SCARP

Swedish Clean Air Research Program

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Proposal for phase 2

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Summary

In this proposal we describe the directions and content for The Swedish Clean Air Research Program (SCARP) for the second phase 2010-2012. The program will follow its original objectives: ... "to increase the scientific understanding of air pollution effects to human health and environment with the aim to support policy development in Sweden and Europe." The program will in large continue its research in line with the original proposal. We have however made substantial changes in the program in relation to recommendations from the evaluation committee.

The program will in the second phase have a large focus on compilation and evaluation of the results obtained in the program. In particular we will

- make sure that the results from the experimental studies within the health areas will be taken further so they can be used for health risk assessments This will be done in close collaboration with Area 2 and 4
- make sure that the results from the research activities in Area 2 will be used in 3D atmospheric models to improve our understanding of the role of primary and secondary aerosols for PM exposure
- make sure that the results from the research activities in Area 3 will be used for further development of the dynamic nitrogen critical loads and for assessment of long term effects of N deposition to forest and aquatic ecosystems
- establish a sound basis for a national version of the GAINS model with particular emphasis on the linkages between the control of air pollution and greenhouse gases. Area 4 will also take a particular responsibility for the integration of the results from areas 1 and 3 into the GAINS modelling systems.

Main achievements Phase 1

The main achievements in phase 1 are described in the Mid Term Report submitted to the Environmental Protection Agency 25 August 2009. .

Some general remarks to the Evaluation of the programme.

The mid-term evaluation of the programme recommended a continuation of the programme but added a number of items to be handled in a proposal for the phase 2.

We agree in large with the main conclusions and also with the detailed comments made in the evaluation report. With the exception of a few minor points we will follow the recommendations in the report. However, with the time constraints for this application, we are not able to fully develop the program plan both with respect to program integration and to communication. This will be done as a start-up of phase 2.

Comments to the main recommendations:

The recommendations of the evaluation committee were summarized in 7 main points and they are taken into account in the application in the following ways:

1. Develop and apply a formal strategy for a better integration between the programme areas.

Items for such a strategy is described in the section Program Integration. This will be further developed at joint meetings in the beginning of phase 2.

2. Deliverables and milestones should be added together with communication goals.

Deliverables and milestones are added into the program under the description of each activity.

3. Strengthen the scientific rigour of Area 4 by support from experienced supervisors.

The inclusion of IIASA in the project application and the creation of an external advisory group will ensure the scientific rigour of Area 4. More details are presented under Area 4.

4. Prepare a list of anticipated - explicit, realistic, and motivated – manuscripts from each work area.

Expected scientific publications (manuscripts) are listed under each activity.

5. Integrate the non-mortality outcomes, including health effects in children, from Area 1 into Area 4.

The activity is described in general terms in the section Program Integration and in detail in project 4.3.

6. Characterize the national cost parameters, even for non-technical measures, and extension (related funds provided) to the impact side for a standalone GAINS Sweden modelling system.

See project 4.2.

7. Develop the ForSAFE-VEG model with special emphasis on making it operational for calculating and mapping critical loads for nitrogen.

Phase 2 of the program has received a stronger focus on this issue with particular direction to the implementation of dynamic nitrogen critical loads. This is further described i project 3.

In the case of communication, we will argue that there is no lack of communication activities in the program neither these communication activities are not part of a systematic plan. We agree however that we could have communicated these activities better and hope that what is presented in this proposal will give a better understanding of how the results are communicated.

Program Integration

Program integration will be a central part of phase 2. The overall objectives of the program integration are

- Certify that the project activities are organised in a way that the full value for the program and for policy development is achieved.
- Develop, test and apply tools for assessments of effects to human health and ecosystems based on research within SCARP. For human health the application should in particular be directed towards health effects on children and for ecosystems towards dynamic critical loads for nitrogen.
- Apply the tools for Swedish conditions; for health effects for at least one urban area and for dynamic nitrogen critical loads on a national scale.

We are foreseeing three overarching activities with respect to integration between research areas:

Integration between Area 1 (health) and 2 (particles)
There is extensive collaboration between SCARP partners on the area of population exposure to pollutants related to traffic and house heating for assessment of effects on a local scale. Concentration fields have been estimated – also retrospectively – based on dispersion models, emission inventories and measurements. From these fields outdoor residential levels were calculated for population groups and samples of the general population, and used in cohort as well as case referent studies.[1]. Further development of the collaboration between the health and particle areas is envisaged in the project proposed for additional funding "Harmonisation of dose-response modelling regarding health effects of specific air pollution components". A main component of this project is the development of a uniform strategy to model local levels of particles in Göteborg, Stockholm and Umeå. The epidemiological studies within SCARP are primarily performed in these cities.

The assessments of health effects will be further developed in relation to the GAINS model system and in comparison with those source-receptor data presently used in the model through collaboration between area 1 and area 4. In Activity 4.3 the activities are further described.

Integration between Area 1 and 4
For those projects, in which it is possible to estimate does response data, such data will be tested and implemented into a GAINS module. In particular, we will look into source-receptor data for asthmatic effects on both adults and children. The process of this activity is further described in Project 4.3.

Integration between Area 3 and 4
The final objective of the integration between Area 3 and 4 is to produce a dynamic nitrogen critical load map for Sweden based on ForSafeVeg and Magic. This work will be done based on the development of the critical loads work in Area 3 and incorporating it to the GAINS Sweden model. In addition, the whole Area 3 will to a large extent be directed towards integration of the results from phase 1 and elsewhere. Extensive integration of N-modelled data in support of dynamic N modelling is planned as a separate activity in Area 3. Scientists from Area 3 will participate in this activity. Scientists from Area 3 and 4 will participate in this activity. This activity is further presented in 3-*Integration with the IAM cluster* and activity 4.3 and 4.4

Program integration group
The program integration group will consists of those project leaders that will take part in the integration activities and may change over time depending on how the different activities are organised. It will be set up early in 2010.

[1] For publications see:
• Bellander T, Berglind N, Gustavsson P, Jonson T, Nyberg F, Pershagen G, Järup L. Using geographic information systems to assess individual historical exposure to air pollution from traffic and house heating in Stockholm. Environmental Health Perspectives 2001;109(6):363-369.
• Rosenlund M, Berglind N, Pershagen G, Hallqvist J, Jonson T, Bellander T. Long-term exposure to urban air pollution and myocardial infarction. Epidemiology. 2006 Jul;17(4):383-390.

Research within the program areas

Area 1

Area coordinator: Göran Pershagen, KI

Objective: To assess health effects related to short- and long term exposure to ambient air pollution relevant to the situation in the Nordic countries. Particular emphasis is on determination and quantification of effects associated with exposure to particles from different sources, such as road traffic and wood burning locally as well as long range transport.

Participating organisations The principle researchers in the area of particulate and health are: Anna-Carin Olin and Gerd Sällsten from Göteborg University, Tom Bellander and Göran Pershagen from Karolinska Institutet as well as Bertil Forsberg and Thomas Sandström from Umeå University.

Results Phase 1: The activities in the health area during Phase 1 have been organised in 12 subprojects. The results from each of the research projects are summarized in the Mid Term Review documents.

Project 1.1. Exposure to traffic related air pollution in early life, lung function and airway disease in 8-yearold children

Project leader: Tom Bellander. **Participants:** Göran Pershagen, Magnus Wickman, Inger Kull, Olena Gruzieva, Saskia Willers, Kristina Eneroth

General Objective: The aim of this study is to assess the impact of life-time exposure to traffic-related air pollutants and heating-related air pollutants on lung function, wheezing, asthma and allergic sensitisation, in children at the age of eight

Phase II
Activites This project will continue in 2010-12 by incorporating outcome data from the 12-year follow-up of the cohort, and subsequently air pollution data for the 8-12 year period. The research questions remain the same as well as the principle methods involved. Longer follow-up of symptoms and not clear-cut chronic conditions, and varying exposures will further increase the wealth of the dataset and allow for a better understanding of the relation between air pollution and different aspects of airway disease in children.

Deliverables The main deliverables from this project will be three scientific publications, with preliminary titles: 1. Residential traffic-related air pollution and sensitization to airborne allergens at age 4 and 8. 2. Residential traffic-related air pollution and lung function at age 4 and 8. 3. Residential traffic-related air pollution and airway symptoms up to age 8.

Project 1.2. Short-term health effects in susceptible subgroups, using newly developed source specific local time series of air pollution

Project leader: Tom Bellander.

Participants: Petter Ljungman, Tomas Lind, Christer Johansson, Göran Pershagen.

General Objective: The aim of the project is to further explore the association between short-term variation in health effect and air pollution in sensitive subgroups. It will apply the best available exposure assessment technique to time series of cardiovascular outcomes

Phase II
Activity This project builds on other, to date only partly reported projects, and is therefore delayed. The use of local time series needs to be somewhat revised, in order to circumvent problems related to co-linearity between local time series data and variables that should be incorporated in temporal analysis of health outcome data.
Budget We therefore propose a no-cost extension of this project to 2012, and that no further funding is allocated during SCARP Phase 2.
Deliverables The main deliverables will be two scientific publications: 1. The application of local time series to studies of inflammatory markers and ventricular arrhythmias. 2. Short-term health effects of air pollution in adults with previous history of hospitalisation.

Project 1.3. "Health effects of short-term and cumulative seasonal exposure to road dust and wood smoke particles at real-world exposure conditions"

Project leader: Bertil Forsberg, Yrkes- och miljömedicin, Umeå Universitet

General Objective: This project will increase our understanding of the respiratory effects of different types air pollution, especially the effects of road dust, which are very policy relevant in Sweden.

Phase II

For Project 1.3. "Health effects of short-term and cumulative seasonal exposure to road dust and wood smoke particles at real-world exposure conditions" the original activity plan is still valid, and the budget request is the same (we got 238 000 SEK/yr). In 2010 we plan to conduct the final analyses and write the papers on the findings from our adult panels. In addition the panel study on road dust and acute respiratory effects in asthmatic school children in Umeå will be done in 2010, with analyses following in 2011.

Deliverables and planned publications:
- Short-term effects of air pollution on airway inflammation among postmen and parking guards
- Short-term effects of air pollution on airway inflammation among adult asthmatics
- Short-term effects of air pollution on lung function and illness among adult asthmatics.
- Short-term effects of air pollution on airway inflammation and illness in asthmatic children.

Project 1.4. "Long-term exposure to traffic exhaust and incidence of obstructive airway disease in a prospective cohort – co-funding

Project leader: Bertil Forsberg, Yrkes- och miljömedicin, Umeå Universitet

General Objective: To analyse long-term exposure to traffic pollution and development of chronic respiratory morbidity in adults. The traffic related asthma incidence in adults will likely be an important part in future analyses of health costs.

Phase II

We plan a study of rhinitis incidence in the existing cohort, which can be done with the same minor level of economic support (60 000SEK/yr) since we have most of the data needed. The new follow up we mentioned in the original application is planned to take part in 2010 and will give us 20 years of follow-up information from approx. 8000 participants in the three cities. The new follow up will include a new more detailed exposure assessment, a postal questionnaire and a clinical follow up of symptomatic and a random sample.

It would be very helpful to have this follow up partly funded by SCARP, for example the exposure modeling.

Deliverables and planned publications:

Modig L, Toren K, Janson C, Jarvholm B, Forsberg B. Vehicle exhaust outside the home and onset of asthma among adults. Eur Respir J. 2009 Jun;33(6):1261-1267.

Modig L, Johansson C, Torén K, Janson C, Jarvholm B, Forsberg B. Levels of vehicle exhaust particles outside the home and the development of rhinitis and asthma among adults. (manus i avh)

Modig L, Johansson C, Torén K, Janson C, Jarvholm B, Forsberg B. Levels of vehicle exhaust outside the home and severeness of adult asthma.

Olsson D, Modig L,… Forsberg B. Levels of vehicle exhaust outside the home and rhinitis in 27.000 Swedish adults.

Project 1.5. Is exposure to particulate air pollution associated with exhaled nitric oxide and blood markers of inflammation?

Project leader: Anna-Carin Olin, AMM, Sahlgrenska Akademin

General Objective: The major aim with the present project is to elucidate the relation between exposure to air pollution and a novel method to measure the fraction of exhaled nitric oxide, a marker for distal airway inflammation.

Project leader and participants:

Anna-Carin Olin, AMM, Sahlgrenska Akademin, Associate professor, project leader, Santosh Dahgam, PhD-student, Fredrik Nyberg, Associate professor, Lars Modig, PhD, Post Doc, Bertil Forsberg, Associate prof, Kristina Wass, epidemiology assistant.

