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Evaluation of SLU´s environmental monitoring and assessment programme acidification

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1. Background

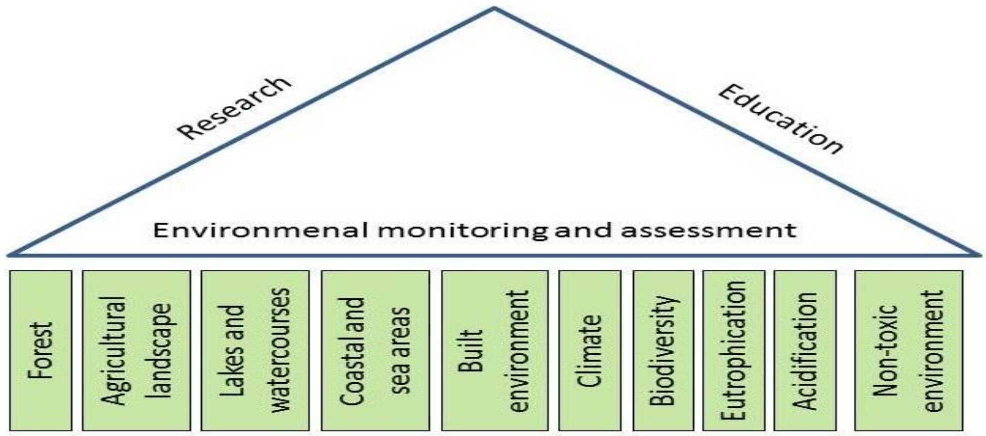
1.1. About the evaluation

As part of the quality development of the environmental monitoring and assessment (EMA) at SLU, the programme acidification was evaluated in autumn 2014 on behalf of the dean of the Faculty of Natural Resources and Agricultural Sciences. The evaluation group consisted of Brit Lisa Skjelkvåle, University of Oslo, Håkan Staaf, Swedish Environmental Protection Agency/Naturvårdsverket, Richard Johnson, vice-dean in charge of EMA, and Marnie Hancke, faculty officer. The assignment is described in attachment 5.1.

The evaluation group supports that contents of the entire report, with Brit Lisa Skjelkvåle focusing on the scientific content and quality of the EMA programme, Håkan Staaf focusing on stakeholders' perspectives and interests, and Richard Johnson and Marnie Hancke focusing on the internal organisation of EMA and collaboration with other EMA programmes coordinated by faculty.

1.2. About SLU's environmental monitoring and assessment

In addition to research and education the Government has charged SLU with the task of conducting environmental monitoring and assessment (EMA). SLU monitors the country's forests, agricultural landscapes, lakes, watercourses and species in order to analyse environmental trends. Consequently, the university is a key player in interpreting and understanding changes in terrestrial and aquatic ecosystems related to land use and a warmer climate. SLU has chosen to organise its environmental monitoring and assessment into 10 programmes, each of which relates to specific Swedish environmental objectives (se figure 1).



Figur 1. A schematic sketch of SLU's organisation combining research, education and environmental monitoring and assessment and the programmes within EMA.

It is SLU's ambition to gather all projects dealing with environmental monitoring and assessment in the relevant programme mentioned above, irrespective of financing. Each programme is organised by a coordinator, while the programmes forest, agricultural landscape, lakes and watercourses, coastal and sea areas, eutrophication and non-toxic environment also have an assistant coordinator due to their size and scope. Each of the programmes has a specific set of objectives.

1.3. About the programme Acidification

The programme is intended to provide a platform for efforts to achieve the national environmental objective 'Natural acidification only' and to assist national commitments under the UNECE/CLRTAP pollution convention.

Compared to the other EMA programmes coordinated by the Faculty of Natural Resources and Agricultural Sciences the Acidification programme is relatively small; total annual economic turnover of the programme ranged from 12 000 to 14 000 tkr during 2009 and 2013. University funding comprises only 6-20 % of the total economic turnover, with the majority of funding from external sources. Annual uncertainties concerning funding (both from the university and external sources) has led to focus on maintaining an active network of SLU researchers engaged in the programme as well as keeping seven core projects prioritised by stakeholders in 2010-2011 running.

2. Conducting the evaluation

The evaluation group has followed the guidelines given in the document ‘Utvärderingsdirektivet’ (attachment 5.1). The self-evaluation (attachment 5.2) authored by the programme’s coordinator and project leaders within the programme forms the basis for the evaluation report.

The evaluation has been conducted by interviewing persons who have an important role within the programme, such as the programme coordinator (Prof Kevin Bishop), or have key positions at SLU. In addition, persons at collaborating authorities such as the Swedish Environmental Protection Agency, Swedish Forest Agency, and the Swedish Agency for Marine and Water Management have been contacted and interviewed concerning their opinion regarding how the programme fulfils the authority’s needs for decision support. Attachment 5.3 gives an overview of the persons interviewed as well as the questions.

As no changes in the flow of information to higher organizational levels have occurred since the evaluation of the programme Eutrophication in 2013, the evaluation group decided not to re-interview key persons at EMA (Prof Göran Ståhl, pro-vice chancellor for EMA), the faculty (Prof Barbara Ekbom, dean of Faculty Natural Resources and Agricultural Sciences) or department level (Prof Willem Goedkoop, head of department environmental monitoring and assessment) All three were informed of this decision and were given the opportunity to send complementary information/comments to Marnie Hancke and Richard Johnson. Richard Johnson (vice dean with focus on EMA) was not interviewed because he was part of the evaluation group. Attachment 5.4 lists the grades and assessment criteria that have been used.

3. Results of the evaluation

3.1 Boundaries, structure and programme implementations

The EMA Acidification programme has a relatively simple structure; one coordinator, project leaders and a reference group. Several other researchers, both within and outside SLU, contribute to the programme by participating in projects and co-authoring articles and reports. Project leaders also serve as contact points for their respective sub-areas and can be contacted via the programme website.

The Acidification programme has chosen to work with the two main issues: acidification of forests and forest land and acidification of lakes and watercourses. Most of the data used by the programme is collected within the two SLU programmes forest and lakes and watercourses. Despite the obvious proximity to these programmes, the Acidification programme manages to maintain its independency in questions regarding soil and surface water acidity. The question was raised if greater synergies could be achieved by incorporating the relatively small

Acidification programme within a larger EMA programme or if the advantages of maintaining the existing classification of programmes by national objectives outweigh an eventual merger of programmes.

The programme structure with seven projects is well anchored in stakeholders' interests. SLU funding for EMA acidification has mainly been used to maintain an active network of researchers engaged in the programme, bringing together expertise from different parts of SLU as well as with other centres of acidification expertise. The scientific approach to environmental monitoring and assessment is judged to be strong within the programme, whereas collaboration or exchange with other EMA programmes is poorly developed. Therefore, we recommend an increased collaboration with other EMA programmes.

3.2 Quality of reports and scientific publications

The main deliverables from this programme are:

- Publications (international publications with review)
- Reports
- Education (teaching classes, supervision of MSc and PhD students)
- Quality assurance
- Seminars

Publications: The programme listed 95 peer-reviewed publications for the 6 year period 2009-2014, with publications evenly distributed among years. Many of the publications have different first authors and numerous co-authors, indicating a scientific depth within the research group. The papers are published in journals with an impact factor generally in the range 2-4, which indicates that the results from the programme are disseminated in internationally recognized journals. The topics of the publications seem to span all parts of the programme. Rating for this part of the programme is 5 out of 5.

Reports: The 44 reports from the programme comprise a combination of mandatory reporting from monitoring and ongoing projects, popular science and conference proceedings. Few of the reports present new scientific results, but are more in the category of reporting and popular science. However, the content and diversity of reporting indicates that the results from the programme are directly useful for stakeholders in several areas. Rating for this part of the programme is 4 out of 5.

Education: Topics of the seven PhD-theses (one finalized and six ongoing) connected to the programme cover a wide range of problems related to acidification of soil and water; weathering, reference conditions, increased biomass harvesting, processes in catchments, browning of waters etc. PhD and MSc students contribute to a dynamic research environment, potentially driving research towards new problems and questions, as well as identifying novel opportunities for using data. Teaching is an important activity for the dissemination of knowledge from programme's activities. Rating for this part of the programme is 5 out of 5.

Quality assurance: The Acidification programme, unlike the other programmes under EMA, has no responsibility for databases, however the programme uses data from databases held by the other programmes. Use of existing data is an important form of quality assurance programmes.

Seminars: Throughout the project period there have been two seminars in 2011 and 2013, with the next seminar planned for 2015. These seminars are designed for stimulating dialog between researchers and stakeholders (see chapter 3.3).

3.3 Collaboration with external parts

The programme cooperates with a number of external partners including regional and national authorities and research groups. Historically, contacts haves been frequent with the Swedish Environmental Protection Agency (SEPA), which is the agency responsible for regular assessments of the environmental objective Natural Acidification Only (Bara Naturlig Försurning). SEPA is also responsible for reporting to the CLRTAP. The Swedish Forest Agency (SFA) is another major stakeholder, responsible for issues on forest management, including measures to counteract acidification. A third important stakeholder is the Swedish Agency for Marine and Water Management (HaV) which in 2011 took over responsibilities for administrating the national surface water monitoring and the programme for liming of lakes and rivers (SEPA was previously responsible for this monitoring programme). Other stakeholders include forestry companies and water management authorities.

A reference group is established to identify important research needs and propose new EMA projects. The three main agencies listed above are represented in this advisory group. A workshop was held in November 2011, constituting good opportunities for invited stakeholders to prioritize among proposed EMA projects. The selected projects have since then produced useful results for policy formulation and input to the presently ongoing evaluation of the environmental objectives to be presented in 2015.

After 2011, contacts with stakeholders have been sparser and less regular. Annual follow-up meetings with the reference group have not been organized since 2011; an unfortunate development according to many stakeholders. Stakeholders would prefer more regular feed-back from the programme concerning progress with EMA projects and also on the programme as a whole. However, regular contacts have been have taken place within other fora such as the CLEO programme, FORMAS programmes ForWater, QWARTS and Mistra Future Forest.

The general impression concerning cooperative activities between the programme and its stakeholders is that over a long time it was much appreciated by external contacts. Cooperation has been interactive, with stakeholders influencing the direction of EMA research, which was highly looked upon. During the last few years, however, as specific meetings with stakeholders have not taken place, contacts have mainly occurred within research programmes. A reason for this might be that funding of EMA projects has been uncertain and declined in the last 3-4 years. Furthermore, decisions on funding for more than one year were not possible due to uncertainties in external funding, complicating the planning of stakeholder meetings and research activities. As for cooperation with research groups outside SLU it is obvious that it has been intense and very fruitful, clearly evidenced by the impressive list of publications.

In conclusion, we give the following scores for cooperation with external parts:

- for cooperation with stakeholder: first programme part 5 (up to 2011), later 2
- for cooperation with external research groups: score 5
- overall score: 4.

3.4 Internal organisation and collaboration

The EMA programme acidification is one of six environmental assessment and monitoring programmes located at the faculty of Natural Resources and Agricultural Sciences. The programme’s co-ordinator (Prof Kevin Bishop) is situated at the Department of Aquatic Sciences and Assessment.

The exchange of information between the faculty and programme coordinators is mainly through the EMA board meetings (FOMAN) where programme coordinators have the opportunity to participate. As a forum for information and dialogue these meetings are highly appreciated. Communication to higher levels within SLU occurs via the chair of the EMA board, representing the NJ-faculty in the SLU EMA council. Moreover, the EMA council plays a vital role in linking the different faculties, programme coordinators and faculty officers.

In the evaluation of the programme Eutrophication in autumn 2013 a number of key persons working in EMA were interviewed. The interviews showed that these persons were considered to have sufficient information of the programme and its activities. As part of the evaluation of the Acidification programme, these persons were given the opportunity to complement their evaluations concerning programme structure, funding and related costs. Comments were raised concerning transparency in how funding is distributed among EMA programmes. This critique has resulted in the organisation of an internal reference group by the EMA council. Each faculty has nominated persons for the internal reference group (November 2014), and biannual meetings are currently planned by the EMA council.

All persons interviewed commented that the Acidification programme is a very research oriented EMA programme. The strategy has been on financing a number of relatively small EMA projects which are integrated in larger projects, thereby filling knowledge gaps not covered by the research projects. This strategy has resulted in continuity, at the cost of reconsidering priorities among projects and poor collaboration with other EMA programmes. Uncertainties concerning funding during the last 3-4 years have likely contributed to what is experienced by other programme coordinators as decreased activity within the programme. It has been suggested that the programme focuses more on the EU Water Framework Directive issues, critical loads, assessment criteria (bedömningsgrunder) and status classification (statusklassningar). The programme’s focus on processes in soils and water was considered to be too spatially limited, resulting in the recommendation that attempts should be made at upscaling to the national scale.

Despite poor collaboration with other EMA programmes, coordinators were satisfied with the amount and flow of information; both among programmes and within SLU’s organisation. The grades for the programme concerning information exchange ranged between 3 and 5, with a mean of 4.25 (1 = not satisfied with the information exchange; 5 = fully satisfied).

3.5 Objectives

SLU has developed a detailed goal structure for all its activities as well as for EMA. In this evaluation we only discuss the general goals for EMA and the specific goals of the programme acidification.

The general goals are:

1) There will be a strong connection between EMA and other missions of SLU;
2) EMA will be a European leader and contribute to international progress in scientifically based assessments;
3) Delivery of decision support that allows the exploitation of resources to be weighed against the environmental consequences of that exploitation.

The EMA council has developed a number of sub-goals with proposed indicators for each general goal to be used evaluations. Most of these sub-goals are expressed as directions rather than absolute targets. Although several of the indicators are difficult to quantify without detailed information on the use of time and resources within the programme, we have concluded that the Acidification programme significantly contributes to the three above-mentioned general goals.

As for Goal 1, it is evident that the EMA Acidification programme has been a strong partner in several large research programmes like CLEO and FORWATER and has also been the basis for a FORMAS Strong Research Environment. Furthermore, the number of peer-reviewed scientific publications is very high, and in total seven PhD-candidates have been working with programme projects. The self-evaluation also describes good participation in teaching at both undergraduate and advanced levels. Considering the low basic SLU funding (1-2 million SEK+ coordination) per year the outcome of the programme has been resource effective and the exchange impressive. The low level of cooperation with other EMA programmes is a negative factor, though.

