ANNUAL REPORT 2002

Science for policy

ASTA

ASTA INTERNATIONAL AND NATIONAL ABATEMENT STRATEGIES FOR TRANSBOUNDARY AIR POLLUTION
A RESEARCH PROGRAMME FUNDED BY MISTRA TOGETHER WITH ELFORSK, SWEDISH ENERGY AGENCY,
THE SWEDISH ENVIRONMENTAL PROTECTION AGENCY AND NATIONAL BOARD OF FORESTRY.

Index

Photographer: Hans Hultberg

Every year ASTA is required to make a yearly report. The report for the activities during the year 2002 is not a traditional report of what has been achieved within the programme during the past year. Instead we have chosen to let the report illuminate the teamwork between research and decision-makers within the area of transboundary air pollution. The reason for this is partly that the greater part of the results from the activities are shown in the synthesis report which was produced in connection with the evaluation of the program's first phase. Furthermore we have perceived that ASTA:s way of working, with teamwork between research and decision-makers, was noticed and was in demand from other researchers and other interested participants. The synthesis report and other descriptions of the work can be found on our home page http://asta.ivl.se.

We hope that this somewhat different disposition will give a new dimension to the work with transboundary air pollution in general and the work within ASTA in particular.

Peringe Grennfelt
Programme Director

The role of science for the Convention on Long-Range Transboundary Air Pollution (LRTAP) and the EU CAFE Programme (Clean Air For Europe)

LARS BJÖRKBOM, FORMER CHAIRMAN OF WORKING GROUP ON STRATEGIES WITHIN CLRTAP AND LARS LINDAU, CHAIRMAN OF ASTA, SWEDISH PARTICIPIANT IN SEVERAL GROUPS WITHIN CLRTAP AND CAFE

Background

The interaction between Research and Development (R&D) and policy-making is generally a complicated process, particularly in the field of environmental protection and still more so when a large number of governments/countries and different research institutions/disciplines and expert communities are involved. These complications have, however, in many cases been successfully mastered in the past, e.g. in the field of transboundary air pollution in the UN/ECE region and in the EU, as well as in global contexts such as the protection of the stratospheric ozone layer and the approaches to curb greenhouse gases.

It is important to differentiate the character of this interaction in, at least, two different phases. The existence of an environmental problem is generally initiated by various research communities and the process to convince policy-makers to address the problem faces its own special problems. If, and when, the politicians become convinced that some kind of measures have to be taken, the relationship between the policy-makers/counsellors and the research/experts communities changes. The politicians then address the research/expert communities asking them to develop effective, preferably alternative, solutions to the problem.

In the field of transboundary air pollution we have since long been in this second phase. No Government or stakeholder in the CLRTAP region today questions the reality of transboundary air pollution in the region and a great majority of political decision-makers are aware of the need to take stiff measures to address and master the environmental and health problems involved. The efforts under the ASTA programme could and should be considered as a response to such demands from the politicians. Therefore the interplay between R&D and policy-makers should focus on this phase and leave the earlier phase of awareness-raising to be considered elsewhere.

R&D as well as policy-making both have to consider uncertainties. R&D findings are always of a preliminary character and temporal in their validity. Policy-making is continuously open to changing priorities in the face of domestic and international circumstances. It is of great importance for both sides to reciprocally understand the conditions under which the other side is working. To achieve positive results, continuous interaction between the two communities during the process from development of the descriptive base, provided by the R&D community, to political decisions is desirable, perhaps necessary. A high degree of transparency should be the aim. The process of negotiating an international agreement is greatly facilitated if negotiators are involved in the process from the start and can act as knowledgeable, two-way intermediators between producers of know-

Informing decision-makers. In 2001, EU´s Commissioner for the Environment, Margot Wallström, visited the Gårdsjön research station and was informed by John Munthe about ASTA and the current status of the acidification and mercury problems.

Photographer: Per Hanstorp

ledge and the policy- and decision-makers in their respective governments and other stakeholders at home.

The process described above requires great competence and understanding among the various actors. The R&D community, often scientists or systems analysts, should interest themselves in, and better understand, the process of national and international governance. Policy experts and government counsellors/negotiators, need to familiarise themselves with the nature of relevant scientific findings. Further research in order to better understand the process briefly described above should be promoted.

LRTAP and EU – CAFE

The production of knowledge in the international cooperation on air pollutants, environmental/health impact and control programmes has been on-going since the early 70s. First within OECD and North America, and later within ECE-LRTAP and the EU. Research projects, interactions between scientists and scientists/policy-makers was started early. Three activities were especially important: The Norwegian development of a dispersion model for long-range transport of pollutants; the Swedish initiative on critical loads, i.e. what the environment can tolerate; and the Dutch/IIASA development of an integrated model (RAINS) where targets for environmental quality were and still are the starting point for development of cost-effective and "fair" control strategies in Europe.

The RAINS model became increasingly central in the development work. Several initiatives were also taken to coordinate research and assessment of the knowledge basis in Europe, e.g. EUROTRAC for research in atmospheric chemistry. The most important step was, however, the structuring of the LRTAP work with several International Cooperative Programmes (ICPs) on effects and EMEP for topics related to emissions, air quality and long-range transport. All of these organisations are based on active participation of scientists with strong links to universities and research institutes. The scientific development of RAINS by IIASA was made in close cooperation with other programmes and was discussed at workshops.

The success of these efforts can mainly be explained by the common interest of the countries in solving a problem and that politicians in many countries understood this problem and judged it as serious. The problems were so serious that the policy-makers were forced to listen to the scientists and experts. A specific problem that was observed early on was the transfer of knowledge from west to east. It was (and still is) necessary that the countries in Central and Eastern Europe participate under the same premises as the Western European countries. A successful method, used by Sweden and the other Nordic countries, was to arrange workshops where internationally renowned scientists could present results and participate in summarising and synthesising the current status of knowledge. Some criticism and specific views came from the private sector, which also contributed by funding complementary research. This proved to be very beneficial and these results could be incorporated into the process thereby increasing its credibility.

In Sweden, the EPA allocated significant sums, several hundred million SEK (several tens of millions EURO) for research on acidification between 1970 and 2000. This research has continued via the ASTA programme. Important efforts were also made in, e.g. Norway, the Netherlands, Germany, United Kingdom, Canada and the USA. These efforts have resulted in increased knowledge, international networks and exert influence on the negotiation process as well as providing an increased general understanding of the needs for control measures in Europe.

Although this interplay between R&D and policy-making functioned reasonably well during the processes leading to the four CLRTAP protocols adopted by Parties in 1994, 1998 and 1999, the review process now under way for revision of the 1999 protocol may face new problems. The situation now 2003 is, however, similar to that in the 90s, where the common basis of knowledge in Europe needs to be strengthened to develop control strategies. The problem is different and more complex. As earlier, solutions to several problems are being sought at once; acidification, eutrophication and oxidants. The introduction of 50 x 50 km EMEP grids may change the hitherto perceived pattern and values of critical loads and levels. This will become even clearer if dynamic modelling is introduced, taking into account the long-term recovery periods of ecosystems. This will be a great challenge for government decision-makers to manage.

At present, health effects are more important as a political driving force. Especially particles give rise to substantial health effects. This is also of relevance for the sulphur dioxide and nitrogen oxides strategies since they may form secondary particles together with ammonia. The control measures are also connected to parallel discussions on climate change. If the control measures are to be driven further with increasing costs and other obstacles, there is a need for common and credible scientific data. To achieve structural changes and to influence the lifestyles of the population, confidence and belief in the basis of decisions is needed. Questions on uncertainties and sensitivity analyses are now more important and scientific methods for evaluation are available. At all times it is important to have openness, transparency, critical reviews and that scientists in all countries are given the possibility to participate in this process. This will make the continuous interplay between the R&D and the policy-making communities in the review process still more important and the role of the inter-mediators still more demanding.

As before, it is important that the international organisations function and also that they influence R&D planning, as well as the collection and assessment of scientific data. The credibility of the system is, of course, critical but so far LRTAP, the EU Commission and WHO-Europe have handled these roles successfully.

ROB MAAS, CHAIRMAN OF UN/ECE
TASK FORCE INTEGRATED
ASSESSMENT MODELLING

Are we sure? Some thoughts about uncertainty treatment in integrated assessment

Rob Maas is an environmental economist. Since 1992 he is chairman of the UN/ECE Task Force Integrated Assessment Modelling. He is head of the Environmental Assessment Bureau at RIVM. The bureau is responsible for the preparation of the annual State of the Environment Report, scenario studies and policy assessments.