Background

We have finished the basic clinical examination of 6600 individuals with NO in exhaled air, using a novel method to detect peripheral airway inflammation, spirometry, blood tests for inflammation markers in blood and genetic analysis, and a series of questionnaires. Acute exposure to air pollution and exposure levels at the residential addresses have been modeled for the first 3600 examined subjects by Bertil Forsberg's research group in Umeå. Analysis of inflammatory markers in blood will be finished October 2009, as well as analysis of polymorphism of genes that control the formation of important anti-oxidant enzymes as well as NO-forming enzymes that may affect the risk of developing airway inflammation. During the previous period we received a grant for partial financing of a PhD-student included in a PhD-program for Health and Environment from Västra Götaland County that will work with analyses and presentation this material.

Activities 2010-2012

The collected material constitutes a very extensive set of data for analyzing and evaluating health effects of air pollution in a large random population in the Gothenburg region. In accordance with the original plan the main activity for the coming period will be analyses and presentation of the collected material. For this purpose, we aim at appointing a post-doc for a two year position from April 2010, Lars Modig, from the research group in Umeå, who will work in close collaboration with project leader and Phd-students within the project. We also hope to include another 4400 subjects in the analyses of genetic polymorphisms for certain anti-oxidants and NOSI-III, for this purpose we are however dependent on additional funding.

In addition to what was described in the initial program, a follow-up study of all subjects included in the study has been initiated; All participants receive 4 years after the initial study a mailed questionnaire, including on emerging respiratory problems. So far, 3700 individuals received the form and around 90% have responded to this. In this dataset, which will be expanded until all subjects are included, we will analyze the incidence of respiratory symptoms in relation to chronic exposure to air pollution and including potential genetic susceptibility.

No further funding has, at present, been approved to cover the costs for further clinical examinations in the basic study and these have therefore been stopped temporarily. This will limit the power of the study, and further funding has been applied for, among other from VR.

Milestones:

- *Database including genetic polymorphisms in 2200 subjects (Febr 2010)*
- *Database including exposure on residential address including 6600 subjects (Dec 2010)*
- *Genetic analyses of additional 4600 subjects (2011, June, dependent on additional financing)*
- *Complete database on follow-up study (2011, Dec)*
- *Manuscripts to be submitted;*
    - Is inflammation in the peripheral airways associated with acute exposure to air pollutants? (2009, Dec)
    - Gene- environment interaction and the induction of inflammation of the peripheral airways (2010, Oct)
    - Is chronic exposure to air pollutants associated with lung function and prevalence of sensitization? (January 2011)
    - Is genetic susceptibility associated with peripheral airway inflammation after chronic exposure to air pollutants? (Dec 2011)
    - Are new onset respiratory symptoms associated with exposure to air pollution, and is there a gene- environmental interaction? (June 2012)

Deliverables

The main deliverables of the project will be a number of scientific publications that will contribute to an increased knowledge on health effects of air pollution. More specifically the project will increase the knowledge on prevalence of peripheral airway inflammation after both acute and chronic exposure to air pollutants in the general population and try to identify sub-populations more susceptible to air pollution, also within the general population. The project will also include training and examination of PhD-student.

Planned manuscripts

Acute exposure to air pollution:

- A manuscript based on the findings of inflammation of the peripheral airways after acute exposure to ozone, based on stationary measurements.
- A manuscript that acute exposure to residential address and modeled self-reported exposure in high traffic density is related to NO formation in the peripheral airways as well as to CRP, an inflammation marker in the blood, and genetic susceptibility.

Chronic exposure to air pollution:

- A manuscript on cumulative exposure based on residential address / distance to main road and lung function and sensitization.

- A manuscript based on peripheral airway inflammation and genetic susceptibility to oxidants and chronic exposure to air pollution.
- A manuscript on new onset respiratory symptoms and exposure to air pollution and gene-environmental interaction.

Project 1.6. Is long term exposure to particulate air pollution associated with an increased risk for ischemic heart disease

Project leader: Anna-Carin Olin, AMM, Sahlgrenska Akademin

Objective: The main aim is to examine whether exposure to different types of air pollution increase the risk for myocardial infarction.

Project leader and participants: Anna-Carin Olin, AMM, Sahlgrenska Akademin, Associate prof, project leader, Santosh Dahgam, PhD-student, Fredrik Nyberg, Associate professor, AMM, Sahlgrenska Akademin, Lars Modig, PhD, Post Doc, Bertil Forsberg, Associate prof, Occupational and Environmental Medicine, Norrlands University Hospital, Umeå, Annika Rosengren Prof, Lena Björk, Nurse, Phd at Dept Internal Medicine, Sahlgrenska University Hospital, Gothenburg, and Kristina Wass, epidemiology assistant.

Background:

We have included 650 consecutive patients who fell ill with acute myocardial infarction or acute angina pectoris during the period 2001-2003 in the Gothenburg region as well as 3600 controls. Acute exposure to PM10, PM2, NOx and ozone days before the infarction/event has been modeled for each individual on the basis of residence, in collaboration with Bertil Forsberg, Occupational and Environmental Medicine, Norrlands University Hospital, Umeå. For further analyses of these data we have received a grant for a PhD-student, included in a PhD-program for Health and Environment from Västra Götaland County. We have also received a grant from Formas for analyses of these data (P.I Fredrik Nyberg).

Activities 2010-12

In accordance with the original plan the main activity for the coming period will hence be analyses and presentation of the collected material. For this purpose, we will appoint a post-doc for a two year position from April 2010, Lars Modig, from the research group in Umeå, who will work in close collaboration with project leader and Phd-students within this project as well as in project 1.5. Genetic polymorphism of important anti-oxidant enzymes, in accordance with the study 2.3, will be analyzed, and its modifying effect on any risk will be analyzed.

The data will be analyzed with different designs;

- A cross-over design to study the effect of acute exposure to air pollution and risk of acute myocardial infarction or angina pectoris.

- In order to study the effect of chronic exposure (5 years), where participants in Apollon study (see project 1.5) will serve as control subjects, the risk to fall ill with acute myocardial infarction or angina pectoris will be analyzed in a case-control study.

Milestones:

The assessment and modeling of chronic exposure to air pollution of included subjects will be performed and completed late 2010.

A complete data base including genotypes will be ready Dec 2010.

Two manuscripts are planned and will be submitted at the end of the project time.

Deliverables
The main deliverables of the project will be a number of scientific publications that will contribute to an increased knowledge on the association between exposure to air pollution and cardio vascular disease, both after acute and chronic exposure. We will also examine if sub-populations with genetically reduced ability to form anti-oxidants, are more susceptible to air pollution. The project will also include training and examination of PhD-student.

Planned manuscripts

- Acute exposure to air pollution and risk of acute myocardial infarction or angina pectoris.

- Gene-environment interaction and the risk for acute myocardial infarction or angina pectoris

Project 1.7. Cohort study on total public health burden related to long term-exposure to air pollution

Project leader: Göran Pershagen, Karolinska Institutet
Participants: Tom Bellander, Johanna Penell, Charlotta Eriksson, Michal Korek, Ulf deFaire, Laura Fratiglioni, Nancy Pedersen, Clas-Göran Östensson

General Objective: Assess relation between long-term exposure to ambient air pollution and total public health burden, primarily involving effects on cardiovascular and respiratory morbidity and mortality.

Phase 2
A residential history from 1991 will be obtained from all study subjects as a basis for the exposure assessment, involving some 50 000 addresses. Follow-up in myocardial infarction, stroke, cancer and mortality registers will enable estimation of exposure response relationships as well as assessment of the public health burden. The cohort forms a part of the ESCAPE project in which air pollution effects on health are assessed in a large number of European cohorts using a uniform methodology for estimation of exposure. The measurement programme for the ESCAPE project has already been completed.

Milestones:	Availability of residential history	month 6
	Creation of a uniform data base	month 12
	Follow-up of health data completed	month 18
	Main epidemiological analyses	month 24
	Manuscripts submitted	month 36

Deliverables: The main ultimate deliverables of the project will be a number of scientific publications. Tentatively, at least three can be identified within the time frame of SCARP:

1) Cardiovascular effects of air pollution, including myocardial infarction and stroke
2) Cancer morbidity in relation to air pollution
3) Overall impact on morbidity and mortality by ambient air pollution.

In addition, several scientific publications are envisaged based on the European collaboration within ESCAPE.

Project 1.8. Long term exposure to traffic related air pollution and genetic susceptibility in relation to myocardial infarction

Project leader: Göran Pershagen, Karolinska Institutet

General Objective: Assess interactions between traffic related air pollution and genetic susceptibility in relation to myocardial infarction.

Phase II: This project finished during Phase I.

Project 1.9. DISOZPOLL; Diesel and ozone effects on the cardiovascular system

Project leader: Thomas Sandström, Lung och allergikliniken, Norrlands universitetssjukhus, 901 85 Umeå, thomas.sandstrom@lung.umu.se

General Objective: : To increased the understanding of how ozone and diesel exhaust interacts with the lungs, leading to events in the cardiovascular system that are linked to the increased health effects related to these pollutants

Phase 2

Continued experimental studies on direct and local events in the blood and blood vessels caused by air pollution. The main deliverables include international scientific publications focused on understanding of contribution of diesel exhaust and ozone to acute vascular events.

Project 1.10. PMMECH – Mechanisms behind particulate matter air pollution induced toxicological effects

Project leader: Thomas Sandström, Lung och allergikliniken, Norrlands universitetssjukhus, 901 85 Umeå, thomas.sandstrom@lung.umu.se

General Objective: To increase the understanding of how source, size and chemical characteristics of particulate matter pollution contributes to adverse cellular and biomedical events, linked to adverse health effects.

The project finished in Phase 1 and will not continue in phase 2.

Projekt 1.11 Woodpart-2. A human experimental study using wood smoke for studies of acute effects of particulate air pollution on inflammation, coagulation and oxidative stress.

Project Leader: Gerd Sällsten, Occupational and Environmental Medicine, Sahlgrenska Academy

General Objective: The specific aims are to find out whether effects of wood smoke on airway inflammation and blood coagulation found in a recently performed study (Barregard et al 2006) can be repeated at lower levels of particles and if the effects differ in relation to the fraction of ultrafines (UFP < 100 nm) in the smoke.

Phase 2

The project has proceeded as expected and follows the original activity plan. In the years 2010-2012 the main focus will be on evaluation of data and preparation of manuscripts. There will probably be at least two publications (see below) from this human chamber experiment.

The project is well integrated in the SCARP programme, for example by collaboration with Thomas Sandström's group in Umeå. We have collected wood smoke particles in our exposure chamber, during different burning cycles, for evaluation in different in-vitro tests. This research has also funding from other sources but is a spin off within the SCARP programme.

Evaluation: 2010 Manuscript preparation and submission: 2011-2012

Deliverables: results from evaluation of chamber studies as well as composition of wood smoke summericed in a report.

Planned publications (one or two):

- Inflammation, blood coagulation and oxidative stress after experimental exposure to wood smoke.
- Wood smoke composition in relation to wood burning processes – polycyclic aromatic hydrocarbons and elements.

Possibly these two manuscripts will be merged into one.

Participants: Gerd Sällsten, Leo Stockfelt, Lars Barregård, Pernilla Gustafsson, Lena Andersson, , Sandra Johannesson, BoSstrandberg, Peter Molnar.

Project 1.12. Health effects of long range transported particles: a population study using air mass trajectories.

Project Leader: Gerd Sällsten, Occupational and Environmental Medicine, Sahlgrenska Academy.

Participants: Gerd Sällsten, Lars Barregård, Eva M Andersson, Annika Rosengren, Leo Stockfelt, Peter Molnar, Karin Sjöberg (IVL), Marie Haeger-Aronsson (IVL).

General Objective: The aim is to test if the risk of myocardial infarction (MI) in Gothenburg increases on days when the origin of the air mass is from certain specific areas in Europe. It is still unclear which properties of PM are significant for toxicity. The role of the origin of the air masses is unknown.

Phase II

We have modified the original investigation to study the effect of air pollutants from both local and distant sources on the risk of myocardial infarction among Swedish men and women in a case-crossover study. We will use 30,000 cases of MI in Gothenburg in 1987-2005. In the first step we will examine long distance transported vs. locally generated PM. For 8,000 days over 23 years we will collect trajectories showing the origin (e.g. continental, Nordic or marine) of the air masses. Climate data and air pollution levels (SO_2, NO_x, NO_2 and particles (soot, PM_{10})) on the date of onset of illness (lag 0 and lag 1) are also utilized. In the case-crossover design, a number of "control days" are identified for each individual. Individual risk factors stable over time need not be considered in the analysis, since each individual acts as "his or her own control". We will have 85% power to show a relative risk of 1.05 for continental air masses. A PhD student already receives his salary from a research school and another co-worker is covered by a post-doc grant from FAS. In order to continue this project we would need further funding (2.2 MSEK). A collaboration with IVL has been initiated and

a grant application has been sent to FORMAS in 2009 (1.8 Mkr). A collaboration is established between researchers at IVL with deep knowledge in air pollution chemistry and modeling (Karin Sjöberg, Marie Haeger-Aronsson) and the main applicant at AMM (Gerd Sällsten). IVL will classify the air mass origins and collect and structure the air pollution measurements. We have applied for 600 000 Swedish Kr for their part from FORMAS. This collaboration will strengthen future research activities between the two organizations.

