



*International and National
Abatement Strategies for Transboundary
Air Pollution*

**Final report from the
ASTA research program**

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Abstract

The Swedish air pollution research program *International and National Abatement Strategies for Air Pollution research program – ASTA* – initiated by The Mistra Foundation was undertaken between 1998 and 2007. Its aim was to support the development of science-based policies on transboundary air pollution in Europe. Priorities and deliverables were set in the perspective of the agendas under the Convention on Long Range Transboundary Air Pollution (CLRTAP) and the EU, which during the time of ASTA developed a Thematic Strategy on Air Pollution called Clean Air For Europe (CAFE).

Specific aims of the ASTA Programme were to improve scientific knowledge and to develop modelling tools to support the development and application of transboundary air pollution policies in Europe and to develop national strategies and measures in various sectors influenced by transboundary air pollution.

The Swedish ASTA programme carried out research on acidification of soil and water, the effects of nitrogen input on forest ecosystems, the effects of ground level ozone on vegetation and regional transport and concentrations of particulate air pollution. The effects of increased extraction of forest biofuels were also studied in conjunction with the effects of acidification of soil and water and the effects of nitrogen input.

The program was funded by MISTRA - Foundation for Strategic Environmental Research, Elforsk, National Board of Forestry, Swedish Energy Agency and the Ministry of Environment.

This report is a brief compilation of the program's main objectives and outcomes, organisation and relations to policy. It contains also lists of publications and reports.

Further information e.g. access to annual reports etc. are given at ASTA's web page <http://asta.ivl.se>

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Background

The International and National Abatement Strategies for Transboundary Air Pollution - ASTA - was given support from the Mistra Board in October 1998. The decision was based on a proposal initiated by the Swedish Environmental Protection Agency but the final application was prepared by a team of scientists. The proposal had a budget of 65 MSEK for a first phase of four years. Mistra decided to cut the program and give it a support of 26 MSEK for including a budget of 4 MSEK for a start-up year. During this first year, the program was slightly modified, reduced and started up in its final shape in 2000. The program was evaluated both with respect to its scientific achievements and its importance for policy support for a second phase in 2002. Based on the evaluation, the program was given support of 33 MSEK for a four year second phase ending in 2006. Some activities continued during the first half year of 2007 and through an additional funding, an international workshop (Saltsjöbaden 3) was held in March 2007. The whole ASTA program was also evaluated in terms of scientific achievements and organisation early 2007.

ASTA was set up as a supporting research program for the development of policies on transboundary air pollution in Europe. Its priorities and deliverables were set in the perspective of the agendas under the Convention on Long Range Transboundary Air Pollution¹ (CLRTAP, LRTAP Convention) and the European Union. The EU activity was organised in the programme Clean Air For Europe (CAFE)². CAFE's main task within the time framework of ASTA was the development of a Thematic Strategy on Air Pollution.

In addition to Mistra, the program was given support from Elforsk, the National Board of Forestry, Swedish Energy Agency and the Ministry of Environment.

Scientific objectives and directions

The objective of the ASTA Programme was to produce scientific knowledge, data and modelling tools in support of international policies to control transboundary air pollution in Europe and to develop national strategies and measures in various sectors that are affected by transboundary air pollution. This means:

- To strengthen and secure the future supply of Swedish expertise and scientific knowledge for the purposes of international negotiations on environmental agreements and national strategies,
- to build a consensus on research findings through international networks, workshops etc.
- to provide information about and visualise the regional air pollution problem in order to increase policymakers' understanding of the issues and
- to promote a better understanding of the interface between science and politics.

The Swedish ASTA programme carried out research on acidification of soil and water, the effects of nitrogen input on forest ecosystems, the effects of ground level ozone on vegetation and regional transport and concentrations of particulate air pollution. The effects of increased extraction of forest biofuels were also studied in conjunction with the effects of acidification of soil and water and the effects of nitrogen input.

During the first phase, the program was organised in relation to environmental problems and competences. For the second phase it was reorganised in order to meet environmental demands. See figures 1 and 2.

¹ <http://www.unece.org/env/lrtap/>

² <http://ec.europa.eu/environment/air/cape/index.htm>

The scientific directions of the program were chosen in a policy perspective. Sweden and the Nordic countries have since the 1970s taken a long term responsibility for scientific research on regional air pollution in support of the LRTAP Convention. Large resources have been allocated within this field since the problem was discovered. It was therefore a request from Mistra that a program should build on these investments in competence and knowledge. Another aspect in the formation of the program was that the research should be of high international standard and make a scientific impact within the fields of research. A third aspect was that the scientific research should deliver results that could be available for policy purposes during a second phase 2003-2006.

In order to fulfil the objectives, the first phase of the activities of the program was organised with respect to disciplines. See figure 1.