Introduction

Are we sure? Are we right? Do we feel confident? These questions summarise the feeling of uncertainty that is always nagging at our conscience whenever a policy-decision is going to be based on scientific models. A feeling that does not go away when mathematical whizzkids show you the statistical uncertainty margins of model results, because the feeling is only partly about the figures. The feeling is more about the things we didn´t look at, either because of time constraints, lack of data or lack of knowledge. Or the things we simply took for granted because most scientists think they are true.

Of course, in integrated assessment modelling there is no complete certainty. The things we know for sure (e.g. that emissions decrease) are hardly politically interesting. And paradoxically many things that are highly unsure such as the effects of climate change policy and of particulate matter are in the focus of public attention. In my view integrated assessors have to try to improve the quality of policy decisions by framing uncertain knowledge in such a way that policy-makers become aware of the scientific uncertainties and our lack of knowledge, and can deal with them.

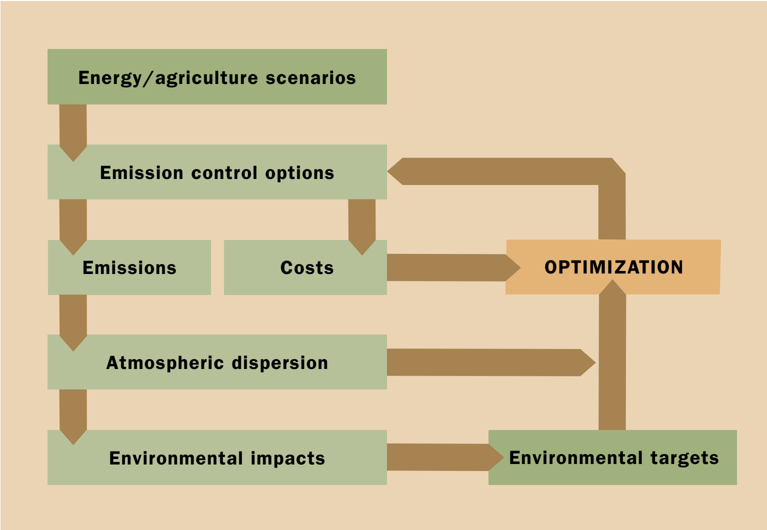
Many people think we have to reduce uncertainties by more data and measurements. They think that the more we measure, the more we know. But does this really help? Even the requirement of validating a theory or model with measurements does not guarantee that such models are true, because the decision on what and how to measure is based on the same theory and thus not objective. Every measurement requires a standpoint. Measurements only give information on the spots we shed light on. And at the same time a solitary measurement gives no information at all, it is the theory that gives the measurements a meaning. It seems like a trap.

Perhaps a more modest view on scientific knowledge is required. To cite Karl Popper: ”A theory is true until it is proven to be wrong”. Or my own thesis: ”The believe in a future scenario (or strategy) is not much larger that the group of people that was involved in constructing it”. A scenario is a social construct, not an objective truth. Thinking along these lines, if absolute certainty in many cases does not exist, wouldn´t it be better to improve scientific knowledge and support of policy decisions by investing more time in exploring the possible impact of those things that are not in our framework, or on the political meaning of alternative theories that cannot be falsified. In doing this we could probably better deal with the blind spots in our knowledge, be specific in what we do not know; and sleep better, confident that all is now in the hands of the policy-maker. I will come back to the policy-maker later.

Nagging questions

First the scientists. Of course modellers believe strongly in the results of their models. But at the same time they are faced with the problem that the more complex the model has become, the smaller the group of people that understands it and will trust its results. Industry has already complained about the lack of openness and transparency of the RAINS-model, although everything is on the internet and the meetings are open. Does this mean that we have to develop simpler models? I don´t think that would be the right approach, because simplified or more reductionistic views would mean that more aspects of a problem will be forgotten: the model will be more transparent, but the system would only describe a part of the relevant reality. Instead I think intensified communication is the way to build trust in integrated assessment models.

Are we sure we don´t base our advise on arbitrary choices in constructing the model? Are we perhaps sometimes selling model-artefacts? What elements of reality are not in the RAINS-model and how do these structural omissions influence the policy decision? We know that the influx of pollutants from North America is significant and that it thus will be harder to meet air quality targets. But it is not modelled. We know that meteorological patterns will probably change in the future, but we still use the weather pattern of the past. We ignore chemical processes nearby the emission sources because we can hardly model them. We ignore the effects of humidity in estimating ozone damage to plants because of lack of data. We know there will be technological progress and a decrease of abatement costs, but we use historical cost data. We know that EU-enlargement, Kyoto-protocol and liberalisation of electricity markets will influence emission patterns, but we hardly know how to put this into the scenarios. How important are these simplifications for our policy advice?



The figure describes optimization in RAINS.

What would happen if we redefine the problem: e.g. if the acidification problem is not defined as an exceedance of a critical load, but as the depletion of buffering capacity, or as a loss of species, or as monetised damage? Or what if we redefine equity: not as an equal gap-closure, but e.g. as equal net-costs per unit of GDP.

What are the things we don´t know or will not know in the coming years? After 50 years of research into the health effects of particulate matter it will come as a surprise to me if in the coming year it would suddenly become certain what species of particulate matter would cause the problem. There will probably also remain fundamental uncertainty whether it is short term or long term ozone exposure that causes health damage. There will be different theories, that cannot be falsified. Do we choose the one that most likely according to most scientists or because WHO or the US-EPA has already adopted it? Or do we explore also the political meaning of alternative theories?

These nagging questions show that there is more to uncertainty treatment than what can be calculated with traditional methods. Of course we have to be aware that average emission factors have a spread, that there is meteorological variation or that critical load functions depend on the level of geographical detail. These technical analyses are awesome and necessary, especially when we try to define weak spots in our analysis. But they do not cover the whole picture.

There are several ways to distinguish the different forms of uncertainty. But the main boundary is between the quantitative uncertainties and the fundamental lack of knowledge (or ignorance). Of course this fundamental lack of knowledge should not only be tackled by philosophical remarks and obligatory disclaimers. We should develop ways to assess whether our policy advises are robust, show what the different theories mean for a policy decision, quantify them in scenarios and present the right policy options for dealing with uncertainties.

What can policy makers do?

Scientific uncertainty is a risk for the policy-maker. A political risk, because if the policy-maker makes the wrong choice she can be accused of not protecting the environment enough or throwing away public money. She then will of course blame the scientists. Good scientists would then show that they have warned for uncertainties and lack of knowledge, otherwise they might be liable or accessory.

How can we improve the quality of decisions when knowledge is lacking? What would a policy-maker do when we present uncertainty margins or probabilities? There are several attitudes towards dealing with uncertainties in environmental policy. The two most extreme positions are ”precaution” and ”no-regret”. But there are different forms in between. The policy-makers that are in favour of the environmental precautionary principle would already act when there are reasonable grounds for concern. They would rather prevent problems, than take the risk of a response that comes too late. ”No-regret”-policy-makers would only take those actions that are anyhow good and act when there is convincing proof that effects are likely and beyond reasonable doubt. They would like to wait until sufficient evidence is available and emphasise the costs of being wrong. They are in favour of economic precaution.

Does more research really help? In the long run the answer is probably yes, but in many cases reasonably certain results can hardly be expected by waiting a few years. Should policymakers wait for more research? That depends on what scientists can realistically achieve in the extra time and whether possible outcomes would really affect decisions and improve the quality of the decision process. Not waiting means more scientific uncertainty and more political risks. But perhaps these risks can be managed better when integrated assessors can more systematically present to policy-makers what the range is in the probable answers in those situations where knowledge is lacking and what these answers would mean for the policy decision in view of the preferred attitude of a policy-maker towards risks. What if scenarios that capture the possible structural uncertainties in integrated assessment models could be useful to test the robustness of policy strategies.

For integrated assessors this would mean more open-mindedness towards conflicting or competing theories and models, as well as an active exchange of ideas with dissident experts, so that their ideas can be understood to the extend that an assessment can be made of whether their alternative views really matter for the robustness of a policy strategy. Do we hear enough dissident views within the scientific framework of the Convention on Long Range Transboundary Air Pollution or do scientists rather prefer to belong to the social group and accommodate to the views of the majority?

How can we build trust?

Not many people understand what we are talking about, when we describe acidification and health effects and use jargon like critical loads, binding grid cells, gap-closure, ozone hills, AOTs or the statistical value of life. Laymen, politicians, businessmen and scientists who are not involved tend to be suspicious about scientific processes that are a black box to them. They complain about closed shops, lack of transparency and technocratic or even undemocratic decisions.

