. whether people really can comprehend and separately value the components of overall ecosystem service.

10. Mr. Douglas MacMillan (University of Aberdeen, United Kingdom) presented a scoping study on the valuation of air pollution effects on ecosystems conducted for the United Kingdom Department for Environment, Food and Rural Affairs. The study critically reviewed the recent literature on attempts to value ecosystem damage from air pollution and proposed priorities for future research into ecosystem benefit estimation in the United Kingdom. Over 100 valuation studies were reviewed, encompassing both terrestrial and freshwater ecosystems, and assessed with respect to their applicability to current policy needs. Relatively few of these studies were considered suitable on the grounds of outdated valuation methodology and/or weak scientific underpinning. The report suggests that new research in ecosystem valuation should (a) incorporate dynamic modelling approaches to predict environmental recovery in ecological rather than chemical terms and (b) apply more sophisticated 'deliberative' approaches to estimating willingness to pay for non-market benefits. Deliberative methods give the general public more time and information to understand the complexities of ecosystem recovery from air pollution than conventional interviews and hence should generate more reliable benefit estimates. The full report is available at: www.defra.gov.uk/environment/airquality/ecosystem.

11. Ms. Elisabeth Ruijgrok (Witteveen en Bos, Netherlands) discussed the role of valuation in the political decision-making process based on the experience in the Netherlands. She presented a range of methodologies that can be used for ecosystem valuation. The key questions are the socio-economic value of nature and how different views on nature determine valuation. A number of approaches can be distinguished:

- The "hands-off" approach leaves no room for economic valuation;
- According to the "classical view" nature needs to be protected against economic activity and this is best done by fencing it off. Also the "nature development" approach favours the creation of areas where natural processes can develop. These approaches favour an ecological valuation with the use of (physical) indicators focusing on the welfare of plants and animals;
- The "co-evaluation" approach emphasizes a dual role for nature and sees a role both for a socio-economic valuation (based on the welfare for human beings by production-, regulation-, information-, and non-use functions) and an ecological ("intrinsic") valuation;

- According to the "functional" view of nature a financial valuation emphasizing the income-generating function of nature for human beings should be pursued.

Any decision-making process has to make some judgement about the value of nature, at least implicitly. A transparent process would make this explicit. Often, nature is kept out of cost-benefit studies and is not adequately taken into account in the decision-making process. It is important to keep economic valuation as a complement to not a substitute for the ecological (intrinsic) value of nature.

## III. SPECIFIC VALUATION STUDIES

### A. Forests and nature in general

12. Ms. Elisabeth Ruijgrok and Mr. Piet Klop (ECORYS- NEI, Netherlands) presented a study on using a contingent valuation method (CVM) to estimate the benefits of increased nature quality due to reduced acidification in the Netherlands. The study aimed at determining the effect of acid and nitrogen depositions on the non-use and perception value of all nature in the Netherlands. In order to determine the benefits of increased nature quality due to the abatement of acidification, it had to estimate the difference between the welfare generated by healthy ecosystems not suffering from acidification and the welfare resulting from unhealthy ecosystems that are affected by acidification.

13. The study shows that CVM can be used to estimate two specific values attached to increased nature quality: the non-use value and the recreational value. For other benefits, other valuation methods are needed. The study also shows that CVM is not suited for specifying benefits of acidification scenarios if they differ only little in their physical effects. To examine the use of CVM for estimating the benefits of increased nature quality related to acidification, a CVM survey was designed. The design of the survey was improved on the basis of a pre-test. All respondents turned out to be familiar with the environmental theme of acidification. A first test survey indicated that the willingness to pay for eliminating the effects of acid and nitrogen depositions to ecosystems was about €30 per year per household, which is equivalent to a total of €200 million per year for the Netherlands.

14. The benefits of increased nature quality due to acidification abatement are estimated in order to allow for a complete cost-benefit analysis of acidification policies. Several benefits of acidification abatement, such as reduced health risks and damage to agricultural crops have already been examined, but the benefits of increased nature quality are still lacking, even though nature is actually one of the most important motivations for abating acidification in the Netherlands. The results of the pre-test presented in the study suggest that the benefits of nature may be quite large.