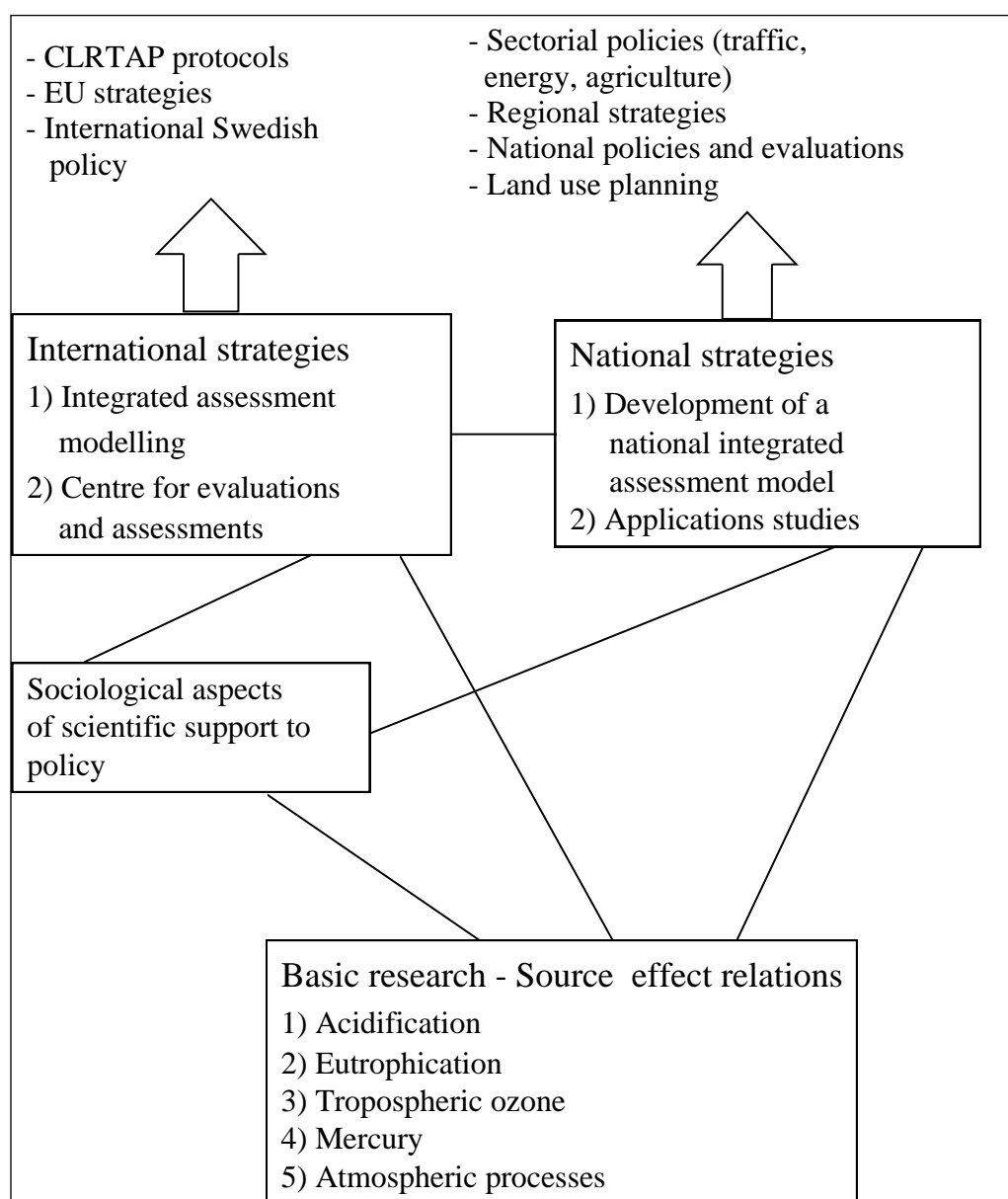


Figure 1 The organisation of the ASTA program under phase 1. Most of the scientific work was directed towards basic research and activities related to International strategies were limited (Program plan for phase 1)

In the second phase (see figure below), the overall organisation was directed towards interdisciplinary research in order to strengthen the links to policy. The basic research activities, dominating phase 1 were directed more clearly towards indicators and target-settings. Economic aspects, which not had been part of phase 1 were added to the program and became a key element in theme 2, which also included analyses of the outcome of present policies. ASTA was also requested by its board to take an initiative to highlight the importance of non-technical measures to reduce air pollutant emissions. Theme 3 included activities related to social science and aspects on how to decrease uncertainties in models. It also included the communication part of the program. Finally, national activities were organised in a separate theme 4 (not supported by Mistra).