Many politicians and businessmen have no time or interest to study environmental problems. They hear about uncertainties and scientific dissent and take a position on the bases of the view of those scientists they trust most, or of the scientists that can bring the message in a simple way or present a vision that does not compete with the stakes one has. Some would already get worried when some scientists express there suspicion that there might be a problem, and people who oppose regulations that could limit freedom and growth would stress the uncertainty and ask for more proof, sound science and peer reviews. Often they use the word uncertainty, while they mean that there is a lack of trust in the integrity of the scientists. Better communication is the only way out of this dilemma.

In my view integrated assessment modellers have already done a lot to improve their communication with the outside world: the model design was optimised to increase transparency, consistency and robustness; procedures were designed for creating consensus on input data and methodology; the participation to the scientific work was open to stakeholders, policy-makers and national experts, and models, data and reports were put on the internet. But nevertheless - due to complexity - the understanding of the model-results is still limited to those involved in the process. Can we make the problem less complex and more transparent? The debate on uncertainties will not make our communication with policy-makers and stakeholders easier. The conclusion is that we have a long list of questions that we need handle in order to achieve an optimal and communicable strategy. However, we know that further emission reductions are necessary in order to achieve the environmental objectives.

Litterature:
Paul Harremoës, David Gee, et al., Late lessons from early warnings; the precautionary principle 1896-2000, EEA-Environmental issue report 22

Marjolein van Asselt, Perspectives on Uncertainty and Risk, Kluwer, Dordrecht, 2000

Jeroen van der Sluijs et al., A guideline for uncertainty scanning and assessment, University Utrecht, 2002

PERINGE GRENNFELT, PROGRAMME
DIRECTOR OF ASTA

Cooperation between research and policy within ASTA - some observations

There has always been close cooperation between research and policy within the field of transboundary air pollution. Already when the problem of acidification was first brought to our attention at the end of the 1960s, researchers described the problem with articles and information aimed directly at political decision-makers. These close relationships have continued since then and throughout there has been collaboration between scientific achievements and political needs.

However, this collaboration between research and policy looks entirely different today compared with 30 years ago, see Figure 1. The earlier research was aimed at mapping the basic relationships and discovering the effects. The contacts between decision-makers and researchers were direct and the decision-makers had to make their decisions directly in accordance with scientific results. Great uncertainty prevailed concerning the general application of the results. The political decisions, for the most part, also involved limited technical sacrifices. In Sweden, for example, gradual decreases of the highest levels of sulphur in fuel oil from 2.5% to 1% were introduced. We can speak of a discovery phase where there still is uncertainty concerning the inter-relationships and which measures are most effective.

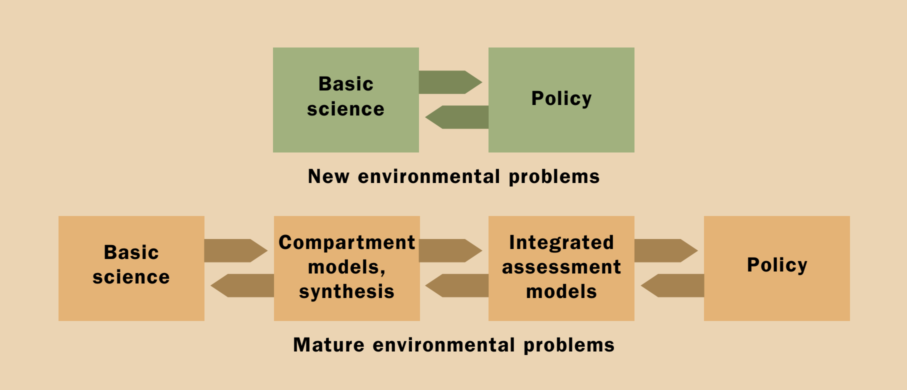


Figure 1. Relations between science and policy for new and mature environmental problems.

Around 1980 the collaboration between researchers and decision-makers changed. There is no longer any uncertainty concerning the overall reasons and all the countries involved were convinced of the importance of measures even if the quantitative relationships were uncertain. Here we have reached a consensus phase. During this period the first sulphur protocol within the UN Convention on Long-Range Transboundary Air Pollution was signed, whereby a large number of European countries agreed to decrease sulphur dioxide emissions by at least 30% between 1980 and 1993.

A third phase can be discerned in the late 1980´s; a phase where knowledge surrounding the inter-relationships could be quantified and used to create goals and work out effective cost strategies. These strategies were the starting point for the latest agreements; the so-called Gothenburg Protocol and the European Union's so-called "Directive on National Emission Ceilings".

In the present international work on atmospheric quality in Europe, it is consequently no longer a question of pushing measures by direct cooperation between scientists and politicians on basic levels of knowledge. The work now comprises a complicated process where the relationships between activities in society, emissions, effects and solutions and their costs are woven together in an advanced model system. Through the model system, different possible measures can be analysed with reference to decreased effects on the ecosystem and on health. The system also gives unique possibilities for optimising measures so that, for example, a certain environmental goal can be reached at a low cost.

How, then, does research and decision-making work together? Göran Sundqvist and others[1], in one of ASTA:s sub-projects, have pointed out the importance of finding common playing-fields and concepts that can be used for communication between researchers and decisionmakers. Among other things, they point to the fact that the concept of critical loads has functioned as such a bridge. The concept helped to find ways for a political solution on scientific grounds for the second sulphur protocol (1994), as well as for later agreements. The concept, according to the authors, does not necessarily have the same meaning for researchers as for decision-makers but it has created a driving force for research in a direction that supports development of abatement strategies for carrying out these measures.

Are there other concepts that have functioned in the same way as critical loads as a bridge between science and policy, and are there also concepts that function only in one of the contexts? From my own point-of-view, I have summarised and assessed some of the most important concepts surrounding acidification and transboundary air pollution. The concepts I have chosen are partly early concepts such as acid precipitation, fish death, transboundary air pollution; and partly concepts that occurred somewhat later, such as forest death, critical loads as well as a new concept – recovery. In Figure 2, I have then placed these concepts in a matrix in relation to how they are used in both of these areas.

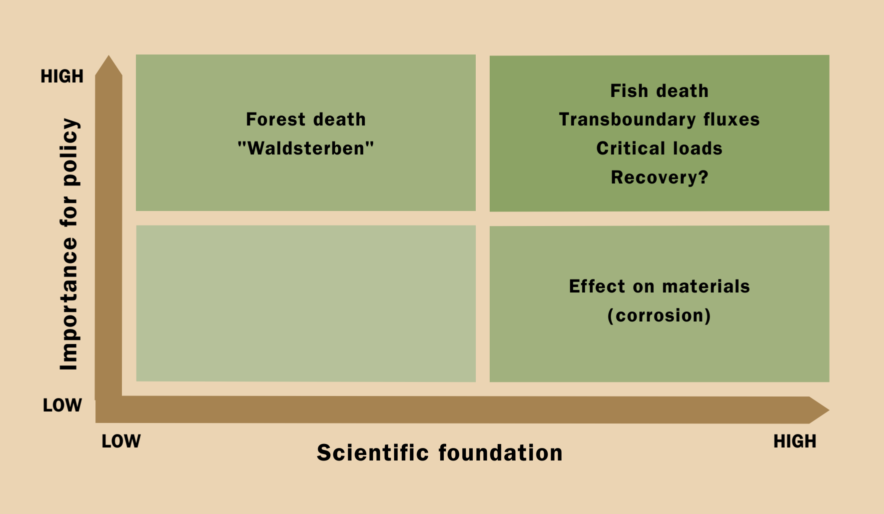


Figure 2. Scientific foundation and importance for policy for some concepts within the framework of regional air pollution.

Acid or acidified precipitation, fish death in the lakes due to acidification and the occurrence of transboundary air pollution were all central concepts when the problem of acidification was discovered in around 1970. They dominated the scientific as well as the political discussion. The concepts had great relevance for research as well as for decision-making. The cause of fish death could be investigated and tied to the polluted precipitation. The observation and quantification of transboundary pollution also had great scientific relevance. The political relevance was also obvious. Fish death was of great importance for the quality of outdoor life and a clarification of how pollutants are transported showed the need for common agreements. One might say that the concept of acid precipitation was doubtful from a scientific viewpoint. Measurements showed that only a limited amount of the acid deposition came with precipitation. The so-called dry deposition was often dominant. Ammonia, which neutralised the acid in the deposition, also contributed to the acidity because it could be oxidised to nitric acid in the ground.