Data collection 2010 -2011, evaluation and manuscript preparation2011- 2012

Deliverable: Results from the association between risk of myocardial infarction and short term changes in levels of particulate air pollution, including the impact of the origin of air masses.

Planned publication:
Risk of myocardial infarction from particulate air pollution – impact of the origin of air masses.

Area 2 Regional and national atmospheric models for particulate matter

*Area coordinator***:** HC Hansson, ITM, Stockholms Universitet

Objective*:* Develop and validate modes for particulate matter (PM), from urban to regional scales for the assessment of effects to human health and climate.

Participating institutions: Stockholm University (HC Hansson, Peter Tunved, Christer Johansson), Swedish Meteorological and Hydrological Institute (Joakim Langner, Lars Gidhagen, Cecilia Bennet), Lund Institute of Technology (Erik Swietlicki), Chalmers / Gothenburg University (Mattias Hallqvist) and Norwegian Institute of Meteorology / EMEP (David Simpson).

Sub-projects
The overall aim of the urban and regional scale modelling work is to develop evaluated modules dealing with both dynamics and chemistry, which can be applied in 3-D models for the prediction of health-related PM data. As a basis for this, we make use of a comprehensive "reference" modelling system against which to develop and evaluate computationally efficient models, which can be used in 3-D models. The reference scheme is based upon existing models from the University of Helsinki group, and further developed to include extended chemical and cloud schemes by ITM, Stockholm University. The same reference model is used in sub-projects (1) and (2), with a focus on chemistry in sub-project (1) and on dynamics in sub-project (2). These two sub-projects are interacting continuously, with frequent exchange of routines in order to merge the chemical and dynamical methodologies into one module.

Summary of accomplished work within Phase I
Considerable effort has been put into further develop the descriptions of the organic chemistry. However our research, which is consistent with others, has shown that the knowledge on the atmospheric organic chemistry is still not sufficient to establish well founded model descriptions. The work has thus been focused on developing, implementing and testing simple organic models.

Aerosol dynamic modules for implementation into the regional atmospheric models, MATCH and EMEP, have been evaluated. SALSA, developed by University of Helsinki and University of Kuopio, was chosen and has been implemented into MATCH, and is currently tested.
The reference model, SU-UHMA, a detailed box model based on the aerosol dynamic model UHMA developed by University of Helsinki, has been further developed including detailed chemistry and a simplified cloud interaction scheme, that has been tested.
A European emission database has been accomplished in close cooperation within the EU-integrate project EUCAARI. Our contribution has been emission estimates on wood combustion and road traffic. The data base gives size resolved estimates on particulate emissions, especially organic and elemental carbon emission have been addressed. The data base will be available the fall 2009.

Suggested work in Phase II
The development of the organic chemistry models will continue using both chamber data as well as field experimental data in cooperation with EUROCHAMP, EUCAARI, EUSAAR and EMEP with the intention to implement the model in the regional 3D models MATCH and EMEP. The organic chemistry in the reference box model will be extended accordingly.
The implementation of SALSA in EMEP and MATCH will be completed and evaluated against the reference box model and EUSAAR data. The evaluation of cloud physics and chemistry the box model will continue with focus on implementation in EMEP and MATCH. The focus is especially on the influence of particles on the cloud formation and precipitation.

Project 2.1 Chemical Modelling of Aerosol Formation

Project leader: David Simpson, EMEP MSC-W, Norwegian Meteorological Institute & Department of Radio & Space Science, Chalmers Institute of Technology

Objective for phase 2
Subproject 2.1 aims at developing modules for aerosol chemical formation which are appropriate for 3D chemical transport models. The modules developed need to be computationally efficient but at the same time of useful quality when compared to more detailed models, and smog chamber data, and to atmospheric observations. During phase 2 we will further develop the dynamic aerosol /cloud model modules, implement and test them in the EMEP and MATCH

Activities in Phase II
- The models implemented within SCARP phase I will be further developed and evaluated against smog chamber data from the EUROCHAMP projects in collaboration with other modelling and smog chamber groups in Europe. The model intercomparison exercise initiated within EUROCHAMP-I will be continued during EUROCHAMP-II. This way the SOA models developed for 3D-application within the EMEP and MATCH models will be compared to both state-of-the art measurements and other advanced models.
- Further work on evaluation of the simplified SOA schemes for use in 3D-models will be performed. The main future plans involve work making use of new data arising from recent field experiments, which include sufficient measurements to allow source-apportionment of the aerosol. Major data-sets involve the recent EMEP intensives and data from the EU EUCAARI project (Kulmala et al., 2009).
- A parameterised cloud scheme for incorporation in 3-D models will be implemented. Detailed treatment of the chemistry is expected to be important for an accurate

description of the aerosol size and chemical evolution over time (especially for remaining CCN population of dissipating clouds). The cloud scheme will also be used to estimate in-cloud scavenging of interstitial aerosol, rainout processes as well as effects on vertical distribution of aerosols resulting from cloud cycling. Aqueous uptake and processing of organic molecules will also be investigated to determine the potential impact on secondary organic aerosol formation. The development will be based on the testing of different schemes with the detailed reference box model, SU-UHMA.

- In recent years glyoxal has been identified as a potentially important SOA precursor (e.g., Volkamer et al., 2007). Collaboration with the group of Barbara Nozière (ITM, Stockholm) has been initiated during 2009 and we plan to investigate the importance of glyoxal further during SCARP Phase II. Modelling will be used to investigate the possible depletion of glyoxal in regions of Europe and to investigate the contribution of the glyoxal chemistry to the formation of SOA. The EMEP model's glyoxal predictions will be compared to the near-explicit Master Chemical Mechanism (MCM, http://mcm.leeds.ac.uk/MCM/). Then the importance of the suggested new reactions on glyoxal concentrations in the atmosphere, and on SOA formation will be tested.
- The organic aerosol model developed in subproject 2.1 will be coupled to the EMEP/MATCH adapted SALSA model being developed within subproject 2.2. The goal being a computationally efficient 3D-version of the combined model.
- In Phase I the focus has been mainly on *biogenic* SOA (from terpene oxidation). In phase II we plan to also look at the importance of *anthropogenic* SOA in more detail. Collaboration with Richard Kamens was initiated in 2008 regarding the biogenic SOA models. Kamens' group is also developing a condensed model scheme for SOA formation from anthropogenic hydrocarbon mixtures. If their work is successful adapted versions of their scheme will be tested for use with the EMEP SOA model.

Time plan

Activity 1 will be on-going during the whole project period (since the SOA models developed within SCARP will be validated against smog-chamber data that become available during the EUROCHAMP-II project). A validation report, taking into account presently available smog-chamber data for both dark and light conditions, will be published during the first half of 2010.

Activity 2 will start during 2010 and also continue during 2011-2012. A first report will be finished by the end of 2010.

Activity 3 will start during the second half of 2010 and will continue during 2011-2012.

The glyoxal chemistry scheme evaluation in Activity 4 will start during 2010 and be finished 2011-03. The 3D-modelling in Europe will be performed during 2011 (possibly starting in 2010, depending on whether the suggested VR-project of Barbara Nozière (SMACC) gets funded or not). A (first) report of this is expected to be finished by 2011-06. If SMACC gets funded more detailed work, including comparisons to the new measurement campaigns of the SMACC-project, will continue during 2011-2012.

Activity 5 will be started in 2010 and a combined SOA-SALSA model is expected to be implemented in the MATCH model during 2010. The coupled model will be evaluated and further developed as the development of better SOA-chemistry schemes continues during the SCARP project (2011-2012).

The relative importance of anthropogenic/biogenic and primary/secondary organic aerosol components in Europe (activity 6) will be investigated further by combining model calculations with detailed measurements that include source-apportionment analysis. This work starts in 2010 and will continue during 2011-2012.

Deliverables

- An updated, validated SOA-chemistry scheme for the EMEP-model
  Report on performance compared to smog chamber studies (2010-06)
  Report on performance against field measurements (2010-12)
- Evaluation (and possible update) of the EMEP scheme for glyoxal chemistry (2011-06)
- A first 3D-version of the combined SOA-SALSA model implemented and tested in the MATCH model (2010-12)
- PhD-thesis (Robert Bergström) covering the work performed in SCARP 2.1 finished during 2011
- A parameterised cloud scheme for 3D-models implemented (and tested) in the EMEP and/or MATCH model (2012)

Project 2.2. Developing dynamic particle description including formation, growth and deposition

Project leader: Cecilia Bennet, SMHI

General objectives

The overall goal of this sub-project is to provide an improved understanding of how the natural and anthropogenic emissions influence the number, mass and composition of the atmospheric particles with high spatial and temporal resolution. A suite of objectives have been identified in relation to aerosol dynamics modelling which is considered to be indispensable in order to meet the overall goal.

Objectives for Phase II

1. Implementation of size resolved emissions as reported within the EUCAARI network and subproject 2.3.
2. Further development of the SALSA module in order to add oxidized and reduced nitrate. Implementation of a thermodynamic equilibrium model will be needed.
3. Coupling to secondary organic aerosols from subproject 2.1.
4. Tests of different nucleation mechanisms and parameterizations.
5. Evaluation with size resolved and chemically separated measurement data.
6. Evaluation of the SALSA-3D CTM system with regard to computational speed and parallelisation of the code.

Time plan

Activities 1 and 2 will be finished in 2010, while activities 3 (interaction with SCARP 2.1) and 4 will be focused during 2011-2012. Evaluation against monitored size distributed measurements will be performed during all years, so that the effect of each change in input data and model code can be documented. During the last year, the optimization of the aerosol model code as regard to computational speed (activity 6) will be performed.

Deliverables

During the first year, there will be a MATCH-SALSA V1 (version 1, result of activity 1 and 2) delivery with documentation and evaluation against measurement data. At project end there will be a MATCH-SALSA V2, result of Activity 3, 4, 5 and 6, also with documentation of model code and evaluation results.

Project 2.3. Construct emission databases for dynamic particle models and validate urban models concerning particle size distribution and chemistry

Project leader: Christer Johansson, ITM, Stockholms Universitet

General Objective: The overall goal of this sub-project is to provide an improved understanding of how the natural and anthropogenic emissions influence the number, mass and composition of the atmospheric particles with high spatial and temporal resolution. A suite of objectives have been identified in relation to aerosol dynamics modelling which is considered to be indispensable in order to meet the overall goal.

The resource allocated for ITM will be used for the further development and testing of the box model SU-UHE, that will be used in the subprojects 2.1 and 2.2.

Objectives for Phase II
The emission date part of the project is finished and will not continue in phase II.
Subproject 2.3 will during phases 2 focus on determining the importance of the different main urban source for the risk for mortality and morbidity for the population in Stockholm. This will be done in very close cooperation with area 1.

Activities for Phase II
The work will contain 2 major activities. Primarily collected data, measurements combined with modelling on air quality, especially particle concentrations, in Stockholm over a period of the lasts 10 years together with health data, will be evaluated to estimate risk factors for especially coarse particles. Secondly in a Nordic cooperation to further refine the emission data bases and models, through intercomparisons and integration of new data collected continuously in the Nordic major cities.
The health investigations will be using data from the period 1998 - 2007 from background sites outside the city and permanent sites in the city to reveal the local contribution and its share of observed health effects. Health data will be based on information as emergency visits, hospitalisation and deaths in the larger Stockholm region. Poison regression will be used to find relations between air pollution and health effects. Changes in e.g. meteorology, incidence of flue, pollen and time trends will be considered.
Emission data base and modelling still needs refinement. Estimates of emission factors will be revised by using urban and road side measurements, continuous long term and short term advanced field campaigns. Besides direct measurements organized such that sources will be clearly identified tracer methodology will be used. Further statistical analysis e.g. source receptor analysis will also be used.
Models, including dispersion and aerosol processes will be further evaluated through intercomparisons between models, comparing with measurements using the same new emission database.

Time plan
The work on reaching estimates on risk factor for coarse particles will be finished during 2010, to be communicated and used in the integrated assessment modelling, i.e. area 4. The emission database and modelling development will also mostly be done 2010 – early 2011 to be used as extensive as possible in the health studies within area 1.

Deliverables
Risk factor for coarse particles.
Further Detailed data base for particle emissions.
Improved particle models.

Project 2.4. Aerosol OA sampling and ^{14}C analysis

Project leader: Kristina Stenström, *Division of Nuclear Physics, Lund University*

General Objective: The general objective of the project is aerosol sampling and ^{14}C analysis for producing data to be used to develop and validate the OA module to be implemented in the 3D chemical aerosol model.