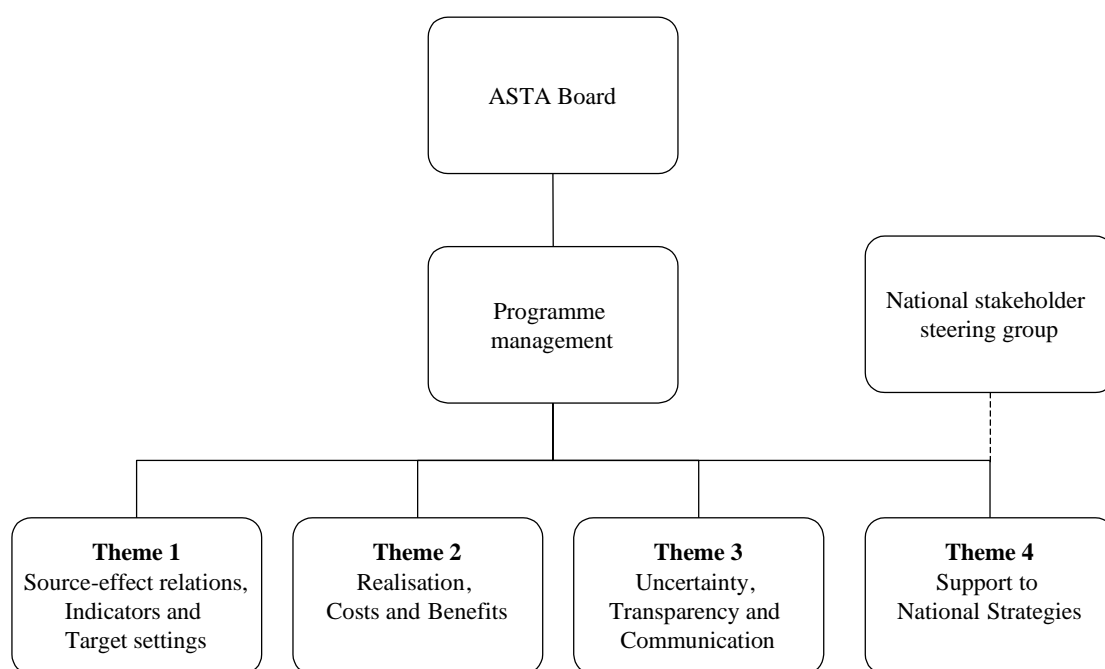


Figure 2. The organisation of the second phase of ASTA. The disciplinary research mainly occurred within theme 1, where it had its direction to support policy development.

Scientific Achievements

Particles

1. Objectives and results

The work was mainly directed towards the following two areas:

- To develop the understanding for atmospheric particles, their abundance, chemical and physical properties, sources and their influence, how particles change during transport, their interaction in and influence on atmospheric processes. This has been used to develop and test new models that will eventually be used within EMEP.
- To describe the present air quality nationally and within EU, specifically from the health effects point of view. The health effects are considerable even for Sweden, with about 5300 premature deaths annually caused mainly by long distance transported air pollution from the continent. However it was shown that there is still considerable uncertainty in the risk estimates for the separate sources.

2. Scientific impact

The main scientific results are on the formation, growth and deposition of both anthropogenic and natural atmospheric particles. Particle formation and growth were studied through field monitoring, which in particular were directed towards Nordic boreal forests and the results formed a basis for model development and application. The large data sets gathered by continuous monitoring during many years have facilitated relatively large progress in our understanding on the interaction between forests and the atmosphere and how forests influences its own climate. Results have been published in highly ranked peer reviewed journals, including Science. The urban studies have shown the influence by the local environment on size and chemistry of particles. They show as well the importance of measurements to verify actual emissions.

The results from the two areas are vital elements in the regional modelling for air quality and climate change.

3. Policy impact

The results have continuously been implemented into the EMEP models and are thus a part of the direct input to the work within the LRTAP Convention and also the EU CAFE policy development. The results have as well been presented in the different working groups and task forces in EMEP, e.g. TFMM and the Expert Group on PM and thus been implemented into the decision process. Program participants have as well been advisors to national representatives in international negotiations. The scientists within this area have participated in different expert groups in CAFE, e.g. the Second Position Paper on PM that formed the foundation for the further discussion on new Air Quality Standards.

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Ozone effects on vegetation

1. Objectives and results

The goal of the activities related to ground-level ozone was to support the scientific process within the LRTAP Convention with respect to the development of exposure indices and dose-response relationships based on ozone uptake. This was achieved by:

- Calibrating simulation models for stomatal conductance in wheat, potato, Norway spruce and silver birch
- Compilation and quality control of data from all relevant experiments with these plants that have been performed in Europe
- Based on models and experimental data dose-response relationships were derived
- Supporting the approval of the methods developed within a European scientific context.

Within the national part of ASTA, methods to quantitatively and economically assess the negative impact of ozone on vegetation in Sweden have been developed. See "Economy"

2. Scientific impact

All important results have been published in the peer reviewed scientific literature. The research has been at the leading edge in terms of the development of ozone uptake based methods to assess ozone effects. The most important publications are:

- Karlsson PE, Braun S, Broadmeadow M, Elvira S, Emberson L, Gimeno BS, Le Thiec D, Novak C, Oksanen E, Schaub M, Uddling J, Wilkinson M (2007) Risk assessments for forest trees: the performance of the ozone flux versus the AOT concepts. *Environmental Pollution* 146: 608-616.
- Pleijel, H., Danielsson, H., Emberson, L., Ashmore, M. & Mills, G. (2007). Ozone risk assessment for agricultural crops in Europe: deriving stomatal flux and flux-response relationships for European wheat and potato. *Atmospheric Environment* 41, 3022-3040.

3. Policy impact

The researchers within the ASTA program have participated in all workshops and expert meetings related to ozone effects on plants in Europe during the period 1999-2007 and have acted as chair persons in working groups etc. The results from the research have been incorporated into the Mapping Manual of the LRTAP Convention – a handbook for how to map environmental load and effects – Four ASTA scientists were active in the development of the text for the manual. Some of the methods have been applied in economic studies of ozone effects and other estimations of ozone effects as well as for the development of national environmental objectives.

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Nitrogen - Low dose effects to terrestrial ecosystems

1. Objectives and results

The main objectives were (1)

1. to produce empirical results to make it possible to determine nitrogen critical loads for ecosystems in areas with low background nitrogen deposition levels and
2. to support the development of ecosystem modeling tools for the same purpose. In focus was nitrogen induced vegetation changes in boreal ecosystems; spruce forest with *Vaccinium myrtillus* dominated field layer vegetation, pine forest with *Vaccinium vitis-idaea* dominated field layer vegetation and *Sphagnum* dominated oligotrophic wetlands.

The results revealed that biotic interactions between plants and the herbivores and pathogens that attack and damage them, are influenced by nitrogen enrichment. Generally, increased nitrogen supply resulted in increased damage on plants from herbivores and pathogens. In turn this triggered drastic changes in plant species composition of the vegetation. Nitrogen induced vegetation changes occurred at lower levels of nitrogen enrichment than previously anticipated. Also vegetation responses differed depending on whether reduced or oxidized nitrogen was added.