15. Mr. Bert Droste-Franke (University of Stuttgart, Germany) discussed the assessment of benefits for ecosystems within the European Community ExternE project series. The impact pathway analysis originally developed within ExternE is a bottom-up approach starting from activities, estimating the resulting state and deriving the related impacts by considering affected receptors of risk and, finally, calculating damage costs. The estimated damage costs are ideally based on direct valuation methods. The methodology for the ecosystem valuation was applied within a number of European Community research projects: the NewExt project, the GreenSense project (focus: green accounting), the UNITE project (focus: transport accounts), and a local project concerning the extension of Frankfurt Airport. The valuation techniques were used in a very heterogeneous manner. The main reason was a lack of knowledge concerning the impact pathway processes and the socio-economic value of total ecosystem services. Thus, the impact pathway could often not be followed to the final impact on human well-being. Often, as a second-best option, only indirect valuation techniques could be applied like, for instance, using abatement and remediation costs. Significant improvement could be expected from increasing the knowledge about cause-effect chains, estimating sound values for welfare-related functions of specific ecosystems, and developing methodologies which are able to cope with life-support functions of the whole ecosystem.

16. Ms. Linda Chapell (Environmental Protection Agency (EPA), United States) presented the Integrated Forestry Ozone Regulatory Modeling System (InFORMS), which was used to estimate the economic benefits of reduced ozone damage to Eastern United States forests resulting from the EPA Heavy Duty Engine/Diesel Fuel Final Rule. The study focused on commercial forest productivity. She also briefly discussed attempts to estimate forestry aesthetic effects related to air pollutants and highlighted future research requirements.

17. Ms. Gina Mills (United Kingdom), Chairperson of ICP Vegetation, presented a study conducted by a consortium of scientists under her direction, and funded by the United Kingdom Department for Environment, Food and Rural Affairs. The overall aim was to provide a comprehensive assessment of the economic effects of ozone on crop yield in Europe for 1990, as a baseline, and for 2010 for three pollution-control scenarios, including the benefits of implementing the Gothenburg Protocol. Within the confines of the uncertainties described, the losses for 1990 were estimated at €6.8 billion across Europe, falling to €4.8 billion assuming implementation of the Gothenburg Protocol across Europe in 2010. Examples of the geographical distribution of the losses were presented, showing, for example, that the highest losses per country were predicted to be for wheat in Sweden (48.9% of total losses), for potato in Belgium (46.8%) and for cotton in Spain (25%), where losses were more evenly spread across several commercially important crops. The study was presented to the Working Group on Effects in document EB.AIR/WG.1/2002/10. Progress with defining ozone-response functions for over 100 species of semi-natural vegetation was also described.

## B. Water ecosystems

18. Mr. Ståle Navrud (Agricultural University, Norway) presented a study that aimed at linking physical and economic indicators of environmental damage from acidic deposition in Norway. The study used the concept of critical loads as an indicator for sustainability to describe the environmental change to be valued. Using a contingent valuation method, it estimated the stated preference for increasing the number of Norwegian lakes with undamaged fish stock.

19. The questions on the willingness to pay (WTP) for reducing acid rain damage to fish stock were framed in the context of a national liming programme that had the same impact as is expected from the 1994 Oslo Protocol on Further Reduction of Sulphur Emissions. These questions were linked to a larger study that also covered respiratory symptoms from air pollution and noise from road traffic. The national liming programme scenario avoided the problem of respondents stating zero WTP to protest against paying for reducing sulphur depositions that are mainly caused by emissions in other countries (Norway receives more than 90% of its sulphur depositions from other countries). Thus, only 7% of the respondents protested against the scenario for this reason. This shows the importance of being careful in constructing contingent valuation scenarios for valuing impacts from transboundary pollution. WTP depended on whether different sums of money were proposed to respondents to choose from or whether the question on WTP was left open-ended. The latter resulted in a lower average WTP. Combining the two, the annual WTP per household for protecting Norwegian fish stock in line with the Oslo Protocol was estimated at €40-80 per year. This would amount to an overall annual WTP in Norway of €80-150 million.

