The Liming in Northern Sweden

- the administrative handling of the scientific disputes

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The Liming in Northern Sweden – the administrative handling of the scientific disputes

Title

Oenighet i Kalkningsfrågan
- den administrativa hanteringen av kalkningen i Norrland

The Liming in Northern Sweden
– the administrative handling of the scientific disputes

Author

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Abstract

During the last four decades, acidification has been seen as a great environmental hazard. To combat the effects of the acidification, the Swedish government is funding liming of affected areas. This practice has been questioned in northern Sweden, since there is no general agreement about the origin of the acidity there. This thesis aims to explain the administrative handling of the scientific disputes, and thereby the relation between the responsible authority, the Swedish Environmental Protection Agency (SEPA) and the research exercised on the matter. Research findings are therefore compared with the content of interviews, performed by civil servants at SEPA. It is concluded that the liming in northern Sweden is a very complicated issue, involving many groups and individuals – so much so that it might not just be an issue of acidification science.

Nyckelord

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Norrköping, August 2003

Abstract
During the last four decades, acidification has been seen as a great environmental hazard. To combat the effects of the acidification, the Swedish government is funding liming of affected areas. This practice has been questioned in northern Sweden, since there is no general agreement about the origin of the acidity there. This thesis aims to explain the administrative handling of the scientific disputes, and thereby the relation between the responsible authority, the Swedish Environmental Protection Agency (SEPA) and the research exercised on the matter. Research findings are therefore compared with the content of interviews, performed by civil servants at SEPA. It is concluded that the liming in northern Sweden is a very complicated issue, involving many groups and individuals – so much so that it might not just be an issue of acidification science.
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1 Introduction

Acidification is one of our greatest environmental hazards. Over large areas in northern and central Europe and eastern North America, its impact on the environment has lead to great losses in ecosystems.  

Sweden is one of the countries where acidification has caused the most serious damage to the ecology. In the end of the 1960’s, the pH decline was rapid in thousands of inland waters, which resulted in a largely decreased flora and fauna. Later in the same decade, the pH decline in Swedish waters could be explained by the large emissions of sulphur dioxide (SO\textsubscript{2}) and nitrogen oxides (NO\textsubscript{x}) in other parts of Europe - predominantly Great Britain, Germany and Eastern Europe.

The long-term solution to acidification is of course to stop hazardous emissions completely. International agreements, like the Convention on Long Range Transboundary Air Pollution (CLRTAP), have resulted in reduced levels of SO\textsubscript{2} by half of what it was in the 1970’s and early 1980’s. Despite this, the negative effects on the environment caused by acidification remain. Since there will take a great length of time to stop the emissions, other remedial measures must be considered. The most common measure of remediating the effects of acidification is liming.

In Sweden, it was for a long time believed that only the south-westerly region of the country was affected by acidification, since the northern regions are further away from the emission sources. Though in 1991, a study indicated that parts of Northern Sweden were also acidic, and it was stated that this was a result of acid deposition. Hence, the Swedish government decided to finance liming in the north as well. In one year, the total liming grant increased from 120 million SEK to 180 million SEK. In year 2003, the total liming grant is 205 million SEK.

This has resulted in heated debates over the liming of water bodies in northern Sweden. Critics claim that the acidic condition in northern Sweden is naturally occurring, and question whether liming should be carried out in the manner in which it is currently executed. Most importantly, they say that liming in these circumstances threatens the very survival of the underlying ecosystems.

1.1 Aim

The aim of this thesis is to explore how the Swedish Environmental Protection Agency (SEPA) deals with the dispute concerning the origin of the acidic condition in northern Sweden, and thereby the liming activity. To elaborate, I want to investigate the relationship between the scientific research and the conduct of SEPA on the matter. I intend to study:

1. Warfvinge and Bertills (red.), 2000, p. 9
2. Warfvinge, P. and Bertills, U., 2000 (red), p. 10
5. Warfvinge, P. and Bertills, U., 2000 (red), p. 10
7. Ahlström and Isaksson, 1990
8. Torbjörn Svenson, interview 2003-04-28
- What research indicates that northern Sweden is naturally acidic, and what research does not?
- How does SEPA work productively with research? Does SEPA carry out research within itself? Is SEPA cooperating with researchers of differing findings? Is decision making based on reasoning within the organisation itself?

1.2 Disposition
To increase the readers understanding of this subject, this thesis begins with an historical background to acidification and liming in Sweden, and briefly details the basis of the disputes concerning the liming of northern Sweden. The theoretical grounds for the study, which are based on the opinions of critics to liming in northern Sweden is then presented. In the materials and method section I explain the purpose of applying content analysis and qualitative interviews on the empirical material. The two sources of empirical material are then analysed separately, and then discussed. From the discussion conclusions are made, which are compared with the opinions of the liming-critics.

To avoid confusion for the reader, I have added a wordlist with shortenings that occurs in the text in the back of the dissertation, before the references.

2 Background

2.1 Acidification
Acidification as a phenomenon is often related to the changes in the environment it causes. During the last three decades, effects have been observed in soil and vegetation, and especially in aquatic ecosystems. During the second half of the 19th century, the surface water in the affected regions has become more acidic since strong acids have consumed the original buffering capacity. One general consequence of this is a decline in the number of plant and animal species in the affected waters. Acidification-sensitive benthic animals such as snails, bivalves and crustaceans already begin to decline in number at pH values of around 6.0. At lower pH levels, sensitive fish species like roach and salmonids also begin to disappear, and lakes with pH values of around 4.5 can be entirely devoid of fish. The main cause of this damage, it seems, is that acidification entails increased concentrations of aluminium in a form which is toxic to many species.

Today it is recognized that the atmospheric deposition of acid substances like sulphur and nitrogen are an important factor that is causing acidification. The deposition is today considerably more acidic than in pre-industrial times because of the combustion of fossil fuels like coal and oil, which results in emissions of SO₂ and NOₓ. These emissions often linger for one or two days in the atmosphere before returning to the ground by deposition. During this time

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11 Hanneberg and Bertills (red.), 1995, p. 15
12 Ibid p. 15
13 http://www.internat.naturvardsverket.se 2003-08-05
14 Hanneberg and Bertills (red.), 1995, p. 9
the wind carries them hundreds or even thousands of kilometres away from the emission source. Many thousands of tonnes of acidifying substances every year are ‘imported’ and ‘exported’ in this way across national boundaries.\textsuperscript{15} Today, nearly 90 percent of the SO\textsubscript{2} and NO\textsubscript{x} deposited in Sweden hail from emissions outside the national boundaries.\textsuperscript{16} Consequently, the imported SO\textsubscript{2} is about three to four times higher than exported emissions. Sweden’s exports of NO\textsubscript{x} is roughly of the same quantity that is imported.\textsuperscript{17}