Scientific impact

Results delivered from the project have received attention both nationally and internationally and have been published in prominent international scientific journals. The research has significantly progressed knowledge on the role of natural enemies (insect herbivores and pathogens) for vegetation development in nitrogen enriched boreal ecosystems.

Currently a very much debated question for the scientific community is how global climatic and environmental changes will influence the biological diversity in different natural ecosystems. In north-latitude ecosystems (boreal and Arctic) it seems likely that nitrogen deposition has the same potential as the expected climate change to alter the biological diversity. Results from the current project have indicated that synergistic effects between nitrogen enrichment and climate change can result in unexpected vegetation responses. These results emphasize that more research is needed to allow for predictions of future biological diversity in Northern ecosystems.

Policy impact

Results have each year been communicated at meetings organized within the CLRTAP (Convention of Long-Range Transboundary Air Pollution); both at various ICP-meetings (Mapping and Modeling; Vegetation) and at joint workshops for ecological modelers and

experimentalists (empirics). This spring a workshop was organized with the objective to revise empirical critical load recommendations for regions with low nitrogen deposition levels.

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Economy - valuation air pollution effects and the inclusion on non-technical measures (NTM)

Objectives and results

The ASTA program and especially the part dealing with environmental economics have had several objectives. Based on scientific results related to tropospheric ozone and acidification the objectives of the project were:

1. to estimate the effects of tropospheric ozone on agriculture and forestry production and to conduct a cost benefit analysis;
2. to estimate acidification's effects on health and the environment (buildings) including costs and benefits of reduced acidification;
3. to estimate the impacts of including non technical measures when abating emissions;

Our studies show that the annual effect of tropospheric ozone on the Swedish agricultural sector including only grain ranges between 5% and 10% leading to a yearly average loss of 160 MSEK. For the forestry sector the impact of ozone on the Swedish production is estimated to 2.6% i.e. 340 MSEK/year. The Cost-benefit analysis of acidification in Sweden shows a high net present value for control measures in all scenarios. The total impacts of acidification in Sweden distributes as follows: 50% being the health effects, biodiversity 15%, base cation and corrosion 15% each.

The overall purpose of this study is to compare the cost effectiveness of non-technical measures and technical measures. Specifically, the study includes two meta-regression analyses in the agricultural- and energy sectors. The shipping sector was studied in a descriptive manner. The results of the meta-regression for the agricultural and the energy sector give some insight on the efficiency of NTM compared to conventional technical measures (TM).

Scientific impact

Our studies together with an ASTA workshop in 2005, gave a focus on NTM and the interest on considering non-technical measures that was not included in policy discussions have increased.

3. Policy impact

The quantified and monetized impacts of ozone on forest production, although not very high, constituted a starting point for including forestry impacts while discussing economic consequences of tropospheric ozone. The finding on the importance of non technical measures became an important tool in the sake of cost effective measures to abate air pollution

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Linking science to policy – a social science angle of the ASTA program

A particular theme of the program has been to study the science policy interrelations from a social science perspective. The focus has however not only been the scientific research *per se* but also the transfer and communication of scientific knowledge into the process. In particular, the involvement of scientists at the negotiation tables were studied as well as the role of concepts as

bridging tools between the scientific and policy communities. The results resulted in a book that have been widely cited after the ending of the program in it illustrates well the uniqueness of the LRTAP Convention in the way science and policy work together.

Reference see below.

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Workshops and other activities

A particular task of the program has been to take a responsibility on improving communication between science and policy. CLRTAP has throughout its history developed a system through which science and policy has become closely linked. Part of the success of the Convention is considered to depend on the linkages, through which scientists and policymakers have been able to talk directly with each other. The system has developed both through the formal systems under the Convention and through informal workshops and meetings, which has been part of the formal agenda of the Convention but at the same time also been an open scientific meeting to which all interested have been able to attend.

The ASTA program already in the first proposal presented the idea of taking a wider international responsibility for the future communication between the scientific community and the policy level. One of the examples of the activities we initiated was strategic non-formal meetings with policymakers and scientists within international air pollution. The first meeting was the *Workshop on future needs for regional air pollution strategies* at Saltsjöbaden, Sweden 10-12 April 2000. At this workshop the needs for future scientific and policy-related activities in relation to the international air pollution agenda was discussed and the conclusions and recommendations from the workshop formed a roadmap for both CLRTAP and the program Clean Air For Europe (CAFÉ) launched by the European Commission in 2001. This workshop has followed by two workshops also organised by ASTA the second in 2004 and the third in March 2007. Reports are available at <http://saltsjobaden5.ivl.se/>

Another example on the role of ASTA has been the introduction of dynamic modelling as a tool for the development of abatement strategies for acidification. The original definition of the critical loads did not take dynamic effects into account. The concept was only related to an equilibrium situation, at which negative effects from air pollution could be balanced by natural processes. In reality, there is an obvious need also to take dynamics into account and the program initiated an international process by first introduce an dynamic concept at a conference on critical loads in 1999 and then by taking responsibility for an international expert group, Joint Expert Group on Dynamic Modelling (JEG) directed towards the future development of dynamic modelling. JEG has organised yearly meetings and become well established and got a given role both scientifically and with respect to policy³. The responsibility was shared with Centre for Ecology and Hydrology (CEH, UK).

The workshops organised by ASTA or where ASTA has been a co-organiser are listed in Appendix 1.