20. Ms. Linda Chapell (EPA, United States) presented results of a study on the acidification of freshwater bodies and the eutrophication of estuaries estimating the benefits and costs of the United States Clean Air Act between 1990 and 2010. One part of the study evaluated the benefits from recreational fishing in the Adirondacks regions of New York differentiating a scenario with and without regulations. Another part attempted to estimate the benefits related to changes in nitrogen air deposition to directly estuary water bodies and indirectly through land use affecting deposition to watershed areas. Decreases in nitrogen deposition ranged from 38 to 43%for the estuaries evaluated. Given the high uncertainty in the estimates, the calculated benefits were not added to the overall benefit assessment for the Clean Air Act. Further work on this project is under way.

## C. Terrestrial ecosystems and groundwater

21. Mr. Rafael van der Velde (Witteveen en Bos, Netherlands) presented a study on benefits associated with groundwater with reduced contamination from nitrate, aluminium and heavy metals. The study developed a method to calculate the benefits of improved groundwater quality,

linking reduced acidic and nitrogen depositions to three factors important for the drinking-water sector:

(a) The avoided costs of additional steps in the treatment of groundwater;

(b) The increased lifetime of the drinking-water infrastructure due to reduced corrosion; and

(c) The reduced or avoided maintenance costs for pumping wells.

Given that some of the effects act only with long delays and much of the damage is irreversible, the estimated benefit strongly depends on the selected time horizon and the assumed discount rate.

22. Mr. Arjen van Hinsberg and Mr. Hans Kros (National Institute of Public Health and the Environment (RIVM), Netherlands) reported on work to model the consequences of air pollution for biodiversity. Multi-stress models (like SMART-SUMO-MOVE) can be used for predicting changes in biodiversity related to air pollution. In the Netherlands these models are used for calculating critical loads for biodiversity reported under the Convention. The natural capital index (NCI), developed as a contribution to the implementation of the Convention on Biological Diversity, can also be computed with these models. Modelled effects on groundwater quality, vegetation structure, and occurrence of species, which are also visible in the field and confirmed through monitoring, can be used for the valuation of the benefits to nature resulting from air pollution abatement.

23. Mr. Wieger Wamelink (Alterra, Green World Research, Netherlands) presented a study on the additional costs of nature management caused by deposition. A method has been developed to calculate the costs of intensifying nature management to counteract the effects of atmospheric deposition. The percentages of protected species belonging to 'nature target types' defined for the Netherlands are used as a measure of the ecological quality resulting from intensified management. Preliminary results show that a set of modelling instruments can be applied to assess these costs. Model outputs show clear shifts in nitrogen availability for heaths and grasslands, though no differences are found for forests. The percentage of protected species in heaths has clearly changed. In the present situation, with sods being removed from heaths every 20 years, the costs of maintaining heaths exceed those in a situation of sod-cutting every 60 years by €1.4 million per year for the whole of the Netherlands. This is approximately €50 per hectare of heath-land protected.

## IV. CONCLUSIONS AND RECOMMENDATIONS

24. In the light of the presentations and the discussion, the workshop agreed on the following conclusions and recommendations related to the role and methodologies for ecosystem valuation and to future work.

## A. Valuation of nature – scope and methods

25. Policy makers should be presented with the following information to reflect the value of natural ecosystems:

(a) Estimates of the socio-economic value (welfare for human beings by estimating production-, regulation-, information-, non-use functions, and if possible, value the life-support function of ecosystems); and

(b) Information about the ecological ("intrinsic") value in physical terms.

It is important to keep economic valuation as a complement to not a substitute for the ecological (intrinsic) value of nature.

26. Valuing nature in economic terms can play an important role in the political decision-making process. Any decision relies on some judgement about the value of nature, often only implicitly. It is better to make such judgement explicit. If nature is kept out of cost-benefit or other studies it may not be adequately taken into account in the decision-making process.

27. Benefits estimates are used for:

- Cost-benefit analyses;
- Calculations of the marginal external cost;
- Macroeconomic indicators (green accounting); and
- Technology assessments.

28. There are numerous methods to determine the economic value of nature related to air pollution abatement. The "filter method" identifies those functions of nature that may be affected by air pollution and assigns economic values to them. Where the market impact of air pollution abatement is limited, non-market techniques have to be applied. Such revealed or stated preference methods include contingent valuation (CV). CV is used to determine the value of some of the functions filtered out, such as the recreational value and the non-use value. CV uses a survey to measure the willingness to pay by questioning the public. This is particularly difficult if the physical differences are too small to be visible.