The concept of forest death appeared in the beginning of the 1980´s in Germany, where

Photographer: Hans Hultberg

the media and many researchers were alarmed at the extensive damage to the forests and the threat of forest death. We learned the concept called "Waldsterben" and the threat became a strong driving force for measures against discharging sulphur and nitrogen oxides in Germany. Even though the feared forest death had great political significance, it was difficult to explain it scientifically and to show mechanisms that led to the observed forest damage. The concept "forest death" consequently worked as a political driving force but the scientific anchorage was not forthcoming.

During the 1980´s the term "critical load" was introduced, a concept that was anchored both scientifically as well as among decision-makers. "Critical load" was very quickly accepted by politicians, particularly in a context of cost-effective measures. Scientific viewpoints have now and then been conveyed concerning the relevance of determining the limit for how much contamination nature can tolerate, but the concept created a focus for research all over Europe

Is, then, the research within ASTA focused on problems and does the research apply concepts that function as a bridge between research and remediation? We do not know this yet as the final result most likely will not appear until the revision of the Gothenburg Protocol and the European Union's directive on National Emission ceilings which will take place from 2005 and onward. We have, nevertheless, within the programme, tried to develop several areas, mainly recovery of the ecosystem, that have been damaged by both acidification and by fertilizing atmospheric deposition. ASTA:s research has here shown that recovery can be quantified and that the course of recovery can be transferred into driving forces for political decisions. Recovery is in the process of being included in the integrated assessment models. Therefore, our expectation is that the recovery, in the same way as many of the earlier concepts, will serve as a bridge between research and political decisions.

Another important area that is developing is particles and health. Here there is great political interest in taking remedial action. The scientific relationships are, nevertheless, still rather unclear and, with the knowledge we have today, it is difficult to work out more advanced strategies.

Are there, then, examples of areas that have worked well scientifically and that should have been significant for environmental work on a political level but which have not achieved enough political attention? It is not easy to find such examples but the effects of air pollution on materials, for example corrosion, might be such a concept. Scientifically there is extensive knowledge showing how pollution affects different materials but the results have not had any decisive significance when working out a strategy for what action is to be taken.

These examples illustrate that the use of research when making political decisions presupposes good communication and that the concepts can be transferred between the different environments. The cooperation between research in the natural sciences and research in the social sciences that takes place within ASTA, is here a help in understanding how the team-work between research and decisions is established and the importance of finding common concepts and playing-fields.

[1] Sundqvist, G., Letell, M. och Lidskog, R. (2002) Science and Policy in Air Pollution Abatement Strategies. Environmental Science & Policy 5(1) 147-156.

New knowledge supports Sweden and Swedish industry

GUNNAR HOVSENIUS, RESPONSIBLE FOR ENVIRONMENTAL ISSUES AT ELFORSK, MEMBER OF THE ASTA BOARD

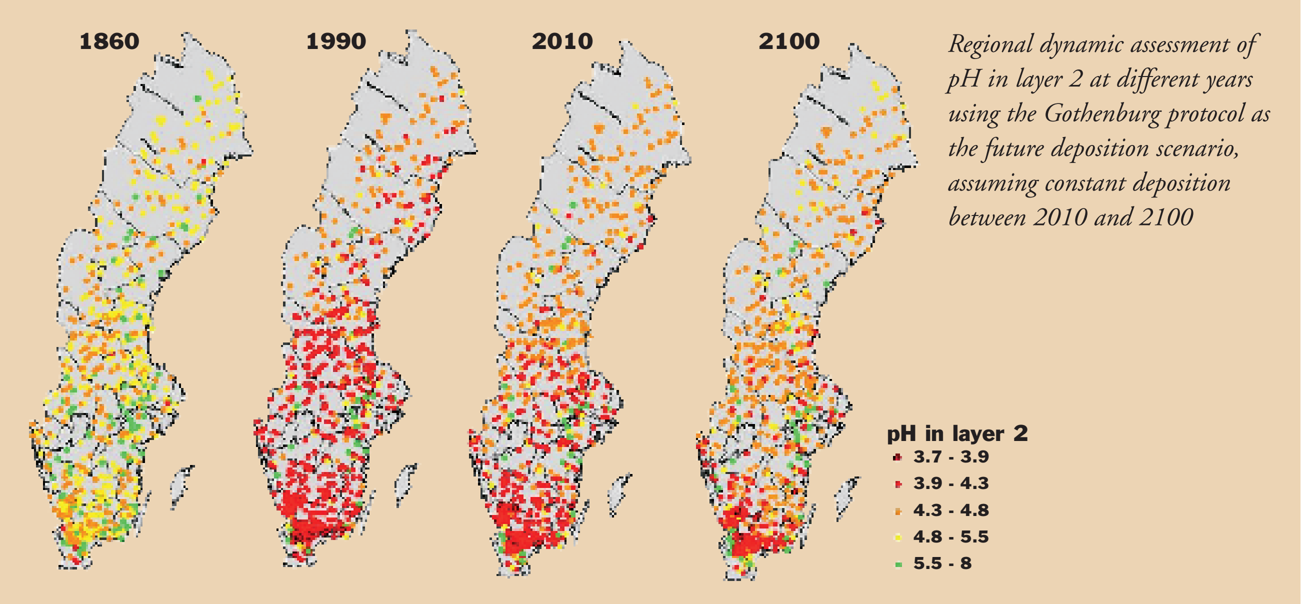
The situation before ASTA:s first phase

Industry has been strongly engaged in questions concerning acidification ever since the problems first were identified. From the beginning, the question for the energy industry concerned the need for and the possibilities of reducing sulphur dioxide emissions. Around 1970 the Swedish emissions of sulphur dioxide were approximately one million tons annually, of which approximately 70% came from the generation of electricity and heat, the largest portion coming from oil combustion. Initially, industry was sceptical about the demands for measures but relatively soon a common opinion developed concerning the extent of the problem as well as the need for remedial measures.

An important reason why Sweden quickly came to a common understanding was without a doubt the close cooperation between state and industry in producing basic information. Consequently, industry quickly became involved in research, not the least through the close cooperation with IVL. During the first half of the 1980s the extensive R&D project, Coal Health Environment, created a platform for long-term measures within the energy sector.

However, the situation was not as simple in many of Sweden´s neighbouring countries. Germany and the United Kingdom showed great scepticism and it was not until the alarm about forest damage in Germany was sounded that remedial measures became interesting there. Nevertheless, industry in the United Kingdom continued to question if emissions in the United Kingdom could result in environmental impacts in Scandinavia. It was not until research cooperation between the Academies of Science in the United Kingdom, Sweden and Norway, supported by the British Coal and Power Industry, demonstrated the source-effect relationship that British industry realized the importance of taking action. This project, which was criticized by many Swedish environmental researchers as having come into existence in order to delay measures, instead led to increased interest in taking action in the United Kingdom.

Within industry, dynamic aspects on acidification were awakened early. The question of the benefits of measures and if, and with what rate, the damaged ecosystem could recover, was interesting for industry in order to understand the long-term value of the work of abatement. Several researchers who participate in the ASTA programme emphasised the need to understand what happened with the acidified system at the end of the 80´s and were actively involved in bringing about the so-called Roof Project at lake Gårdsjön. The main financiers behind this project were Vattenfall and the British energy industry in the form of the Central Energy Generating Board. The Roof Project has perhaps become the most important initiative for understanding and quantitatively describing what happens when deposition decreases, as well as demonstrating the results of control measures.



Regional dynamic assessment of pH in layer 2 at different years using the Gothenburg protocol as the future deposition scenario, assuming constant deposition between 2010 and 2100

The Figure illustrates that the Gothenburg protocol is not enough to accomplish recovery in Swedish forest soils, not even in a hundred year perspective.

In the last few years, the interplay between the use of land and air pollution has become an increasingly important question for the energy industry as well as for the forest industry. The forest is a very important resource for Sweden but it is also a sensitive ecosystem where excessive exploitation may jeopardize the sensitive balance of mineral nutrients. In order to set up boundaries for long-term use of the forest there is, consequently, a great need for developing dynamic models that describe the link between the changes in deposition and forestry, and environmental effects.

The new dynamic approach on critical loads will favour Sweden

One of the original aims of the ASTA project was to develop the dynamic critical loads and to gain acceptance for these new models before the re-negotiations on decreased emissions, which are scheduled to begin in 2004/2005. This was in itself a bold challenge since the earlier statistical approach was used as recently as at the negotiations in 1999/2000.