Phase II

The plan for Phase II within SCARP is still valid (see 2nd revision of the proposal) and the budget remains (190 kSEK/year for year 4-6 for 14C analyses).

Project leader and participants

Project leader: Kristina Stenström, *Division of Nuclear Physics, Lund University*
Participants: Johan Genberg (PhD student), Mattias Olsson (research engineer), Erik Nilsson (PhD student), Erik Swietlicki (professor)

Activities

- Improvement of mass detection limit for ^{14}C- analysis: aiming at samples down to 10 µg of carbon.
- Development of methods for ^{14}C-determination for fractionated aerosol samples.
- Analyses of ^{14}C content in aerosol samples from different campaigns and long-term measurements from Vavihill.
- Coordination of research efforts as stated in the objectives.

Deliverables

- Analysis of ^{14}C content in aerosol samples from different campaigns, starting with Vavihill in autumn 2009.
- Coordination of research efforts as stated in the objectives.
- Achieved detection limit of 10 µg of carbon.
- ^{14}C analyses of fractionated aerosol samples.

Expected manuscripts

Examples:

- J. Genberg, K Stenström, M. Elfman, M. Olsson: *Development of graphitization of µg-sized samples at Lund University.* Submitted to Radiocarbon, 2009.
- J. Genberg, K. Stenström et al: Manuscript on OC/EC analysis
- J. Genberg, K. Stenström et al: Manuscript on Vavihill ^{14}C measurements
- J. Genberg, K. Stenström et al: Manuscript on ^{14}C measurements from OC/EC measurements
- J. Genberg, K. Stenström et al: Manuscript on source apportionment from Vavihill ^{14}C measurements
- Manuscripts with participants from different campaigns

Area 3

Area Coordinator: John Munthe, IVL Swedish Environmental Research Institute, PO Box 5302, 400 14 Göteborg, Sweden, email: john.munthe@ivl.se

Partners & Participants: Filip Moldan (IVL), Sofie Hellsten,(IVL), Salim Belyazid (BCC), Cecilia Akselsson (Lund University. Physical Geography and Ecosystem Analysis), Harald Sverdrup (Lund University, Chemical Engineering), Annika Nordin (SLU), Lars Högbom (Skogforsk).

Overall objective

The objective of the ecosystem subprogram is to improve our understanding of short and long term effects of nitrogen deposition as regards recovery from acidification, effects on ground vegetation and eutrophication issues In addition, to provide scientific support for counter actions to reduce negative impacts of nitrogen deposition on the environment.
The following sub-goals were identified at the start of the program:

- To further clarify the fate of nitrogen deposited to forest ecosystems, and the effects on acidification of soils and surface waters as well as on nitrogen induced vegetation changes
- To evaluate and further develop dynamic models for nitrogen in forest ecosystems including-vegetation interactions and acidification and to apply the modelling results to development of critical loads and other forms of policy support.
- To assess the future status of forest and aquatic ecosystems for different scenarios of deposition, climate change and forestry.

The two first sub-goals were in focus in Phase I of SCARP whereas the research in Phase II will focus on the last.

Activities in phase 2

In addition to the main proposal for Phase II, two additional proposals are attached:

1. **Critical loads in Sweden – Integration with the IAM cluster.**
   In this project the results from the ecosystem subprogramme will be further integrated with SCARP subprogram 4. The planned activities include critical load calculations and evaluation of emission scenarios for different options of air pollution abatement in Europe.
2. **Quantitative modelling of biotic interactions within plant communities in response to N deposition.**
   In this project a quantitative model describing how internal biotic processes are involved in altering plant community composition in response to N deposition, will be developed, based on a conceptual model developed in Phase I. This model will be incorporated into ForSAFE-VEG and and applied to test sites.

Nitrogen cycling in forest soils - Assessment of data from national monitoring and forestry research.

Project leader: Annika Nordin, SLU

Objective

The objective of this project in Phase II is to evaluate, synthesise and publish experimental data obtained from a series of experiments with N additions. Furthermore to provide data sets to be used for model application and evaluation.

Project leader and participants

Annika Nordin, SLU
Lars Högbom, Skogforsk
Filip Moldan, IVL

Budget

kSEK		IVL	SLU	Skogforsk	Total
Nitrogen cycling in forest soils - Assessment of data from national monitoring and forestry research.	Lars Högbom, Skogforsk			125	125
	Filip Moldan, IVL	125			125
	Annika Nordin, SLU		125		125
Total					375

Activities

N-additions and vegetation change

Effects of nitrogen deposition on forest biodiversity can be both direct and indirect. An example of a direct effect is when nitrogen enrichment alters the competitive interactions between species so that nitrogen favored fast-growing species outcompetes slow-growing nitrogen conservative species. Indirect effects of nitrogen enrichment on plant diversity can be mediated by higher trophic levels, i.e. natural enemies to the plants. Studies performed during SCARP phase I have demonstrated that for example snow blight fungi on *Vaccinium vitis-idaea* (lingonberry shrub) increases in frequency on plots treated with 12 kg N ha^{-1} yr^{-1} in years when snow conditions are favorable for fungal growth (Nordin et al. manuscript). For *Vaccinium myrtillus* it has been demonstrated that another pathogenic leaf-fungi, *Valdensia heterodoxa*, increases in frequency on shrubs treated with 12 kg N ha^{-1} yr^{-1}, which in turn cause increased grass growth (*Deschampsia flexuosa*) (Nordin et al. 2005, 2009). Hence, the interaction between plants and their natural enemies appears to be one important factor structuring plant communities subjected to nitrogen enrichment. However, besides nitrogen supply the long time series of data from the field experiments in north Sweden show that also weather conditions are important, as for example growth of many fungal plant pathogens are favored by extended periods of rainy weather during summer, or by a thick snow pack that melts slowly in spring (snow blight fungi).
Moreover, recent studies have indicated that nitrogen enrichment effects on forest understorey vegetation can be either reinforced or diminished by forest management. For example, nitrogen enrichment effects on the vegetation can appear to be non-significant in a full-grown forest with a closed tree canopy, while following clear-cut and regeneration of the trees,

nitrogen effects on understorey vegetation becomes significant (Strengbom & Nordin, 2008, Strengbom & Nordin, manuscript). This is probably due to the limitation of light to the understorey in the full-grown forest, while in the newly regenerated forest the non-limiting supply of light supports proliferation of nitrogen-favored understorey species.
In this activity, synthesis of the results from SCARP Phase I will be performed. Complementary field data on understorey vegetation dynamics in experimental plots subjected to low nitrogen additions will be collected to support the synthesis and the modelling activities.

N-fertilization – soil and soil water chemistry
The main activity during the project period will be to evaluate, synthesise and publish experimental data obtained from a series of experiments with low dose N additions. The experiments (n=3) were all established in 2000 and treatment started in 2001. The experimental sites cover a range both as regards N deposition and site productivity. Available data cover soil and soil solution chemistry as well as aboveground production.
The treatments includes; Control, 20 kg N ha^{-1} annually, 60 kg N ha^{-1} every 3:rd year and 120 kg N ha^{-1} every 6:th year all treatments given in triplicates at each site. In 2007 all plots received an additional "spike" with the stable isotope ^{15}N in order to be able to trace the fate of added N in greater detail. Sampling of soil- and tree compartments was conducted at tree occasions following the ^{15}N addition. The analysis of these samples are as yet not finalized. During the second phase some additional sampling will be done in order to provide the modelling subprojects within SCARP with needed background information as regards soil properties.

Table x+1. An overview of treatments used at the 3 experimental sites 265 – Asa, 266 – Kågeröd and 267 – Tönnersjöheden.

Year	Control	20 kg N ha^{-1} annually	60 kg N ha^{-1} every 3:rd year	120 kg N ha^{-1} every 6:th year
2001	-	20	60	120
2002	-	20	-	-
2003	-	20	-	-
2004	-	20	60	-
2005	-	20	-	-
2006	-	20	-	-
2007	-	20	60	120
2008	-	20	-	-
2009	-	20	-	-
2010	-	20	60	-
2011	-	20	-	-
2012	-	20	-	-
Total	**0**	**240**	**240**	**240**

N-fertilization – N - leaching

Gårdjön NITREX is a catchment-scale N addition experiment, where a small catchment G2 NITREX has been fertilised with small doses of nitrogen distributed about 24 times a year since 1991. It is an experiment, where a transition from an originally N-poor to eventually N-rich site is experimentally induced at forested catchment typical for many areas of Scandinavia. The experimental site has been extensively investigated through a sweep of national, Scandinavian and European projects. The last three years (2006/7-2008/9)of treatment were financed through SCARP phase 1 programme. There is a wealth of results, which are published in ca 40 peer reviewed articles. The amount of information and the 18 years of monitoring data make the site ideal as a test site for models of N cycling.
In this activity the treatment of the G2 NITREX will continue during the first year of the program. Data collected during the phase I will be analysed, evaluated and published. Data-sets on deposition, runoff chemistry, soil chemistry, climate and hydrology provided for biodiversity modelling (Belyazid, S., and Moldan, F., 2009), and for modelling of N leaching (Futter et al., 2009) will be extended up to 2008/9. Data will be published to make them widely accessible.

Deliverables

D3.1.1: Provide experimental and background data from all three experimental activities for SCARP modelling activities in the phase II

D3.1.2: Synthesis of results from the experiments for SCARP ecosystem project on synthesis and integration. See also planned publication.

Manuscript

The following manusripts are planned for this project:
Högbom, L., Sikström, U., Persson, T (20xx) On the fate of N addition to N rich sites I - Effects soil solution N concentrations following low dose N addition to N rich sites.
Högbom, L, Sikström, U., Persson, T (200x) On the fate of N addition to N rich sites II. – tracer study with ^{15}N.
Sikström et al. (20xx) On the fate of N addition to N rich sites III. – the effects on tree growth.
Moldan et al. Nitrogen leaching and accumulation in a forested catchment after 19 years of N-additions. Planned year 2.

Impacts of deposition, forestry and climate change on soil and surface water quality

Project leader: Filip Moldan, IVL

Objective: To assess the future status of forest and aquatic ecosystems for different scenarios of deposition, climate change and forestry

Project leader and participants

Filip Moldan, IVL; Salim Belyazid, BCC; Sofie Hellsten, IVL; Cecilia Akselsson, LU; Annika Nordin, SLU

Budget

3.3. Impacts of deposition, forestry and climate change on terrestrial ecosystems and surface waters	IVL	Lund Univ, Nat Geogr	BCC	Lund tek hsk, Chem eng	Total
3.3.1 Scenario development, data compilation	100	100			300
3.3.2 Evaluation of climate change impact on ecosystem response -Catchments and aquatic ecosystems	600				600
3.3.3 Evaluation of climate change impact on ecosystem response -Catchments and aquatic ecosystems - Terrestrial ecosystems and vegetation	200		800	150	1150
Total	**900**	**100**	**800**	**150**	**2 050**

Activities

Scenario development, data compilation

The dynamic models are driven by time series of the so called driving variables. Future scenarios of air pollution, land use and climate need to be estimated and converted to a format suitable for the models. In some cases it is a straight forward task. Variables such as temperature or atmospheric deposition (derived by downscaling of GCM models and calculated from future emission scenarios by EMEP model, in both cases tasks undertaken outside this programme) could be directly fed to models such as MAGIC or ForSAFE-VEG. In other cases more elaborate scenario development is needed. Projections of future forest growth must be converted to amount of nutrients removed from the soil by harvest. Increased temperature and humidity (or decreased) might affect accumulation/decrease of soil organic matter which may be necessary to solve outside the model frames. More/less winds may in future cause higher/lower deposition of sea salts and frequency of wind throws, which might be desirable to take into account.
Scenario development is therefore an important task of this modelling exercise which has to be undertaken. Ongoing activities of several research teams in Sweden made it possible to scale down the estimated budget to undertake this task. Apart from the production of the EUROLIMPACS EU project, ASTA and SWECLIM programmes and SCARP phase I, there is also an expected output from newly established MISTRA programme “Future Forests — Sustainable Strategies under Uncertainty and Risk” and pending proposal for NV research programme CLEO (Climate Change and Environmental Objectives), expected to start in 2010. There is a certain overlap between all the above mentioned programmes and SCARP both in terms of involved institutions and involved individual research groups within the institutions. It is expected that the scenario modifications and development will benefit from the work done within especially CLEO and Future forests. The key task within CLEO will be to modify and further develop the future air pollution, climate and land use predictions for the specific purposes of modelling within SCARP.

A small activity (reduced in size in comparison to the original proposal) is also planned for assessment of research performed outside SCARP.. The intention was to assess climate change impacts on terrestrial and aquatic ecosystems to provide input to the modelling activities (climate change influences not being part of SCARP Phase I). Again, sufficient work and coordination with e.g. the CLEO program is expected.