29. Among the difficulties with CV is how to deal with multiple effects: CV studies look at entire ecosystem ("service flow") functions not at specific ecosystem damage (e.g. acidification

and eutrophication effects on the dunes). Policy would, however, need an estimate of a problem-specific WTP or it would have to change the approach and focus on ecosystem functions.

30. A method to measure the value indirectly is to use compensation costs or avoided costs as a proxy. Using the abatement costs for the measures adopted may reveal the preference of the policy makers, but such benefit estimates (unless derived from different policy areas) deducted from abatement costs cannot be used for cost-benefit analysis. An example of using such a method to value ecosystem benefits from air pollution abatement would be to examine the implementation of the EC Habitat Directive. This Directive leads to high costs to protect certain species and some of these species are also threatened by acid and nitrogen depositions.

31. Methodologies for valuing nature are uncertain and there is a danger of under/or overvaluation. Undervaluation may especially occur in the case of risk of irreversible damage if only a limited time horizon is considered.

32. Ecosystem benefit estimates are likely to give very different results for different countries in Europe. European critical loads for acidification have been assessed for many, mainly terrestrial, ecosystems. These ecosystems respond in a different way to exceedances of their critical loads and at different time scales. Many of these ecosystems will have different use and non-use values, which will also vary across national boundaries.

### B. Future work

33. There is a clear need for more research, i.e. more ecosystem valuation studies. Funding in this area of research has so far been inadequate. The studies should be designed to allow for benefit transfer so that their results can be much more easily applied to other countries/areas.

34. To be able to develop ecosystem benefit estimates on a European scale it is necessary to apply the techniques of benefit transfer so as to use the results of the few existing studies focusing on one country on a broad geographic basis. Such a transfer usually implies adjusting for differences in income levels.

35. Validity tests suggest that the errors made by benefits transfers roughly range from 20 to 40%. (This does not include the uncertainty at other levels of the analysis.) More validity tests of this kind should be conducted in order to improve the benefit transfer. A European valuation study on mountain lakes in four countries (focusing on non-use benefits) is under way. It will also address the question of benefit transfer. An international database, the Environmental Valuation Reference Inventory (EVRI, http://www.evri.ec.gc.ca/), hosted by Environment Canada, has collected existing studies worldwide. NEBEI should use and contribute to this international database. All valuation studies should aim at including an annex conforming to the data format required by EVRI.

36. In the case of transboundary pollution, the benefit of pollution abatement should take into account the willingness to pay nationally (where the effects are observed) and abroad. There is the potential for a transboundary WTP, for instance, when particular natural heritage or biodiversity is concerned. The distributional questions, i.e. who should pay the cost, are not addressed by cost-benefit analysis.

37. Studies on the economic valuation of natural ecosystems should be based on a close link between natural scientists and economists so that the chemical/biological data are understood and used correctly and that natural scientists can produce the data economists need. This requires a closer link to the ICPs under the Working Group on Effects. NEBEI could offer support to work like that done by ICP Vegetation (see para. 17 above). A good link is also needed between economists and policy makers to ensure that the right questions are addressed.

38. Ideally, studies should adopt a long-term perspective using, where available, dynamic models to take account of hysteresis effects.

39. Stated preference methods are continuously being further developed as they are being applied. Increased application of deliberative stated preference methods (more in-depth interaction with the public that is questioned) could, for instance, raise the quality of the valuation.

40. Work to develop monetized ecosystem benefit estimates for the review of the Gothenburg Protocol has to be initiated soon. All Parties should examine possibilities for doing further work in their countries. These could be linked to the work at the European level and results be presented at forthcoming workshops.

41. Mr. M. Vainio (Directorate-General Environment of the European Commission) announced that, as part of the Clean Air for Europe (CAFE) programme, an open call for tenders would be launched before the end of 2002 to carry out the cost-benefit analysis of the options to further improve air quality in the enlarged EU. As the contract on cost-benefit analysis was likely to cover 3-4 years, the Commission could include one or several workshops under the contract. The purpose of the workshop(s) could inter alia be to improve the unit values used in the benefit assessment of improved air quality. In addition, such workshop(s) could be organized in a collaborative manner and thus provide one platform to continue the discussions started in the NEBEI workshops. He invited experts to come up with specific suggestions.