Taking responsibility for supporting science policy interrelations has also included other activities. The most important one is probably the initiative taken by ASTA to make a long term assessment of the data EMEP has produced since its start in 1977. This activity was based on a proposal and an offer from ASTA. The background was that EMEP all the time since its start had collected a large amount of concentration and deposition data from measurements with

³ Reports from JEG meetings are processed through the CLRTAP system. Official reports are available on <http://www.unece.org/env/documents/2005/eb/wg1/EB.AIR.WG.1.2005.13.e.pdf> for the meeting in 2004 and <http://www.unece.org/env/documents/2006/eb/WG1/ece.eb.air.wg.1.2006.14.e.pdf> for 2005.

methodologies that were standardised and checked in inter-comparisons but the data had never been thoroughly evaluated in terms of regional impacts and trends. It was also obvious that many countries had not made use of their data. Under the period 2001-2004 ASTA together with the EMEP meteorological synthesising centre west (MSC-W) led the preparation of the assessment report.⁴

Another example of activities in direct support of policy is the review of the EMEP unified model. EMEP had over several years developed a unified Eulerian model for establishing source-receptor matrixes for its modelling domain. In November 2003 the model was evaluated at a workshop in Oslo. One of the tasks was to compare the model with monitored data. Since the model continuously has used data from the EMEP network such data were not suitable for the model evaluation. However through the ICP Forest monitoring network in Europe, an independent set of data had been established and in an ASTA short term project, the data from the network were extracted, quality checked and then compared with the modelled results. The outcome of this inter-comparison gave a surprising good agreement and was one of the main basis for the conclusions on the quality of the model⁵.

Organisation of the program

The program has been directed by a Program Board. The program board had the overall responsibility of the program and Mistra interacted not directly with the program under its different phases.

Three members have been part of the board for the whole program period:

Lars Lindau, Swedish Environment Protection Board, Chairman
Gunnar Hovsenius, Elforsk (A research organisation for the Swedish energy industry)
Anton Eliassen, Norwegian Meteorological Research Institute.

The program leader Peringe Grennfelt has also been a member of the board for the entire period.

In addition, there have been both ordinary and associated members of the program board for more limited periods. Among those being involved for the longest time are

Anna Lundborg, Swedish Energy Agency
Hillevi Eriksson, Swedish Forest Agency
Karsten Pederssen, Göteborg University

There has also been an associated Mistra representative in the board. The Mistra member has changed several times over the program period. The following persons have been representing Mistra in the program Board: Kerstin Lövgren, Jan Nilsson, Eva Thörnelöf, Olof Olsson and Marie Uhrwing.

Internally, the Program has been directed by a management group. The management group met 2-3 times a year. In addition, there have been yearly meetings, at which the Board and all scientists were invited. A limited number of stakeholders were also invited to these meetings.

The program was also hit by a severe fatality. Olle Westling, leader of the national subprogram and an international well-known scientist within the field of air pollution and its effects to forests and forest ecosystems, passed away in an accident in July 2006.

In all about 30 scientists have been involved actively in the program. Those involved are listed in Appendix 2.

⁴ The EMEP Assessment report is available on http://www.emep.int/index_assessment.html

⁵ See reference list Simpson et al.

PhD dissertations

Nine scientists have concluded their dissertations within the ASTA program. (See Table 2) A couple of them had started their PhD studies already before the start of the program, but they finished their work within the program.

Name, University	Title	Year
Martin Letell, Göteborg University	Governable Air - Studies on the Science and Politics of Air Pollution in Europe.	2006
Cecilia Akselsson, Lund University	Regional nutrient budgets in forest soils in a policy perspective.	2005
Adam Kristensson, Lund University	Aerosol Particle Sources Affecting the Swedish Air Quality at Urban and Rural Level.	2005
Peter Tunved, Stockholm University	On the lifecycle of aerosol particles: Sources and dispersion over Scandinavia.	2004
Liisa Martinsson, Lund University	Recovery from acidification - policy oriented dynamic modeling.	2004
Gunilla Pihl Karlsson, Göteborg University	Clover as a bioindicator for phytotoxic ozone.	2003
Helena Danielsson, Göteborg University	Exposure, Uptake and Effects of Ozone.	2003
Jörgen Persson, Swedish University of Agricultural Sciences	Organic Nitrogen Uptake by Boreal Forest Plants.	2003
Joakim Strengbom, Umeå University	Nitrogen, parasites and plants - key interactions in boreal forest ecosystems.	2002

Table 2. PhD dissertations within the ASTA program

Associated activities

The National Program

In addition to the MISTRA fund, there has been a national program associated to the core program throughout the whole program period. This program has directed its main activity towards forest ecosystems and has received support from Swedish Forest Agency and Swedish Energy Agency and the Swedish Environment Protection Board. The overall budget for the national program was approx. 8 MSEK. Much of the data used in the model development was collected within the national program.

International research projects

ASTA scientists have been involved in several EU funded projects on relevant topics in the course of the program. These include NEPAP, RECOVER, EUROLIMPACS, BIOFORE, PARFORCE, EPICA, PROCLOUD, EUROTRAC2, ACCENT, EUSAAR and EUCAARI.

ASTA scientists have also taken leading roles in Nordic cooperation via participation in research projects funded by the Nordic Council of Ministers. These projects have focussed on mercury, acidification and recovery and long-range transport of particulate matter.

Scientific achievements

The scientific results from the ASTA program have to a large extent been communicated through peer-review papers. In addition results are presented at scientific meetings and conferences. A part of the scientific material is also presented in special reports, in particular in reports from workshops etc. A particular activity in terms of publications was a Special Issue of *Ambio*, published in 2005. Another important activity with respect to scientific presentations of the ASTA results was the 7th Acid Rain conference in Prague in June 2005. The program directed a large part of its scientific output to this conference, which was the largest event within the field of international air pollution during the ASTA program. In all, the program contributed with 18 posters and with 9 oral presentations at the conference.