Evaluation of climate change impact on ecosystem response - Catchments and aquatic ecosystems

To assess the future status of forest soils and aquatic ecosystems for different scenarios of deposition, climate change and forestry, the MAGIC model will be used in this activity. While the nitrogen deposition is of prime focus of this activity (and of whole ecosystem part of the programme), the correct assessment of future N deposition effects requires to take into account other drivers of future change and history of deposition and land use. The N deposition is affecting ecosystems which are recovering from acidification, responding to climate change and which will also be affected by changing forestry practices (due demands for more biomass production driven by efforts to replace the fossil fuels). All these factors must be taken into the account.

MAGIC (Model of Acidification of Groundwater In Catchments) is a lumped-parameter model of intermediate complexity, developed to predict the long-term effects of acidic deposition on soils and surface water chemistry (Cosby et al. 1985, Cosby et al. 1985, Cosby et al. 2001). MAGIC has been modified and extended several times from the original version of 1984. In particular, organic acids have been added to the model (Cosby et al. 1995) and most recently nitrogen processes have been added (Cosby et al. 2001). The MAGIC model has been extensively applied and tested over the past 20 years at many sites and in many regions around the world (Cosby et al. 2001). The MAGIC model has also been used to model effects of climate change on surface waters quality (Wright et al., 2006). In Sweden the MAGIC model was used to model a large number of lakes in order to assess the acidification and recovery of Swedish surface waters (WWW.IVL.SE/magicbibliotek, Moldan et al., 2004). Overall, the model has proven to be robust, reliable and useful in a variety of scientific and environmental management activities (Cosby et al. 1995, Ferrier et al. 1995, Jenkins et al. 1998, Wright et al. 1998). Recently MAGIC was used to assess the recovery of European surface waters given the CLE (Gothenburg protocol and other agreed legislation) deposition scenario (Wright et al. 2005) and of relative importance of various aspects of climate change (Wright et al., 2006). The development of the MAGIC model is ongoing. While the wide use and popularity of the original version is based on demonstrated ability of the model to reproduce observed trends in soils and surface waters with respect to acidification and recovery, the further development of the model is mainly focussed on C and N cycling in the soils. This only reflects the shift in relative importance of air pollution on one side and climate change and land use on the other side as drivers of future ecosystem change.

In this activity we will continue the modelling of surface waters and soils in Sweden to assess the effects of various plausible future scenarios to provide the regional assessments. Under all circumstances the model predictions will be compared to observed data as much as possible. The National lake survey (Riksinventering, http://info1.ma.slu.se/) and from the Swedish National Forest Inventory (Riksskogstaxering, http://www-markinfo.slu.se/) will be the two primary sources of observations. Special attention will be given to the long term effects of nitrogen on both soils and surface waters. Assessment of uncertainty in the model predictions will be a part of the work. The model predictions will be confronted with output of vegetation modelling done by the ForSAFE-VEG model. The research group at IVL will also continue the long term co-operation with research teams at NIVA (Norwegian Institute for Water Research) and university of Virginia, where the MAGIC model is continuously updated. That opens for possibility to have an influence on further model development by identifying the gaps of knowledge and contradictions between observed reality and model predictions.

Evaluation of climate change impact on ecosystem response - Terrestrial ecosystems and vegetation

Testing and applying of N-dynamics module in ForSAFE-Veg

The newly developed module for nitrogen processes in soils that was developed in SCARP 1 and subsequently included in the ForSAFE-Veg model will be tested on a set of intensively monitored sites. Model outputs will be compared with and without the N module with field data so as to identify the improvement brought about by including further nitrogen dynamics. Model outputs will be evaluated for soil chemistry, N leaching and N effects on the ground vegetation.

The testing of the model requires input data from intensively monitored sites. While most of the data is available, there are some missing figures for specific sites. For this, it is required that further but limited measurements be carried out at some of the monitoring sites.

The results from the modelling will be discussed within a workshop bringing together experimentalist and modellers within the group. We will test hypothesis of what we think new N processes might contribute to model performance, and what the group thinks could be the majors remaining weaknesses to be addressed subsequently. The work will be documented both as an internal progress document and a scientific manuscript.

Scenario calculations for acidification, nitrogen cycling and vegetation response

Part 1 – site specific modelling

A set of 8 intensively monitored and/or manipulated sites will be simulated, with focus on N leaching, plant community composition, or both, depending on the availability of field data (Figure 1). The sites are selected to cover a wide range over the stand index scale, ranging from very poor to very fertile sites. The wide stand index range will allow us to model N processes at different stages of N load, from severe limitation (sites in northern Sweden) to saturation (sites in southern Sweden).

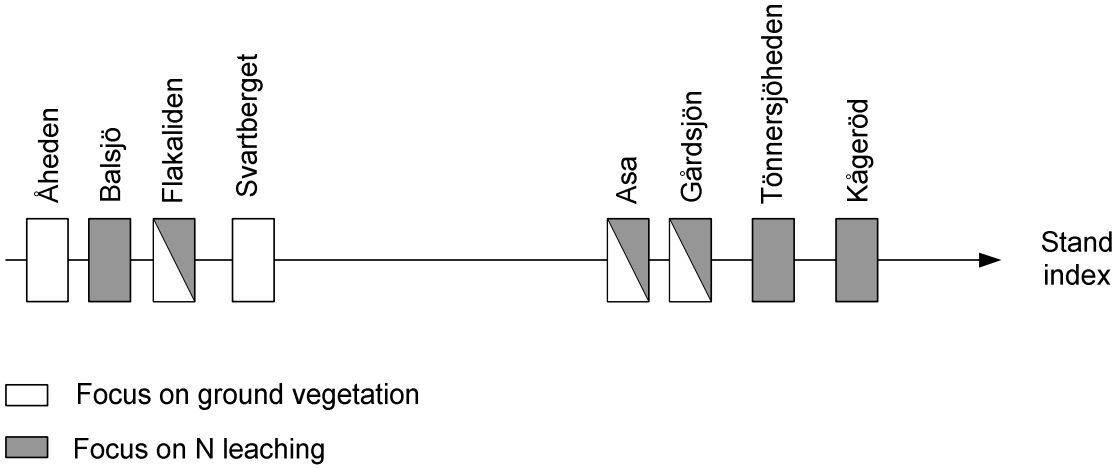

Figure 1: A set of 6 sites with different stand indices, N load statuses and climate zones will be modelled with focus on N leaching, plant community composition, or both.

The simulations will aim at testing different hypotheses explaining ecosystem response to their specific N-loads. The hypothesis formulations and testing will be done within a series of 3 workshops where the modellers and experimentalist will work together on the measured and modelled data, and discuss future scenarios.

Part 2: scenario analysis
The developments and simulations that will be carried out in parts 1, 2 and 3 will be the basis for an extensive scenario analysis study that will make the findings of the present sub-project available for supporting decision making through linkage with the IAM sub-project within SCARP. The scenarios that will be investigated concern future changes in climate, future atmospheric deposition levels, and future forest management methods. The scenarios will be first carried out at the specific sites described above. For delivery to SCARP IAM, simulations on a national scale with 660 sites will be carried out in collaboration with parallel projects supported by NV.

Time plan
Year 1:

- 3.2 will be completed here. Input data for the testing sites will be put together and the rest simulations executed. A first workshop will be held where the outlines for a scientific paper will be drawn in May 2010. Writing with the aim of a submission in summer 2010.
- In this year, data will also be collected and formatted for the simulations in part 4.3.
- The biotic model will be partly quantified here, with the aim of identifying the missing values and processes to be addressed in year 2

Year 2:

- Simulations on all specific sites will be carried out, with the aim of testing different hypotheses on why N leaches in some places and not others, why N contributes to C accumulation at some sites and not others, what the effect of forest management is on responses to N… a set of questions will be set up prior to a meeting. The simulations will be completed by May 2011, and shortly followed by a workshop to discuss the outcome among experimentalists and modellers. We will focus both on the risk of N leaching and on effects on the ground vegetation.
- Writing two scientific articles with the joint experiment/model investigations of processes of N leaching and vegetation community changes.
- The biotic interaction model will be completed, tested and documented in a scientific paper so as to give us the possibility to investigate if it should be included in the wider national modelling.
- Take the simulations to national level by preparing the database for site data, climatic input, site histories and deposition. The resulting national input tree will be used in Year 3 to provide national CL maps to SCARP IAM and to illustrate the outcome of different emissions scenarios on ground vegetation and N leaching. The national input tree should be ready for use by September 2011.

Year 3:

- This year will be focused on synthesis and support for the integration with SCARP IAM.
- The papers should be completed and submitted, hopefully revised.
- Carrying out an extensive scenario analysis based on the climate, deposition and management scenarios used for the specific sites to analyse national trends using the national database.
- Reporting and party!

Deliverables

D2.1.1: Time series of driving variables for modelling of waters, soils and vegetation under various air pollution emissions, climate change and land use scenarios. Year 1 and 2, output will directly feed into the modelling activities
D2.2.1 Results of the modelling activities will be publixhed in international journals (see below)
D2.2.2 Results of the modelling activities will be delivered to project 3. Synthesis.

Manuscript

- Belyazid, S., Högbom, L., Moldan, F., Nordin, A., Sverdrup, H.. Integrated soil Nitrogen processes in the ForSAFE-Veg model – implications for modelled predictions on soil chemistry and plant community composition.
- Belyazid, S., Högbom, L., Akselsson, C., Sverdrup. H.. Nitrogen retention and carbon storage in response to forest management practices.
- Belyazid, S., Nordin, A., Sverdrup, H., Akselsson, S.. Plant community responses to N deposition and interactions with forestry practices. Moldan, F., et al. Model predictions of surface water quality in Sweden. Report to NV and manuscript submitted to a scientific journal in year 3.
- Moldan F., et al., Modelling N addition experiment at Gårdsjön Sweden: soil and surface waters chemistry. Manuscript submitted to a scientific journal in year 2.
- Moldan, F., et al. Model predictions of surface water quality in Sweden. Report to NV and manuscript submitted to a scientific journal in year 3.

Synthesis

Project leader*:* Cecilia Akselsson, Lund University

Objective

To synthesize results from experiments, modelling activities and reviews in SCARP, to make the best possible future predictions of nitrogen effects on acidification and eutrophication of terrestrial and aquatic ecosystems under different deposition, forestry and climate scenarios based on the scenario analyses in activity 2.1 and to highlight remaining knowledge gaps in the understanding of nitrogen cycling in ecosystems and weaknesses in the models. The SCARP synthesis will work in close collaboration with on-going projects on development of critical loads financed by other sources.

Project leader and participants

Project leader: Cecilia Akselsson, Lund University
Participants: Harald Sverdrup; Lund University, Annika Nordin, SLU; Lars Högbom, Skogforsk; Sofie Hellsten, IVL; Salim Belyazid, BCC; Filip Moldan, IVL; John Munthe, IVL. BCC will participate via budget in 2.3.

Budget

	IVL	Lund Univ, Nat Geogr	BCC	Lund tek hsk, Chem eng	SLU	Skogforsk	Total
3.4 Synthesis and integration	100	210	100	250	185	185	930

Activities
The experimental activities in (1) the modelling work (2.2, 2.3) and the reviewing activities (2.1) will be synthesized in this project. The work will be based on a set of workshops bringing together all partners, experimentalists as well as modellers, within the group. The synthesis will result in a final report as well as documentation of the intermediate discussions from the workshops. The participation of SLU, LU and Skogforsk in scientific papers in other SCARP activities will also be financed in this project. High emphasis will be put on synthesizing the results from SCARP both from a strictly scientific aspect and from a policy perspective. The main activities are:
-A workshop, held in year 1, that will focus on input data and planning of the continuation of the work. The broad outline of the scientific papers and reports will be drawn.
-A workshop, held in year 2 when the first results are delivered, where the results are discussed and compared with the actual field data from the experimental sites. The focus will be on the risk of nitrogen leaching and the effects on ground vegetation. This workshop will be very central in the integration of modelling approaches and experimental data, bringing together competences from modellers and experimentalists with experience from the chosen sites, interpreting result, discussing scenarios and identifying model weaknesses and possible improvements of the model.
-Final synthesis and writing the final report. This work will be initialized in year 1 and continuing throughout the three years, but will be intensified in the third year. The work will be performed through a close collaboration between all partners. The final report will synthesize results from experiments, modelling activities and reviews for the whole programme period of SCARP, present the best possible future predictions of nitrogen effects on acidification and eutrophication of terrestrial and aquatic ecosystems under different deposition, forestry and climate scenarios and highlight remaining knowledge gaps in the understanding of nitrogen cycling in ecosystems. Further, the results will be related to on-going work within other projects on critical loads.