We also consider that the programme significantly contributes to Goal 2, based on the large number of published scientific papers and the contents of the articles.

Goal 3 is complex and difficult to evaluate, but the EMA Acidification research projects were prioritized by stakeholders and thus considered to be important for policy development in relation to national or international processes concerning effects of air pollution and mitigation efforts. Several studies in EMA and associated research programmes have dealt with acidification effects of forestry, including cost-benefit of different strategies of forest liming and ash return. Other projects have dealt with improving liming strategies of rivers and lakes and developing guidelines for effective water management in forestry on a landscape scale. Thus, we conclude that the programme also contributes to fulfilment of this goal.

The programme has a list of nine *project-specific goals*. Many of them can be considered more as action plans or activities than actual goals, while some of them are too ambitious considering the low basic SLU-funding and the 5-year time frame. The Acidification programme is organized in seven projects, each of which has a specific focus. Each of these projects addresses the major goals of the programme in different ways. It is not clearly evident from the self-evaluation in which way or to what level each of the goals are achieved. However, all the goals are addressed in one or more of the seven projects.

We recommend that the comprehensive list of goals should be revised by a division of the overall strategic objectives and quantitative and measurable targets. This would make the programme objectives and priorities clearer and easier to monitor and evaluate.

3.6 Ideas for development

A major question for this programme is “Is acidification a solved problem?” and “Is there any need for future focus on this problem?” The programme has particularly focused on questions related to the present status of the acidification situation in Sweden, forestry, climate change, the questions about reference conditions (and goals), remediation, in particular liming, the possible conflict between reduced acidification form long-range transport and more intensive forestry. Two workshops organized by the programme, and the third planned for 2015 is dedicated to questions “What is the state of the art?” and “What is the way forward?”

The interviews with the coordinator, the project participants and the stakeholders have given the evaluation team an impression that there is a strong awareness about possible future questions as well as concern that some issues may lose attention by the society and thereby funding.

There is a broad agreement among stakeholders on issues related to the future development of forestry in Sweden and its environmental consequences. Most future scenarios suggest an increased forest production and a higher use of forest biomass for energy as a means of reducing greenhouse gas emissions. A crucial issue will be to what extent such a development will counteract the recovery of acidification of soil and waters and if the present mitigation methods are sufficient. Several scientists claim, for example, that ash return is an inefficient way of safeguarding recovery in rivers and lakes.

Another issue for future research is if the acidifying effect of nitrogen will increase, and if so when and where it will occur. At present, nitrogen leaching from forest soils only exceeds the uptake in trees and soil over relatively small areas in south-western Sweden. Some other important questions mentioned by the stakeholders and project members are:

- past and future development of acidity in forest soils,
- brownification of waters and drinking water quality,
- weathering rates and weathering processes,
- assessment of acidity in streams on a landscape scale,
- influence of climate change on DOC and DON,
- importance if mobile anions for transport of acidity to waters

4. Conclusions and recommendations

The evaluation group draws the following main conclusions on the outcome of EMA Acidification programme during the last five years:

During the period 2009-2013 the programme has focused on building a national network on acidification-related issues and taken part in several large research programmes. This approach has been very fruitful in terms of scientific output; despite low basic funding from SLU. On the other hand, the chosen approach has resulted in an almost non-existent collaboration or exchange with other EMA programmes and limited cooperation with stakeholders.

The scientific quality of the published papers from the programme must be regarded as high and definitely in line with the international scientific front for these topics. The papers reflect large cooperation within the group and also a large cooperation with other national and international scientific groups.

Historically the programme has been much appreciated by the main stakeholders. Cooperation has been interactive and in regular meetings stakeholders were invited to present their research needs and prioritize among project proposals. Thus, the stakeholders had a major influence on the selection of the seven basic projects during the present programme period. After 2011, however, specific meetings with stakeholders have not taken place and they regret this lack of feed-back during the last years.

A major strength with the Acidification programme is the strong interaction between environmental monitoring, research and education. The programme actively uses monitoring data in large research projects on national and international level, and is highly involved in dissemination (publication) of their findings and education.

Some of the successes of the programme is due to strong scientific leadership, with clear scientific goals, a large national and international network and cooperation and participation in large national and international projects. There is, however, a lack of formal communication structures, both internally and externally.

The programme seems to contribute to fulfilling the three general goals, but with reservation for the low cooperation with other EMA programmes. The progress towards the programme-specific goals is difficult to evaluate from the self-evaluation but all goals are addressed in one or more of the seven basic projects.

We make the following recommendations:

- We strongly recommend that the Acidification programme should be continued as a separate programme as it is today, and not be merged with any of the other EMA programmes. This is important for a future focus on the problems of long-range transported air-pollution and acidification.
- We recommend SLU to make all possible efforts to secure timely funding of EMA programmes, preferably over several years.

We also recommend the programme to:

- Revise the comprehensive list of goals by a division of the overall strategic objectives and quantitative and quantitative targets. This would make the programme objectives clearer and easier to monitor and evaluate.
- Increase the collaboration with other EMA programmes.

- Re-establish the reference group by a broader representation of stakeholders and annual meetings to exchange information on research needs and progress of established projects.
- Increase the internal communication in the programme with regular internal meetings, at least 1-2 times per year with all personnel involved in the project, including students.
- Continue teaching and supervising MSc and PhD students.

5. Attachments

5.1 Assignment

(Parts of the instructions for the evaluation which are relevant for the evaluation group have been lift in).

Syftet med utvärderingen av SLU:s miljöanalysprogram är att få underlag för beslut om strategisk programutveckling, allokering av statanslag och justering av programvisa mål.

Utgångspunkter för utvärderingen

– Den görs med utgångspunkt såväl från LSU:s allmänna mål för den fortlöpande miljöanalysen, som de programvisa mål som finns för varje miljöanalysprogram.
– Den beaktar hur programmet bidrar till arbetet med de nationella miljökvalitetsmålen, Sveriges internationella åtaganden enligt konventioner och EU-lagstiftning, samt sektorernas behov av beslutsunderlag för hållbart nyttjande av naturresurser.
– Den omfattar aspekter på arbetets kvalitet, nytta för avnämare, samt interna organisatoriska frågor.
– Den omfattar hela miljöanalysprogram, det vill säga såväl de delar som har statsanslag som de som finansieras med externa medel. Särskild vikt ska dock läggas vid de statsanslagsfinansierade delarna av programmet.
– Den beaktar lämplig rollfördelning mellan olika nationella utförare med utgångspunkt från inom vilka områden SLU:s forskning och miljöanalys har en stark kompetensbas.
– Den leder fram till betygssättning a programmets prestation, förslag om utvecklings- och nedprioriteringsområden, förslag om justerade programvisa mål, samt eventuella förslag om förändringar för att förbättra programmets effektivitet (inom de ramar som ges av SLU:s övergripande organisation av den fortlöpande miljöanalysen).
– Den ger underlag för bedömning av hur stora statsanslag som bör fördelas till programmet.

Redovisning av utvärderingen

– En kortfattad beskrivning av hur man genomfört utvärderingen.
– En betygssättning av programmet med tillhörande kortfattade beskrivande texter – för vart och ett av momenten:
  – programmets genomförande, kvalitetsarbete och leveranser i relation till SLU:s allmänna mål och de programpecifika målen,
  – samverkan med uppdragsgivare, avnämare av resultat, andra utförare, och internt inom SLU (bland annat samspelet miljöanalys – forskning respektive utbildning, samt
  – strategi och utvecklingsplaner
– Utvärderingsgruppens syn på programmets styrkor, svaghet och nisch i förhållande till

andra utförare, nationellt och internationellt.
- Förslag om på vilket vis man anser att programmet behöver utvecklas.

5.2 List of analysed documents

1. Self-evaluation of the programme acidification (Kevin Bishop et al. 2014)

2. Programme specific objectives for environmental monitoring and assessment programmes at the faculty of agricultural resources.

https://internt.slu.se/Documents/internwebben/foma/faststt%c3%a4lldaFomaDokument/programvisaM%c3%a5l_NL-fak_2011-02-01.pdf

3. Objectives for SLU's environmental monitoring and assessment

https://internt.slu.se/Documents/internwebben/foma/faststt%c3%a4lldaFomaDokument/m%c3%a5lstrukturFoma101105.pdf

5.3 Interviewed or consulted people and questions used in the interviews

Interviews with stakeholders:

Interviewed persons: Ulla Bertills (Naturvårdsverket), Per Olsson (Havs- och Vattenmyndigheten), Stefan Andersson (Skogsstyrelsen).

Interview questions:

- Beskriv din ”karta” över försurningsområdet: ditt nätverk och dina viktigaste kontakter. Hur stort är försurningsprogrammets utrymme i förhållande till de övriga aktörernas utrymme?
- Beskriv på vilket sätt du har nytta av SLU:s försurningsprogram i ditt arbete? Eventuellt utvidgning mot hur myndigheten/organisationen har nytta av programmet.
- Betygsätt de delar som nyttjas i din organisation på en skala 1-5 där 1 = inte viktigt alls, 5 = mycket viktigt.
- Motsvarar programmets inriktning dina behov av data/underlag/resultat/stöd?
- Tror du att försurningsprogrammet bidrar till att nå det nationella miljökvalitetsmålet Bara naturlig försurning ja/nej/vet inte. Om nej, vad saknas?
- Finns det andra utförare som erbjuder samma utbud/tjänster till högre kvalitet? / Hur är kvaliteten på SLU:s tjänster jämfört med andra utförare av liknande tjänster.
- Ur din verksamhets perspektiv, vad är styrkorna med programmet
- Ur din verksamhets perspektiv, vad är svagheterna med programmet?
- Har du nytta av att programmet har nära kontakt med forskningen?
- Ur din verksamhets perspektiv, vilket utvecklingsbehov ser du för programmet Försurning i framtiden? Saknar ni något i programmets utbud/tjänster?
- Hur nöjd är du med (på en skala 1-5 där 1 = inte nöjd alls, 5 = mycket nöjd)
    - Dataleverans överlag
    - Data levereras i tid
    - Data uppfyller ditt behov av kvalitet
    - Kontakter med personer inom försurningsprogrammet

Interviews with project leaders within the programme

Interviewed persons: Kevin Bishop, Jens Fölster, Annemieke Gärdenäs, Johan Stendahl, Stefan Löfgren, Hjalmar Laudon, Anneli Ågren, Stephan Köhler.

Interview questions:

- Vilken roll har du haft i programmet?
- Vilken betydelse har programmet haft?
- Har programmet varit organiserat bra?
- Hur kommer externa uppdrag in (genom programmet eller direkt kontakt med enskilda forskare)?
- Vilka ändringar bör göras i programmet?
- Vilka framtidsfrågor är relevant för programmet?

Interviews with EMA programme coordinators

Interviewed persons: Jens Fölster (eutrophication), Anna-Lena Axelsson (forest), Jenny Kreuger (non-toxic environment), Stina Drakare (lakes and watercourses).

Interview questions:

- Vad känner du till om programmet försurning?
- Har programmet varit organiserat bra med tanke på att programmets inriktning ska bidra till att nå det svenska miljökvalitetsmålet ’Bara naturlig försurning’?
- Behöver inriktningen ändras eller anpassas?
- Programmet har i samarbete med de viktigaste avnämarna bestämt att att programmets fokus ska ligga på två huvudområden: a) acidification of forests and forest land, b) Acidification of lakes and watercourses. Vad tycker du om det?
- Programmet beskriver i sin självvärdering att genom val av projekt involvera forskare och miljöanalytiker vid institutionerna för vatten och miljö, mark och miljö, skoglig ekologi och skötsel. Hur tycker du att programmet lyckats med det?
- Skulle du kunna beskriva hur kopplingarna ser ut från ditt håll (som koordinator för programmet x)? Skulle det kunna finnas fler kopplingar som ökar det interna samarbetet?
- Beskriv nyttan för ditt programme med kopplingen till försurningsprogrammet.
- Hur får du information om programmet? Informationsflöden som rör programmet – beskriv dessa utifrån ditt perspektiv (din roll). Betygsätt på en skala 1-5, där 5 är mycket nöjd och 1 inte alls nöjd.
- Vad behövs för att höja betyget om ett steg?
- Finns det något negativt med programmet?
- Vilka framtidsfrågor är relevant för programmet?
- Något vi borde frågat om, som du tycker att vi missat?

5.4 Assessment criteria

In the evaluation the following grades and assessment criteria have been used.

Grade	Criteria		
	scientific	Collaboration/ strategy and development	fullfillment
5	Internationellt hög	Utmärkt	Mycket nöjd
4	Internationellt erkänd	Mycket bra	-
3	Måttlig	Bra	-
2	Otillräcklig/bristande	Otillräcklig/bristande	-
1	Dålig	Dålig	Inte alls nöjd

SLU's Environmental Monitoring and Assessment Program for Acidification: Self Evaluation

Introduction

SLU evaluates its Environmental Monitoring and Assessment (EMA) programs every five years. This evaluation covers the period from the last evaluation in 2009 until the spring of 2014. The self-evaluation has been prepared by Kevin Bishop (program coordinator) in cooperation with project leaders in the acidification program, Jens Fölster, Jon-Petter Gustafsson, Annemieke Gärdenäs, Stephan Köhler, Hjalmar Laudon, Stefan Löfgren, Bengt Olsson, Johan Stendahl, Anneli Ågren and Ingrid Öborn.

Program Overview

This programme promotes SLU's efforts to contribute to Sweden's progress towards the environmental objective "Natural Acidification Only". Acidification has seriously impacted Sweden's soils and waters. But it is also one of the best examples of how science can contribute to not only identifying an environmental problem, but also solving that problem. Scandinavia and SLU can look with satisfaction upon the international cooperation to reduce acid emissions. Atmospheric deposition levels of sulphate in Sweden have returned to levels not seen for almost a century, and the trends of reduced acidification in surface waters and soils are also being tracked in long-term monitoring programs run by SLU.

As a result of the international cooperation to reduce acid emissions, and the subsequent improvements in the environment, both national and international research priorities have shifted away from acidification. That, however, does not mean that the need for new analyses to support decision makers has disappeared.