Publications

About 150 peer-reviewed papers have been published with scientific contributions from the ASTA program. Many of them are pure ASTA products but a substantial part is publications prepared in collaboration with scientists outside the program. Since a main objective of the program is to develop knowledge in an international context and to form consensus, it has been an objective in itself to publish in collaboration with other scientists and groups. In addition there are also a number of scientific reports. These are mainly directed towards integrating areas.

All peer-review publications and scientific reports are listed in Appendix 3 and Appendix 4. The lists are also available on the web.

In addition to the papers and reports listed, there have been a large number of talks and posters presented at conferences and workshops all over the world. Since a large part of them have occurred as scientific papers and reports, we have chosen to list them.

Yearly reports

It is a request by Mistra to publish a yearly report. These reports have throughout the program had various themes as mentioned in the table.

Table 3 The yearly reports from ASTA and their themes. The yearly reports are available at the ASTA web site.

Year	Theme	Language
1999	Presentation of the program	Swedish
2000	Program presentation - explaining the needs for new approaches	English
2001	Effects of air pollution in Sweden	Swedish
2002	Science for policy	English and Swedish
2003	New effects and tools	Swedish
2004	<i>Ambio</i> Special Issue	English
2005	Air pollution strategies on the Agenda - what does the CAFÉ program mean for the Swedish population and Swedish ecosystems?	Swedish

For 2006 there was not an annual report. Instead a book was published compiling the main knowledge on transboundary air pollution. See under Books

Books

Two books have been published based on the ASTA research and financed to a large extent by ASTA. The first one was edited by Håkan Pleijel and is directed to students and professionals with an interest in air pollution.⁶ ASTA participants were main authors and the book and illustrating examples were taken from the ASTA research. The second is an anthology of social science aspects of air pollution policies and the book was edited by Rolf Lidskog and Göran Sundqvist.⁷

ASTA scientists as international and national experts

Even if this is a scientific review, we want to mention that many of the scientists involved have been deeply involved as experts both nationally and internationally. A detailed list is presented in Appendix 5.

Continuation of Swedish air pollution research

As a continuation of the ASTA research a new research program Swedish Clean Air Research Programme –SCARP – was initiated by the Swedish Environmental Protection Agency. The program is running over 6 years included a budget of approx. 36 MSEK. <http://www.scarp.se/>

⁶ Pleijel, H. Ed. 2007 Transboundary Air Pollution. Scientific Understanding and Environmental Policy in Europe. Studentlitteratur (231 pp)

⁷ Lidskog, R. and Sundqvist, G. Eds. (2012) Governing the Air: The Dynamics of Science, Policy, and Citizen Interaction <https://mitpress.mit.edu/books/governing-air>

Appendix 1 - Workshops and meetings organised by ASTA or in close collaboration with other organisers.

Workshops with ASTA as a main organiser
Nitrogen critical loads for terrestrial ecosystems in low deposition areas, A workshop of the Convention on Long-range Transboundary Air Pollution (LRTAP), 29 – 30 March 2007 in Stockholm, Sweden
Air pollution and its relations to climate change and sustainable development - Linking immediate needs with long term challenges "Saltsjöbaden 3", 12-14 March 2007, Gothenburg, Sweden
The seventh meeting of the Joint Expert Group on Dynamic Modelling, 25-27 October 2006 in Sitges (Spain)
The importance of Non-Technical Measures for reductions in emissions of air pollutants and how to consider them in Integrated Assessment Modelling - A Workshop in collaboration with the UN/ECE Task Force on Integrated Assessment Modelling, 7-9 December 2005, Göteborg, Sweden Report: http://www.ivl.se/rapporter/pdf/B1664.pdf
The sixth meeting of the Joint Expert Group on Dynamic Modelling, 28 October 2005 in Brighton (United Kingdom) Report: http://www.unece.org/env/documents/2006/eb/WG1/ece.eb.air.wg.1.2006.14.e.pdf
Towards Robust European Air Pollution Policies: Constraints and Prospects for a wider dialogue between scientists, experts, decision-makers and citizens, Göteborg, October 5-7, 2005 Report: http://www.ivl.se/rapporter/pdf/B1671.pdf
The fifth meeting of the Joint Expert Group on Dynamic Modelling, 28–29 October 2004 in Sitges (Spain) Report: http://www.unece.org/env/documents/2005/eb/wg1/EB.AIR.WG.1.2005.13.e.pdf
Workshop on Review and Assessment of European Air Pollution Policies, Gothenburg Sweden, 25-27 October 2004 Report: http://asta.ivl.se/Workshops/WORKSHOPREPORT.pdf
Emissions, transport, deposition and effects of base cations in relation to acidification, Gothenburg Sweden November 2003 Report: http://www.ivl.se/rapporter/pdf/B1585.pdf
The fourth meeting of the Joint Expert Group on Dynamic Modelling, 5-7 November 2003 in Sitges (Spain) Report: http://www.unece.org/env/documents/2004/eb/wg1/eb.air.wg1.2004.13.e.pdf
CAFE workshop on the Second Particulate Matter Position Paper Stockholm Sweden October 2003 Report: http://ec.europa.eu/environment/air/cafepdf/working_groups/2nd_position_paper_pm.pdf
Establishing Ozone Critical Levels II, Gothenburg Sweden 19-22 November 2002 Report: http://www.ivl.se/rapporter/pdf/B1523B.pdf
The third meeting of the Joint Expert Group on Dynamic Modelling, 6-8 November 2002 in Sitges (Spain)
1st International Workshop on Validation and Evaluation of Air Emission Inventories, Gothenburg Sweden 14-16 October 2002
National Expert Workshop (nitrogen), Stockholm Sweden 27 February, 2002
The second meeting of the Joint Expert Group on Dynamic Modelling, 6-8 November 2001 in Ystad (Sweden)
Workshop on future needs for regional air pollution strategies Saltsjöbaden 2000 Report: http://asta.ivl.se/Saltsjobaden1.pdf
The first meeting of the Joint Expert Group on Dynamic Modelling, 3-5 October 2000 in Ystad (Sweden)