Deliverables
D3.3.1 Synthesis A final report comprising a synthesis of the results from SCARP covering both the scientific progress and the policy aspects.
D3.3.2 A conceptual scientific paper synthesizing the progress on N cycling made in SCARP.

Manuscript
A conceptual paper revising the N saturation theories in the light of the SCARP knowledge.

Project collaborators

This project will be conducted in close collaboration with the CLEO programme which, is funded, will start in 2010. CLEO is focussed on climate change impacs on environmental objectives (Clean Air, No Eutrophication, Zero Acidification and A Toxics Free Environment). CLEO will include large research efforts to evaluate the role of climate change on the leaching of N, S, and C from forest soils to surface waters but does not include influences of climate change on vegetation composition. The involved partners are slightly different and there is very little overlap in experimental sites and scientific approach. Nevertheless, harmonisation and cooperation between the two programs will be necessary to avoid overlaps and to increase the mutual benefits. One important area of collaboration are the development of scenarios. In CLEO, scenarios for climate change will be developed in close cooperation with other main research activities at the Rossby Centre and other research programs. Forestry scenarios will also be preared in cooperation with the MISTRA funded program Future Forests at SLU.

Over all budget

Budget - Additional application

Activities and budget for Ecosystem Sub-programme Phase II

Sub projects and Activities	Responsible scientist, participants	IVL	Lund Univ, Nat Geogr	BCC	Lund tek hsk, Chem eng	SLU	Skogforsk	Total
Coordination	John Munthe	300						300
3.1. Nitrogen cycling in forest soils	Annika Nordin, SLU							
Assessment of data from national monitoring and forestry research.	Lars Högbom, Skogforsk						125	125
	Filip Moldan, IVL	125						125
	Annika Nordin, SLU					125		125
3.3. Impacts of deposition, forestry and climate change on terrestrial ecosystems and surface waters	Filip Moldan, IVL							
3.3.1 Scenario development, data compilation	Sofie Hellsten, Filip Moldan, IVL; Salim Belyazid, BCC, Cecilia Akselsson, LU; Annika Nordin, SLU	100	100					300
3.3.2 Evaluation of climate change impact on ecosystem response - Catchments and aquatic ecosystems	Filip Moldan, IVL	600						600
3.3.3 Evaluation of climate change impact on ecosystem response - Catchments and aquatic ecosystems - Terrestrial ecosystems and vegetation	Salim Belyazid, BCC; Sofie Hellsten, IVL	200		800	150			1150
4 Synthesis and integration	Cecilia Akselsson, LU; Harald Sverdrup, LU; Sofie Hellsten, Filip Moldan, John Munthe, IVL; Annika Nordin, SLU; Lars Högbom, Skogforsk.	100	210	100	250	185	185	930
Total main proposal		**1425**	**310**	**900**	**400**	**310**	**310**	**3655**
Additional proposal 1								550
Additional proposal 2								380
Sum additional proposala								930
Grand total								**4585**

Other results and communication efforts

In addition to the deliverables and planned manuscripts described above, the results of this research will be communicated via national and international workshops and conferences. To ensure the applicability of the results to the development of international air pollution policies, specific communication efforts will be made to present the results at events arranged within the LRTAP Convention (e.g. CCE workshops) and related events. Presentations at scientific conferences and workshops will also be made.

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Area 4 Integrated Assessment Modelling

Area coordinator: Jenny Arnell, IVL

Introduction
The main priorities during phase II will lie on further development of the GAINS Sweden model, further incorporation of results from other parts of the SCARP programme as well as further development of the theoretical considerations regarding abatement cost calculations. At the start-up of phase II, specific priorities of the area 4 activities will be discussed with the Swedish Environmental Protection Agency as well as the IIASA GAINS modelling team.

Overall objective
The long term objective of the subproject is to develop a National version of the GAINS model with possibilities for testing, evaluation and improvement of various components of the model system according to priorities set by Swedish environmental authorities and Swedish scientists.

The main objective with phase II of the SCARP-IAM project is:
The developed GAINS Sweden online model, including additional features related to health impacts, GHG abatement costs and other abatement options currently not represented in GAINS.

The objectives of the second phase is an extension of the efforts achieved in phase 1 of the project in order to develop a National version of the GAINS model with possibilities for testing, evaluation and improvement of various components of the model system according to priorities set within the programme and further discussed with Swedish environmental authorities.

The prerequisites needed to obtain this effect-oriented objective are the following:

1. An Integrated Assessment Model on a national and European scale will be open to use by national parties. IVL and the SCARP research team will perform the model changes needed together with IIASA in the GAINS Sweden online.
2. -Background data on emission related activities
    i. -Scenario-specific projections on emission related activities
    ii. -A number of model calculations performed with results on abatement costs, environmental impact and health effects.
3. A method for further implementation of new results from other areas of the SCARP programme. SCARP areas of special interests are 1. Health and 2. Ecosystem effects.

Delimitations
SCARP-IAM will primarily be based on the present version of the GAINS model. It will, for example, for transfer matrices rely on the matrices calculated by the EMEP model. SCARP-IAM will not necessarily perform any energy system modelling.

Activities in phase 2

SCARP-IAM will during it's second phase have three main activities:

4.1 GAINS Sweden adaptation, online/offline,
4.2 Behavioural changes, transaction costs, adaptation and uncertainties
4.3 Integration with other SCARP research areas (health, ecosystems)

The first two activities are mainly involving the SCARP-IAM working group, while the third activity is considered as a separate 'integrating' activity, which is performed with the SCARP-IAM group collaborating together with other research groups in SCARP. Activity 1 links together the GAINS Sweden offline as a test site for model adaptations, and the GAINS online as an 'online implementation site' of the model adaptations tested in the GAINS offline if feasible.

Further activities
There are several case studies that are important for the GAINS Sweden work, often related to energy use and emissions from the transport sector. These case studies are not considered as main activities of the SCARP-IAM project but are still considered as very important. Due to the budget constraints over the three remaining years of the SCARP-IAM, these case studies will be co-financed by other institutions.

Supervision of Area 4:

Advisory group. In order to make sure that we can keep quality and make use of experience in the development of national IAMs in other countries we will establish an advisory group. Our intention is to meet with this group at least twice a year. We will also make use of international meetings (e.g. IAM Task Force and NIAM) for the advisory group's meetings. Preliminary participants in the Area 4 advisory group are: Eli-Marie Åsen, Norway, Julio Lumbreras, Spain, Tiziano Pignatelli, Italy.

4.1 GAINS Sweden online/offline

Project leader
Stefan Åström (IVL)

Objective Develop a version of GAINS Sweden online and offline.

Project leader and participants
Project leader: Stefan Åström (IVL)
Participants: Maria Lindblad (IVL), Håkan Blomgren (IVL), Jenny Arnell (IVL) Janusz Cofala (IIASA)

Budget

	Year			
Activity	1 (2010)	2 (2011)	3 (2012)	**Total [kSEK]**
1. GAINS Sweden				
1.A Bio fuel	300	75	75	**450**
1.B CO2 costs	250	250	250	**750**
4.C NRMM	100	150	50	**300**

IVL: 1350 kSEK
IIASA: 150 kSEK

Activities

A. Emissions from biofuels in the road transport sector
Current expert estimates on emissions from transport have stressed that ethanol use seems to cause higher NOX and VOC emissions than gasoline when used in light duty vehicles. Currently, the GAINS model calculate the impact on CO_2-emissions based on the fossil carbon content of the fuel mix (dependent on the % of renewable in the fuel mix).
The aim of task A would be to reformulate (or to introduce an additional calculation) the way in which emissions from renewable fuels in the transport sector is performed. This would be done for renewable in GSL (ethanol). This addition to the emission calculations is suggested to first be performed in the GAINS Sweden offline model and thereafter communicated to IIASA and implemented in the GAINS Sweden online model if suitable.

B. CO_2 abatement costs presented in the GAINS Sweden online
Since the national and international air pollution abatement options more and more coincide with the CO_2 abatement options, there is need further investigation of how to allocate and calculate costs and co-benefits (between air pollution and GreenHouse Gases) of such options. The needs have been put forward by the Swedish EPA as a priority activity for phase 2.

The suggested task B needs to be further discussed in means of performance. There are a number of options, for example a number of scenario estimates with associated CO_2-costs could be explored. In the GAINS Sweden model, fully optimised scenarios are not considered as crucial, more important is that we should find a way to estimate the CO_2 abatement costs associated with different energy scenarios. This activity needs some further method development and we intend to put forward different options for discussions with IIASA, the advisory group and the Swedish EPA: Regardless of how task B is practically performed the aim is to have CO_2 abatement cost illustrated in the GAINS Sweden online version.

C. Abatement options in the non-road mobile machinery (NRMM)
IVL has delivered estimates on emission reduction possibilities in the NRMM sector to the Swedish EPA[2]. These emission reduction possibilities are mainly based on shifts from 2-stroke to 4-stroke engines or electric engines (smaller machinery). The possibilities are currently not presented as options in the GAINS model.

The aim of task C would be to introduce the 4-stroke option and maybe electric engines as a control option in the smaller non-road mobile machinery sectors in GAINS (TRA_OT_LD2, TRA_OT_LB). As mentioned IVL has done estimates on costs and improvement potentials for NRMM emission sources, and this task would build on the experiences from this study.

Deliverables (time plan)

- Deliverable 4.1.I: A functional GAINS Sweden online model, serving as a Swedish online test version of the improved functionalities from the GAINS offline version, as well as a standard GAINS online version (2012)
- D.4.1.II: Functional offline version of the GAINS model, enabling tests on feasibility of model improvements before implementation in the GAINS Sweden online model (2010)

[2] Fridell F. & Åström S., 2009, Analysis of measures to reduce Swedish emissions by 2020 for NOX, PM2.5 and NMVOC, IVL report U2617

- D4.1.III: Improved representation of emissions related to the use of bio fuels in the road transport sector, initially focused on ethanol in small cars (2011)
- D4.1.IV: A representation of CO2 abatement costs in the GAINS Sweden online model (2011)
- D4.1.V: Further representation of abatement options for Non Road Mobile Machinery (NRMM) (2011)

Manuscript
Tentative titles are:
Environmental Impacts from increased use of ethanol in the road transport sector (D4.1.I)
Further emission reduction from non-road mobile machinery implemented in GAINS - costs, emission reductions & impact on the environment (D4.1.II)

4.2 Behavioural changes, transaction costs, adaptation and uncertainties

Project leader
Mohammed Belhaj, IVL

Objective
Additional assessment of the transport sector including behavioural and structural changes and their costs and incorporation of these in the other Swedish sectors

Assessment of transaction costs and review of their impacts in GAINS-Sweden costs effectiveness analysis

Project leader and participants
Project leader: Mohammed Belhaj (IVL)
Participants: Maria Lindblad (IVL)

Budget

	Year			
Activity	1 (2010)	2 (2011)	3 (2012)	**Total [kSEK]**
2. Behavioural changes, transaction costs, adaptation and uncertainties				
2.D Behavioural change	225	150	45	**420**
2.E Sensitivity	50	50	150	**250**

IVL: 600 kSEK
IIASA: 70 kSEK

Activities
In general, the non inclusion of important variables such as non technical measures in integrated assessment modelling may leads to limited results. In order to assess the importance of additional variables in the model setting this activity will include the following tasks:

D. Behavioural change and transaction costs
Since adaptation in behaviour could be one important measure to achieve lower emissions the exclusion of non-technical measures may lead to limited results when analysing different

sectors. However, the GAINS model does not explicitly capture the costs of behavioural changes that may reduce the anthropogenic driving forces generating pollution. The reference of cost behaviour is not based on whether the behaviour is bad or good. Cost behaviour refers to the sensitivity of consumers and/or producers to costs. These considerations may also be related to benefits or energy saving as well as environmental concerns. The inclusion of these considerations in the GAINS model would most probably lead to further decreasing the cost of emission reduction both at the micro (firm, household) and macro level. Furthermore, abatement procedures are loaded with transaction costs (i.e. expenditures that are not directly involved in the production of goods or services e.g. administration and research costs that may be significant and would increase the costs of emission reduction. Therefore, addition of costs of behaviour as well as transaction costs into the GAINS model would lead to consistent results.

The aim of this task to study the impact of transaction costs and behavioural changes and their costs on emissions reductions in different sectors.

E. Adaptation and sensitivity analysis
Based on the fact that GAINS is a static model where temporal aspects of adaptation to policies, measures etc are not captured the aim of this task is to study the effects of adaptation to already taken measures on the results of the GAINS model. Furthermore, this task will study the effect of changes in different variables by mean of sensitivity analysis related to:

- data uncertainty,
- model uncertainty including causal link between the different variables included in the model,
- different discount rates,
- different dose- response functions.