- Increased use of forest biofuels increases the acidification pressure on soils and waters where there are already indications that even conventional forestry may not be sustainable from the standpoint of acidification. Defining the sustainability of forestry with respect to acidification requires improved quantification of weathering rates and increased spatial resolution in the identification of the landscape's sensitivity to acidification pressures.
- Liming to combat acidification remains one of Sweden's major environmental expenditures, at ca 200 million crowns per year. Adapting that liming program as surface water's recover from acidification is a complex challenge.
- Much of the surface water acidification in running waters is found in the myriad of smaller (< $15 km^2$) catchments. Such headwaters comprise 90% of the length of all running waters, and systematic documentation of acidification in all of these waters, as mandated by the Water Framework Directive, has been difficult. Efficient and reliable methods are needed to identify acidification sensitive headwaters in order to guide remediation efforts, as well as the practice of intensive forestry to avoid exacerbating the acidification of the more sensitive headwaters.
- While nitrogen has not yet been a major factor in Swedish acidification, atmospheric deposition of nitrogen has not decreased to the extent that sulphur deposition has. Forest fertilization is also likely to help meet increased demands for forest biomass, and there is general agreement in the research community that the understanding of nitrogen's long-term fate in the face of increased accumulation, not to mention climate change, is inadequate. Therefore increased nitrate concentrations in surface waters remain a possible source of acidification that remains to be defined.
- Decadal trends of increasing dissolved organic carbon, a major source of acidity in surface waters, raise questions both about what the natural reference levels of acidity are, and how climate change will influence acidification.

Due to this ongoing need for acidification-related decision support in the face of limited resources for new research, SLU's EMA Acidification program has endeavored to provide timely, high-quality analyses to decision makers and the international reporting of critical loads that are firmly grounded in both good science and the extensive observations of both the natural environment and long-term field experiments. The intention is to bringing expertise and data to bear on society's urgent questions concerning acidification. In many cases these have been provided directly to the major stakeholders, the Swedish Environmental Protection Agency (SEPA), the Swedish Forest Agency (SFA) and, since its creation in 2011, the Swedish Agency for Marine and Water Management (SWAM). But the analyses are also subjected to peer review for publication in the international literature, and support is provided to those responsible for the international reporting of both soil and surface water critical loads.

The EMA Acidification Program focuses on two main issues that were arrived at after consultation with the major stakeholders. These issues are addressed by projects, which the stakeholders decided upon from a larger field solicited from researchers at SLU.

1. **Acidification of forests and forest land**. The data in the Swedish Forest Soil Inventory is a key resource for acidification assessment, but these data are complex. While administered by the EMA Forests Program, EMA Acidification is co-financing quality control and evaluation of the data in order to provide more reliable assessments. Since the acidifying impact of forestry is becoming more significant as acidic deposition declines, forecasts are needed showing how forest management strategies will affect soils and waters. The interest in forest biomass fuels has led to plans for sharp increases in growth and abstraction, which may exacerbate soil acidification. One key issue is therefore whether the threat posed by acidification should set limits for the quantity of biomass fuel that can be abstracted from forests.
2. **Acidification of lakes and watercourses**. While the acidification pressure from atmospheric deposition is decreasing towards the critical loads, there is a need for greater reliability in the assessments, including the determination of the reference conditions against which acidification is measured. These assessments are needed to guide decisions about where to reduce liming activities, how to comply with the requirements of the Water Framework Directive, and identification of influences from forest harvest as well as the changing levels of organic carbon. Nitrogen deposition may become the next major source of acidification. The effect of forest soil amendments (liming and ash return) on surface waters must also be evaluated.

In working with these issues, the EMA Acidification Program seeks to engage researchers and environmental analysts at SLU. In some cases, this has meant seeking to bring researchers back into the field of acidification related research. This has been the case with regards to both weathering and nitrogen acidification in the forest landscape. The departments with the greatest involvement in EMA Acidification are Aquatic Sciences and Assessment, Soils and Environment, and Forest Ecology and Management.

The seven projects that are currently supported by the program have their origins in a major effort to recruit SLU researchers to address acidification issues identified by the stakeholders in 2010-2011. As there has been uncertainty from year to year about the funding available from FOMA, and a generally lower level of direct EMA Acidification support since 2011, the strategy within the program has been to maintain an active network of SLU researchers engaged in the program with its explicit mission to provide decision support, and also engage them in a work with other centers of acidification expertise (e.g. the Swedish Environmental Research Institute (IVL) and Lund University). This has helped the network of EMA Acidification researchers to leverage their EMA support to work directly with the stakeholders in specialized projects, but also in being attractive partners for other research efforts. This has succeeded in affiliating EMA Acidification researchers with major research programs with an acidification component such as the IVL led consortium "Climate Change impacts on Environmental Objectives related to long-range transport of air pollutants" (CLEO), the MISTRA Future Forests Program and the FORMAS Strong Research Environments on Forest Waters (FORWATER) and Integrating Microorganisms in predictive models of soil carbon sequestrations (IMPRESS). The greatest successes were in several projects from

EMA Acidification creating the basis for both the 24 Mkr FORMAS Strong Research Environment Quantifying WeAthering RaTes for Sustainable Forestry (QWARTS) and SLU's inclusion in CLEO, both of which have made it possible to pursue these issue far more thoroughly, and in collaboration with researchers at Lund and Stockholm Universities, as well as SMHI and IVL.

SLU's Niche

SLU has collected and hosted most of the relevant environmental data concerning soils and surface water acidity. These data are publicly available via the internet, including a custom database of decades of water quality data, along with associated climate and soils data that was assembled by the CLEO program (www.slu.se\CLEO\Data). SLU researchers have also taken a lead in analyzing, reporting and publishing these data. In the case of the soil data, this is particularly complex material that requires considerable expertise to work with, and SLU provides that support (in part with funding from EMA Acidification). SLU is also home to many of the researchers with a high degree of process understanding with regards to acidification. This has been used to make assessments, but also to develop the criteria and methods for assessment. A particular strength has been harmonizing biological and chemical indicators of acidification in the national environmental quality criteria. SLU also leads the ongoing research program (IKEU) to follow up the effects of liming.

Despite these many niches though, SLU does not have a monopoly on acidification decision support. Lund University and the Swedish Environmental Research Institute IVL both have leading roles in developing and applying the models that are used to calculate the critical loads of acid deposition for both forest soils and surface water acidification.

With the renewed focus on improving the accuracy of acidification models to better define the sustainability of increased forest biomass extraction as well as the downscaling of liming, there is an urgent need to bring the data and expertise at SLU together with the model developers at Lund and IVL. The EMA Acidification program has consciously sought to provide SLU researchers with opportunities to work with their modeling colleagues outside SLU to improve inter-institutional coordination. Such cooperation will best serve the national interest with regards to understanding the extent of acidification and the measures needed to reduce that acidification, whether it be through further emission controls, refinement of the liming program, or directing intensified forestry to reduce impacts on sensitive sites.

Economic Summary

The total annual economic turnover of the program ranged from 12,000 to 14,000 tkr (Table 1). The size of the EMA project funding started at around 2,300 tkr, but has fluctuated around 1,200 tkr since 2011. The overall magnitude of external funding has increased somewhat (even though the single largest external project, Integrated Liming Effects (IKEU), has decreased). Thus the total turnover has remained relatively stable during the half-decade reporting period.

Table 1. Funding (tkr) 2009-2014 for the SLU EMA Acidification Program

Year	2009	2010	2011	2012	2013	2014 prognosis
Coordination	200	200	210	210	215	215
EMA Projects	2 400	2 200	1 400	900	1 100	1 230
IKEU	5 900	5 872	4 160	3 700	3 500	3 000
SLU Projects	1 400	400	900	900	900	900
External Projects	2 170	5 069	7 289	8 658	6 519	6 249
Total	**12 070**	**13 741**	**13 959**	**14 368**	**12 234**	**11 594**

Most Important Results and Stakeholders

The most important stakeholders so far have been the Swedish Environmental Protection Agency (SwEPA), the Swedish Forest Agency (SFA), and, since its creation in 2011, the Swedish Agency for Marine and Water Management (SWAM). These agencies have taken an active role in defining priorities for the EMA Acidification program, evaluating project proposals, and making use of the results provided by the program.

The 139 publications (Appendix) bear witness to the success of the EMA Acidification Program in using SLUs expertise and data to provide knowledge that is used and communicated. Key results are summarized below from each of the currently ongoing projects that the program supports

1. Försurningsbedömning i vattendrag på landskapsnivå

Quantifying Assessment Uncertainty in Limed Waters: Estimating what the acidification status of a limed lake or watercourse would be if liming were stopped is one of the major challenges facing the work to revise the liming program as reduced deposition of sulfur leads to recovery. The uncertainty in the Ca/Mg ratio method used to estimate unlimed water chemistry has been combined with the uncertainty in the assessment of acidification status to arrive at the overall reliability of acidification assessment of limed waters

Extensive Assessment of Running Waters: The assessment of acidification in running waters has been hampered by the lack of spatially representative data. This problem was solved for lakes through national surveys with thousands of samples in space that could then be related to more frequent samples in a subset of lakes. This approach has now been extended to running waters. Starting in 2010, 1500 limed water courses and a similar number of unlimed references have been sampled. The large temporal variability in the chemistry of running waters presents special challenges. Using time series data from national and regional monitoring, a method was developed to estimate a volume weighted mean stream chemistry from high flow samples and three samples at fixed times. This was then developed into a national assessment of running waters using national liming data, GIS resources and SMHI's S-HYPE model.

Downstream Chemistry Support GIS to Predict Headwaters Status: Further efforts to better determine the status of the status of running waters have involved developing statistical techniques to make use of the more frequent monitoring of downstream water chemistry data in conjunction with synoptic surveys of upstream headwaters. The methodology for getting statistically representative samples from headwater in a landscape has been developed and is now being tested in the counties of Västra Götaland and Dalarna.

2. Fördjupad analys av försurningsdata för skogsmarken baserat på Markinventeringen

Trends in Soil Acidity: 25 years of soil inventory data has been quality controlled and evaluated. It indicates a slowly declining soil acidification, although during the last decade the trend has shifted towards slightly increased acidification, which has led to further questions about the cause of this trend that does not follow the decline in acid deposition.

Deeper Soils – Better Acidification Indicators: Confounding factors in the analysis of acid deposition impacts on soil acidification status have been investigated. In the upper horizons, the soil pH decreases with increasing stand age (most so for pine forests). In the deeper soil horizons, pH decreases with increasing S deposition (most so for spruce forests). This suggests that deeper soils are a better indicator of acid depositions acidifying effects.

Acid Deposition vs Tree Uptake: Biological acidification of harvesting spruce forests has been quantified, and exceeds current acidification from acid deposition, while for pine forest it's at the same level.

Aluminum as a Soil Acidification Indicator: The indicators used in assessing acidification status have been evaluated. Exchangeable aluminum was found to be an uncertain indicator of soil acidification, due the dominance of organically bound Al in the upper part of the soil. The reduced ionic strength following a decline in acid deposition may also lead to stronger affinity for Al on the soil complexes and consequently more acid soil, while at the same time the acidity in the soil solution is reduced

Towards a Better Indicator of Soil Acidification: The C horizon better reflects acidification caused by deposition of strong acids than the B horizon, but the current soil acidification indicator only includes chemistry in the B horizon. The recommendation for an improved acidification indicator has been made which would include the C horizon chemistry.

Workshop Series on Soil Acidification and its Indicators:
Försurningsutvecklingen i mark och markvatten. Workshop Uppsala 10 oktober 2011.
Kriterier och indikatorer för bedömning av skogsmarkens försurning. Workshop Sigtuna 30-31 oktober 2012.
Kriterier och indikatorer för bedömning av skogsmarkens försurning II. Workshop Sigtuna 20-21 augusti 2013.

3. Vittrings- och försurningsprocesser i skogsmark – jämförelse mellan modeller och mätdata

Model Comparison to Assess Weathering Uncertainties: To evaluate uncertainties in the weathering rates upon which critical loads are based, the weathering rates estimated by the PROFILE Model and the Zirconium depletion methods were compared. They correspond for Ca and Mg, but not for K and Na. This indicates a possible knowledge gap in the modeling of K and Na. The methods also show opposite weathering gradients with depth indicating conceptual differences. The correspondence between the methods for Ca and Mg weathering suggests less of a discrepancy than has been reported when comparing published studies that did not seek to coordinate the definition of system boundaries.

Uncertainties in Mass Balance Weathering Estimates: Mass balance budgets from comprehensive, long-term stand-scale monitoring sites run by SLU indicate that weathering is not the only critical factor when estimating the sustainability of forestry. Large uncertainties were also found in the atmospheric deposition, the leaching and the allometric equations used to determine uptake in biomass.

Whole Tree Harvest Exceeds Weathering: The effect of whole-tree harvesting on soil acidification status was investigated using the mass-balances from long-term stand-scale monitoring sites. Bearing in mind the uncertainties in the mass-balance approach, the effects of whole tree harvesting were found to exceed the replacement of base cations by weathering when estimated using either the PROFILE model or and the Zirconium depletion method

Biological vs. Strong Acid Acidification: A critical, and unresolved issue in the “biological” acidification created by biomass uptake is the effect on surface waters. On an equivalent basis, biomass uptake is comparable to the acidifying influence of sulfur deposition before major reductions in emission occurred. But biological acidification does not supply a strong, mobile acid anion that will deliver acidity to surface waters. This issue is being examined with both modeling and empirical approaches.

4. Kritisk belastning av kväve – test av koncept och modeller i långliggande försök

Microbial Indicators of Nitrogen Leaching: The Swedish throughfall network was used to test the value of different soil indicators as predictors of nitrogen leakage from soils, The C/N ratio, which is commonly used to predict the risk of nitrogen leakage lacked predictive value. Microbial indices (the fungi to bacterial ratio), however, did had predictive power, explaining 65% of the variation in N leaching below spruce forests. These indices also go beyond empiricism to provide insight into the processes influencing nitrogen mobilization in soil water. Ectomychorhizzal fungi in particular are important for the N-cycling from an acidification perspective.