Since we now have left ASTA:s Phase I and are one the way to Phase II, we can with satisfaction state that the development of dynamic models for acidification, as well as nitrogen and ozone loads, to say the least, live up to expectations. The new concepts have been well received by the research community. A science-based decision, supporting the dynamic approach will probably be reached during 2003. This will open the door for the use of new approaches in the next round of negotiations on decreased emissions. This, of course, would be very gratifying for ASTA:s researchers. The big long-term winner, however, will be the Swedish nature, the reason being the dynamic approach to, e.g., acidification, teaches us that we must also take into consideration the earlier large depositions of sulphur as well as the influence of forestry on the mineral balance in the soil. The former circumstances will force countries that export acidification to Sweden to "pay" for their previous offences via more stringent demands. This gives, to a corresponding degree, long-term degrees of freedom for Swedish industry.

To dare to expose the quality and uncertainties of new insights is important

The ceiling in the so-called Roof Project has now been dismantled, but the instruments still generate data, giving researchers good possibilities for testing the dynamic acidification models in a new dynamic situation. If the project is successful, great credibility will be won.

Another way in which ASTA:s ambitions are a challenge concerns the development of tools in order to be able to understand the uncertainties in the modelled environmental improvements in comparison with those that can now be measured in different places in Europe.

The forest can tolerate long-term removal of biomass for energy production if we recycle the ashes

The models for acidification and nitrogen loads, that are continuing to be developed within ASTA, show that Southern Sweden's forest soil is seriously acidified. But they also show that a recovery is in progress, thanks to the fact that the acid loads have decreased considerably as a consequence of earlier international agreements on decreased emissions. Calculations have also shown that removal of biomass for energy purposes leads to increased acidification of the soil that, at least for Southern Sweden, must be compensated by adding mineral substances. The easiest and most natural way to do this is to recycle woodash in stabilized form. If we do this, calculations suggest that biomass from the forest are a long-term, sustainable source of energy in relation to acidification. With that, the energy sector has received an answer to one of the questions asked when the ASTA project started.

Particles - an increasingly current problem causing concern

ASTA:s work with measuring particle concentrations, combined with medical studies conducted by the European Union sponsored APHEIS project (Air Pollution and Health: a European Information System) indicates that the concentration of particles smaller than 10 µm is a health problem in large cities. For Greater Stockholm and Gothenburg, data from APHEIS show that if the particle concentrations decreases by 5 microgram per cubic meter it would lead to 15-30 and 8-15 fewer deaths per year, respectively.

Burning of biomass may lead to increased emissions of particles - especially the kinds that are around µm size or smaller. Therefore, there is every reason for the energy sector to follow ASTA:s reporting on particle contents so that measures can begin to be developed before emissions from wood burning become a problem.

The work done before re-negotiations on decreased emissions becomes transparent thanks to ASTA

ASTA:s result- and person-related competence will play a major role in the work that has already begun, before re-negotiations are commenced concerning transboundary air pollution. Cooperation with IIASA, where models were developed for calculating where decreases in emissions should be carried out in order that planned environmental goals can be reached in a cost-effective way, already exists. The new contribution is that researchers within ASTA have become more involved in IIASA:s calculations and now are acquainted with the models. This gives Sweden good possibilities of providing input to IIASA so that future modelling can better take into account Swedish marginal costs when more emission decreases are actualized. Swedish industry has never before had such good possibilities for making its situation known.

Other significant work is taking place around the revision of the European Union's directive on National Emission Ceilings. Scientists from ASTA take part in this work as experts and give the parties within ASTA early information as to what the outcome may be in the re-negotiations.

Prince Andrew visited Gårdsjön a few years ago and got during the day information about the cause of acidification, its effects and the importance of international measures to solve the problem. In the picture Hans Hultberg shows the so-called Roof-project.

Photographer: Agneta Hultberg

GÖRAN SUNDQVIST, GOTHENBURG UNIVERSITY, SCIENCE AND TECHNOLOGY STUDIES

Studies on science-based policy processes

Teamwork between research and measures

The advantages and benefits of environmental research have often been understood in a simplified way. It has been assumed that the results of environmental research are of great importance for making environmental political decisions. Interest has, therefore, been focused on the obstacles that society puts up for the effective use of research results in order to make decisions concerning what measures to take.

The social scientific research within ASTA, which focuses on the interplay between research and measures, is aimed at questioning the common linear understanding of the relationship between research and policy, which means that only one side is considered problematic and is thought to be an obstacle for successful teamwork. Instead we want to start with a more equal relationship between research and policy. In order to improve the teamwork, and also to increase the legitimacy of political decision-making on technical issues, it is not only required that decision-makers and the public are more open for research results, but it is equally important that researchers become socially competent experts. The goal is not to get results based on a passive acceptance of research results but social arenas that can manage different viewpoints and knowledge conveyed by different groups.

In this contribution, examples are given as to how social studies can be used to strengthen the teamwork between research and measures taken. Examples are taken from the work with developing abatement strategies before future negotiations about convention protocols and directives from the European Union, where ASTA:s research on the course of acidification recovery comprises an important part.

Forests with blueberry or grass? The deposition of nitrogen has made the blueberry disappear from large parts of the forests in the south of Sweden. ASTA has studied the relations and established critical load of nitrogen in pine forests in Sweden.
Photographer: Annika Nordin

The democratization of expertise

Measures to prevent long-range air pollution are often seen as one of the big successes within environmental work in Europe. The second generation's protocol under the LRTAP Convention, based on the critical loads concept, is considered to be successful from scientific, economic as well as political perspectives. Close cooperation between researchers and decision-makers, which is established in the Convention's different workgroups, is considered to be an important reason for the successful result.

In spite of the success, certain shortcomings have been noted. Even the participants themselves consider the close contact between researchers and decision-makers to have led to shortcomings in transparency and involvement, and the utilized research results have not been officially scrutinized to a sufficient degree. Unity has been rewarded at the cost of debate, and uncertainty has been toned down. In the meantime, credibility has been high in spite of limited insight and participation. This has led to a situation where expert knowledge might have had great credibility, perhaps sometimes more than deserved.

Today there is focus on the transparency in decision processes, especially those that have to do with expert-based regulation. Within the European Union there is talk about a necessary "democratization of expertise". The legitimacy of the European Union rests, to a great degree, on the credibility of expert opinions. Current questions, such as mad cow disease, gene modified crops and climate change, have placed the interplay between expert opinions and decisions in the spotlight. A highlighted problem is that an expert-based regulation is inaccessible and hard for the uninitiated to follow. The cure for this is increased transparency and participation. To democratise the expertise means to make clear how experts are recruited, what background and possible loyalties they have, and how expert knowledge is distributed, examined and utilized in public decision-making.

The European Union's CAFE programme has the ambition to strengthen the cooperation between research and policy. This is specified in the form of five objectives. One of these is "transparency and stakeholders involvement". Through the distribution of information citizens will be better involved and the attention given to the European work with air quality measures will increase. CAFE identifies citizens to be the most important partner since they are assumed to comprise the fundamental driving force for further development of abatement measures. The LRTAP Convention has, in its latest communication strategy, in a similar way pointed out that its meetings must be more transparent for the public and that wider participation should be encouraged.

Today within the European Union as well as within LRTAP, a more equal relationship between research and the abatement measures is stressed. From this approach we can find support for a critique of a linear relation.

The example of recovery

The intertwined questions about democratization of expertise and public involvement are important to take into consideration when developing cooperative European air quality measures. ASTA has worked in a purposeful way to include the course of events for acidification recovery in the coming abatement strategies. In this work there are many uncertainties. How far below critical loads should the new targets be set in order for the recovery of the soil to begin? How should Scandinavia's sensitive forest soils be weighted in relation to the reduction of emissions in Europe as a whole? What will the control measures cost and what results can the research guarantee?

Photographer: Per-Erik Karlsson

When the load is reduced and gets close to the calculated target - the critical load - it will be important not to hide the uncertainties. The new initiatives to include recovery in the abatement strategies require support from different groups in society. Not least industry must be convinced of the importance of reductions under the critical loads. If this support is missing the coming negotiations will be problematic. The work of recovery has already today a high degree of credibility within a small group of experts and administrators but we still know very little concerning the reactions from others. In a negotiating situation where the European Union's CAFE programme is competing with the LRTAP Convention and a closer connection with the negotiations on climate change is seen to be desirable, we can expect the public attention to increase. In such a situation the prescription should not be to conceal problems and uncertainties. ASTA assumes that the way uncertainties are handled will be of great importance in the coming development of strategies, which means the broadening of interests while at the same time strengthening the credibility of expert knowledge.