2.2 SEPA and liming
Sweden, because of its geographical position and its sensitive nature, is one of the countries where acidification has caused most serious damage to the ecology.\textsuperscript{18} The bed-rock is large in scale containing Archaean rock, in which the weathering process is very slow – in contrast to calcareous bed-rock. The weathering process determines the level of acidification in watersheds and lakes, since the decomposed mineral is neutralizing acids by consuming its hydrogen ions, which results in lower pH values.\textsuperscript{19}

To help prevent short-term effects of acidification, some 200 000 tonnes of fine-ground limestone is spread in acidic lakes and watercourses or in their watersheds every year, with the aim of restoring biological diversity and possibilities of fishing in acidified waters. The lime is gradually dissolved by the same kind of weathering processes as in calcareous soils. In this way, the water is made less acidic.\textsuperscript{20} This same method of preventing the effects of acidification is also utilized in other affected countries, for example Norway, Finland and Canada. In Finland, which to a geological extent is similar to northern Sweden, liming is employed in a small scale. Norway on the other hand, spends approximately 100 million NOK yearly on liming. The impact of anthropogenic acidification is not questioned since there are obvious signs of acidification in the limed waters (Sörlandet and areas of Västlandet). The layer of soil is thin in these areas, and as such has a very low buffering capacity.\textsuperscript{21}

The Swedish liming programme is however the most extensive in the world.\textsuperscript{22} Today, 85 percent of liming in Sweden is financed by state subsidies.\textsuperscript{23} During the period 1983 – 2001, the Swedish government spent approximately 2.5 billion SEK on liming. The liming activity is thereby the largest ever Swedish effort for the preservation of the environment.\textsuperscript{24}

In 1976, liming of waters financed by state subsidies was initiated. The first five years was a trial period, and the responsible authority was the Board of Fishery. In 1982, the liming activity was initiated on a larger scale and on a permanent basis. At the same time, the Swedish Environmental Protection Agency (SEPA) became the responsible authority.\textsuperscript{25} SEPA is a central environmental authority in Sweden. The task of the agency, according to the

\textsuperscript{15} http://www.internat.naturvardsverket.se, 2003-07-29
\textsuperscript{16} Henneberg and Bertills (red.), 1995 p. 16
\textsuperscript{17} Ebbeson, 2000, p. 16
\textsuperscript{18} Warfvinge and Bertills (red.), 2000 p. 10
\textsuperscript{19} Bernes, 2001, p. 103
\textsuperscript{20} http://www.internat.naturvardsverket.se, 2003-06-01
\textsuperscript{21} Laudon 2003-09-30
\textsuperscript{22} Ibid
\textsuperscript{23} Warfvinge, 1997, p. 153
\textsuperscript{24} SEPA: Handbok 2002:1, p. 3
\textsuperscript{25} SOU 1996:53, p. 21
instructions laid down by the Government, is to coordinate and drive forward environmental work nationally and internationally.\textsuperscript{26} Hence, SEPA is responsible for the liming programme in Sweden. The county administrative boards are regionally responsible. The agency distributes state subsidies to the county administrative boards and is also responsible for following up the effects of the liming activity.\textsuperscript{27}

\subsection*{2.2.1 Assessment Criteria for Environmental Quality}
SEPA has developed Environmental Quality Criteria (SEQC) constituting a system of classification that facilitates the interpretation of environmental data. The motive for this is to facilitate the environmental work for local and regional authorities, that otherwise would have to process and interpret data themselves, something that is very time consuming.\textsuperscript{28} The criteria can be used to determine whether measured values are high or low, in relation to either a national average or baseline readings. In the Criteria for Acidity of Lakes and Watercourses, it is explained by what levels a water is acidic (see below).\textsuperscript{29}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
Class & Buffer Capacity & Alkalinity (meq./l) \\
\hline
1 & Very good & $>0.20$ \\
2 & Good & 0.10-0.20 \\
3 & Weak & 0.05-0.10 \\
4 & Very weak & 0.02-0.05 \\
5 & None or insignificant & $<0.02$ \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
Class & pH  \\
\hline
1 & Almost neutral & $>6.8$ \\
2 & Mildly acid & 6.5-6.8 \\
3 & Moderately acid & 6.2-6.5 \\
4 & Acid & 5.6-6.2 \\
5 & Very acid & $<5.6$ \\
\hline
\end{tabular}
\end{table}

\textbf{FIGURE 1. Table describing what levels water is acidic.}\textsuperscript{30}

\subsection*{2.2.2 Objectives for liming}
Since the liming began, the aim has been the same. The biological objective is to neutralize the water to protect flora and fauna. The chemical objective is pH levels above 6.0 and an alkalinity higher than 0.05 mekv/l. In 80-90 percent of the limed waters these two objectives have been reached.\textsuperscript{31} The pH- and alkalinity-levels have increased while the content of poisonous metals have decreased, which have resulted in larger populations of different species and an increased biodiversity. In most cases fish population has been favoured while

\textsuperscript{26} http://www.internat.naturvardsverket.se, 2003-06-01  
\textsuperscript{27} SEPA: Handbok 2002:1, p. 15  
\textsuperscript{28} http://www.internat.naturvardsverket.se, 2003-08-07  
\textsuperscript{29} Ibid  
\textsuperscript{30} The table is copied from SEPA: http://www.internat.naturvardsverket.se, 2003-08-09. It is also presented in the book "Bedömningsgrunder för miljökvalitet, sjöar och vattendrag", see references p. 26.  
\textsuperscript{31} SOU 1996:53, p. 23
the populations of species favoured by the acidification usually have decreased or disappeared.  

However, negative effects of the liming have been observed. Most obvious is the damage to mosses and lichens in connection to liming of wetlands. Algal bloom and the rapid increase of vegetation have also been noticed during short periods. Shallow lakes have been overgrown by vegetation that disappears when re-acidification occurs.

2.2.3 Disputes concerning liming of northern Sweden

There is an important difference between the appellations ‘acidification’ and ‘acidic condition’. Acidification is a dynamic process, caused by acid deposition. An acid condition can be a result of acid deposition, but it can also be a cause of natural processes. One example of a natural process that causes acidity is the snowmelt in spring, normally referred to as ‘spring flood’. The spring flood contains half of the yearly flow of water in northern Sweden, and when it flows over thin and frozen soil it does not lead to any interaction, and thereby neutralisation of the water. Hence, the acidity in the waters that are affected by spring flood increases.

Naturally acidic waters should not be exposed to liming, since it threatens the naturally occurring ecosystems. However, even naturally acidic waters can be affected by acid deposition and thereby acidification. State subsidies are therefore handed out even during these circumstances.

Until the 1990’s, it was believed that only the south westerly parts of Sweden were affected by acidification, since the northern regions are further away from the emission sources. But in 1990, a study indicated that parts of Northern Sweden were also acidic, and it was stated that this was a result of acid deposition. Hence, the Swedish government decided to finance liming in the north as well.