Field Studies of long-term N addition: Experimental work on how forest N addition influences N-losses at several of SLU and Czech long-term forest study sites has been evaluated. At one site, Stråsan with annual N fertilizations during four decades, elevated concentrations of nitrate and dissolved organic nitrogen (DON) in the leachates from the organic horizon were found in the ongoing N1 treatment indicating a move towards N saturation. In the mineral soil leachates, the dissolved organic carbon (DOC) increased as a result of N fertilization and this effect continued two decades after termination of N fertilization, moreover it is even more pronounced in the terminated N treatment. The elevated DOC appears to depend on soil organic matter processes in the mineral soil rather than processes in the organic layer above.

We hypothesize that N influences carbon allocation by the trees, such as root exudates and litter, and/or priming of old soil organic matter that influences the DOC in the mineral soil layers. Long-term monitoring data on the (de-)coupling of DON and DOC are needed to improve the model conceptualizations of DON- and DOC- leaching where our current understanding is limited.

Furthermore, data from long-term monitoring sites in Sweden and the Czech Republic are explored to improve the model concepts of soil microbial regulation of N leaching along gradients of climate and N deposition.

Biogeochemical modeling of Acidification from Nitrogen: If and when increased nitrogen leaching will become a larger factor in Swedish acidification than current critical load calculations allow for requires more than just indices. The rapid downward transport of N in the soil profile during major precipitation events and snow melt is a crucial dynamic to capture. These processes can be captured with biogeophysical models like the Coup Model, but possibilities to test these model estimations are limited due to the difficulties of getting soil water samples during snowmelt. Therefore there is a lack of measurements from this critical period when so much mobilization of N can occur. A national scale analysis of N leaching for climate change, atmospheric deposition and management scenarios showed that N deposition and temperature are the most important drivers of N leaching. Work with the Coup Model to analyze the combined effects of forest management, climate and atmospheric deposition on N leaching is continuing in co-operation with Skogforsk.

5. Effekt av åtgärder

Ash return Cost Benefit Analysis (CBA): Different strategies for ash recycling in southern Swedish forests were compared using CBA, with a special emphasis on the potential to use ash recycling as a measure to ameliorate acidification of soils and surface waters caused by acid deposition. Benefits transfer was used to estimate use values for sport fishing and non-use values in terms of existence values. The results show that the optimal share of acidified forest land that should be treated with ash depends on how optimistic one is about the effect of using ash to restore lakes and streams from acidification. More optimistic assumptions imply that the ash to a larger extent should be used to ameliorate acidification. Using the more realistic assumptions, given the experiences of forest liming, shows that acidified forest land should not be treated with ash with the aim of restoring lakes and streams from acidification. From a socioeconomic point of view, ash does more good as fertilizer on forested organic soils.

Spatial variation in the sensitivity of surface water pH: The pH sensitivity to perturbation was defined from stream water pH and related to catchment characteristics and stream water acid–base chemistry. At the national level, catchments with till soils and a large proportion of forested wetlands form the most pH sensitive areas. Because of regional variability in acidification history, amount and distribution of quaternary deposits, vegetation cover, etc. pH sensitivity is determined by different landscape elements in different regions. At the regional level, lakes and forests on mineral soils were also identified as sensitive landscape types. Southwestern Sweden, historically the most acidified, is the least pH sensitive due to the high buffering capacity at low pH.

Targeting Remediation Measures and Restrictions to protect Running Waters: In order to develop effective management guidelines across Sweden, it is most critical to better understand streams with the highest pH sensitivity, those within the pH range 5.0–6.2. The patchy spatial distribution of sensitive landscape types makes it difficult from an administrative point of view to develop simple guidelines for where forest slash harvest, for example, should be restricted or where ash applications should be recommended.

6. Löst organisk kol (DOC) roll i försurningsbedömning under en förändrad klimat

Decades of Changing Surface Water DOC warrant reconsideration of Reference Conditions pH: If the pre-industrial reference levels for DOC are higher than they were in the 1980s, then the pH in 1860 was lower than previously estimated, which changes the actual extent of surface water acidification. This emphasizes the need to establish reference levels for DOC. Palaeolimnological reconstructions show promise in this regard.

Modeling Surface Waters DOC: DOC is a major anion in Swedish surface waters, often having an important influence on the pH and aluminum speciation/toxicity. “Acid Episodes” are a critical feature of running waters where dilution of minerogenic constituents dilutes the acid neutralizing capacity at the same time as DOC and associated organic acidity can increase. Peak flow DOC concentrations could be predicted from baseflow DOC. This can be estimated from geographical information, although the increased role of groundwater at low flows is another important consideration in defining the spatial patterns of baseflow DOC.

Operational Aluminum Speciation Model for DOC-rich Waters: An improved method for estimating aluminum speciation in DOC-rich surface waters was developed from Fennoscandian observations of this critical parameter in surface waters. This provides a more reliable way to determine this critical parameter that links stream chemistry to the response of fish to acidification.

Contradictory DOC trends in surface waters and soil/groundwater: DOC in soil waters on the integrated monitoring sites has been compared to the trends in surface waters. The tendency for increasing trends in many surface waters (1990-2010) was not found in groundwater. A process-based explanation of the competing influence of ionic strength and pH was used to explain these apparently contradictory trends in DOC.

Putting it all together: Modeling DOC a century into the Future: Using the insight from the different EMA modeling projects, the DOC of streams 100 years into the future is being predicted with scenarios of intensified forestry and climate change. The modeling results suggest that the DOC concentrations are much more sensitive to climate change than the effect of land-use perturbation at a regional landscape scale. Potential changes in the hydrological conditions likely provide the key to understanding the long-term effect on DOC and its impact on surface water pH.

Evaluation of Water Planning tool: The forestry planning tools NPK+ (BIS+) and “Blå målklassning” (Blue targets) have been evaluated with regards to their assessment of acidification. DOC concentrations can affect the buffering capacity of waters in different ways in different regions. The BIS+ criteria “Clear water” correlates with TOC concentrations and may therefore have the potential to determine buffering capacity and acidification status of forest headwaters.

7. Skogsbrukets försurningspåverkan

Acidification effects of Whole-Tree Harvest (WTH) are Temporary and Site-Specific: Removal of logging residues may lead to soil and surface water acidification by lowering the amount of buffering base cations. The long-term treatment differences in soil exchangeable calcium pools (down to 20 cm) and soil solution calcium concentrations at 50 cm soil depth were examined at three coniferous sites in Sweden following conventional and whole-tree harvesting in 1974–1976. The soil water concentrations of calcium were 17 µeq l-1 lower in whole-tree harvested (WTH) plots compared with conventional harvested plots, 27–30 years after harvest. The main treatment differences had largely disappeared 32–35 years after harvest although site specific treatment differences were still measurable at the well-buffered site in northern Sweden. These results are in agreement with soil data showing that previously found treatment differences in calcium pools had diminished in the forest floor but remained in deeper soil layers. The presence of an interaction effect in the 10–15 cm soil layer indicates, however, that the treatment response on calcium pools is much less at the southern sites. These results indicate that the effect of WTH on soil and soil solution concentrations is temporary but site specific.

Well-buffered sites most sensitive to Whole Tree Harvesting (WTH) in Empirical Studies: Contrary to common beliefs, the greatest soil and soil water effect was observed at the well-buffered site where the loss of calcium during WTH is less likely to lead to acidification effects. The treatment effects on soil solution at the more acidic sites in southern Sweden were much smaller and probably not large enough to fully counterbalance the general recovery from acidification during the study period whereas treatment effects persisted longest at the well-buffered site in northern Sweden.

MAGIC Modeling of Whole Tree Harvest (WTH): Three of Sweden's Integrated Monitoring Catchments were subjected to virtual whole tree harvests using the Model of Acidification of Groundwater in Catchments (MAGIC). Large depletions in soil Ca^{2+} supply and a reversal of the positive trend in stream Acid Neutralizing Capacity (ANC) were predicted for all three sites after WTH. However, the magnitude of impact on stream ANC varied depending on site and the concentration of mobile strong acid anions. The largest decrease in modeled ANC was observed at the well-buffered site Gammtratten. The effects at Kindla and Aneboda were much more limited and not large enough to offset the general recovery from acidification. Varying the tree biomass Ca^{2+} concentrations exerted the largest impact on modeled outcome. Site productivity was the second most important variable whereas changing biomass amounts left on site only marginally affected the results.

Self-Evaluation of Results

SLU's role as a valued provider of decision support in the field of acidification has been substantially strengthened by the projects funded in the EMA Acidification program. SLU has been able to do a better job of providing relevant decision support. The "pump-priming" provided by the program has also increased the funding provided directly by government agencies and research councils to SLU. This is both a result of the dialog EMA funding has generated with stakeholders about their goals, and a result of getting more of SLU's experts engaged in the dialog with stakeholders. The capacity to provide timely expert analyses is highly regarded by stakeholders who need prompt answers. SLU, with its broad range of scientific expertise, has not been in a position to make full use of that expertise because key experts have not reserved time for this work. The EMA funding helps to get those experts to refocus on issues of relevance to stakeholders, which then leads to new assignments from those stakeholders.

SLU has general goals for Environmental Modeling and Assessment (EMA), as well as specific project goals. Each of these goals are considered below:

Goal 1: There will be a strong connection between EMA and other missions of SLU

Research and Education are SLU's two other missions, and EMA Acidification has found productive interfaces with both. The existence of EMA has made SLU an attractive partner to invite into larger research programs, such as the Swedish EPA's CLEO program and FORMAS FORWATER. In one case, EMA-Acidification projects on weathering became the foundation for an entire FORMAS Strong Research Environment (QWARTS) that has gathered researchers from two other universities to join the EMA-Acidification researchers in doing much more to reduce uncertainties in weathering estimates than the original EMA funding of a few hundred tkr could ever have done. The fact that many of the EMA projects have been associated with other research projects or larger research programs has contributed to a strong interplay between EMA-Acidification and research. The 94 articles in peer-reviewed journals since 2009 are a good indicator of this. The strategy of building a long-term network within EMA Acidification funding has also promoted interaction between SLUs researchers in different departments and faculties.

With regards to education, EMA acidification issues are a pillar of several courses (listed below) dealing with environmental assessment where the history of the acidification issue is an example to help students appreciate the challenges of environmental assessment. Acidification provides an excellent example of how science supported international cooperation to reduce a major pollution source (sulfur emissions) but also good examples of the difficulties in assessing human impacts (uncertainty in weathering and critical loads), or implementing mitigation efforts (liming). EMA support to engage teachers in acidification keeps the material in the teaching up to date. The developing goal conflict between forest biofuels and further acidification, as well as the debate surrounding limits on sulfur in the fuel used by ships in the Baltic, means that acidification is not just an historical case study, but an active, thought-provoking issue for the students.

There are also seven PhD students working with EMA Acidification projects (six ongoing), and seven MSc students have written their theses in conjunction EMA projects (Appendix).

Courses at the bachelor's level:

- Miljöanalys (MX0077 5hp)
- Akvatisk Miljöanalys (ITV021 5hp, 65 Miljö och Vattenteknik Civilingenörsstudenter, SLU/UU)
- Energisystemens miljöpåverkan (KE0060 10hp, 60 Energisystem Civilingenörsstudenter SLU/UU)
- Energi och miljö (MX0059, 5hp)

Courses at the advanced level:

- Applied Environmental Assessment (MX0052, 10hp)
- Environmental Assessment (1HY126 60 Sustainable Development MSc Students UU/SLU)

Goal 2: EMA will be a leader and contribute to international progress in scientifically based assessments

The quality and relevance of the 95 refereed journal articles and 44 other reports in the Appendix testify to the internationally leading stature of SLU's EMA acidification assessments. The researchers are successful in attracting both national funding and are participating in Nordic and EU research collaborations as well. The coordinator of the Program is on the scientific committee for the 2015 Acid Rain Conference, and EMA Acidification expects to be a strong presence at this premier international meeting place for the field of acidification.

Goal 3: Delivery of decision support that allows the exploitation of resources to be weighed against the environmental consequences of that exploitation

The interest in increasing the biomass harvest from Swedish forests places EMA Acidification at the center of an issue where the environmental consequences of more intensive exploitation of the forest resource needs to be weighed against the environmental consequences. Most of the EMA Acidification projects and the associated research programs like CLEO and QWARTS are involved in supporting such assessments.

The EMA-projects are also supporting the development of the modeling of acidification pressures and critical loads done by other organizations for international reporting in the framework of the UNECE Convention on Long-Range Transport of Air Pollutants. The cooperation with SLU's Forest Economists in doing cost-benefit analyses for surface water and forest liming are an example of going beyond supporting assessments to actually conducting the assessment, with direct implications for policy. The IKEU Program that is an externally funded part of SLU EMA Acidification work is also working directly with improving operational acidification mitigation efforts, and the ongoing efforts to adjust the liming efforts in Sweden to the improving acidification status.

Program specific goals

EMA Acidification has a set of program-specific goals. The progress on these goals is found above in the section "Most Important Results and Stakeholders". Cross-references to the projects relevant to each goal are found below.

1. Improve the determination of reference conditions for acidification as well as quantifying the uncertainty in the assessment of acidification. Supported by Projects 1, 2, 6, 7.
2. Evaluate the effects of acidification mitigation measures, including surface water acidification and ash return. Supported by Project 5.
3. Support quality control in the major acidification related environmental monitoring programs and their databases (National Forest Soils Inventory, Integrated Monitoring, Integrated Liming Effects Follow-up). Supported by Project 2.
4. Develop and adapt environmental monitoring and assessment systems to improve the follow up of environmental goals and support the international negotiations on the control of long-range acidifying pollutants. Supported by Projects 1, 2, 3, 4 ,6, 7.
5. See that SLU's acidification expertise and databases are maintained and used in conjunction with other national and international actors. Supported by all projects.
6. Quantify goal conflicts between increased biofuel harvest and reducing acidification by improving knowledge about how the production of biomass influences surface water acidification status. Supported by Projects 3, 7.
7. Improve the determination of soil weathering which is the key to calculating the acidification pressure that nature tolerates. Supported by Project 3.
8. Predict how climate change influences acidification during the coming decades, especially with regards to dissolved organic carbon. Supported by Projects 4, 6.
9. Improve the knowledge of nitrogen's future role in acidification with continued N deposition and more widespread forest fertilization. Supported by Project 4.