Deliverables (time plan)

- D4.2.I: Assessment of impact of behavioural changes, their costs and implication on emission reductions (2011)
- D4.2.II: Study of the importance of transaction costs on total abatement costs (2011)
- D4.2.III: Study of adaptation and uncertainties in the GAINS model (2012)

Manuscript
Behavioural change, costs and emission reductions in the Swedish transport and energy sectors (D4.2.I)
Importance of transaction costs in the abatement cost function (D4.2.II)

4.3 Integration with other SCARP research areas (health, ecosystems)

Project leader
Maria Lindblad, IVL

Objective
Develop GAINS Sweden online to include effects modules on health and ecosystems. This activity will be undertaken through extensive collaboration with other SCARP areas; Area 1-Health and Area 3 – Ecosystems.

Project leader and participants
Project leader: Maria Lindblad (IVL)

Participants: Stefan Åström (IVL), Håkan Blomgren (IVL), Gunnar Malm (IVL)
In collaboration with Tom Bellander (KI), Göran Pershagen (KI), Bertil Forsberg (Umeå University), John Munthe (IVL), Cecilia Akselsson (LU), Filip Moldan (IVL), Annika Nordin (SLU Umeå), Salim Belyazid (BCC), Sofie Hellsten (IVL)

Budget

	Year			
Activity	1 (2010)	2 (2011)	3 (2012)	**Total [kSEK]**
3. Integration with other SCARP research areas (health, ecosystems)				
3.F SCARP health	50	150	250	**450**
3.G SCARP ecosystems	100	50	0	**150**

IVL: 540 kSEK
IIASA: 60 kSEK

Activities
In activity 4.3, IIASA and IVL have previously discussed the possibility to include results from the SCARP-health research area. During the midterm review of the SCARP programme, integrating efforts involving the SCARP-nitrogen research area was also identified as important. The activity 4.3 is divided into two suggested tasks.

F. Integration of health effects in the GAINS model
The GAINS model is currently limited in its description of impacts from air pollution on human health. These limitations are mainly based on WHO agreements. The GAINS currently describe impacts on mortality from exposure of fine particulate matters and ozone.

The SCARP-health research area is anticipated to deliver results indicating the children morbidity effects related to air pollution mainly induction of asthma in young and adult populations[3],[4]. These results will be possible to reformulate into exposure-response functions suitable for a GAINS modelling environment. Health effects of considerations are mainly the onset of asthma in healthy adults and asthma periods in adult and young populations.
The aim of task F would be to adapt the methodology used for mortality estimates in the GAINS model, but reproduce this methodology on the basis of other morbidity endpoints (asthma induction in young and adult population). This will require an introduction of the young population sub-set into the current population estimates in the GAINS model. These GAINS model adaptations are suggested to first be performed in the GAINS Sweden offline version and thereafter implemented in the GAINS Sweden online version.

This task will be operated in collaboration and integration with SCARP area 1 (Health) and to some extent area 2 (PM). SCARP Health is responsible for producing and converting the health effects results needed. SCARP IAM is responsible for incorporation these results in the GAINS offline/online model.

[3] Bråbäck &Forsberg, 2009, Does traffic exhaust contribute to the development of asthma and allergic sensitization in children: findings from recent cohort studies, Environmental Health 8:17
[4] Modig et al., 2009, Vehicle exhaust outside the home and onset of asthma among adults, European Respiratory Journal 2009, volume 33

G. Integration between the GAINS model and FORSAFEveg
In the SCARP-ecosystems research area, the FORSAFEveg model is being developed and adapted to illustrate the effects on vegetation (biodiversity) from deposition of air pollutants. During the phase II of the SCARP research programme, the SCARP-ecosystem research group is anticipated to deliver national estimates on vegetation effects of air pollution as well as Critical Loads related to vegetation.

The first step of the integration between the SCARP area 4 and area 3 will be to report scenario-specific results on Swedish deposition of air pollutants to the FORSAFEveg model from the GAINS model.

The second step will be to introduce maps on Critical Loads related to vegetation into the GAINS model, this step is further presented in the additional application to the GAINS Sweden.

Deliverables (time plan)
D4.3.I: Results from SCARP area 1 (health) mainly regarding asthma occurence, integrated into the GAINS Sweden online model (2012)
D4.3.II: Results on air pollutant deposition delivered from SCARP area 4 to area 3 (2010)

Manuscript
Morbidity effects in children following improved EU AQ policies (D4.3.I)

Project collaborators
The following organisations are collaborators to the project group and are important as interpreters and reviewers of the projects interim results. These groups are collaborating with IVL in other projects related to Integrated Assessment Modelling and the results from these projects will most likely benefit the work performed in SCARP-IAM phase II and vice versa.

- Finland's environmental administration (SYKE)
- The Norwegian Meteorological Institute (met.no)
- JSC Scientific Research Institute for Atmospheric Air Protection, Russian Federation
- NIAM, Network of National Integrated Assessment Modelling
- IIASA

Overall budget Area 4

	Year			
Activity	1 (2010)	2 (2011)	3 (2012)	**Total [kSEK]**
Project coordination	75	75	75	**225**
1. GAINS Sweden				
1.A Bio fuel	300	75	75	**450**
1.B CO2 costs	250	250	250	**750**
1.C NRMM	100	150	50	**300**
2. Behavioural changes, transaction costs, adaptation and uncertainties				
2.D Behavioural change	225	150	45	**420**
2.E Sensitivity	50	50	150	**250**
3. Integration with other SCARP research areas (health, ecosystems)				
3.F SCARP health	50	150	250	**450**
3.G SCARP ecosystems	100	50	0	**150**
SUM Area 4	**1 150**	**950**	**895**	**2995**

Other results and communication efforts

The communication of the SCARP-IAM project will occur through the active participation in several workshops and meetings, via reports and submitted articles.

The main meeting arena for the SCARP-IAM project results are at the UNECE TFIAM meetings (2 / year) and when suitable at the NMR Air & Climate meetings, NIAM - Network for Integrated Assessment Modelling etc.

Communication activities within SCARP

The communication targets and activities have in line with the recommendations of the evaluation group been specified in more detail. We will still build on the communication plan established in phase 1. In this proposal we have concentrated on the policy related communication activities, which are separated in national and international activities. We are therefore not describing activities related to normal scientific literature and participation in international networks etc.

Policy-related communication

National processes

The main national policy process is through the **National Environmental Objectives** (NEO) and the Council for National Environmental Objectives. The program has frequent contacts with the NEO secretariat and has contributed both to the evaluation of the measures to reach the objectives and the further development of the objectives (see table xx). In the future we will continue this process through more formal contacts.

Of particular importance for the NEO council is the comprehensive assessment which is done every fourth year. The last evaluation was published in March 2008 and the next is scheduled

to the first quarter of 2012. Recently, the NEO system has been reviewed and a proposal for a change in the organisational system is proposed. If this proposal will be taken, the next evaluation will be published the first quarter in 2014. Since the evaluation will involve several steps, input from research needs to be ready at least a year before the date for publication.

We will be closely linked to the NEO processes and will, as for the comprehensive assessment in 2008, be active in contributing to supporting reports. These activities will be further defined through the contacts with NEO secretariat and those directly responsible for preparing the supporting reports.

Swedish environmental policies are to a large extent directed to **sectors** (transport, energy, agriculture etc.) and the authorities are also responsible for environmental policies and measures within this sector. SCARP will produce research results that are important for the development of environmental policies within several sectors, in particular:
The National Road Administration (Vägverket)
The National Energy Agency (Energimyndigheten)
The National Forestry Agency (Skogsstyrelsen)

The program has a well established contact system with these three organisations and will continue to keep contacts. These organisations have also supported research and assessments connected to SCARP e.g. through the EMFO research program.

Regional and local authorities have also a large interest in the results from the SCARP program. Contacts are well established with the local health and environmental authorities in the three cities Stockholm, Göteborg and Umeå, in which experimental studies are conducted. Local and regional authorities will be invited to the seminars and conferences organised by ScARP.

Finally **industry** and the **public** are also stakeholders to the programme. Direct contacts are especially linked to the transportation industry (manufactories, carriers etc.) in the same way as with the national authorities mentioned above.

With the limited budget for communication, SCARP will seek collaboration with national agencies and other organisations in order to reach our ambitious goals. These organisations include: Swedish Environmental Protection Agency, Sector authorities, Confederation of Swedish Enterprise, The Swedish Air Pollution Control Association and also with our host organisations.

International processes
The main policy organisations are as mentioned earlier CLRTAP, WHO and the European Commission.

European Commission
The ongoing and upcoming processes include
Implementation of the Air quality directive, which is handled through **the EC Ambient Air Quality Committee**. Through the committee and its subgroups the implementation of the AQ directive is further developed. It will also be responsible for the upcoming **review of the PM directive**, which is expected to start in 2011. Deliverables from the program will fit well into this process and we will through the Swedish representative make sure that our results will be

available in the process. It is most probable that scientists from SCARP will participate as experts in this process.

CLRTAP
SCARP scientists participate in a number of Task Forces and expert groups under the Convention, in most cases with financial support from other sources. Our intention is that these activities should continue. We see our participation in this work as a two-way process. Through our participation we will both make sure that our results will be presented, discussed and implemented in relevant policy forums, but we will also through our participation get information and extend our international networks.

Compilation of communication activities in relation to national and international policy development

	2010				2011				2012			
	1	2	3	4	1	2	3	4	1	2	3	4
NEO secretariat (PC)	Fromal contact				Formal contact				Formal contact			
NEO eval. (all)									Delivery?			
TFIAM (4)		M				M				M		
TFRN (3 and 4)		M				M				M		
TFMM (2)		M				M				M		
TF mapping (3)		M				M				M		
TF Health (1)		M				M				M		
ENA (PC, 3)		Draft				Report						
SCARP seminar					X							
SCARP conference												X
ERS	--------	-------	--------	-------	--------	--------	--------	--------	-------	-------	-------	-------
Tramsport Forum					Conf.							
EC AAQC			contact				Contact					
AQD review						--------	--------	--------	-------	-------	-------	-------
Nat authorities				Seminar						Seminar		
Industry				Seminar						Seminar		
The public												

PC:	Program coordinator
M	Scheduled meetings with international bodies.
TFIAM:	Task Force on Integrated Assessment Modelling (Stefan Åström)
TFRN:	Task Force on Reactive Nitrogen
TFMM	Task Force on Measurements and Modelling
TF Mapping	Task Force on Mapping Critical Loads and Levels
ENA	European Nitrogen Assessment
ERS	European Respiratory Society Environmental and Health Committee.
LS	The Swedish Society of Medicine. Working Group for Occupational and Environmental Medicine: 3-4 times a year
EC AAQC	The EC Ambient Air Quality Committee
AQD review	Directive is expected to be reviewed 2011-2013.

Additional funding

In the original proposal for the SCARP program, we had a budget substantial larger than what was finally approved. It is also obvious that several of the research activities are underfinanced. In 2008, we therefore put forward an application for an extension of the program. The Swedish Environmental Protection Agency decided not to support the overall proposal but only a limited part directed towards synthesis and communication. For the larger part of the proposal the agency said that this should be considered in view of the evaluation and proposal for the second phase. In the following we are outlining some activities, which we think will be of outmost value for the success of the program.

Project 1. Supplementary proposal on harmonisation of dose-response modelling regarding health effects of specific air pollution components

There is still substantial uncertainty regarding which particular sources and features of traffic related air pollution that are responsible for the observed adverse health effects. For example, it is not clear how long-term exposure to combustion related fine particulate differs in its potential to cause health effects in comparison with the more coarse particles generated by road wear. The SCARP project has a unique possibility to address this problem since epidemiological studies are performed in areas with differing air pollution mixtures. Primarily three areas are included: Göteborg, Stockholm and Umeå. These three areas differ to some extent in their air pollution because of differences in climate and important sources, e.g. use of studded tyres and local wood combustion. Unfortunately, the methodology for assessment of local air pollution levels differs to some extent between the three areas, making direct comparisons of the results unnecessarily difficult.

In order to facilitate comparisons of results as well as combined analyses of the epidemiological studies performed in Göteborg, Stockholm and Umeå we propose the development of a uniform strategy to model local levels of particles of different types from various sources. This should involve comparisons between available emission data bases, emission factors, dispersion models, handling of regional background and use of the models in different urban areas. Some measurements are also necessary to validate the models.

We estimate that the project will cost around 1 MSEK, evenly distributed over three years. It will primarily involve the health and particulate areas of SCARP, and facilitate integration of the activities. Furthermore, enhanced information on dose-response relations will be of great use for the overall risk assessment and potentially for the IAM.

Project 2. Critical loads in Sweden – Integration with the IAM cluster

Project leader: Sofie Hellsten, IVL

Objective

To assess how new emission reduction strategies will affect exceedance of critical loads in Sweden. Furthermore, to map critical loads in Sweden based on future deposition scenarios using vegetation change as indicator of environmental performance.