But uncertainties are easy to forget, for example when results from integrated assessment modelling are to be presented on effects and costs that will be the result of the defined targets. With these results groups of experts want to convince decision-makers and others that something has to be done. And to assert that the results are based on certain scientific knowledge is often seen to be a successful strategy.

Within ASTA we are working to develop the handling of uncertainties in cooperation between social scientists and natural scientists. The starting point is that the efforts of the researchers should not be limited to delivering the foundation for the models but that they should also participate and ensure the quality of the continued use in the integrated models that form the basis for the decisions by the negotiators. Comments from the researchers who have provided the basis are often missing and through ASTA we will try to improve this situation. By providing a forum for the researchers' viewpoints on the modelled results, the teamwork between research and policy can be strengthened and become less linear as well. Such a process can also provide a guarantee that uncertainties are brought to attention and in this way negotiators and the public are given better possibilities to appraise the results. In this way, better possibilities are created for expert knowledge to be given the credibility it deserves.

For further reading see Collins, H.M., Evans, R. 2002. ”The third wave of science studies: Studies of expertise and experience”. Social Studies of Science vol. 32, and Sundqvist, G. 2003. ”Recovery in the acid rain story: Transparency and credibility in science-based environmental regulation”. Forthcoming in Journal of Environmental Policy and Planning.

How does sociology of scientific knowledge work?

Sociology of scientific knowledge asserts that the credibility of knowledge rests upon its availability. An important task is, therefore, to carry out studies about experts and expert opinions which will increase the understanding of how experts act and how their knowledge is presented and spread. In order to bring about increased availability, and therewith create credibility, it is required that the much-talked about transparency be combined with increased understanding of how experts act. Sociological studies describe the publicly unavailable parts of the expert work, and thereby making it possible for the public to critically examine the experts' presentations of knowledge, for example the handling of uncertainties.

Sociology of scientific knowledge refers to interactive expertise. Sociological studies, communicated to scientists as well as to decision-makers and the public, are of importance in order to create understanding and decrease the distance between groups who risk misunderstanding one another. This kind of studies can be used in a practical way, for example by suggesting how uncertainties can be pointed out without decreasing credibility.

Expert knowledge must be interpreted and understood. In order to reach the goal of the European Union concerning democratised expertise, sociological case studies can fill an important function for the purpose of not only increasing transparency but also the general understanding of how experts act and expert credibility is achieved.

Critical levels for ozone

Driving forces for scientific synthesis

HÅKAN PLEIJEL, GÖTEBORG UNIVERSITY, APPLIED ENVIRONMENTAL SCIENCE

Development of an environmental problem

Knowledge of environmental problems has a tendency to develop in a certain pattern. It often starts with discoveries or observations, which are qualitative. These can be made by experts or by laymen or both of them together. Then a development occurs where research and decision-making gradually work together towards a better quantitative understanding of problems and their causes. Research often results in the development of advanced models, which tie together the activities of society with different types of environmental influences. Research around the effect of ozone on plants is a striking example of how research in this way has developed increasingly sophisticated tools for political decisions. Since the middle of the 70's Swedish researchers have also actively partaken in this work. ASTA has had a key role for the development of the latest concepts and models within this area. The following describes how research over the past fifty years has led to today's knowledge and models.

The effects of ground-level ozone on plants were first identified by observing visible injury on leaves, chiefly in agricultural crops, but soon also in trees. In this way, the process leading to today's knowledge of the effect of ozone on plants, was initiated. To establish the factors that caused different symptoms was scientific detective work for biologists and chemists, and was initiated in the USA at the end of 40's.

For a relatively long time, until the early 70's, scientific development within this area continued to be mainly qualitative. Phenomena that, with a greater or lesser probability, were caused by ozone, were mapped out and enabled bioindicators (see Figure 1) to be developed for determining where damage or no damage by ozone could be found. The degree of damage could sometimes be placed in relation to the measured ozone content. In this way it was possible to find simple connections between exposure and effect. Research had taken its first steps from being purely qualitative to being quantitative.

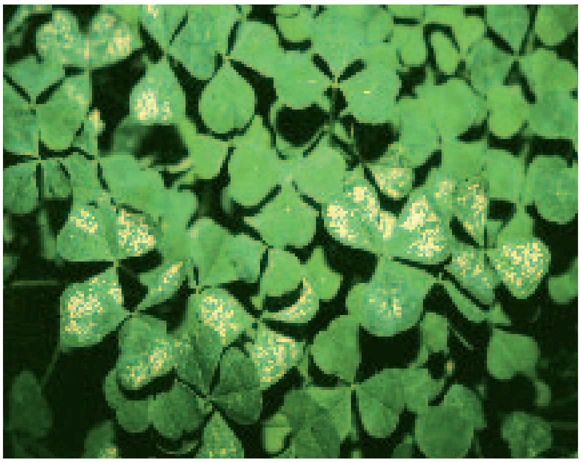


Figure 1: During the 1990's subterranean clover (Trifolium subterraneum) was one of the most used bioindicators for ground-level ozone in Europe. This species already suffers noticeable damage to its leaves from moderate exposure to ozone.

Photographer: Håkan Pleijel

From quality to quantity

Criticism was raised that the effects upon which the interactions were based were generally partly artificial. Very sensitive plants were cultivated in pots without competition from other plants and with good access to water and nourishment. How could this actually be related to economic or ecological effects on, for example, the agricultural ecosystem or forests? Could spots on the leaves of a certain kind of tobacco or clover be easily associated with decreased harvest of wheat or potatoes? Response to this criticism led to the development of exposure systems that could be used under field conditions in, for example, economically important crops, to register ozone contents during the entire grow-

Figure 2. An open-top chamber is a transparent plastic cylinder, which is provided with air through a fan that either filters off or adds pollution. Here, spring wheat is exposed to ozone at the experimental station at Östads säteri, 40 km northwest of Gothenburg.

Photographer: Håkan Pleijel

ing season. The most important of these systems was the open-top chamber (see Figure 2).

The birth of critical levels

During the 1980's, after the convention on long range transboundary air pollution (LRTAP) in Europe came into existence, and environmental questions generally became more important, the effects of ozone and other pollutants also received increased political interest. The first generation of limit values for ozone effects on vegetation, so-called critical levels, was presented in Europe in 1988. In order to avoid the risk of damage to vegetation, it was stated that critical levels of ozone calculated as averages over fixed time intervals should not be exceeded. This was an important first step.

The first generation's critical levels were weak as an instrument for supporting political decisions concerning reduction of emissions, since they were hardly even indicative when used for estimating the size of the damage that could arise at different ozone exposures. On the other hand, demands for quantitative relationships were not so great at this point. It was agreed that the emission of pollutants was much too massive in Europe. To identify the potentially important effects of pollution with scientific methods was regarded as a sufficient basis for suggesting measures.

A second generation

However, with time the demands for more precise knowledge of the size of the effects increased and effect-based abatement strategies were elaborated. These strategies looked for links between the extent of the damage and the resources required to combat them using measures that limited the emissions.

The need for quantitative data led researchers to continue their work on developing concepts and critical levels. Parallel to this, the empirical knowledge, in the form of experimental research into the effects of ozone, increased. This led to the introduction of a new exposure index - AOT40 - summing up the effect of exceeding 40 ppb ozone. Certain effects, for example, yield loss of wheat, were found to have a relatively strong correlation to this exposure index. In the middle of the 1990's critical levels for ozone based on AOT40 were incorporated into the official manual for mapping of environmental effects, which since then has been used in abatement strategies within the LRTAP Convention. They formed the second generation of critical levels for ozone in Europe.

The manual pointed out that these critical levels should only be used to identify different degrees of risk for damage, not to make direct estimates of actual decreases in growth in agriculture and forestry. It was also emphasized that it was the ozone content at plant level that should be used for determining this risk. This is of great importance since there is a strong gradient in ozone concentration from higher situated strata of air down to the soil-plant system where ozone is deposited (Figure 3). In certain circumstances the restrictions and prerequisites for use of the critical levels formulated by the scientific community were nevertheless ignored. This led to the reporting of high and irrelevant levels for AOT40 and in certain cases even to the proposal of unreasonably high effects of ozone on plants using AOT40 as the basis. The example shows the problems that may arise when data are used incorrectly.