Quality Control

SLU works systematically with quality control so that the data and assessments are reliable and available. Since this program has focused on making use of the data administered by other programs (primarily EMA Forests and EMA Lakes and Watercourses) most of the work in this area has been on testing assessment tools. One example is the use of historical fish data and palaeolimnological studies as independent measures of acidification that were compared to the official national acidification "MAGIC Library" (e.g. Valinia et al. 2014; Erlandsson et al. 2011. The most enduring work of the EMA

Acidification program with quality control is in the project that co-finances the work of the Soils and Environment Department to improve the soils data in the National Forest Soil Inventory on which the environmental goals regarding soil acidification are assessed.

Synergies with Research and Education

See reporting above in the section "SLU EMA Goal 1: There will be as strong connection between EMA and other missions of SLU for information" about this topic.

Trends and Future

Measures to mitigate the effects of climate change may lead to indirect effects on the environment. One of the most important such measures in Sweden is to increase the usage of renewable energy. Forest growth can be increased by over 50% in Sweden by fertilization in combination with improved forest practices such as drainage, whole tree harvest and stump extraction. Effective as these silvicultural measures may be for increasing the supply of timber and renewable energy, the risk for serious soil and water quality implications are considerable. Increasing forest growth will increase the biological acidification which already accounts for between 30% and 70% of the total acidification pressure at present in Sweden. Growth enhancing management may thus affect the long term sustainability of forestry with respect to soil base cations. Some large-scale experimental manipulations suggest that a lack of base cations does not limit forest growth. But other authors have pointed out that mass balance considerations based on the tools used in Sweden to define the critical loads for acidification indicate a serious depletion of soil base cations within the next one to two forest generations. The possibility of more nitrogen reaching surface waters due to forest fertilization compounded by climate change is a further concern since forested areas are already a major supplier of nutrients to the Baltic.

Thus in the coming years, the issues surrounding intensified forestry will be a major focus of the acidification program. Further down the road, a better of understanding of how climate change will influence the "natural" acidity status of Swedish surface waters needs to be addressed. The implementation of the European Water Framework also requires follow-up on remediation plans to achieve good ecological status in lakes and running waters. This will entail a new focus on liming and the goal conflict between intensification of forest harvest and acidification. In all this work, the challenge of reliably assessing the status of 100,000 lakes and even more running waters in the face of a changing climate will require further improvements in assessment techniques that better capitalize on environmental monitoring data and assessment expertise.

Strengths, weaknesses, opportunities and threats

Strengths:

SLU's highly qualified researchers in many disciplines related to acidification (from soil science and aquatic geochemistry to tree physiology and aquatic biodiversity).

The data from environmental monitoring and long-term forestry experiments which SLU is responsible for.

Weaknesses:

SLU is not responsible for the operational assessment models used in determining soil and surface water critical loads.

Uncertainties in the future of EMA

Opportunities:

The emphasis on forestry and climate change as future factors in acidification provides excellent opportunities for SLU to increase its role in providing decision support since knowledge of silviculture and its environmental consequences is an area of great SLU expertise.

For climate change issues, as well the defining the recovery from acidification, long-term monitoring records hold a key for more precisely defining how these influence acidification status, and the possibilities for redirecting liming and other aquatic ecosystem restoration activities.

Threats:

Difficulties in cooperation with other universities or institutes could delay advances in the understanding of acidification issues.

SLU experts do not make decision support in the field of acidification a priority for the use of their time, so decision makers turn elsewhere for expertise.

Program Development

The projects that were initiated at the start of the evaluation period (2009-2011) represent a balance between the demands of stake holders, SLU's expertise, and the funding available. The creation of an active network of EMA Acidification researchers proved a successful basis for cooperation with other major research efforts as detailed above. Excellent EMA Acidification projects do, however, remain unfunded. Further funding could thus be used very effectively, both for collecting relevant data, and conducting further analyses that engage yet more of SLU's experts in dialog with decision makers.

The projects have been guided since 2011 by guidelines from a major consultation with EMA stakeholders and the scientific community, and project ideas suggested by SLU researchers. It is now time to use this evaluation in 2014 as the starting point for redefining the goals and priorities for EMA Acidification. Several major research programs are wrapping up (CLEO, Future Forests, and ForWater). Thus now is a good time to take stock of the results from these projects, along with those of the EMA Acidification Program. This provides a good basis for dialog with the stakeholders about integrating new knowledge into operational assessment tools and policies. It will also be an occasion to define a new suite of EMA Acidification program specific goals, and then solicit suggestions broadly from within SLU for new projects appropriate to these goals that will renew and hopefully expand the network of researchers engaged by the EMA Acidification Program.

Hopefully more stable, long-term funding for EMA will also create a situation where more regular realignments of the EMA projects can be conducted in consultation with the stakeholders. Every second year might be an appropriate interval to aim for.

The EMA Acidification program has concentrated on making use of the extensive data that has been collected concerning acidification. But there is lack of long term data on the effects of forest management, especially for surface waters draining managed forests. This lack has been particularly apparent when trying to quantify the goal conflict between forestry and acidification, including new silvicultural treatments to intensify production. This is an opening for new long term experiments. The monitoring of smaller watercourses is also not representative of the landscape. The ability to get a representative sample of headwaters in a landscape has been demonstrated, pointing the way to a new form of synoptic stream monitoring that would cover the managed forest landscape which is the source of the majority of Swedish surface waters.

Finally, the implementation of the Water Framework Directive in Swedish water management has brought a new emphasis on involving the public. One of the PhD students associated with EMA Acidification has been exploring the implications for acidification assessment, particularly reference conditions. This is a theme that could be developed further, possibly in conjunction with using historical information on fish occurrence that has been improved and made more generally available.

SLU's Environmental Monitoring and Assessment Program for Acidification: Self-Evaluation Appendix

Scientific publications

2009

Bishop, K., Beven. K., Destouni, G., Abrahamsson, K., Andersson, L., Johnsson, R., Rodhe, J., Hjerdt, N. (2009) Nature as the "natural" goal for water management: A Conversation. Ambio. 38(4):209-214.

Cory, N., I. Buffam, H. Laudon, L. Björkvald, C-M. Mörth, S. Köhler, K. Bishop. (2009) Particulate aluminium in boreal streams: Towards a better understanding of its sources and influence on dissolved aluminium speciation. Applied Geochemistry 24:1677-1685.

Köhler, S.J., Buffam, I., Seibert, J., Bishop, K and Laudon, H. and. (2009). Dynamics of stream water TOC concentrations in a boreal headwater catchment: controlling factors and implications for climate scenarios. J. Hydrology 373(1-2):44-56.

Laudon H, Hedtjärn J, Schelker J, Bishop K, Sørensen R, Ågren A (2009) Response of dissolved organic carbon following forest harvesting in a boreal forest. Ambio 38(7):381-386.

Löfgren, S., Cory, N., Zetterberg, T., Larsson, P-E. & Kronnäs, V. 2009. The long-term effects of catchment liming and reduced sulphur deposition on forest soils and runoff in southwest Sweden. For. Ecol. Man. 258:567-568. doi:10.1016/j.foreco.2009.04.030.

Löfgren, S., Ring, E., von Brömssen, C., Sörensen, R. & Högbom, L. 2009. Short-term effects of forest harvesting on water chemistry in two boreal streams in northern Sweden – a paired catchment study. Ambio 38(7):347-356.

Rapp, L. and Bishop, K. (2009). Surface water acidification and critical loads: exploring the F-factor. Hydrology and Earth System Sciences 13:2191-2201.

Seibert, J., Grabs, T., Laudon, H., Winterdahl, M., Bishop, K. (2009). Linking soil- and stream-water chemistry based on a Riparian Flow-Concentration Integration Model. Hydrol. Earth Syst. Sci., 13:2287–2297, 2009

Temnerud, J., A. Düker, S. Karlsson, B. Allard, S. Köhler, K. Bishop. (2009) Landscape scale patterns in the character of natural organic matter in a Swedish boreal stream network. Hydrology and Earth Systems Sciences. 13:1567-1582.

2010

Bostedt, G., S. Lofgren, S. Innala, and K. Bishop (2010), Acidification Remediation Alternatives: Exploring the Temporal Dimension with Cost Benefit Analysis, Ambio, 39(1), 40-48. DOI 10.1007/s13280-009-0004-9

Erlandsson, M., N. Cory, S. Kohler, and K. Bishop (2010), Direct and indirect effects of increasing dissolved organic carbon levels on pH in lakes recovering from acidification, Journal of Geophysical Research-Biogeosciences, 115.

Futter, M. N., E. Ring, L. Hogbom, S. Entenmann, and K. H. Bishop (2010), Consequences of nitrate leaching following stem-only harvesting of Swedish forests are dependent on spatial scale, Environmental Pollution, 158(12), 3552-3559.

Haei, M., M. G. Öquist, I. Buffam, A. Ågren, P. Blomkvist, K. Bishop, M. Ottosson-Löfvenius and H. Laudon. (2010) Cold winter soils enhance dissolved organic carbon in stream water. Geophys. Res. Lett., 37 doi:10.1029/2010GL042821.

Högberg, M.N., Briones, J.I., Keel, S.G., Metcalfe, D.B., Campbell, C., Midwood, A.J., Thornton, B., Hurry, V., Linder, S., Näsholm, T., Högberg, P.(2010) Quantification of effects of season and nitrogen supply on tree belowground carbon transfer to ectomycorrhizal fungi and other soil organisms in a boreal pine forest. New Phytologist 187:485-493.

Högberg, P., Johannisson, C., Yarwood, S., Callesen, I., Näsholm, T., Myrold, D.D., Högberg, M.N. (2010). Recovery of ectomycorrhiza after 'nitrogen saturation' of a conifer forest. New Phytologist 187:485-493

Löfgren, S. & Cory, N. 2010. Groundwater Al dynamics along boreal hillslopes at three integrated monitoring sites along a sulphur deposition gradient in Sweden. J. Hydrology. 380:289-297. DOI: 10.1016/j.jhydrol.2009.11.004.

Löfgren, S., Cory, N. & Zetterberg, T. 2010. Aluminium concentrations in Swedish forest streams and co-variations with catchment characteristics. Environ. Mon. Assess. 166:609-624, http://dx.doi.org/10.1007/s10661-009-1027-1.

Löfgren, S., Gustafsson, J.P. & Bringmark, L. 2010. Decreasing DOC trends in soil solution along the hillslopes at the two IM sites in southern Sweden – Geochemical modelling of organic matter solubility during acidification recovery. Sci Tot Environ 409-:201-210. doi:10.1016/j.scitotenv.2010.09.023.

Nickus, U., K. Bishop, M. Erlandsson, C. D. Evans, M. Forsius, H. Laudon, D. M. Livingstone, D. Monteith, H. Thies. 2010. Chapter 3 - Direct impacts of climate change on freshwater ecosystems. Pp. 38-64 In: Climate Change Impacts on Freshwater Ecosystems (eds. M. Kernan, R. Battarbee and B. Moss). Blackwell Publishing Ltd.

Sjöstedt, C.S., J.-P. Gustafsson and S.J. Köhler. 2010. Chemical Equilibrium Modeling of Organic Acids, pH, Aluminum, and Iron in Swedish Surface Waters. Environ. Sci. Technol. 2010, 44:8587–8593

Temnerud, J., J. Fölster, I. Buffam, H. Laudon, M. Erlandsson and K. Bishop (2010). "Can the distribution of headwater stream chemistry be predicted from downstream observations?" Hydrological Processes 24(16): 2269-2276.

Wright, R.F. Aherne, J., Bishop, K., Dillon, P.J., Erlandsson, M. Evans, C.D., Forsius, M., Hardekopf, D.W., Helliwell, R., Hruška, J., Hutchins, H., Kaste, Ø., Kopáček, J., Krám, P., Laudon, H., Moldan, F., Rogora, M., Sjøeng A.-M. S., and de Wit, H.A., 2010. Interaction of climate change and acid deposition, Chapter 7 in: Climate Change impacts on Freshwater Ecosystems – direct effects and interactions with other stresses. Wiley Blackwell.

Ågren, A., I. Buffam, K. Bishop, and H. Laudon (2010), Sensitivity of pH in a boreal stream network to a potential decrease in base cations caused by forest harvest, Canadian Journal of Fisheries and Aquatic Sciences, 67(7), 1116-1125. doi:10.1139/F10-052

Ågren, A., Haei M., Köhler S. J., Bishop K and Laudon H.(2010) Regulation of stream water dissolved organic carbon (DOC) concentrations during snowmelt; the role of discharge, winter climate and memory effects. Biogeosciences, 7: 1-13.

Ågren, A., I. Buffam, K. Bishop, and Laudon, H. (2010) Modeling stream dissolved organic carbon concentrations during spring flood in the boreal forest: A simple empirical approach for regional predictions, J. Geophys. Res., 115, doi:10.1029/2009JG001013.

2011

Cunningham., L., Bishop, K., Mettävainio, E., Rosén, P. (2011) Paleoecological evidence of major declines in total organic carbon concentrations since the 19th century in four nemoboreal lakes. Journal of Paleolimnology. 45(4): 507-518 DOI 10.1007/s10933-010-9420-x

Eriksson Ljusk O., Löfgren S., Öhman K. 2011. Implications for forest management of the EU Water Framework Directive's stream water quality requirements — A modeling approach Forest Policy and Economics vol. 13 284-291

Erlandsson, M., N. Cory, J. Fölster, S. Köhler, H. Laudon, G. Weyhenmeyer and K. Bishop. (2011). "Increasing Dissolved Organic Carbon Redefines the Extent of Surface Water Acidification and Helps Resolve a Classic Controversy." Bioscience 61(8): 614-618.