The necessity of liming in northern Sweden has been intensely disputed during the 1990’s, since there is no general agreement of the origin of the acidity in these regions. This has resulted in different liming strategies between the county administrative boards in northern Sweden. In 2003, Västernorrland limes with 17 million SEK, Jämtland with 34,1 million SEK, Västerbotten with 24,6 million SEK, while Norrbotten limes with an amount of just 22 000 SEK.

32 SOU 1996:53, p. 37
33 SOU 1996:53, p. 37
34 Warfvinge, 1997, p. 114
35 Ibid, p. 115
36 SOU 1996:53, p. 32
37 Ahlström, 1990
38 http://www.naturvardsverket.se, 2003-04-07
3 Theoretical perspective

The theoretical research for this thesis is the content of two articles written by researchers at the Swedish University of Agricultural Sciences (SLU).\textsuperscript{39} In these articles theories about the administrative handling of the liming programme in northern Sweden are presented.

The authors believe the acidic condition in northern Sweden is a foremost natural occurrence, hence the authors are opposed to today’s extensive liming there. In other words, they are critical to SEPA’s handling of the situation. Therefore I refer to the authors from here on as ‘the critics’.

3.1.1 Environmental risks

The critics express a concern that naturally acidic surface waters in the coastal and inland areas of northern Sweden, especially those of Västerbotten county, have been limed in the mistaken belief that they were significantly acidified by acid deposition.\textsuperscript{40} While natural sources of acidity are important, there is a risk that liming might harm the aquatic ecosystems, the critics say. They go on to state that liming, like most remedial actions, entails environmental risks. According to the critics, healthy - if sparse - acid tolerant biota can be harmed by liming. The liming of wetlands is a clear example of this, they argue, saying that liming destroys important components of wetland vegetation. Thereby the natural wetland is sacrificed in the hope of restoring the natural state of the adjacent watercourse, they say.\textsuperscript{41}

3.1.2 The national guidelines

The critics are strongly opposed to the national guidelines for liming, which they say are written in a contradictory manner:

“While acknowledging that acid deposition is not the only potential cause of a pH less than 6.0, the guidelines go on to state that most such naturally acid waters are also acidified, and that these should be limed back to at least their natural level of alkalinity. This could be interpreted as an authorization of liming to alkalinitities above natural levels. In fact, the final sentence of the guidelines specifies that the pH in Swedish waters should always be above pH 6.0 with an alkalinity of more than 50 µeq L\textsuperscript{-1}. That is tantamount to saying that pH and alkalinity should be raised to levels above what is natural for naturally acid water.”\textsuperscript{42}

An application of a standard for water quality based solely on the generic features of pH and alkalinity, the critics say, will result in incorrect conclusions about the extent of anthropogenic acidification. Such error, they continue, may lead to liming that does not serve to restore the ecosystem to a more ‘natural’ state.\textsuperscript{43}

\textsuperscript{39} Bishop et al. 2001 and Bishop 1997
\textsuperscript{40} Bishop 1997, p. 49-50
\textsuperscript{41} Bishop 1997, p. 57
\textsuperscript{42} Bishop et al. 2001, p. 1417
\textsuperscript{43} Bishop 1997, p. 54
3.1.3 New knowledge ignored

The critics go on to state there is a conflict between geographic generalization and locality in environmental policy, and that it is evident in the Swedish liming programme. The rules for the liming programme are applicable to all of Sweden but they were developed in response to specific circumstances along the west coast of southern Sweden, according to the critics.\(^44\)

The critics explain that little scientific attention was paid to northern Sweden in the 1980’s when the guidelines for liming were established.\(^45\) The importance of organic acids, for example, was not investigated:

"More often than not however, natural organic acidity is simply not considered. A telling example of this is the report on acidification in the mountains and inlands areas of northern Sweden which contributed to a large-scale expansion of the liming programme into the north after 1990. This report presented the chemistry of some 9000 lakes and water courses without making a single mention of organic acidity."\(^46\)

Liming in northern Sweden was initiated because of a lobbying campaign by the county administrative boards and politicians from the northern parts of Sweden in the 1990’s, the critics say. That is the reason, they continue, why the Swedish parliament decided to earmark more funding for liming to the northern counties.

The knowledge about natural impact on the acidity, however, has increased during the 1990’s, the critics say. They claim this new knowledge has been ignored by SEPA. The ten-year plan for liming, developed by SEPA, does not incorporate many of the scientific key advances, they claim. The authors are criticising the plan since it does not foresee a decrease in acidification even in northern Sweden until after 2010, despite sustained deposition declines since 1990. Liming of naturally acidic waters in northern Sweden might therefore increase as a result of this plan, the critics argue.\(^47\)

The reason that these scientific advances have not been incorporated into the ten-year plan, the critics say, could be that not enough time has passed since the publication of the scientific advances. SEPA, however, was involved in these developments and were informed before the results appeared in print.\(^48\)

Further research and evaluation of the data may reduce the uncertainty about the role of surface water acidification in northern Sweden, the critics argue. They state that environmental policy-makers can rarely wait for scientists to resolve their differences before making a decision.\(^49\)

\(^{44}\) Bishop 1997, p. 51-52
\(^{45}\) Bishop et al. 2001, p. 1415
\(^{46}\) Bishop 1997, p. 53
\(^{47}\) Bishop et al. 2001, p. 1420
\(^{48}\) Bishop et al. 2001, p. 1418
\(^{49}\) Bishop 1997, p. 56
4 Material and methods

The material I am using contains two different sources: articles and interviews. The research articles have been analysed by content analysis and the interviews have been of a qualitative approach. To use more than one information-collection technique can be referred to as ‘Triangulation’.50

4.1 The research articles

The publication of articles in peer-review journals is the final outcome of most natural scientific research. For many scientists it is proof of international scientific acceptance and credibility, as well as an insurance of recognition, especially among the members and representatives of the research field in question.51 Therefore I consider this medium as a good source of information on this matter.

4.1.1 Searching for relevant articles

The search for relevant articles was done by searching through natural science databases. The databases were selected according to the subject examined. I limited the searching to three databases: Science Citation Index, Science Direct and Biological Abstracts. The search profiles were “Sweden AND (acidification OR liming)” and “(spring flood) AND Sweden”. The criteria I used for the selection of articles was:

- Do they suggest anthropogenic or natural sources to the acidity in northern Sweden, and in which case, on what basis?
- Do they present any methods developed for estimating the origin of the acidity?

The articles of relevance were then selected, 16 in total. Hence, this study could be referred to as a pilot study, which could be enlarged, for example by including further databases.52

4.1.2 Content analysis

The research articles content was conducted by content analysis. Content analysis is employed when the content of textual material is quantified in a systematical and replicative fashion, by categories designed in advance.53 This method is suitable when investigating the presence of specific phenomenon, and it is very efficient when analysing wide range material.54 In this case, I wanted to distinguish a pattern in the research articles, based on the two questions mentioned above. To get an overview, I developed a code scheme. A code scheme is a tool when utilizing content analysis, which indicates what factors should be observed in the material.55

50 Christensen et al. 2001, p. 166
51 Benyamine, 2002, p. 18
52 Bergström and Boréus, 2000, p. 51
53 Bryman, 2002, p. 192
54 Nilsson, 2000, p. 111
55 Bergström and Boréus, 2000, p. 50
4.2 The interviews
SEPA’s relation to research has been studied through interviews with three civil servants within the agency. The interviewees are all working directly with the acidification and liming issue on a daily basis, although in different departments. By interviewing these individuals, the possibility of getting a more rounded picture of SEPA’s movements on liming and acidification in Sweden, and thereby its relation to scientific research on the matter, is considered sufficient.