ASTA involved
ACCENT workshop on Common issues on Air Quality and Climate, Dublin, 2006
Task Force on Integrated Assessment Modelling, December 2005, Göteborg, Sweden
Workshop and Task Force Meeting of the ICP Modelling and Mapping, 19-23 May 2003, Tartu, Estonia
Workshop on a Communication Strategy for the Convention on Long- Range Transboundary Air Pollution, 9-11 April 2003, London, United Kingdom
Task Force on Measurements and Modelling, 9-11 April 2003, Valencia, Spain

Appendix 2 - ASTA Phase II participants

Name		Organisation/University	Function
Peringe	Grennfelt	IVL Swedish Environmental Research Institute	Programme Director
John	Munthe	IVL Swedish Environmental Research Institute	Deputy Programme Director
Jenny	Arnell	IVL Swedish Environmental Research Institute	Information Officer, Programme secretary
Håkan	Pleijel	Göteborg University	Co-ordinator Theme 1
John	Munthe	IVL Swedish Environmental Research Institute	Co-ordinator Theme 2
Peringe	Grennfelt	IVL Swedish Environmental Research Institute	Co-ordinator Theme 3
Olle	Westling	IVL Swedish Environmental Research Institute	Co-ordinator Theme 4
Hans-Christen	Hansson	Stockholm University	Steering Group Member
Annika	Nordin	Swedish University of Agricultural Science	Steering Group Member
Göran	Sundqvist	Göteborg University	Steering Group Member
Harald	Sverdrup	Lund University	Steering Group Member
Mattias	Alveteg	Lund University	Scientist
Mohammed	Belhaj	IVL Swedish Environmental Research Institute	Scientist
Kevin	Bishop	Swedish University of Agricultural Science	Scientist
Helena	Danielsson	IVL Swedish Environmental Research Institute	Scientist
Lars	Ericsson	Umeå University	Scientist
Per-Erik	Karlsson	IVL Swedish Environmental Research Institute	Scientist
Veronika	Kronnäs	IVL Swedish Environmental Research Institute	Scientist
Joakim	Langner	SMHI	Scientist
Rolf	Lidskog	Örebro University	Scientist
Gun	Lövblad	IVL Swedish Environmental Research Institute	Scientist
Filip	Moldan	IVL Swedish Environmental Research Institute	Scientist
Torgny	Näsholm	Swedish University of Agricultural Science	Scientist
Gunilla	Pihl Karlsson	IVL Swedish Environmental Research Institute	Scientist
Catarina	Sternhufvud	IVL Swedish Environmental Research Institute	Scientist
Joachim	Strengbom	Swedish University of Agricultural Science	Scientist
Erik	Swietlicki	Lund University	Scientist
Stefan	Åström	IVL Swedish Environmental Research Institute	Scientist
Cecilia	Akselsson	Lund University/IVL	PhD Student
Adam	Kristensson	Lund University	PhD Student
Martin	Letell	Göteborg University	PhD Student
Liisa	Martinsson	Lund University	PhD Student
Peter	Tunved	Stockholm University	PhD Student

Appendix 3 – Peer reviewed publications

Papers

Peer reviewed scientific publications. There are additional papers published after ASTA was finished which are not included in this list.