Futter, M.N., Keskitalo, E.C.H., Ellison, D., Pettersson, M., Strom, A., Andersson, E., Nordin, J., Löfgren, S., Bishop, K., and Laudon, H., (2011) Forests, Forestry and the Water Framework Directive in Sweden: A Trans-Disciplinary Commentary. Forests 2011, 2, 261-282; doi:10.3390/f2010261

Köhler, S. J., Zetterberg, T., Futter, M. N., Fölster , J. and Löfgren, S. 2011. Assessment of Uncertainty in Long-Term Mass Balances for Acidification Assessments: A MAGIC Model Exercise. Ambio 40(8): 891-905. doi:10.1007/s13280-011-0207-7

Köhler, SJ,Zetterberg, T,Futter, MN, Fölster, K and Löfgren, S. (2011) Assessment of uncertainty in long-term mass balances for acidification assessments: a MAGIC model exercise. AMBIO A Journal of the Human Environment (Impact Factor: 2.3). 12/2011; 40(8):891-905. DOI: 10.1007/s13280-011-0208-7

Klaminder J, Grip H, Mörth C-M and Laudon H 2011a Carbon mineralization and pyrite oxidation in groundwater: importance for silicate weathering in boreal forest soils and stream base-flow chemistry Appl. Geochem. 26 319–25

Klaminder, J., R.W. Lucas, M.N. Futter, K.H. Bishop, S.J. Köhler, G. Egnell, H. Laudon. 2011. Silicate mineral weathering rate estimates: Are they precise enough to be useful when predicting the recovery of nutrient pools after harvesting? Forest Ecology and Management. 261(1):1-9 doi:10.1016/j.foreco.2010.09.040

Laudon, H., Sponseller, R.A., Lucas, R.W., Futter, M.N., Egnell, G., Bishop, K., Ågren, A., Ring, E., and Högberg, P. (In press.). Consequences of More Intensive Forestry for the Sustainable Management of Forest Soils and Waters. Forests. 2(1), 243-260.

Laudon, H., Berggren, M., Ågren, A., Buffam, I., Bishop, K., Jansson, M., Köhler, S., (2011) Patterns and dynamics of Dissolved Organic Carbon (DOC) in boreal streams: The role of processes, connectivity and scaling. Ecosystems. DOI: 10.1007/s10021-011-9452-8

Löfgren, S., M. Aastrup, L. Bringmark et al., 2011. Recovery of Soil Water, Groundwater, and Streamwater From Acidification at the Swedish Integrated Monitoring Catchments. Ambio 40:8 836-856

Lucas, R.W., Klaminder, J., Futter, M.N., Bishop, K.H. Egnell, G. Laudon, H. Högberg, P. 2011. A meta-analysis of the effects of nitrogen additions on base cations: Implications for plants, soils, and streams. Forest Ecology and Management 262:95-104.

Lyon, S.W., Grabs, T., Laudon, H., Bishop, K.H., and Seibert, J. (2011). Variability of groundwater levels and total organic carbon (TOC) in the riparian zone of a boreal catchment, Journal of Geophysical Research-Biogeoscience, 116, G01020, doi:10.1029/2010JG001452.

Löfgren, S. & Zetterberg, T. 2011. Decreased DOC concentrations in soil water in forested areas in southern Sweden during 1987-2008. Science of the Total Environment 409:1916-1926. doi:10.1016/j.scitotenv.2011.02.017

Löfgren, S., Aastrup, M., Bringmark, L., Hultberg, H., Lewin-Pihlblad, L., Lundin, L., Pihl Karlsson, G. and Thunholm, B. 2011. Recovery of soil water, groundwater and runoff from acidification at the Swedish Integrated Monitoring catchments. Ambio 40(8):836-856. doi:10.1007/s13280-011-0207-8

Rosén, P., R. Bindler, T. Korsman, T. Mighall, K. Bishop. 2011. The complementary power of pH and lake-water organic carbon reconstructions for discerning the influences on surface waters across decadal to millennial time scales. Biogeosciences 8:2717-2727.

Winterdahl, M., Futter, M., Köhler, S., Laudon, H., Seibert, J., and Bishop, K. 2011. Riparian soil temperature modifies relationship between flow and organic carbon concentration in a boreal stream. Water Resources Research. (47), W08532, doi:10.1029/2010WR010235,

Winterdahl, M., Temnerud, J., Futter, M. N., Löfgren, S., Moldan, F. & Bishop, K. 2011. Riparian Zone Influence on Stream Water Dissolved Organic Carbon Concentrations at the Swedish Integrated Monitoring Sites. Ambio 40(8): 920-930. doi:10.1007/s13280-011-0199-4

2012

Bergman, I., K. Bishop, Q. Tu, W. Frech, S. Akerblom, and M. Nilsson (2012), The Influence of Sulphate Deposition on the Seasonal Variation of Peat Pore Water Methyl Hg in a Boreal Mire, Plos One, 7(9). : e45547. doi:10.1371/journal.pone.0045547

Erlandsson, M., N. Cory, J. Fölster, S. Köhler, H. Laudon, G. Weyhenmeyer and K. Bishop. (2011). Increasing Dissolved Organic Carbon Redefines the Extent of Surface Water Acidification and Helps Resolve a Classic Controversy. Bioscience 61(8): 614-618.

Eklöf, K., Kraus, A., Weyhenmeyer, G.A., Meili, M., Bishop, K. (2012) Forestry influence by stump harvest and site preparation on methylmercury, total mercury and other stream water chemistry parameters across a boreal landscape Ecosystems. DOI:10.1007/s10021-012-9586-3

Futter, M.N., J. Klaminder, R.W. Lucas, H. Laudon, S.J. Köhler. Uncertainty in silicate mineral weathering rate estimates: source partitioning and policy implications. Environ. Res. Lett. 7 024025 doi:10.1088/1748-9326/7/2/024025

Grabs, T., K. Bishop, H. Laudon, S. W. Lyon, and J. Seibert. 2012. Riparian zone hydrology and soil water total organic carbon (TOC): implications for spatial variability and upscaling of lateral riparian TOC exports. Biogeosciences, 9, 3901-3916, 2012

Iwald, J., Löfgren, S., Stendahl, J. & Karltun, E. 2012. The acidifying effect of tree stump and logging residue harvesting in Sweden – quantification and comparison with atmospheric deposition of acidity. Forest Ecology and Management 290:49-58 http://dx.doi.org/10.1016/j.foreco.2012.06.022

Rosén, P., R. Bindler, T. Korsman, T. Mighall, K. Bishop. 2011. The complementary power of pH and lake-water organic carbon reconstructions for discerning the influences on surface waters across decadal to millennial time scales. Biogeosciences 8:2717-2727.

Schelker, J., Eklöf, K., Bishop, K. and Laudon, H. 2012. Effects of Forestry Operations on Dissolved Organic Carbon (DOC) Concentrations and Export in Boreal First-Order Streams. JGR-Biogeosciences 117

Valinia, S., Hansen, H.-P. Futter, M. N., Bishop, K., Sriskandarajah, N. Fölster, J., 2012. Problems with the reconciliation of good ecological status and public participation in the Water Framework Directive. Science of the Total Environment. 433:482–490

Winterdahl, M., Erlandsson, M., Bishop, K. (2012). Acidification, DOC and Climate Change in Handbook of Global Environmental Pollution, Vol. 1 Global Environmental Change (ed Freeman, B.) Springer

DOI:10.1007/SpringerReference_349956; http://www.springerreference.com/index/chapterdbid/349956

Ågren, A., & Löfgren, S. 2012. pH sensitivity of Swedish forest streams related to catchment characteristics and geographical location – Implications for forest bioenergy harvest and ash return. For. Ecol. Man 276:10–23 http://dx.doi.org/10.1016/j.foreco.20

Ågren, A., Haei, M., Blomkvist, P., Nilsson, M.B. and Laudon, H. (2012) Soil frost enhances stream dissolved organic carbon concentrations during episodic spring snow melt from boreal mires Global Change Biology. doi:10.1111/j.1365-2486.2012.02666.x

2013

Angeler, D. and Johnson, R. 2013. Temporal scales and patterns of invertebrate biodiversity dynamics in boreal lakes recovering from acidification Ecological Applications, 22(4), 2012, pp. 1172–1186

Davies, J., Beven, K., Rodhe, A., Nyberg, L. and Bishop, K. (2013) Integrated modeling of flow and residence times at the catchment scale with multiple interacting pathways. Water Resources Research 49(8), 4738-4750.

Göthe, Emma ; Angeler, David G ; Gottschalk, Steffi ; Löfgren, Stefan ; Sandin, Leonard. 2013. The influence of environmental, biotic and spatial factors on diatom metacommunity structure in Swedish headwater streams. PloS one, 2013, Vol.8(8), pp.e72237

Högberg, M, Högbom, L. Kleja, D. Soil microbial community indices as predictors of soil solution chemistry and N leaching in Picea abies (L.) Karst. forests in S. Sweden. Plant and Soil, Volume 372, 1-2, 507-522

Laudon, H., Taberman, I., Ågren, A., Futter, M., Ottosson-Löfvenius, M., Bishop, K. 2013. The Krycklan Catchment Study-A flagship infrastructure for hydrology, biogeochemistry, and climate research in the boreal landscape. Water Resources Research 49(10), 7154-7158. DOI: 10.1002/wrcr.20520

Ledesma, J.L.J. Grabs, T., Futter, M.N., Bishop K., Laudon, H., Köhler, S. 2013. Riparian zone controls on base cation concentrations in boreal streams. Biogeosciences. 10:3849–3868, doi:10.5194/bg-10-3849-2013

Lucas, R.W., Sponseller, R.A., and Laudon, H. (2013). Controls over base cation concentrations in stream and river waters: A long-term analysis on the Role of deposition and climate, Ecosystems, 16, 707-721, DOI: 10.1007/s10021-013-9641-8.

Muller, R.A., Futter, M.N., Sobek, S., Nisell, J., Bishop, K. and Weyhenmeyer, G.A. (2013) Water renewal along the aquatic continuum offsets cumulative retention by lakes: implications for the character of organic carbon in boreal lakes. Aquatic Sciences 75(4), 535-545.

Oni, S. K., Futter, M. N., Bishop, K., Köhler, S. J., Ottosson-Löfvenius, M., and Laudon, H. 2013. Long-term patterns in dissolved organic carbon, major elements and trace metals in boreal headwater catchments: trends, mechanisms and heterogeneity, Biogeosciences, 10, 2315-2330, doi:10.5194/bg-10-2315-2013

Rappe-George, M.O.; A. I. Gärdenäs ; D. B. Kleja. 2013. The impact of four decades of annual nitrogen addition on dissolved organic matter in a boreal forest soil. Biogeosciences, 2013, Vol.10(3), p.1365

Róbert Blaško Peter Högberg Lisbet Holm Bach Mona N. Högberg 2013 Relations among soil microbial community composition, nitrogen turnover, and tree growth in N-loaded and previously N-loaded boreal spruce forest. Forest Ecology and Management 302: 319-328

Schelker, J., Öhman, K., Löfgren, S. & Laudon, H., 2013 Scaling of increased dissolved organic carbon inputs by forest clear-cutting - What arrives downstream? Journal of Hydrology 508:299-306. http://dx.doi.org/10.1016/j.jhydrol.2013.09.056

Schelker, J., L. Kuglerova, K. Eklof, K. Bishop, and H. Laudon (2013), Hydrological effects of clear-cutting in a boreal forest - Snowpack dynamics, snowmelt and streamflow responses, Journal of Hydrology, 484, 105-114.

Schelker, J., Grabs, T., Bishop, K. and H. Laudon. 2013. Drivers of increased organic carbon concentrations in stream water following forest disturbance: Separating effects of changes in flow pathways and soil warming. Journal of Geophysical Research-Biogeosciences, 118(4):1814-1827 DOI: 10.1002/2013JG002309

Schneider SC, Kahlert M, Kelly MG. 2013. Interactions between pH and nutrients on benthic algae in streams and consequences for ecological status assessment and species richness patterns. Sci Total Environ. 2013 Feb 1;444:73-84..

Simonsson, M., Bergholm, J., Olsson, B. and Öborn, I., 2013. Estimating uncertainties in base cation weathering rates according to mass balance. Mineral. Mag. 77, 2216 (se även: http://goldschmidt.info/2013/abstracts/abstractView?abstractId=5272).

Sjostedt C, Andren C, Folster J, Gustafsson JP. Modelling of pH and inorganic aluminium after termination of liming in 3000 Swedish lakes. Applied Geochemistry. 2013 Aug;35:221-9.

Stendahl J, Akselsson C, Melkerud P-A, Belyazid S. 2013. Pedon-scale silicate weathering in forest soils in different time scales; comparing concepts and weathering rates from the PROFILE model and the depletion method. Geoderma 211-212, 65-74.

Temnerud, J., A. Duker, S. Karlsson, B. Allard, K. Bishop, J. Folster, and S. Kohler (2013), Spatial patterns of some trace elements in four Swedish stream networks, Biogeosciences, 10(3), 1407-1423.

Zetterberg, T. ; Olsson, B.A. ; Löfgren, S. ; von Brömssen, C. ; Brandtberg, P.-O. 2013. The effect of harvest intensity on long-term calcium dynamics in soil and soil solution at three coniferous sites in Sweden. Forest Ecology and Management, 5 August 2013, Vol.302, pp.280-294

Ågren A., Buffam I., Cooper D. M., Tiwari T., Evans C. D., Laudon H. (2013) Can the heterogeneity in stream dissolved organic carbon be explained by contributing landscape elements? Biogeosciences Discuss., 10, 15913-15949.

Åkerblom, S., Bishop, K., Björn, E., Lambertsson, L., Eriksson, T. and Nilsson, M. (2013) Significant interaction effects from sulfate deposition and climate on sulfur concentrations constitute major controls on methylmercury production in peatlands. Geochimica et Cosmochimica Acta 102:1-11

2014

Ekvall, H., Löfgren, S. and Bostedt, G. (2014). Ash recycling - A method to improve forest production or to restore acidified surface waters? Forest Policy and Economics 45:42-50. http://dx.doi.org/10.1016/j.forpol.2014.04.002

Futter, M., Valinia, S., Löfgren, S., Köhler, J. and Fölster, J. (2014). Long-term (1987-2012) trends in water chemistry of acid sensitive lakes show slow recovery from historic acidification. Accepted for publication in Ambio.

Garmo, Ø., B. Skjelkvåle, H. Wit, L. Colombo, C. Curtis, J. Fölster, A. Hoffmann, J. Hruška, T. Høgåsen, D. Jeffries, W. B. Keller, P. Krám, V. Majer, D. Monteith, A. Paterson, M. Rogora, D. Rzychon, S. Steingruber, J. Stoddard, J. Vuorenmaa and A. Worsztynowicz (2014). "Trends in Surface Water Chemistry in Acidified Areas in Europe and North America from 1990 to 2008." Water, Air, & Soil Pollution 225(3): 1-14.