It should be stressed that interviews can never supply one with the exact representation of the people you are studying, in this case the organisation that presents itself as SEPA as a whole. The generalization of the interviews thereby depends greatly on the selection of the interviewees, and how much their opinions correspond with the organisations.\(^{56}\) Hence, the interviews utilized for this study should not be seen as representative for the whole agency, they only contribute with further understanding and reflection.

4.2.1 Finding interviewees
In order to know which people to contact, I simply wrote an e-mail addressed to SEPA, and was then referred to two of the interviewees. One of these two suggested me to interview a third person, with the motivation it would supply me with a more accurate picture of the way SEPA is working with the acidification.

4.2.2 Qualitative interviews for studying SEPA:s relationship to science
The interviews were carried out through a qualitative approach, since the focus then can rest on the subject matter’s entirety.\(^{57}\) The objective of the qualitative interviews is to receive a more balanced description of the world surrounding the interviewees.\(^{58}\) In this case, it is of interest to see the way involved individuals at SEPA argue the agency’s actions.

The interviews were then conducted through a semi-structured approach. A ‘semi-structured’ interview is an interview technique where the content, as well as the order of questions and topics discussed varies between each interview. This sort of interview does not only focus on why or how something has occurred, it also investigates the underlying causes, and motives. You could say it has an explorative purpose, since the interviewer has the possibility to add attendant questions and the interviewee can make her or his answers clearer.\(^{59}\)

To maintain structure, an ‘interview guide’ was employed.\(^{60}\) During the interviews I had a list - an interview guide - with questions that should be discussed during the interview. The interview guide contained following questions:

- What is SEPA:s relation to research, and how is SEPA working actively with the research?
- What is considered as a reliable foundation concerning decision making on liming?

\(^{56}\) Christensen et al, 2001, p. 109  
\(^{57}\) Christensen et al, 2001, p. 160-165  
\(^{58}\) Kvale, 1999, p. 36  
\(^{59}\) Christensen et al, 2001, p. 166  
\(^{60}\) Christensen et al p. 165
- How do you interpret natural acidity, and how is it taken into consideration?
- Is there a strategy, and in which case, what strategy is proposed by SEPA for developing the Assessment Criteria for Environmental Quality (SEQC)?

The interviews were carried out separately at SEPA in Stockholm, to make it as easy and as comfortable as possible for the interviewees. The interviews were recorded and later transcribed for my own reference.

Following the interviews, the interviewees were given a transcription so they could check for misquotation and thereby verify and approve the material before it was utilized in this study. One author suggests that the interviewees should not be given this opportunity, since they then might question the interviewers interpretations. However, I believe though it is of great importance to let the interviewees correct and clarify any misinterpretations and any areas of confusion in the interviews content after it is completed. I believe it increases the reliability of the study.

5 Results

5.1 The content of the articles

To represent the research of the acidity in northern Sweden, 16 research articles were selected, all describing, in one way or another, the acidity in northern Sweden. My aim with studying the research articles was to identify the opinions of the researchers on the acidification issue. In the code scheme I added variables that are of interest to my study, to clarify what the researchers believe affects the acidity in northern Sweden (TABLE 1). The articles matching the selection criteria are compiled in TABLE 2.

### TABLE 1: Code scheme for analysis of the factors contributing to the acidity in northern Sweden.

<table>
<thead>
<tr>
<th>Sampling unit</th>
<th>Recording unit</th>
<th>Variables</th>
<th>Categories</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 articles discussing the acidity in northern Sweden</td>
<td>An article</td>
<td>Factors contributing to the acidity</td>
<td>Acid deposition</td>
<td>AD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Organic acids</td>
<td>OA</td>
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<td>Geology</td>
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<td>Sulphate</td>
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<td>Total organic carbon</td>
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</table>

### TABLE 2. Articles suggesting factors that determine the acidity in northern Sweden.\(^{62}\)

<table>
<thead>
<tr>
<th>Article</th>
<th>AD</th>
<th>OA</th>
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<tr>
<td>Ivarsson and Jansson, 1994a(^{1, x})</td>
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<td>Ivarsson and Jansson, 1994b(^{1, x})</td>
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<td>Laudon and Hemmond, 2002(^{2, 3})</td>
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<td>Krám et al., 2001(^{2, 6, x})</td>
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<td>Laudon et al., 2001(^{3, x})</td>
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<td>Laudon and Bishop, 2002a(^{2, x})</td>
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<td>Bishop et al., 2000(^{7, x})</td>
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<td>Laudon et al., 1999(^{2, x})</td>
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<td>Korsman, 1999(^{1})</td>
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<td>Warfvinge et al., 1995(^{8, 9, 10, x})</td>
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<td>Kullberg et al., 1993(^{1, 2, 11})</td>
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\(\text{AD} = \text{Acid deposition}\)
\(\text{OA} = \text{Organic acids}\)
\(\text{Ge} = \text{Geology}\)
\(\text{St} = \text{Sulphate}\)
\(\text{SF} = \text{Spring flood}\)
\(\text{Hu} = \text{Humus}\)
\(\text{TOC} = \text{Total organic carbon}\)

\(^{1}\)University of Umeå, \(^3\)SLU, \(^4\)IVL, \(^5\)ITM, \(^6\)Massachusetts Institute of Technology, \(^7\)Czech Geological Survey, \(^8\)County administrative board of Jämtland, \(^9\)Lund Institute of Technology, \(^10\)County administrative board of Kopparbergs län, \(^11\)University College of Karlstad, \(^11\)University of Lund.

\(^{62}\)Financial support by SEPA

5.1.1 Majority suggesting natural acidity

In 15 of the 16 articles, the authors express that acid deposition only has a marginal impact on the acidic condition in the waters of northern Sweden. Instead, the authors suggest that other, natural sources are contributing. In five of those 15 articles, an Episode Model for quantifying the acid deposition during spring flood is presented.\(^{63}\) In only one article (Edberg et al., 2001), no statement against the influence of acid deposition is made.

5.1.2 The role of acid deposition

According to Laudon and Hemmond (2002), the acid deposition has decreased by 50 percent between 1990 and 1999. They argue that reduced emissions of acid substances have generated significant improvements in the surface water chemistry during episodes associated with spring thaw in northern Sweden. They also argue that the declining anthropogenic acidification component during spring flood is demonstrated to be directly proportional to a decrease in sulphuric deposition in individual catchments over the course of a decade.