Phase II Theme Area

- 1 H. Sverdrup, S. Belyazid, B. Nihlgård, L. Ericson 2007. Modelling change in ground vegetation response to acid and nitrogen pollution, climate change and forest management at in Sweden 1500-2100 AD
Water, Air and Soil Pollution Focus (X:Y01-Y18)
- 1 H. Sverdrup, I. Stjernquist, G. Thelin, J. Holmqvist, P. Wallman and M. Svensson 2005. Application of Natural, Social, and Economical Sustainability Limitations to Forest Management, Based on Swedish Experiences Journal of Sustainable Forestry 21:147-176
- 1 H. Sverdrup, L. Martinsson, M. Alveteg, F. Moldan, V. Kronnäs, J. Munthe 2005, Modeling recovery of Swedish ecosystems from acidification Ambio 34:25-31
- 1 S. Belyazid, O. Westling, H. Sverdrup 2005: Modelling changes in soil chemistry at 16 Swedish coniferous forest sites following deposition reduction. Environmental Pollution 144:596-609.
- 1 Sverdrup, H., Belyazid, S., Haraldsson, H., Nihlgård, B 2005. Modelling change in ground vegetation from effects of nutrients, pollution, climate, grazing and land use. In: Edda Oddsdottir and Gudmundur Halldorsson: (Eds.) Effects of afforestation on ecosystems, landscape and Rural development. Proceedings from a conference held at Reykholt, Iceland, June 20-23, 2005. Andre nordiske publikasjoner, Chapter 1:33-43. Nordic Council of Ministers, Copenhagen
- 1 Haraldsson, H. V. and Sverdrup 2004, H. Finding Simplicity in complexity in biogeochemical modelling. In: J. Wainwright and M. Mulligan (Eds.), Environmental Modelling: Finding Simplicity in Complexity. Wiley, New York, pp. 211-223.
- 1 P. Wallman, M. G.E. Svensson, H. Sverdrup and S. Belyazid 2004. ForSAFE--an integrated process-oriented forest model for long-term sustainability assessments, Forest Ecology and Management, 207:19-36, Issues 1-2
- 1 P. Wallman, M. Svensson, H. Sverdrup and S. Belyazid. DECOMP--a semi-mechanistic model for litter decomposition. Environmental modelling and software 21:33-44
- 1 Sverdrup, H, Thelin, G., Robles, M., Stjernquist, I., Sörensen, J. Assessing sustainability of different tree species considering Ca, Mg, K, N and P at Björnstorp Estate. Biogeochemistry, 81:219-238
- 1 G. Thelin, H. Sverdrup, J. Holmqvist. U. Rosengren, M. Linden 2002. Sustainability in spruce and mixed forest stands In: Developing principles for sustainable forestry Results from a research program in southern Sweden. H. Sverdrup and I. Stjernquist (Eds.) Managing Forest Ecosystems 5: 337-354 Kluwer Academic Publishers, Amsterdam
- 1 J. Holmqvist, G. Thelin, U. Rosengren, I. Stjernquist, M. Svensson, P. Wallman, H. Sverdrup 2002. Assessing sustainability in the Asa research park In: Developing principles for sustainable forestry Results from a research program in southern Sweden. H. Sverdrup and I. Stjernquist (Eds.) Managing Forest Ecosystems 5: 381-426 Kluwer Academic Publishers, Amsterdam
- 1 C. Kalen, B. Nihlgård, H. Sverdrup 2002: Forests, acidification and the socio-economic cost. In: Developing principles for sustainable forestry. Results from a research program in southern Sweden. H. Sverdrup and I. Stjernquist (Eds.) Managing Forest Ecosystems 5: 297-316 Kluwer Academic Publishers, Amsterdam
- 1 T. Fumuto, J. Shindo, N. Oura, H. Sverdrup 2001. Adapting the PROFILE model to calculate the critical loads for east Asian soils by including volcanic glass weathering and alyernative aluminium solubility system. Water, Air and Soil Pollution 130:1247-1252.
- 1 Kurz, D., Rihm, B., Alveteg, M. and Sverdrup, H. (2001) Steady-state and dynamic assessment of forest soil acidification in Switzerland. Water, Air and Soil Pollution 130: 1217-1222
- 1 M. Semenov, V. Bashkin and H 2001. Sverdrup Critical loads of acidity for forest ecosystems of North Asia. Journal of Water, Air and Soil Pollution 130:1193-1198
- 1 Grennfelt, P., Moldan, F., Alveteg, M., Warfvinge, P. and Sverdrup, H. (2001) Critical loads - Is there a need for a new concept. Journal of Water, Air and Soil Pollution Focus 1: 21-27
- 1 M. Holmberg, J. Mulder, M. Posch, M. Starr, M. Forsius, M. Johansson, J. Bak, H. Ilvesniemi, H. Sverdrup. Critical loads of acidity for forest soils, tentative modifications. Journal of Water, Air and Soil Pollution Focus 1; 91-101

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- 1** Sverdrup, H., Martinson, L., Alveteg, M., Moldan, F., Kronnäs, V., and Munthe, J. 2005. Modeling Recovery of Swedish Ecosustems from Acidification. *Ambio*, 34, 1. 25-31.
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Appendix 4 – Reports

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Appendix 5 - Engagement from ASTA scientists in international and national expert committees and groups

Name	Expert group	Function
HC Hansson	CAFÉ Expert Group on Particulate Matter	Expert
	CLRTAP Expert Group on PM	Expert
	EMEP - Task Force for Modeling and Measurements, TFMM	Expert
	EMEP Expert group on particles	Expert
John Munthe	EU Working Group on Mercury - Position Paper	Expert, national representative
	UNEP Global Mercury Programme	Expert
	Arctic Council Action Plan for Mercury (ACAP)	National representative
Per-Erik Karlsson	Expert group for preparation of ozone chapters in CLRTAP -Mapping Manual.	Expert
	EC, "Scientific Committee on Health and Environmental Risk", (SCHER),	Expert
	Expert group for development of methods for calculating ozone uptake in trees under the LRTAP conventions ICP Modelling and Mapping Task Force.	Chair
	ICP-Vegetation since 2000. Organiser of LRTAP-workshop on critical levels ozone in 2002 (Hindås, Sweden).	Participation
Håkan Pleijel	Expert group for preparation of ozone chapters in CLRTAP -Mapping Manual	Expert
	ICP Vegetation for scientific publication of flux-based methods for crops in LRTAPs Mapping Manual.	Responsible
	ICP-Vegetation since 2000. Organiser of LRTAP-workshop on critical levels ozone in 2002 (Hindås, Sweden).	Participation
Peringe Grennfelt	EMEP Steering Body and its Bureau	National representative
	TFMM	National representative
	TFIAM	Expert
	TFHTAP	National representative
	NEGTAP	Member of the group
	NMR Air and Sea Group	Program coordinator and responsible for secretariat
	RAINS Review	Chairman of the review group
	Royal Society expert group on ozone in the 21st century	Member of the panel
Filip Moldan	Joint Expert Group on dynamic modelling, CLRTAP	Co-chair