Hansson, L., Ring, E., Franko M.A., Gärdenäs A.I. 2014. Impacts of mechanical site preparation on soil moisture and temperature in a boreal forest regeneration area. Forest Ecology & Management (in revision).

Lestander, R. Henrikson, L. Löfgren, S. Ågren, A. (2014) Nya verktyg för skoglig vattenvård: NPK+ och Blå Målkassning – hur väl fungerar de? Fakta Skog 3.

Löfgren, S., Fröberg, M., Yu, J., Ranneby, B. (2014). Water chemistry in 179 randomly selected Swedish headwater streams related to forest production, clear-felling and climate. Environmental Monitoring and Assessment Online First Articles: 1-22. http;//dx.doi.org/10.1007/s10661-014-4054-5

Oni, S. K., Tiwari, T., Futter, M. N., Ågren, A., Teutschbein, C., Ledesma, J., Schelker, J., Laudon, H. Negative effects of climate change on boreal fluvial carbon dynamics will exceed impacts of more intensive forestry. (manuscript)

Oni, S.K., Futter, M.N., Teutschbein, C., Laudon, H., (2014). Cross-scale ensemble projections of dissolved organic carbon dynamics in boreal forest streams. Climate Dynamics, DOI 10.1007/s00382-014-2124-6.

Peralta-Tapia, A., Sponseller, R. A., Tetzlaff, D., Soulsby, C., and Laudon, H., (2014). Connecting precipitation inputs and soil flow pathways to stream water in contrasting boreal catchments, Hydrological Processes, DOI: 10.1002/hyp.10300

Schelker, J., Öhman, K., Löfgren, S. and Laudon, H (2014).Scaling of increased dissolved organic carbon inputs by forest clear-cutting - What arrives downstream? Journal of Hydrology, 508, 299–306.

Simonsson et al. (in review). Estimating base cation weathering rates by mass balance in a Norway spruce stand on podzolic soil: Analysis of flows and uncertainties. Submitted to Forest Ecology and Management.

Sponseller, R.A., J. Temnerud, K. Bishop, and H. Laudon. 2014. Patterns and drivers of riverine nitrogen (N) across alpine, subarctic, and boreal Sweden. Biogeochemistry, 120, 105-120.

Tiwari T, Laudon H, Beven K, Ågren A. (2014) Downstream changes in DOC: Inferring contributions in the face of model uncertainties, Water Resources Research, http://dx.doi.org/10.1002/2013WR014275

Valinia, S., G. Englund, F. Moldan, M. N. Futter, S. J. Köhler, K. Bishop and J. Fölster (2014). "Assessing anthropogenic impact on boreal lakes with historical fish species distribution data and hydrogeochemical modeling." Global Change Biology: n/a-n/a.

Winterdahl, M., M. Erlandsson, M. N. Futter, G. A. Weyhenmeyer, and K. Bishop (2014), Intra-annual variability of organic carbon concentrations in run-ning waters: Drivers along a climatic gradient, Global Biogeochem. Cycles, 28, 451–464, doi:10.1002/2013GB004770.

Winterdahl, M., M. Erlandsson, M. N. Futter, G. A. Weyhenmeyer, and K. Bishop (2014), Intra-annual variability of organic carbon concentrations in run-ning waters: Drivers along a climatic gradient, Global Biogeochem. Cycles, 28, 451–464, doi:10.1002/2013GB004770.

Zetterberg, T., Köhler, S. and Löfgren, S (2014). Sensitivity analyses of MAGIC modelled predictions of future impacts of whole-tree harvest on soil calcium supply and stream acid neutralizing capacity. Sci Tot Environ 494-495:187-201. http://dx.doi.org/10.1016/j.scitotenv.2014.06.114

Ågren, A. M., Buffam, I. Cooper, D. M., Tiwari, T., Evans, C. D., Laudon, H. (2014a) Can the heterogeneity in stream dissolved organic carbon be explained by contributing landscape elements? Biogeosciences, 11, 1199-1213, DOI: 10.5194/bg-11-1199-2014

Reports

2009

Fölster, J. (2009). Bilaga 3, 2.b:1. Allmän vattenkemi i rinnande vatten inom IKEU-projektet - status, typvis jämförelse och trender. Utvärdering av IKEU 1996 - 2006. Syntes och förslag. J. Munthe and A. Jöborn. Stockholm, Naturvårdsverket.

Ivalo, C., J. Nisell and J. Fölster (2009). Förändringar i markanvändning - en jämförelse mellan Häradsekonomiska kartan och nutida data för 24 avrinningsområden . Institutionen för Vatten och Miljö, SLU. Rapport 2009:5. .

Löfgren S. (Ed.). 2009. Integrerad övervakning av miljötillståndet i svensk skogsmark - IM. Årsrapport 2007. Dep. Aquatic Sciences and Assessment, SLU Report 2009:11, 34 pp + appendix. In Swedish. English summary.

Löfgren, S. 2009. Ökande humushalter i ytvatten - en effekt av klimat eller återhämtning från försurning? I G. Wiklander & H. Aronsson (Eds), Mark och miljödagen 2009 - Marken och klimatet (Mark och miljödagen 2009 – Soil and climate). Dept. Soil and Environment, SLU report 1:63-74. ISBN 978-91-86197-57-5

Löfgren, S., Stendera, S., Kahlert, M. & Willen, E. 2009. Klassificering av sjöar och vattendrag - nordisk jämförelse utifrån svenska bedömningsgrunder. KSLAT 3:2009, 33 pp.

Temnerud, J., J. Fölster, F. Pilström and K. Bishop (2009). Synoptisk provtagning av små vattendrag i södra Sverige oktober 2007. Rapport 2009:6; Institutionen för vatten och miljö, SLU. Uppsala.

2010

Ågren, A. & Löfgren, S. 2010. Försurningskänsliga bäckar – var, när och varför finns de? Fakta Skog Nr 8, 2010, 4pp.

Eriksson O., Löfgren S., Öhman K. 2010. Implications for forestry of stream water chemical demands: an introductory study, Institutionen för skoglig resurshushållning och geomatik, SLU Arbetsrapport vol 271.

Fölster, J. and P. Rönnback (2010). Sjöinventering i omdrev. Resultat från de två första åren 2007 – 2008. Institutionen för vatten och miiljö, SLU. Rapport 2010:17.

Gärdenäs A.I., Ring E., Högbom L. and Jacobson S. 2010. Short-term and post-felling impacts of nitrogen fertilization and climate on nitrogen leaching from a boreal pine forest. In N. Raghuram et al. (Eds.) 5th Nitrogen Conference, 3 - 7 Dec 2010, New Delhi, India 'Reactive N management for sustainable development - science, technology & policy'. Abstracts. pp. 86. (speaker)

Högberg P, Högberg MN, Näsholm T. (2010). Ektomykorrhizan minskar förluster av kväve från skogen. Rön från Sveriges lantbruksuniversitet. Fakta Skog 11

Löfgren S. (Ed.). 2010. Integrerad övervakning av miljötillståndet i svensk skogsmark - IM. Årsrapport 2008. Dept. Aquatic Sciences and Assessment, SLU Report 2010:10, 38 pp + appendix. In Swedish. English summary.

Rappe George, M., Gärdenäs, A. I. & Berggren Kleja, D. (2010). "Four decades of yearly nitrogen fertilization in a boreal forest – impact on dissolved organic carbon and nitrogen". In N. Raghuram et al. (Eds.) 5th international Nitrogen Conference, 3 - 7 Dec 2010, New Delhi, India 'Reactive N management for sustainable development - science, technology & policy'. Abstracts. pp. 335.

Rappe George, M. (2010). Influence of climatic drivers and long term N fertilization on the production and leaching of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) in a Norway spruce (Picea abies) forest stand. Master's Thesis in Soil Science, Agriculture Programme – Soil and Plant Sciences, Department of Soil and Environment, Swedish University of Agricultural Sciences (SLU), Uppsala 2010, Examensarbeten 2010:10. 41 pp.

2011

Fölster, J. and S. Köhler (2011). Försurningsläget i Sveriges ytvatten 2010. Rapport 2011, Institutionen för vatten och miljö, SLU

Fölster, J., F. Moldan and J. Stadmark (2011). Målsjöundersökningen 2007–2008. Naturvårdsverket. Rapport 6412.

Fölster, J., S. Köhler, C. von Brömssen, C. Akselsson and P. Rönnback (2011). Korrigering av vattenkemi för kalkningspåverkan - val av referenser och beräkning av osäkerheter. Institutionen för vatten och miljö, SLU. Rapport 2011:1.

Köhler, S. and J. Fölster (2011). Granskning och dokumentation av bedömningsgrunder för försurning - MAGIC-modellering. Rapport 2011:23, Institutionen för vatten och miljö, SLU.

Löfgren S. (Ed.). 2011. Integrerad övervakning av miljötillståndet i svensk skogsmark - IM. Årsrapport 2009. Dept. Aquatic Sciences and Assessment, SLU Report 2011:20, 23 pp + appendix. In Swedish. English summary.

Stendahl, J. & Akselsson, C. 2011. Försurningsutvecklingen i mark och markvatten. Rapport från workshop i Uppsala 10 oktober 2011.

2012

Fölster, J. and R. Djursäter (2012). Nationell kalkeffektuppföljning 2010-2011. Uppföljning av första årets provtagning av kalkade sjöar och vattendrag med referenser. Rapport 2012:19, Institutionen för vatten och miljö, SLU.

Fölster, J. and S. Valinia (2012). Försurningsläget i Sveriges ytvatten 2010. Komplettering till rapport 2011:24. Underlag till utvärdering av miljömålet ”Bara naturlig försurning. Rapport 2012:5, Institutionen för vatten och miljö, SLU.

Löfgren S. (Ed.). 2012. Integrerad övervakning av miljötillståndet i svensk skogsmark - IM. Årsrapport 2010. Dept. Aquatic Sciences and Assessment, SLU Report 2012:04, 34 pp + appendix. In Swedish. English summary.

Löfgren, S. 2012. Regional övervakning av avrinningen från brukad skogsmark i Västra Götalands, Hallands och Jönköpings län. Utvärdering av perioden 1996-2009 och förslag till framtida utformning. Rapport Länsstyrelsen Hallands län 2012:03, 41 pp, ISSN: 1403-1

Löfgren, S. 2012. Regional övervakning av avrinningen från brukad skogsmark i Västra Götalands, Hallands och Jönköpings län. Utvärdering av perioden 1996-2009 och förslag till framtida utformning. Rapport Länsstyrelsen VG län: 2012:02, 41 pp, ISSN: 1403-168X

Naturvårdsverket, 2012. Steg på vägen. Fördjupad utvärdering av miljömålen 2012. Rapport 6500 Naturvårdsverket. (se sid. 213-215, samt sid. 217)

Nilsson, T. Stendahl, J. & Löfgren, O. 2013. Markförhållanden i svensk skogsmark - data från Markinventeringen 1993-2002. Rapport, Institutionen för mark och miljö, SLU. (manuskript)

Stendahl, J. 2011. Presentation: ”Fördjupad analys av försurningsdata för skogsmarken baserat på Markinventeringen” vid seminarium ”Försurning: Var problemet inte löst?” Rapporter från SLU Fortlöpande Miljöanalys, Future Forests, ForWater CLEO. 15 november 2011.

Stendahl, J. 2012. Bedömning av skogsmarkens surhetstillstånd baserat på Markinventeringen 1983-2008. Underlag till fördjupad utvärdering av miljömålet Bara naturlig försurning. Dnr NV-04165-12. 26 pp.

Stendahl, J. & Akselsson, C. 2012. Kriterier och indikatorer för bedömning av skogsmarkens försurning. Rapport från workshop i Sigtuna 30-31 oktober 2012.

2013

Ågren A (2013) Skilj på surhet och försurningskänslighet page 10-11, in: Mark och Vatten, Future Forests Rapport 2013:3, SLU, Umeå.

Bishop, K. 2013. The Cleo Database: A resource for research. Swedish Environmental Protection Agency Report. 21 pp.

Bostedt, G., Innala, S., Löfgren, S. & Bishop, K. (2013): Fallstudie 1 – Kalkningsstudie. I: Kriström , B. & Bonta Bergman, M. (Eds.): Samhällsekonomiska analyser av miljöprojekt - en vägledning. Sid 55-72, Naturvårdsverket, Stockholm.

Löfgren S. (Ed). 2013. Integrerad övervakning av miljötillståndet i svensk skogsmark - IM. Årsrapport 2011. Dept. Aquatic Sciences and Assessment, SLU Report Report 2013:10, 23 pp + appendix. In Swedish. English summary.

Valinia, S, MN Futter, K Bishop. 2013. Vattendirektivet: en inbyggd konflikt och en väg framat. Future Forests Syntes

Wilander, A., Östlund, L. & Andrén., 2013. Utvärdering av pegelmätningar i IKEU-vattendrag 2007-2011

Ågren, A. Skilj på surhet och försurningskänslighet, Mark och vatten - Rapport från Future Forests fas 1 2009-2012 , Future Forests Rapport 2013:3

2014

Choma Michal, Čapek Petr, Gärdenäs Annemieke I., Kaštovská Eva, Rappe-George Martin and Šantrůčková Hana 2014. Minor answer response of soil microbial biomass and activity to changes in soil chemical properties caused by nitrogen deposition of in a Norway spruce forest ecosystems to changes in soil chemical properties caused by nitrogen deposition. Biogeomon 13-17 July Bayreuth, Germany.

Gärdenäs, A.I., Rappe George M, …Bishop; K, et al. 2014. Leaching processes at interface soil-water. In Munthe, J. et al., Climate change and environmental objectives, Report to Swedish Environmental Agency for 2015 evaluation of environmental objectives, 75-81 pp. (In Swedish). Available at http://www.cleoresearch.se/publications

Hansson L., Rappe George M. Gärdenäs A.I. 2014. Site preparation in Swedish forestry present and in the future with focus on environmental consequences. Markberedning i svenskt skogsbruk nu och i framtiden med fokus på miljökonsekvenser litteraturstudie och expertintervjuer med Skogsstyrelsen och Skogforsk CLEO-rapport D1.2.2 26 pp.