Laudon et al. (2000) sought to distinguish the anthropogenic and natural factors that drive episodic pH decline in Sweden, by analysing samples from 12 streams during the spring flood run-off of 1997–1998. While further quantification of the human impact on the spring thaw chemistry is important,

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\(^{62}\)Four articles are not suggesting any factors in the table. The authors of these articles are though focusing on the Episode model (see p. ?), and claim that the majority of the acidity in northern Sweden is natural.

\(^{63}\)Laudon and Hemmond (2002), Laudon and Bishop (2002b), Laudon et al. (2001), Laudon and Bishop (2002a), Bishop et al. (2000)
they argue, it is clear that a substantial pH decline during spring thaw episodes is a natural feature of the boreal ecosystem and not only a result of acid deposition.

Laudon et al. (2001) argue that there is a strong correlation between acid deposition and anthropogenic acidification during the spring flood. They have studied the natural preindustrial ANC and pH decline associated with 11 streams during the spring flood of 1997 and 1998 in northern Sweden by using the Boreal Dilution Model. According to them, the anthropogenic component probably was significantly higher (ca 100 percent) a decade ago when the deposition was more than twice the current level. Their conclusion is that the regional impact of anthropogenic deposition to the ANC and pH in northern Sweden is currently limited.

Krám et al. have applied a geochemical model on lake Aborrträsket in Västerbotten county, to simulate biogeochemical patterns. Their conclusion is that the atmospheric deposition can be consistent with the slight changes in lake water pH indicated by a diatom record.

Laudon and Bishop (2002a) quantified the sources of episodic pH decline in four streams in northern Sweden during the autumn of 1996. The export of sulphate during the episodes was two to nine times higher than what was expected from deposition only.

Laudon and Bishop (2002b), studied the correlation between sulphuric concentration in snow and the anthropogenic component of spring flood ANC decline, mean that the failure to account for episodic response greatly underestimates the immediate benefits of reducing acid deposition.

Laudon et al. (1999) state that the acid deposition in the forested headwater catchment at Västrabacken only made a minor contribution (5-8 percent) to the ANC and pH decline during the spring flood of 1997. The pH decline from approximately 6.4 to 4.6 was, according to an ANC dilution model, driven almost exclusively by organic acids originating from the soil and dilution by low ionic strength snowmelt water. The authors state that a large pH decline and aluminium decrease in relation to the spring flood can be a natural property of the boreal ecosystems, something that the aquatic life has adapted to over thousands of years.

Fölster and Wilander (2001) have investigated trends of water chemistry between 1985-1998 in 13 streams in both northern and southern Sweden. They argue that if difference to the southern part of Sweden, any changes to water chemistry in northern Sweden can be attributed to natural variation in climate and marine influence, and the effect of anthropogenic acidification is negligible.

Ivarsson and Jansson (1994a) studied the highly acidic River Lillån in the coastal zone of central northern Sweden, and according to them, there are reasons why the acidic conditions in northern Sweden may have other sources than atmospheric deposition of acidifying substances. The atmospheric loading of sulphate and nitrate in the studied stream is rather low compared to heavily polluted areas in the southwest of Scandinavia and central Europe.

Ivarsson and Jansson (1994b) studied eight large rivers between the Gulf of Botnia and the Caledonian mountain range in central northern Sweden, to explore the factors that are controlling the acidity in running waters. They claim that the acid conditions in northern Sweden are of mostly natural origin.
Warfvinge et al. summarizes conclusions from a workshop on natural versus anthropogenic acidification arranged by SEPA in 1995:

“It was shown that organic substances have a key role in determining the acidity in surface waters in the region, although anthropogenic effects are documented in some boreal systems and in the southern mountain range. /…/
It appears clear that many surface waters that were naturally acidic have been limed to unnatural pH levels.”

Edberg et al. (2001) studied 13 streams in the province of Jämtland in northern Sweden during spring 1995, to see changes in water chemistry and metal concentrations during snow melt. They say that changes in the biological and water quality conditions have occurred over the last 30 years. The most profound changes are reduced densities of brown trout and an increase in watercolour. During the acidic episodes some metals were released, and the concentrations of Al, Zn, Pb, Cu and to some extent Mn, were increased.64

5.1.3 Natural factors
Ivarsson and Jansson (1994b) claim that acid episodes during the summer and the autumn, when the lowest pH-values of the year occurs are entirely caused by organic acids:

“Organic acids are the most important single source followed by sulphate from geological sources while the impact from acid atmospheric deposition is small.”

Laudon et al. (2000) agree. Natural organic acids and dilution of the buffering capacity play an important role in depressing the spring melt buffering capacity and pH in the region:

“In only three of more than 22 events studied was the anthropogenic contribution to pH decline as large as the natural contribution.”

Ivarsson and Jansson (1994a) claim that apart from acid episodes, acid conditions, in the sense that they constitute a problem for biota, do not exist in the highly acidic River Lillån. The pH values and the alkalinity during low flow periods in the summer and in the winter are thus well above the limits constructed to define waters as acidified and in need of restoration in Sweden. In river Lillån, the episodic acidity appears to be governed mainly by organic and sulphuric acids in combination with dilution of base cations, and the authors identify this dilution as being by far the most important factor in explaining the drop in pH:

“Since the atmospheric loading of anthropogenic sulphuric acid in the River Lillån catchment is among the highest in northern Sweden, the study in River Lillån suggests that the importance of atmospheric pollution for acid episodes in the spring has been strongly overestimated in northern Sweden in general and that organic acids are more important than previously believed.”

64 The authors do not mention whether this is caused by natural processes or by acid deposition, but I am assuming their hypothesis is that acid deposition has lead to the biological changes since they stress that changes have occurred during the last 30 years. Therefore I placed the article in the acid deposition column in the code scheme.
They argue that the sulphate export from the catchment is considerably higher than the input from the atmosphere. This is remarkable, they say, since there is generally a significant retention of atmospherically derived sulphate in the soils of northern Sweden. Although they add that the severely reduced buffer capacity means that comparatively small amounts of acid can lower the pH. Therefore, the possible role of sulphate-derived acidity during the snowmelt must be emphasized.

Laudon and Bishop (1999) investigated the effects of dilution organic acids and strong mineral acids for five rivers in northern Sweden during spring floods of 1994-1995. They conclude that some degree of ANC depression is natural in the spring flood of many boreal catchments.

Laudon and Bishop (2002a) believe that the large export of sulphate is most likely due to the oxidation of natural sulphate bearing minerals in the soil and previously deposited sulphate driven by the low groundwater level preceding the episodes.

5.1.4 Geology
According to Ivarsson and Jansson (1994a), the bed-rock and soils in northern Sweden are poor in base minerals and comparatively rich in sulphides, which may be a significant source of acidity. If the geological background is underestimated, they argue, the portion of sulphur derived from anthropogenic sources can be considerably overestimated when taken as the difference between the present day concentration and the estimated background (1994b).