Project leader and participants

Project leader: Sofie Hellsten (IVL)
Participants: Salim Belyazid (BCC), Filip Moldan (IVL), Cecilia Akselsson (Lund University) and Annika Nordin (SLU). (+ participants from the IAM cluster)

Budget

Total budget: 550 (+ budget for the IAM cluster)
IVL: 330
BCC: 100
Lund University: 70
SLU, Umeå: 50

Activities

To derive deposition scenarios for year 2010, 2015, 2020, 2025 & 2030 (N & S) from the IAM cluster (Area 4). Critical loads maps based on dynamic modelling of ground vegetation effects (ForSAFE-VEG) and surface waters (MAGIC) are calculated. The corresponding climate and management scenarios will be delivered from SCARP subproject 4.3.

To generate critical loads maps (50 x 50 km) to the IAM cluster (area 4). These CL-maps are based on calculated CL-values (ForSAFE-VEG) and MAGIC for a given number of lakes and sites in Sweden (660 terrestrial ecosystem sites). These results are scaled to EMEP grid level (50 x 50 km), based on the representativeness of each site or lake within the grid cell.

The IAM cluster will assess the CL-map based on different emission scenarios from the GAINS-model, to assess how new emission reduction strategies can affect the exceedance of critical loads in Sweden, both for terrestrial and aquatic ecosystems.

Deliverables

An assessment of different emission reduction strategies and their impact on the critical load in Sweden.
Critical loads exceedance maps based on different deposition scenarios from the IAM cluster.

Proposed manuscripts

Åström, S., Belyazid, S., Akselsson, S., Hellsten, S., Sverdrup, H.. Implications of biologically based critical loads of acidity on national emissions ceilings in Sweden.
Hellsten, S., Belyazid, S., Nordin, A., Åström, S., Akselsson, S., Sverdrup, H.. Effects of national emission scenarios on the plant biodiversity in Sweden – linking emissions and effects through deposition.

Project 3. Quantitative modelling of biotic interactions within plant communities in response to N deposition

Project leader: Salim Belyazid (BCC)

Additional partners: Annika Nordin (SLU, Umeå)

Objective:

- to develop a quantitative model describing how internal biotic processes are involved in altering plant community composition in response to N deposition, based on the conceptual model that was developed in Phase I from results of experimental studies.
-to incorporate the model in ForSAFE-VEG and to do model runs on a test site.

Background:

During the first phase of the SCARP program, a conceptual model (Figure) was devised to describe the internal biotic processes involved in altering plant community composition in

response to N deposition, based on experimental studies. In this phase of the project, we propose to quantify the proposed system. The quantification is needed to anchor the assumptions made in European vegetation composition models about adverse effects of N on certain plant species. The work will be closely done between modellers and experimentalist, and result in a scientific manuscript to be submitted during the second year of Phase II.

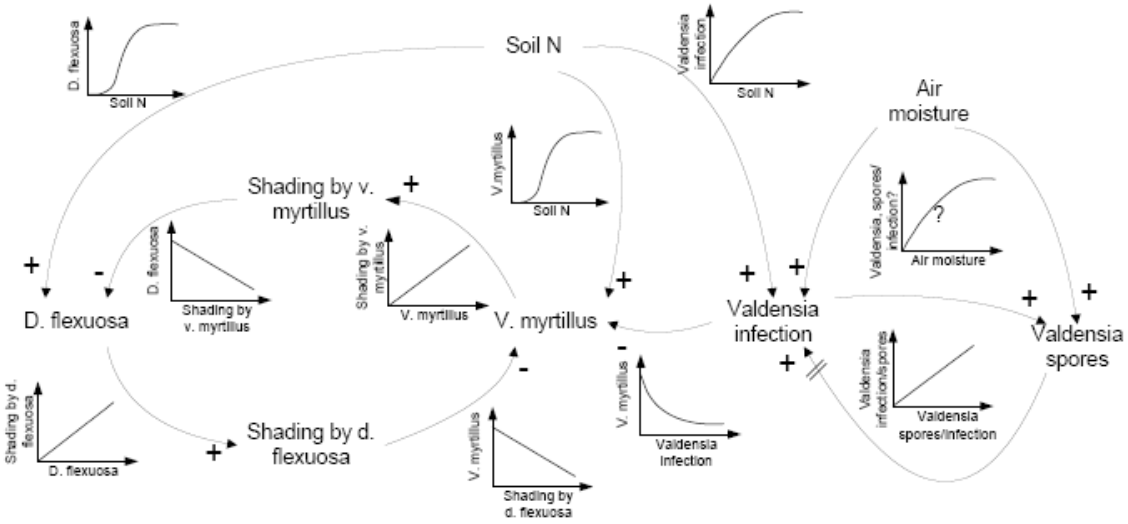

Figure 1: conceptual model for the biotic interaction behind a blueberry-deschampsia competition

Activites

- Collection of site-specific data (SLU)
- Model setup (BCC)
- Parametrisation (BCC & SLU)
- Testing (BCC & SLU)
- Writing report (BCC & SLU)

Deliverables

-Scientific paper: Belyazid, S., Strengbom, J., Akselsson, C., Nordin, A. A model of how biotic interactions drive vegetation change in nitrogen exposed boreal forest.

Budget:

Total budget: 380 000 SEK
BCC: 200 000 SEK
SLU: 180 000 SEK

Project 4 Integrating of vegetation effects in the GAINS model

Project leader
Maria Lindblad, IVL

Objective

Further development of GAINS Sweden online through extensive collaboration with other SCARP areas; Area 1- Health and Area 3 – Ecosystems.

Project leader and participants
Project leader: Maria Lindblad (IVL)
Participants: Stefan Åström (IVL), Håkan Blomgren (IVL), Gunnar Malm (IVL)
In collaboration with John Munthe (IVL), Cecilia Akselsson (LU), Filip Moldan (IVL), Annika Nordin (SLU Umeå), Salim Belyazid (BCC), Sofie Hellsten (IVL)

Activity description
In the SCARP-ecosystems research area, the FORSAFEveg model is being developed and adapted to illustrate the effects on vegetation (biodiversity) from deposition of air pollutants. During the phase II of the SCARP research programme, the SCARP-ecosystem research group is anticipated to deliver national estimates on vegetation effects of air pollution as well as Critical Loads related to vegetation.
These maps on Critical Loads related to vegetation would in task H be implemented in the GAINS model by using a methodology similar to the Critical Loads for acidification and eutrophication already existing in the model. The task H involve more GAINS modelling adaptation than task F since the new calculations on exceedance of CL are needed as well as new maps illustrating exceedance of CL.

Deliverables (time plan)
- D4.4.II: Swedish maps on Critical Loads of vegetation changes incorporated in the GAINS Sweden online model. (2012)

Budget: 500 kSEK.

Manuscript
Study of environmental impacts in Sweden from pan-European low nitrogen emission scenarios when using vegetation change as indicator of environmental performance (D4.4.II)

Additional Communication

The outlined communication activities in this proposal will not be able to fulfil within the limited budget allocated. This budget will only cover the administration of the web site, internal communication and other routine activities. Seminars, workshops and conferences need additional funding.

In the communication plan we have planned for two seminars directed towards national stakeholders in the program. One of the seminars will primarily be directed towards air pollution and health risks and include primarily results from area 1 and 2. The second seminar, which is supposed to take place the last year of the program is intended to be directed towards integrated assessments directed both towards cost-effective approaches and assessment of health and ecosystem risks.

Budget: 200 kSEK for each seminar, in total 400 kSEK.

Programme management

The programme is managed through a programme director (Peringe Grennfelt) and the team of programme area coordinators:
Programme area 1: Göran Pershagen
Programme area 2: HC Hansson

Programme area 3: John Munthe
Programme area 4: Jenny Arnell.

In addition, the program has a communication officer, who is responsible for SCARP's web page, internal communication and other outreach activities. The communication officer will be Sofie Hellsten.

The programme will still keep its management group consisting of the program director, the programme area coordinators and the communication officer. The management group will meet regularly through teleconferences (8-10 times a year). Representatives from Naturvårdsverket are always invited to take part in the management group meetings. In addition there is an annual meeting every year, to which all participants and key stakeholders are invited.

Each programme area has then its own organisation and scientists within these meet regularly.

Overall Budget for phase 2

Area	Project	Name	Project leader	2010	2011	2012	Tot Phase II
1		**Exposure and health effects**					
	1	Exposure to traffic related air pollution in early life, lung function and airway disease in 8-yearold children	Tom Bellander	210	210	216	636
	2	Short-term health effects in susceptible subgroups, using newly developed source specific local time series of air pollution	Tom Bellander	0	0	0	0
	3	Health effects of short-term and cumulative seasonal exposure to road dust & wood smoke particles ...	Bertil Forsberg	220	220	241	681
	4	Long-term exposure to traffic exhaust and incidence of obstructive airway disease in a prospective cohort – co-funding	Bertil Forsberg	76	76	75	227
	5	Is exposure to particulate air pollution associated with exhaled nitric oxide and blood markers of imflammation?	Anna-Carin Olin	245	285	287	817
	6	Is long term exposure to particulate air pollution associated with an increased risk for ischemic heart disease	Anna-Carin Olin	30	30	31	91
	7	Cohort study on total public health burden related to long term-exposure to air pollution	Göran Pershagen	390	390	400	1180
	8	Long term exposure to traffic related air pollution and genetic susceptibility in relation to myocardial infarction	Göran Pershagen	0	0	0	0
	9	DISOZPOLL; Diesel and ozone effects on the cardiovascular system	Thomas Sandström	296	306	306	908
	10	PMMECH – Mechanisms behind particulate matter air pollution induced toxicological effects	Thomas Sandström	0	0	0	0
	11	Woodpart-2. A human experimental study using wood smoke for studies of acute effects of particulate air pollution ...	Gerd Sällsten	272	272	273	817
	12	Health effects of long range transported particles: a population study using air mass trajectories.	Gerd Sällsten	30	30	31	91
		Synthesis		38	38	60	136
		Sum		**1807**	**1857**	**1920**	**5584**

2		**Regional and national atmospheric models for PM**					
	1	Chemical Modelling of Aerosol Formation	David Simpson	380	333	333	1046
	2	Developing dynamic particle description including formation, growth and deposition	Cecilia Bennet	333	333	380	1046
	3	Construct emission databases for dynamic particle models and validate urban models ...	Christer Johansson	380	380	380	1140
	4	Aerosol OA sampling and ^{14}C analysis Area 3 Ecosystem impacts of air pollution – nitrogen and acidification	Kristina Stenström	190	190	190	570
		Sum		**1283**	**1236**	**1283**	**3802**
3		**Ecosystem impacts of air pollution**	John Munthe	100	100	100	300
	1	Nitrogen cycling in forest ecosystem	Annika Nordin	125	125	125	375
	2	Dynamic nitrogen model development and evaluation					
	3	Future impacts of forestry, deposition and climate change	Filip Moldan	650	650	650	1950
	4	Synthesis	Cecilia Akselsson		300	730	1030
		Sum		**875**	**1175**	**1605**	**3655**
4		**Integrated assessment modelling**	Jenny Arnell	75	75	75	225
	1	Gains Sweden	Stefan Åström	650	475	375	1500
	2	Behavioural changes, transaction costs, adaptation and uncertainties	Mohammed Belhaj	275	200	195	670
	3	Integration with other SCARP research areas (health, ecosystems)	Maria Lindblad	150	200	250	600
		Sum		**1150**	**950**	**895**	**2995**
		Overall budget for scientific areas		**5115**	**5218**	**5703**	**16036**
5		**Programme co-ordination and support to policy**	Peringe Grennfelt				
	1	Program management	Peringe Grennfelt	190	140	140	470
	2	Program communication	Sofie Hellsten	143	95	95	333
	3	Program coordinated activities	Peringe Grennfelt	78	79	104	261
		Sum		**411**	**314**	**339**	**1064**
		Overall annual budget					**17100**

Budget - Additional Application

Area	Project	Name	Project leader	2010	2011	2012	Tot Phase II
1 & 2	**1**	Harmonisation of dose-response modelling regarding health effects of specific air pollution components		**330**	**330**	**340**	**1000**
3	**2**	Critical loads in Sweden – Integration with the IAM cluster	Sofie Hellsten	100	200	250	550
	3	Quantitative modelling of biotic interactions within plant communities in response to N deposition	Salim Belyazid	180	100	100	380
		Sum		**280**	**300**	**350**	**930**
4	**4**	Integrating of vegetation effects in the GAINS model	Maria Lindblad	**150**	**150**	**200**	**500**
5		Additional communication	Sofie Hellsten	**200**		**200**	**400**
		Sum (additional application)		**960**	**780**	**1090**	**2830**