Lestander, R., Henriksson, L., Löfgren, S. & Ågren, A. 2014. Nya verktyg för skoglig vattenvård: NPK+ och Blå målklassning – hur väl fungerar de? Fakta Skog Nr 3, 2014, 4pp.

Löfgren S. (Ed.). 2014. Integrerad övervakning av miljötillståndet i svensk skogsmark - IM. Årsrapport 2012. Dept. Aquatic Sciences and Assessment, SLU Report 2014:17, 34 pp + appendix. In Swedish. English summary.

Stendahl, J. Nilsson T. & Lundin, L. 2014. Omanalys av pH på jordprov från Markinventeringen 1983-2006 – jämförelser och trender. Reanalyzing pH in soil samples from the Swedish Forest Soil Survey 1983-2006 – comparability and trends. (Manuscript)

Stendahl, J. & Nilsson T. 2014. Omanalys av utbytbara baskatjoner och aluminium på jordprov från Markinventeringen 1983-1987. Reanalyzing exchangeable base cations and aluminium on soil samples from the Swedish Forest Soil Survey 1983-1987. (Manuscript)

PhD Theses

Casetou, S. The role of weathering to sustainable forest production. Ongoing

Iwald, J. Spatial and temporal trends in soil acidity and carbon pools in Swedish forest soils – evaluation of data from the Swedish Forest Soil Inventory. Ongoing

Ledesma, J.: Riparian Zone Functioning In Forested Boreal Landscapes and Their Vulnerability. Ongoing

Tiwari, T: Intensive studies of forestry and climate change effects on catchment processes Ongoing:

Valinia, S.: Credible targets for environmental management - Comparing alternative reconstructions of reference values for human impact. Ongoing

Zetterberg, T.: Acidification of surface waters due to increased extraction of forest biomass. Ongoing

Martin Erlandsson, Assessment of Acidification (Ph.D. 2009)

MSc Theses

Boström, M.: Winter condition effects on spring flood DOC in boreal streams: Implications for climate change in northern latitudes, Degree thesis in Physical geography, 30 hp. Spring term 2009; Umeå University

Isaksson, L. 2013. MSc/BSc thesis 30 HEC. pH-sensitivity in boreal streams – the influence of landscape characteristics. Dept. of Aquatic Sciences and Assessment, SLU. http://stud.epsilon.slu.se/5792/

Johansson, M. 2014. MSc/BSc thesis 30 HEC. Wood-ash application on forest soil – a meta-analysis of the effects on surface water acid-base chemistry. Dept. of Forest Ecology and Management, SLU no 14:4. In Swedish. English summary. http://stud.epsilon.slu.se/6530/

Karlsson, R.: The Swedish Liming operation – A Study about the liming officer's opinions in some aspects regarding Ecology, Economy and Organization.
Course title: Independent project in Environmental Science – Master´s thesis
Course code: EX0431 Programme/education: Multidisciplinary

Khoussainova, G. 2010. MSc/BSc thesis 15 HEC. The acidity status of streams upstream liming dispensers in the county of Dalarna. Dept. of Aquatic Sciences and Assessment, SLU. In Swedish. English summary. http://stud.epsilon.slu.se/1293/

Lestander, R. 2014. MSc/BSc thesis 30 HEC. En utvärdering av de skogliga vattenplaneringsverktygen NPK+ och Blå målklassning med avseende på vattenkvalitet och vattenkemi. Dept. of Forest Ecology and Management, SLU no 14:8. In Swedish. English summary. http://stud.epsilon.slu.se/6601/

Rappe George, M. (2010). Influence of climatic drivers and long term N fertilization on the production and leaching of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) in a Norway spruce (Picea abies) forest stand. Master's Thesis in Soil Science, Agriculture Programme – Soil and Plant Sciences, Department of Soil and Environment, Swedish University of Agricultural Sciences (SLU), Uppsala 2010, Examensarbeten 2010:10. 41 pp.

Programs from Workshops Organized Centrally by EMA Acidification

Försurning: Var problemet inte löst?

SLU Fortlöpande Miljöanalys, Future Forests, ForWater CLEO

15 nov. 2011 09:00-16:00 vid SLU Undervisningshuset i Ultuna Sal K

08:30	Kaffe	
09:00	Introduction	Prof. Kevin Bishop (SLU/UU)
09:15	Fördjupad analys av försurningsdata för skogsmarken baserat på Markinventeringen	Dr. Johan Stendahl (SLU)
09:30	Weathering Uncertainty	Dr. Martyn Futter (SLU)
09:45	A synthesis of long-term base cation records in streams to evaluate terrestrial predictions	Dr. Richard Lucas(SLU)
10:00	Uttag av skogsbiomassa och försurningspåverkan på bäckvatten - en känslighetsanalys	Dr. Anneli Ågren (SLU)
10:15	Kaffe	
10:35	Uncertainties in weathering estimates in relation to observed whole-tree harvesting effects	Dr. SLU Bengt Olsson (SLU)
10:50	Vittrings- och försurningsprocesser i skogsmark - jämförelse mellan modeller och mätdata	Prof. Ingrid Öborn (SLU)
11:05	Försurning i ett förändrat klimat med ökat uttag av skogsbränslen	Dr. Cecilia Akselsson (Lund U.)
11:20	Discussion	
11:40	Lunch	
12:45	Kritisk belastning av kväve – test av koncept och modeller i långliggande försök	Dr. Annemieke Gärdenäs (SLU)
13:00	Kan markmikroorganismsamhällets sammansättning prediktera marklösningens kemi och kväveläckage?	Dr. Mona Högberg (SLU)
13:15	Aluminum Speciation and Acidification Assessment	Dr. Stephan Köhler (SLU)
13:30	Modeling of Reference Conditions with MAGIC	Dr. IVL Filip Moldan (IVL)
13:45	Bensträckare	
14:00	Historical Fish Data, Paleolimnology and MAGIC	Prof. Kevin BIshop (SLU/UU)
14:15	Ask och kalk återföring till skogsmark - samhällsekonomisk konsekvensanalys	Dr. Hans Ekvall (SLU)
14:30	Var kan vi sluta kalka?	Dr. Jens Fölster (SLU)
14:45	Kaffe	
15:00	'HaV:s syn på försurning och kalkning'	Per Olsson Hav och Vattenmiljö
15:15	Future Concerns	Stefan Andersson Skogsstyrelsen
15:30	Future Concerns	Ulla Bertills Naturvårdsverket
15:45	Slutdiskussion: Quo Vadis	

Where are Sweden's Forest Waters headed? Preparing a Consolidated Summary Workshop for Stakeholders hosted by FOMA Acidification and CLEO

Dear Forest- Water Colleagues,
Welcome to the Nov. 11-12 workshop at Sunnersta Herrgård! There will be 27 participants representing 9 major research programs. The program is appended at the end of this page, and an excel sheet with participants and sessions is attached.

1. Please confirm by e-mail that the details of your participation in the ConForWat3.xls file are correct. Let me know about any food preferences too!
2. Let me know which sessions you prefer
3. Provide any background material that you want considered in your sessions by Tuesday, Nov. 5th. We will distribute this to all the participants

Location and Time: Sunnersta Herrgård Monday November 11 09:00 Tuesday Nov. 12 16:00

Objective: This scientific workshop will summarize the state of the art regarding six research questions and two potentially conflicting perspectives related to forestry, i.e. surface water quality and forest production (c.f. the national environment goals and the Forestry Act).

Method: The questions will be discussed and reported in half-day parallel sessions with 3 issues dealt with separately in small groups (2 hours), followed by a discussion of the outcomes in plenum (1 hour). The two potentially conflicting perspectives of researchers and practitioners will be dealt with at each session. On the second day, ranking the environmental importance of the six issues and implications for forest management will be discussed in parallel sessions.

Each session will be led by two researchers mainly directed towards surface water issues and forest production, respectively. The pair leading each session will be invited to report the outcome at the "1-day Consolidated Summary Workshop" for stakeholders in 2014. The goal for the reporting is not to present a consensus, but rather the state of the art.

During each two hour session, we suggest that the chairs provide a 10 minute introduction, and then move right into a discussion of the views from their respective research programs. You are encouraged send out material you want to share with other participants before the meeting (Please send any preparatory materials to me by Friday, Nov. 8, so I can distribute them). After the introductory round, the group should work on answering the following questions, under the guidance of the discussion leaders.

Questions for the sessions on Day 1

1. What is the status of forest waters with regards to the relevant "Miljömål"
2. To what extent do forestry operations impact water quality at local (headwaters), regional (>1000 ha) and national scales (the sea)? Use the scale: low=difficult to measure, medium=chemically detectable, high= biological effects detectable)
3. Which forestry operations have the largest impact on the water quality?
4. How should the forestry practices be improved in order to help achieve the relevant Milömål
5. Are there any other measures, besides forestry, that could be used within forested catchments in order to counterbalance the forestry impact on water quality?

During the ranking and forest management sessions on Day 2, please focus on the following questions:

1. Which of the following water quality issues eutrophication, stream carbon, suspended matter/sedimentation, acidification, mercury, biological diversity are most important to deal with within forestry in the context of Sweden's Miljömål?
2. Which forest management practices are most important to change and how in order to reduce the water quality impact and achieve Sweden's Miljömål?

After two hours, it will be time to gather in plenum. Each pair of discussion leaders will have 10 minutes to summarize the answers to the questions, and 10 minutes to get feedback from the rest of the group.

On the basis of this day, the discussion leader pair will invited (if they wish) to prepare a 30 minute presentation on their "issue" at the stakeholder meeting to be held in 2014. Such presentations will be circulated with the other session participants one month prior to the stakeholder meeting, so that there will be adequate time to see that the different viewpoints from the research community are represented at the stakeholder meeting.

Research Issues	**Surface water/Production**
Day 1 Morning 9:30-12:30 (Coffee available from 9:00, and 10:30-11:00, Lunch 12:30-13:30)	
Eutrophication	Martyn Futter/Lars Högbom
Stream Carbon	Kevin Bishop/Tord Magnusson
Sedimentation/Driving	Eva Ring/Isabelle Bergkvist
Day 1 Afternoon (13:30-16:30, Coffee available from 14:30-15:00; dinner at 18:00	
Acidification	Filip Moldan/Ulf Sikström
Mercury	Ulf Skyllberg/ Anja Lomander
Aquatic Biodiversity	Erik Degerman/Elisabet Andersson
Management Issues Day 2 Morning (08:30-11:30, Coffee available from 9:30-10:00, Lunch 11:45)	
Ranking and Prioritization	Kevin Bishop/ NN
Forest management	Stefan Löfgren/Ola Karen

Major Research Programs Contributing to the Summary:

NV CLEO –	John Munthe
SNS CAR-ES	Lars Högbom
MISTRA Future Forests –	Annika Nordin
FORMAS ForWater	Hjalmar Laudon
FORMAS Skog-Land-Samhälle	Per Angelstam
FORMAS QWARTS	Kevin Bishop
SLU FOMA Sjöar och Vattend.	Stina Drakare
STEM Bränsleprogram	Anna Lundborg
BECC – National Strategic	Henrik Smith

Stakeholders: HaV, NV, EM, Skogsstyrelsen, Vattenmyndigheterna, Länsstyrelserna, skogsnäringen, Sportfiskarna, WWF.

FINAL ”Avnämar” CONFERENCE Planned for 2015

Miljötrender i svenska skogsvatten sett ur ett forskningsperspektiv

Välkomna till ett seminarium där slutsatser från ett dussintal forskningsprogram redovisas.

KSLA xxxxxx 2015

Det finns många frågar kring hur skogsvatten klarar att leva upp till Sveriges miljömål.

Vatten finns överallt i skogslandskapet, men hur påverkas tillståndet i dessa vatten med avseende på biodiversitet och ekosystemtjänster under påverkan av klimatförändringar, nya skogsbruksmetoder och förbättrad hänsyn till vatten? Mycket forskning pågår för att belysa detta. Mer än ett dussin forskningsprogram arbetar med dessa frågor inklusive Naturvårdsverkets Climate Change and Environmental Objectives (CLEO), Mistra Future Forests, Samnordisk Skogforsknings Centre of Advanced Research on Environmental Services from Nordic Forest Ecosystems (CAR-ES), FORMAS FORWATER, FORMAS Kvantifiering av vittringshastigheter för ett uthålligt skogsbruk (QWARTS) och den regering-strategisk forskningsområde Biodiversity and Ecosystem services in a Changing Climate (BECC). Vi har tidigare samlat forskare från dessa program för att sammanfatta det rådande forskningsläget kring olika miljömål och med syfte att kunna presentera detta för er avnämare. Ni är välkomna att ta del av detta arbete måndag den 22 september 2014 på KSLA.

Meddela om ni kan delta genom att registrera Er vid:
Registreringsformulär (senast 140901)

09:00	Introduktion	KSLA
09:15	Vattenförvaltning och åtgärder i skogsvatten	Vattenmyndigheterna/Hav (tillstånd och påverkan i skogsvatten samt hur nationella miljömål och internationella åtaganden (BSAP t.ex.) påverkar vattenförvaltningen och åtgärdsprogrammen)
09:45	Surhetstillstånd	Filip Moldan, IVL, , Jenny Stendahl, Skogsstyrelsen
10:25	Kaffe	
10:55	Näringstillstånd	Lars Högbom, Skogforsk och Martyn Futter, SLU
11:35	Slam, sedimentation/Körskador	Eva Ring och Isabelle Bergkvist, Skogforsk
12:15	Lunch	
13:00	Kvicksilver	Ulf Skyllberg, SLU och Anja Lomander, Skogsstyrelsen
13:40	Humus/vattenfärg	Stefan Löfgren och Tord Magnusson, SLU
14:20	Biodiversitet	Erik Degerman, SLU och Elisabet Andersson, Skogsstyrelsen
15:00	Kaffe	
15:30	Uppföljning och övervakning för adaptiv förvaltning	Erik Sollander, Skogsstyrelsen
16:10	Vad kan skogsbruket göra?	Ola Kåren, SCA
16:50	Sammanfattande diskukussion - framtides forskningsfrågor	
17:30	Middag	