Korsman (1998) has studied the changes in lake water pH, alkalinity and watercolour by studying diatoms in sediment samples from pre-industrial times from 118 lakes in northern Sweden. His conclusion is that presently acidic lakes have faced a long-term acidification trend over several thousand years due to soil-forming processes and vegetation development. However, due to the acidic sensitivity of the region, future acidification trends in northern Swedish lakes should be very closely observed and assessed.

5.1.5 Land usage
Korsman (1998) suggests that land-use affects the acid base chemistry of the northern Swedish lakes. There have been substantial changes in land-use in northern Sweden, involving both natural and man-induced re-forestation of agricultural land, and cessation of former agricultural practices, such as forest grazing and burning for pasture improvement. This result in changed soil conditions and run-off from the catchments.

Ditching operations, common in northern Sweden during the 19th century, can, according to Korsman (1998) also may have lead to a decrease in pH-levels. A pH decrease in the lake Blämissusjön from past values between 6 and 7 to the present value of ~3, has been estimated from earlier sediment based analysis. This decline was caused by oxidation of sulphides in the marine sediments of the catchment area, which took place due to an extensive ditching operation in the 1940’s.

Korsman (1998) claims that the currently acidic lakes have faced a long-term acidification over several thousand years due to soil-forming processes and vegetation development. However, due to the acid sensitivity of the region, future acidification trends in northern Swedish lakes should be carefully observed and assessed.
5.1.6 Humic substances and TOC
Other causes were also suggested in the articles. Ivarsson and Jansson (1994a) claim that the high concentrations of aluminium in River Lillån are probably not a result of the anthropogenically induced release of aluminium from the earth, as in atmospherically acidified areas, but rather a natural characteristic linked to the high concentrations of humic substances.

Kullberg et al. (1993) mean to say that humic substances may buffer against acidification, but may also add acidity to the surface waters. This they say, might be an important factor in the northern part of Sweden, whereas further south pH is primarily attributed to anthropogenic sources.

Laudon and Bishop (2001) quantified the sources of episodic pH decline in four rivers in northern Sweden during the autumn of 1996. TOC was, according to them, the major source of pH decline associated with both rain driven and snow driven hydrological events in the region.

Laudon et al. (2001) state that the most important factors driving the natural pH decline were TOC increase in combination with ANC dilution. However, they believe, even marginal anthropogenic sources of acidity in addition to the natural pH dynamic could, of course, lead to more toxic levels of acidity in sensitive systems and hence create negative consequences for the biological diversity.

5.1.7 Method for quantifying the anthropogenic contribution to the spring flood
Five of the articles (Bishop et al 2000, Laudon et al 2001, Laudon and Bishop 2002a+b, Laudon and Hemmond 2002) are presenting an Episode Model (the Boreal Dilution Model). This model is developed by researchers at SLU. According to SLU, the Episode Model makes it possible to quantify the anthropogenic contribution in areas that are not chronically acidified or where the degree of base flow acidification can be assessed. The results of the Episode Model show that the anthropogenic contribution is marginal. Laudon et al. (2001) suggest that the anthropogenic component was more important a decade ago when the deposition load was substantially higher. Bishop et al. (2000) recognize that the model can not provide exact results, but gives an indication of the anthropogenic impact:

“Even if there is a degree of uncertainty in the results of the BDM, trends in space and time of anthropogenic and natural acidity during spring flood will have a value in their own right.”

5.2 The interviews
The interviewees, Roger Sedin, Torbjörn Svenson and Håkan Marklund, are working in three different departments of SEPA. Sedin works at the Environmental Assessment Department. He is working with reforming of the Swedish Environmental Quality Criteria (SEQC) in lakes and watercourses. Svenson is coordinating the liming activity at the Department of Natural Resources. Marklund is responsible for the monitoring of freshwater at the Department of Environmental Monitoring.

5.2.1 SEPA’s strategy
On the matter of SEPA actively working from research, Sedin explains that SEPA does not perform research on its own - instead the agency consults various research institutions and commissions investigations.
5.2.2 The research institutions
On the subject of acidification, SEPA mainly consults the Swedish University of Agricultural Sciences (SLU), the Institute of Applied Environmental Research (ITM) at Stockholm University and the Swedish Environmental Research Institute Ltd (IVL), Sedin says.

According to Sedin, SLU and ITM are studying the acidification issue through different perspectives. When assessing the effects and the origin of the acidic condition during the spring flood, SLU call more attention to classical parameters like water chemistry while ITM are more focused on metals, for example inorganic aluminium. Naturally, Sedin says, they interpret the problem differently. In the ongoing debate, he continues, SLU and ITM are not really opposed to each other directly. The debate has rather taken place between SEPA, the county administrative boards and the researchers, involving the media and so on, Sedin says. The county administrative boards have then chosen to rely on the institution whose results match their interests, he adds.

Sedin says there have been a lot of discussions within the agency as well. The fact that one department coordinates the liming activity (Department of Natural Resources) while another is working with the guidelines for assessment of acidification (Environmental Assessment Department) creates problems, which can only be solved with more cooperation between the departments. SEPA has though improved its handling of this debate, he adds. A few years ago, it was not as diplomatic as it is today. Sedin means that the debate matured. He adds that SEPA is keeping a low profile in the debate.

5.2.3 Reliable foundation
According to Svenson, most of the incoming material derives from the consulted research institutions, and the material has therefore been through many stages before reaching SEPA, he says. SEPA, Svenson says, simply wants to hear the opinions of the researchers, evaluate and compare it with other existing views. When developing the SEQC, knowledge and experience from both research and liming in practice are utilized.

5.2.4 The initiating of liming in northern Sweden
When the reports came from the county administrative boards there was a panic situation, Svenson says. The county administrative boards saw that there had been important changes in the biology, so there was reason to believe that it was the result of acid rain, he says. Svenson says that in the start, mainly water chemistry was observed. The knowledge about the biology was very limited, he says. The budget was small, he continues, and no guidelines on biology follow-ups after liming were presented by SEPA, which resulted in the county administrative boards did not do their analysis in the same fashion. The necessity of liming in the northern regions clearly showed the need of new guidelines on estimating acidification, Svenson adds.

In the early 1990’s, Svenson continues, the debate on whether northern Sweden should be limed or not, was intensive. The county administrative boards demanded liming grant from the government. SEPA suggested that the liming should start at a low level, and that all of the liming grant should not be given out at once, instead increase gradually. Then there would have been better opportunities to develop a better organisation of the liming in northern Sweden, who could give the county administrative boards advice based on real
experience. But 1991 was an election year, and the county administrative boards wrote directly to the government, demanding grant for liming. The government then gave SEPA the amount SEPA had suggested to be released gradually, and above that the government added ten million SEK. SEPA’s suggestion that the money should only be handed out gradually was ignored, and SEPA simply had to hand the money out to the county administrative boards at once. In one year, the total liming grant increased by 60 million SEK, from 120 million SEK to 180 million SEK, because of the liming in northern Sweden. That is where the problem actually started, Svensson says, and agrees with the researchers who are criticizing this.