A scientific anomaly

In the middle of the 1990's the problems that were identified with the use of AOT40 led

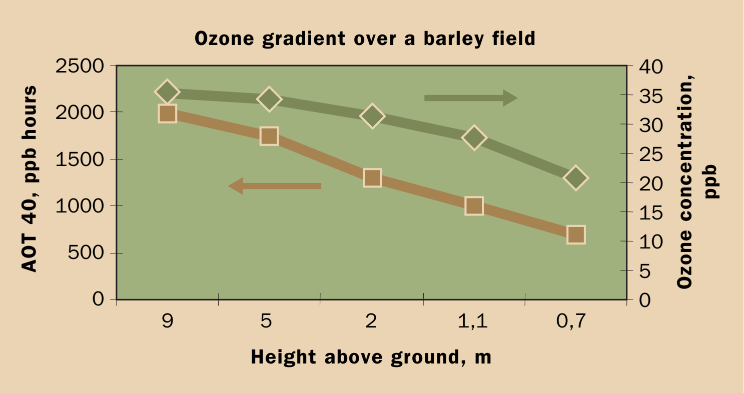


Figure 3. Average contents of ozone and AOT40-values from different heights over a grain field during the month of July. As you get closer to the canopy you get lower content and lower AOT40-values. The figure shows that AOT40 is more sensitive to the measuring height than the average content because of the threshold of 40 ppb upon which the index is based. The large systematic error that is made in estimating the plant´s exposure is more important, if, ignoring the manual, the value from 1.1 m is replaced by the one from a height of 5 m or 9 m, which sometimes was done. In the experiments that are the basis for estimating the effects, the ozone contents are measured approximately 0.1 m above the canopy. The canopy in the example was approximately 1 m high.

to a development of exposure indices based on ozone uptake. For a long time there had been a relatively broad consensus among re-searchers that it is more correct to relate effects to how much ozone the plants take up than to the ozone concentration in the air surrounding the plants. There was, however, no established method to quantify ozone uptake, but work in that direction had begun. The results of the first calculations with an early version of this model led to something that could be likened to an anomaly, in the scientific theoretical spirit of Thomas Kuhn. Ozone uptake was far from always highest where the ozone content was the highest. Many areas with high ozone content have a dry and warm climate, which greatly limits the plant´s gas exchange. On the other hand, there were areas with more moderately increased ozone content where climate conditions for ozone uptake were very favourable. The map listing the risk zones for ozone damage in Europe had to be redrawn. This was very difficult for many people to accept since it was in conflict with earlier statements based on AOT40 and other content-based exposure indexes. The reappraisal has not been painless since time, energy and prestige had been invested in another approach. Actually, parts of the research community were, and still partly are, greatly opposed to changing the method. Besides, the groups who thought that the development should quickly go in the direction of methods based on ozone uptake were divided.

The new models based on ozone uptake have also been subjected to formal and other objections. They presuppose knowledge about climate conditions with high time resolution and are harder to explain to laymen than the simple content-based AOT40. The new models assume plant physiological principles, which are not commonly known. In order to understand the idea about ozone uptake itself is relatively simple, but methods for calculating ozone uptake are considerably more complicated than for AOT40. To communicate more sophisticated models to decision-makers, which comprise a better representation of reality, may be difficult, not least at a time with a great flow of information. Simplifications then become attractive. Here, being balanced is very difficult. Simplifications should be made but not to such a degree that they violate the foundation at the base of natural science.

Towards critical loads for ozone

At present, despite possible objections, progress towards the third generation´s critical levels, which is based on the ozone uptake of plants, is in progress. Considering that the argument that ozone uptake is a more relevant measure of exposure than content, it is hard to defend AOT40, since response relationships based on that can be strongly criticized from a purely natural scientific perspective. Today there are dose-response relationships for ozone uptake for foremost wheat and potatoes (Figure 4). The EMEP-model, that describes the occurrence and transport of air pollution within Europe, also contains routines for calculating ozone uptake. One of the remaining difficulties is to adapt the largely biologically-based dose-response relationships to the chemical-meteorological EMEP-model. At present, great efforts are being made to get both of the models to function together. Ultimately, the new model concept will make it possible to make assessments of yield loss with relatively good precision for certain crops in Europe. When this has been successfully achieved, a major step from the discovery of a qualitative problem to quantification of important effects for society will have been completed.

Environmental scientific synthesis

Demands on the scientific basis for environmental inputs, which is the foundation for decisions on often costly measures for limiting emissions, have increased. In dose-response relationship, such as in Figure 4, it is therefore important that data from different coun-

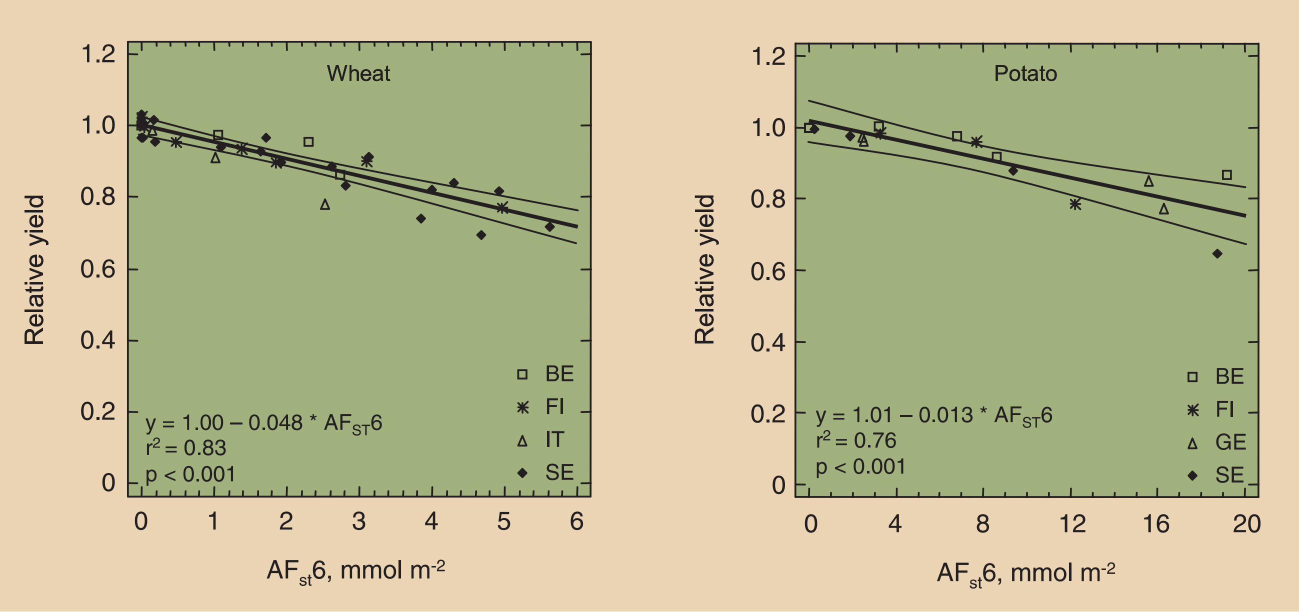


Figure 4. Relationship between the relative yield of wheat and potato and the accumulated ozone uptake with an uptake rate threshold 6 nmol ozon m^{-2} s^{-1} *(*$AF_{st}6$*) based on experimental data from Belgium, Finland, Italy and Sweden (wheat) and from Belgium, Finland, Germany and Sweden (potato).*

tries are included, that genetic variation within the crop is represented, while at the same time the experiments that are included must be of high quality. This means, among other things, that experiments made with crops that have been grown in pots were excluded, since it was shown that such experiments do not give data that is representative for ozone effects in fields. Including data from different countries means an active integration of different research groups, which isn't always encouraged by today's pronounced system of competition within research, where cooperation in reality is not rewarded. Synthesis of data from different sources is, nevertheless, necessary for testing the potential to generalize dose-response relationships, but this requires forms for a constructive dialogue, where individual research groups cannot have complete hegemony over the work of development.

Work of adjusting the results of scientific syntheses so that they can be used in larger model structures, is, of course, included, in this case to get the models linked to models describing atmospheric chemistry and meteorology. Even here, different approaches must be made compatible with one another in order to finally melt together in a common structure that covers the entire process from emissions to effect. This type of synthesis, like its validation to reality, will probably make up a big part of environmental science in the future. Integration and synthesis of high qualitative research to more advanced models that integrate different environmental problems and their solutions will, therefore, become central areas of development within environmental research.