“There you can give the researchers the right to criticize. From the outset it was too aggressive, and and resulted in some mistakes... The liming of wetlands started sometomes off on the wrong foot, and I think some natures values were destroyed, which could have been avoided with patience and proper research.”

5.2.5 Natural acidity

There is no doubt the interviewees are very aware of the complexity of the acidic condition in the waters of northern Sweden. Sedin says that the ultimate solution would be to have an objective for every specific lake.

“There should be a separate liming objective for every single lake, based on its natural condition. This has to be the starting point, because as far as I can see it, the liming grant is written... to stop acidification – it should not be aimed at the protection of good fishing and salmon and so on... it should be natural.”

When liming of lakes and watercourses started, Sedin continues, the goal was to protect valuable fishing waters. Today the liming grant is meant to neutralize the acidification with the purpose to protect biodiversity, not to protect good fishing. Therefore, Sedin continues, a lot of waters that are naturally acidic are probably limed.

“Personally, I think that it should not be like this, not with state subsidies, and I would suppose that it is something that everybody has felt... We have to realize that this has not been dealt with in the best way, partly on the national level. Partly because of lack of knowledge and... there are explanations but... this has to be solved.”

5.2.6 Industry

According to Sedin, liming today is a big industry, deeply dependent on the liming grant. There are enormous interests in thinking that the natural acidification is nothing to care about, and that lime should be used everywhere. Many people profit from the liming activity and the industry surrounding it. The liming has nearly become a matter of public interest as well, Sedin adds. People know that lime is used to reduce the effects of acidification, and if the state decides to stop it anywhere, they interpret it as if the state just wants to save money.

At the Department of Natural Resources, Sedin continues, they receive postcards from children begging for their lake not to die because of stopped

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66 Roger Sedin 03-04-16
67 Roger Sedin 03-04-16
liming. There are surely politicians who think that liming is good, and then they are pressed by lobbying groups, Sedin says. It is quite interesting he adds, that the liming has increased in northern Sweden while the acid deposition has decreased.

5.2.7 Quality instead of quantity
The Department for Environmental Analysis, have really tried to reduce the number of new liming objects, Sedin says. His department have agreed with the Department of Natural Resources that the quality of the liming activity should be improved, rather than the quantity. Svenson says that just because the acid deposition has decreased, it does not mean that the effects of the acidification have disappeared, even if it has started to improve in some places. Another thing, he adds, is that the liming at the start was not of the same quality as today. The liming today is more efficient, something that has also lead to bigger costs. Costs have also increased, he adds. It is the amount of lime that is of interest in this case, not the money.

5.2.8 Increased knowledge
Svenson says that knowledge has grown, though it is still undetectable in SEPA’s guidelines for liming. When it considers the complexity of the spring flood in northern Sweden, SEPA has supported an Episode Model (The Boreal Dilution Model), developed by researchers at SLU. According to SLU, this model makes it possible to quantify the anthropogenic contribution to the spring flood from the natural contribution.

The Episode Model has been a subject for intense discussions both within as well as outside the agency. There is still no general agreement between the county administrative boards about the model’s reliability. Sedin believes that one reason for the scepticism towards the Episode Model is the consequences it implies. Liming is a big industry and it involves a large amount of money. According to the model, the amount of lime that is spread in the waters of northern Sweden today is far too excessive.

Marklund acknowledges the problem of there being no general agreement on the Episode Model. But the question is, he says, if you actually want to plan the whole liming activity with models that you cannot verify. Sedin, on the other hand, means that it would have been better if the model would have been presented in the liming handbook, and thereby something to lean on until something new is coming up. After all, he says, the Episode Model is scientifically investigated. Svenson agrees, and says that that was the opinion of himself and his colleagues on the Department of Natural Resources also. Svenson goes on to explain that the superiors of the department were of a different opinion. They simply thought it would mislead people, if SEPA had presented the model in the handbook. To publish and suggest a scientific model that is not proven, could lead to SEPA withdrawing the model, which would affect the credibility of the entire agency.

5.2.9 Vague orders from SEPA
The fact that the SLU and ITM view parts of the acidification problem differently has been a big problem when consulting these two institutions about the acidification issue, and of course it slows down the developments of the

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environmental quality criteria for lakes and watercourses, says Sedin. Sedin and Svenson both agree that the instructions from SEPA have been too vague.

“We have great use for the researchers, but I think that SEPA has to dictate concise specific orders to the researchers, something that SEPA has not previously done consequently. The questions have been too vague, and of course the researchers can then interpret them the way it suits.”

Researchers are basically like consultants, Sedin declares. Why would one institution praise another institutions research, when it would lead to less subsidies for its own institution? Svenson agrees, and believes there is a lot of prestige involved in the scientific community, and that finding the truth is not necessarily as important as the image for these researchers. According to Svenson, SEPA has had great use for the researchers, but the assignments that the agency hands out must be a lot clearer, he says.

5.2.10 Cooperation between the institutions
According to Sedin, there is huge pressure within SEPA to develop a SEQC that can actually be utilized. The debate is tiring for the individuals involved in the agency, and with a good SEQC, that is accepted by all, it would cease. He says that the only possible way to develop a new SEQC that are generally accepted, is to make the research institutions agree. Both Sedin and Svenson believe that it is possible for the research institutions to do so. Svenson says that when hearing the research institutions discussing the same problem, they use different terminology, but in the end they are of the same opinion. What they have done so far, he goes on to say, is that they have chosen to highlight a specific part of the acidification issue and then argue with each other about their findings. Marklund agrees, saying that the researchers seem to argue about the differences in their results, rather than the similarities.

This cooperation between the institutions and SEPA is now in its first stage. During the summer of 2003 there will be preparations. Among other things, SLU and IVL will carry out a prognosis of the relevance of the coming spring floods during 2000 and 2020, something that will be crucial if the spring flood will be a part of the coming SEQC. In September 2003, SEPA will arrange a workshop with among others IVL, ITM and SLU, aiming to make them agree about what research projects that must be done.

One example proving that it works to cooperate between institutions is the IKEU-project (Integrierad Kalknings Effekt Uppföljning). IKEU is a programme involving, among others, researchers from SLU and ITM. The aim of the programme is to follow up the effects of liming, but the problem, according to Svenson is that it has not produced the answers that SEPA needs. Hence, the programme has been criticized for its costs: 7-8 million SEK yearly. According to Svenson, IKEU has been more of a monitoring programme, studying the way biology, water chemistry and metals are affected by liming, and trying to make conclusions from comparisons with un-limed waters and thereby the differences and similarities between limed and un-limed waters. According to Svenson, it should rather study how to develop the efficiency in the liming activity, e.g. whether it is better to lime in tributary water than the lake itself.

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5.2.11 Varied strategies between the county boarders

According to Svenson, the SEQC is meant to be the standpoint of the SEPA when it comes to estimating the acidification within a given area. Sedin says that the SEQC is not really utilized today within the county administrative boards because of the vague definitions of how to actually measure acidification. The county administrative boards therefore choose to rely on the scientific result that suits their own opinions about acidification and liming, which leads to completely different liming strategies between northern county borders. The county administrative board of Norrbotten for example, uses the Episode Model and recommends it, while other county administrative boards, e.g. Västerbotten, do not find the model reliable and disregard it. According to Sedin, it is a catastrophe that two completely different strategies are being used. There simply has to be national guidelines recommending specific strategies for the liming, he says.

5.2.12 The European Water Framework Directive

Marklund believes that the European Water Framework Directive will help to set agreements on liming activity in northern Sweden. According to the directive, measures will be employed within the drainage area, and not only within the county boarders like today. This is very good, says Marklund. The liming activity has to be characterized by a comprehensive view. Of course this will lead to conflicts within the district. When the liming boarders change, there will be different priorities, and some waters that are now being limed might not be of priority within the districts, and vice-versa.

6 Discussion and conclusions

In this section, theory is compared with the results of the analysed material. At the end, some final conclusions are presented.

6.1.1 The generalization of the liming programme

The frustration among critics of the liming in northern Sweden is obvious. Despite scientific advances during the last 13 years, the liming policy remains unchanged. SEPA’s generalization of the liming programme has been widely criticised, as shown in the theory section. The critics claim that naturally occurring species have been sacrificed, and that environmental policy-makers can rarely wait for scientists to resolve their differences before making a decision.

6.1.2 Ill-prepared start

Svenson says the sacrificed species are a result of the extensive initial heavy handed phase of the liming in northern Sweden. Knowledge about the acidic condition was lacking, and since the acidification was a definite in south westerly Sweden, it was easy to believe the acidity in northern Sweden was caused by acid deposition also.

Despite SEPA’s advice to start liming in northern Sweden on a small scale, the government decided to earmark a vast budget for the northern counties. I believe this was a foolhardy act from the government, and I believe it was the start of the whole conflict. If liming would have been initiated on a small scale,
according to SEPA’s advise, growing knowledge would probably have saved many ecosystems from higher pH levels that they were not adapted for.

6.1.3 The credibility of SEPA

It seems rather strange that SEPA has not incorporated many of the scientific advances presented in this study into the liming policy - the number of research articles opposed to extensive liming in northern Sweden speaks volumes.

Researchers mainly from SLU, but also from other institutions, employ different methods, but come up with the same conclusion: the acidity in northern Sweden is mainly of natural origin.

These results appear to be far more reliable and well researched than the current basis for the liming policy, which says that waters with pH levels below 6.0 and alkalinity below 0.05 mekv/l are affected by acidification - and therefore should be limed.

Bishop et al. (2001) write that it may be that not enough time has passed since the publication of these scientific advances for them to be included in policy documents. However, SEPA were involved in these scientific developments and informed before the results appeared in print, they add. This is true - SEPA financed most of these developments, but there has to be something else behind SEPA’s actions.

The interviewees acknowledge the inaccuracies of the policy. When hearing their views on the current liming policy, the actions of the agency are more understandable. The liming activity in northern Sweden today is dependent by the state budget. Liming has become an industry, and many jobs are involved. This study does not cover the importance of lobbying today, only speculations can be made on that.

The most important reason for there being so few of the scientific advances mentioned actually being implemented into the liming policy, I believe - is that SEPA simply does not want to risk its credibility. There is no clear evidence about the impact of the anthropogenic acidity in northern Sweden. By adapting the current liming strategy to the scientific developments that have been achieved during the last 13-14 years, there might be a risk that SEPA would have to change its policy.

7 Conclusions

When comparing the content analysis with the interviews carried out with employees of SEPA, three conclusions stand out. For the first, scientists at the research institutions and the civil servants at SEPA speak on different terms and have different priorities. Secondly, scientific investigations do not necessarily lead to widespread acceptance. And thirdly, the credibility of SEPA is at stake.

7.1.1 Different terms

While the researchers job is to be critical, and produce unbiased scientific results, the employee of the responsible authority has to take a lot other aspects into consideration when suggesting strategies to high level directors. New scientific results must be compared with existing research and empirical experience, in this case from liming. Naturally, these two groups view the problem with acidification and liming in northern Sweden differently, because of their different stand points. Difficulties stem from the differing positions and
the associated responsibilities and implications of making these weighty decisions.

7.1.2 Scientific reliability
Despite the fact that the conclusion of the majority of the articles covered in this study claim that the majority of the acidity in northern Sweden is of natural origin, and despite the Episode Model is scientifically derived, there is still no general agreement for the liming in northern Sweden being reduced. This proves that scientific investigations do not necessarily lead to acceptance and then action. A scientific result can never be objective enough to be considered reliable by all, at least not in circumstances like these. Interpretations of what causes the acidic conditions and what impact it has on the biology are many, depending on what facts you choose to look at.

7.1.3 The credibility of SEPA
There are many ways you can interpret the acidification, and before SEPA decides to change the liming policy, there must be more evidence speaking for the marginal contribution of the anthropogenic acidification, as well as its impact on the biology. If the liming strategy would be adapted to the results shown in this study, there would be, at least theoretically, a risk that SEPA would have to take it all back, and SEPA cannot risk its credibility on such sensitive matters.

The liming of northern Sweden has become more than a simple case of ‘should we or shouldn’t we’; after so much conflicting research and discussion, there is a thick layer of underlying politics, etiquette and responsibility to consider.

7.1.4 Strategy for the future
I believe that cooperation, foremost between ITM and SLU, would improve the situation. Until now, these institutions have been opposed to each other in the debate, since they choose to lean on different perspectives when it comes to examining acidification in northern Sweden. As they continue to perform independent research with undefined orders from SEPA, they are focusing on what they disagree on, and not what they actually do agree on.

It is impossible that an institution performing research on its own can come up with an ultimate, all-encompassing solution to the problem. This is not guarantied if the institution is cooperating with others either, but I believe it would result in a more educated understanding of the problem.

Cooperation between ITM and SLU will also hopefully lead to a more united strategy in the northern counties, since the research results would likely be more integrated. Another factor that probably will contribute to a more united strategy in the northern counties, I believe, is the European Water Frame directive, which will lead to the liming activity being dealt with within the catchments instead of the county boarders.
8 Wordlist

ANC
Acid Neutralization Capacity

IKEU
Integrrad Kalknings Effekt Uppföljning – programme following up the effects of liming.

ITM
Institute of Applied Environmental Research, Stockholm University

IVL
Swedish Environmental Research Institute Ltd

NOK
Norwegian Crowns

SEK
Swedish Crowns

SEPA
Swedish Environmental Protection Agency

SEQC
Swedish Environmental Quality Criteria

SLU
Swedish University of Agricultural Sciences

TOC
Total Organic Carbon
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