From Phase I to Phase II

JOHN MUNTHE, DEPUTY
PROGRAMME DIRECTOR OF ASTA

In 2003 the second phase of the ASTA programme started. The move from one programme phase to the next was preceded by an evaluation of the progress in Phase I, performed during spring 2002. The major driving force for deciding the focus of Phase II was the time schedule for the re-negotiation of the CLRTAP protocol and the process of reaching final decisions within the CAFE programme. Both these processes are scheduled for completion in 2005-2006 which means that most of the fundamental scientific results will have to be available during 2004, if an influence on the decision-making process is to be achieved. To ensure the usefulness of the programme output, the ASTA programme will shift in focus from generation of basic effect data and model development, to synthesis, model application and generalisation of results, in the second phase. A new component has also been added with economic valuation of environmental effects. In Phase II, experimental activities will be gradually phased out during the first two years.

The interaction between science and policy will increase during the second phase and ASTA will act as an important communication partner throughout the preparation and negotiation process. To fulfil this objective it is necessary that the programme is active throughout the negotiation process and thus ASTA Phase II will continue until 2006. The work with the Gothenburg Protocol led to the experience that continuous scientific input is essential for the success of the process, even after the input to the more obvious science-driven process of integrated assessment modelling has been completed. Due to the expected intensive work with the development of strategies during 2003 and 2004, the programme will focus most of its activities to the first two years. This is especially the case for the development of control strategies, e.g. new concepts for critical loads and levels, and characterisation of particles.

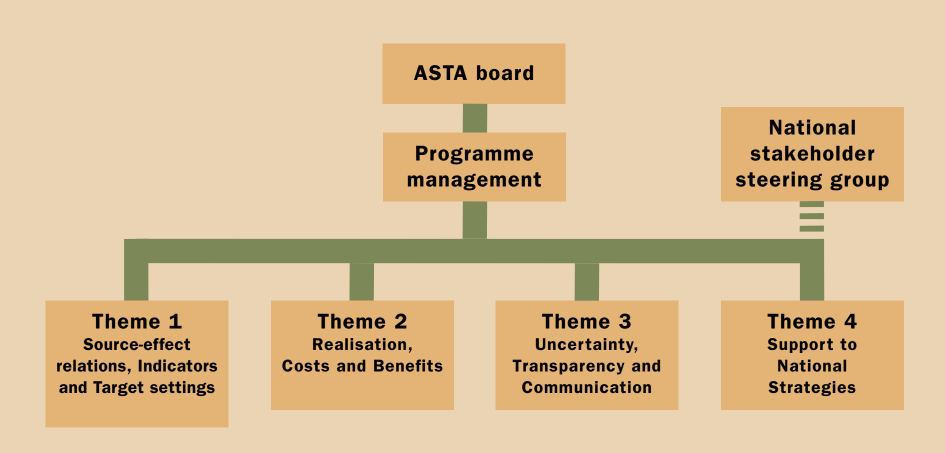


Figure 1. The organisation of ASTA Phase II.

A new organisation of the work

Our intention is to reorganise the ASTA programme around four interdisciplinary, principal Themes: A schematic sketch of the ASTA Phase II organisation is presented in Figure 1. The aim is to more clearly focus on the interactions between basic science and the policy development as well as the needs of other stakeholders.

Organisation

ASTA has benefited from a very active and highly qualified board, which to a large part has remained intact over the first phase. This board will largely remain during Phase II.

The programme management of ASTA Phase II will consist of the programme director, a deputy director and a programme secretary. In addition there will be a Steering Group composed of the programme management, the co-ordinators of the four Themes and 4 additional leading scientists. The Theme Co-ordinators are responsible for the progress of the work in the four themes. This includes facilitating the co-operation within and between the themes as well as the administrative responsibility for funding, reporting etc. The national programme (Theme 4) will have a reference group with representatives from the funding agencies and other stakeholders.

The ASTA Phase II programme will work with budgeted activities in relation to deliverables in more stringent way than under Phase I. This will enable the programme to keep the focus of the programme and to make changes and additions to the programme in relation to achievements and policy needs.

ASTA board members

Lars Lindau	Chairman, Swedish Environmental Protection Agency
Gunnar Hovsenius	ELFORSK
Anton Eliassen	DNMI, Norway
Hillevi Eriksson	National Board of Forestry
Anna Lundborg (adj)	The Swedish Energy Agency
Jan Nilsson (adj)	MISTRA

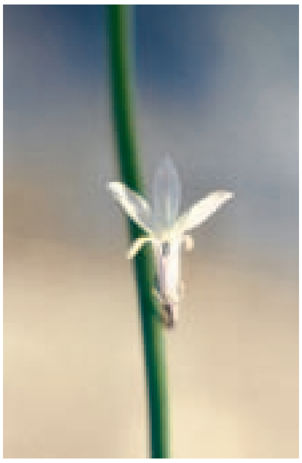
ASTA Phase II participants

Name	Function
Peringe Grennfelt	Programme Director
John Munthe	Deputy Programme Director
Jenny Arnell	Programme secretary
Håkan Pleijel	Co-ordinator Theme 1
John Munthe	Co-ordinator Theme 2
Peringe Grennfelt	Co-ordinator Theme 3
Olle Westling	Co-ordinator Theme 4
Göran Sundqvist	Steering Group Member
Harald Sverdrup	Steering Group Member
Hans Christen Hansson	Steering Group Member
Annika Nordin	Steering Group Member
Filip Moldan	Scientist
Veronika Kronnäs	Scientist
Mattias Alveteg	Scientist
Rolf Lidskog	Scientist
Catarina Sternhufvud	Scientist

Name	Function
Mohammed Belhaj	Scientist
Gun Lövblad	Scientist
Per-Erik Karlsson	Scientist
Lars Ericsson	Scientist
Kevin Bishop	Scientist
Joakim Langner	Scientist
Erik Swietlicki	Scientist
Helena Danielsson	Scientist
Torgny Näsholm	Scientist
Joachim Strengbom	Scientist
Gunilla Pihl Karlsson	Scientist
Liisa Martinsson	PhD Student
Cecilia Akselsson	PhD Student
Martin Letell	PhD Student
Adam Kristensson	PhD Student
Peter Tunved	PhD Student

Abbreviations

LRTAP, (CLRTAP)	Convention on Long-Range Transboundary Air Pollution.
CAFE	Clean Air For Europe, the EU-programme on air quality in Europe.
UN/ECE	United Nations Economic Commission for Europe.
WHO	World Health Organization.
EUROTRAC	The EUREKA Project on the Transport and Chemical Transformation of Environmentally Relevant Trace Constituents in the Troposphere over Europe.
IIASA	International Institute for Applied Systems Analysis.
RAINS	Regional Air Pollution INformation and Simulation, the integrated assessment model forming the base for development of air pollution strategies in Europe.
OECD	Organisation for Economic Co-operation and Development.
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe.



Photographer: Per-Erik Karlsson

The ASTA programme
c/o IVL Swedish Environmental Research Institute
P.O Box 47086   SE - 402 58 Göteborg
Tel. +46 31 725 62 00   Fax +4631 725 62 90
Web-site: http://asta.ivl.se

Department of Ecology and Earth Science
Umeå University
SE - 901 87 Umeå
Tel. +46 90 786 50 00

Department of Forest Genetic and Plant Physiology
Swedish University of Agricultural Science
SE - 901 83 Umeå
Tel. +46 90 786 58 00

Department of Environmental Assessment
Swedish University of Agricultural Science
P.O Box 7050
SE - 750 07 Uppsala
Tel. +46 18 67 10 00

Department of Chemical Engineering
Lund University
P.O Box 124
SE - 221 00 Lund
Tel. +46 46 222 70 10

Department of Physics
Lund University
P.O Box 118
SE - 221 00 Lund
Tel. +46 46 222 70 10

Section of Science and Technology Studies
Göteborg University
P.O Box 700
SE - 405 30 Göteborg
Tel. +46 31 773 10 00

Department of Applied Environmental Science
Göteborgs University
P.O Box 461
SE - 405 30 Göteborg
Tel. +46 31 773 10 00

The Institute of Applied Environmental Research (ITM)
Stockholm University
SE - 106 91 Stockholm
Tel. +46 8 674 70 00

SMHI - Swedish Meteorological and Hydrological Institute
Folkborgsvägen 1
SE - 601 76 Norrköping
Tel: +46 11 495 80 00

IVL Swedish Environmental Institute
P.O Box 47086
SE - 402 58 Göteborg
Tel. +46 31 725 62 00

AB GÖTATRYCKERIET GÖTEBORG 2003