

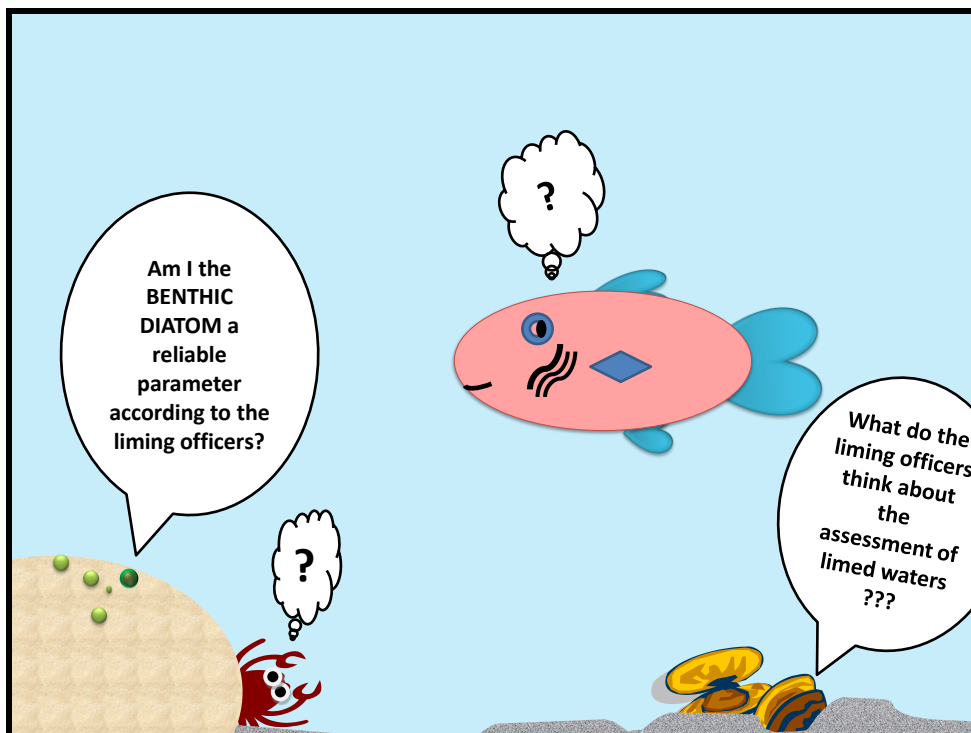
The Swedish Liming operation

- A Study about the liming officer's opinions in some aspects regarding Ecology, Economy and Organization.

Den svenska kalkningsförvaltningen

- En studie om kalkningshandläggares åsikter i några aspekter rörande Ekologi, Ekonomi och Organisation.

Rebecka Karlsson



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Credits: 30 hec

Level: Advanced A2E

Course title: Independent project in Environmental Science – Master´s thesis

Course code: EX0431

Programme/education: Integrated Water Resource Management

Place of publication: Uppsala

Year of publication: 2013

Cover picture: Rebecka Karlsson

Online publication: <http://stud.epsilon.slu.se>

Keywords: acidification, county administrative boards, liming

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Sammanfattning

Detta är en studie om kalkningshandläggares åsikter om den svenska kalkningsbedömningen med fokus på några aspekter rörande ekologi, ekonomi och organisation. Dessa aspekter har bland annat valts eftersom handledningen för bedömningen av kalkade vatten nyligen har ändrats. Förändringar av beslutsprocesser och en neddragning av budgeten för kalkningen har föreslagits. Och pågrund av komplexiteten i hur försurningen påverkar ekologin. Studien gjordes för att få kunskap om kalkningshandläggares åsikter för att bättre kunna möta deras behov när det gäller bedömningsverktyg och även undersöka om andra saker rörande kalkningsverksamhet kan förbättras. Studien är också ett led i att öka möjligheten att ta tillvara aktörers kunskap, åsikter och erfarenheter i relation till den naturvetenskapliga forskning som pågår om försurning och kalkning. Studien bygger på en enkätstudie som gjordes 2010 och en intervjustudie som gjordes 2012-2013.

Resultatet visar att åsikter om kalkningsdoser har förändras mellan enkätstudien och intervjustudien. Ett flertal kalkningshandläggare ser möjligheten till ytterligare neddragningar av kalkningsdoser om de görs systematiskt och baseras på adekvat kunskap. Majoriteten av kalkningshandläggarna ansåg att arbetsuppgiften med att utföra försurningsbedömningar som svår under 2010, och användandet av den nya försurningsbedömningen som tidskrävande och osäker. När kalkningshandläggarna tillfrågades om användbarheten av olika parametrar värderades alkalinitet och mätning av färg före kalkning högt. Fiskdata ansågs tillförlitlig, men osäkerheter nämndes också. Ett flertal kalkningshandläggare ansåg att kiselalger hade en hög tillförlitlighet och hade ökat provtagningen. När det gäller organisatoriska aspekter visar studien vidare att kalkningshandläggarna lägger mycket tid på administrativt arbete och att länsstyrelser och kommuner inte verkar ha en aktiv dialog om de omkalkade vattnen. Kalkningshandläggarna ser vidare risker med de föreslagna förändringarna av beslutsfattning och den minskade resurserna för kalkning.

Denna studie kom bland annat fram till att det kan behövas mer provtagningar och mer data för att kunna utföra den nuvarande försurningsbedömningen. Att kalkningshandläggarna bör få möjlighet till mer utbildning och att försurningsbedömningen bör göras mer användarvänlig. Avslutningsvis noterar denna studie att mer kan göras för att göra försurningsbedömningen tillgänglig för fler aktörer och allmänhet förslagsvis med en pedagogisk och intresseveckande figur. I dagsläget saknas en pedagogisk figur som beskriver MAGIC modellen och MAGIC biblioteket i föreskrifter, handböcker och hemsidor rörande försurningsbedömningen.

Nyckelord: försurning, länsstyrelser, kalkning

Abstract

This is a study about the Swedish liming operation and the Swedish liming officer's opinions of some aspects regarding ecology, economy and organization. The study objectives was motivated due to the recent changes in manuals for the assessment of limed waters and the suggested changes in decision making and decreased budget for liming. Moreover the anthropogenic acidification effects on the ecology are in many ways complex. Furthermore it was made in order to gain knowledge about the liming officer's opinions in order to improve the ability to meet their needs regarding the assessment tools and also to investigate if other things can be improved concerning the liming operation. The study is also a step to increase the use of different stakeholder's knowledge, opinions and experience in relation to the natural science about acidification and liming. The study is based on answers from an inquiry performed 2010 and on semi structural interviews conducted in 2012-2013.

The result shows that the opinions about liming doses were changed between the inquiry and the interviews. Several liming officers see a possibility of further reductions of liming doses, if done systematically and based on adequate knowledge. The majority of the liming officers perceived the task of performing the new acidification assessment in 2010 as difficult, and the use of the acidification assessment as time consuming and uncertain. Alkalinity and color measurement before liming were considered useful by the liming officers. Fish data were considered reliable, but uncertainties with the parameter were also mentioned. Diatoms were further mentioned as reliable and several liming officers had increased the sampling. Regarding organizational aspects, the study shows that the administrative tasks take a lot of time. It further seems like the municipalities and the county administrative boards not have an active dialog about the relimed waters. The liming officers further perceive risks with the proposed changes of decision making and the reduced liming budget.

The study concludes, among other things, that there might be a need for more sampling and data in order to perform the current acidification assessment. The liming officers should be offered more education and the acidification assessment should be made more user-friendly. This study further acknowledges that more can be done to make the acidification assessment more available for other stakeholders as well as the public. An educative and interesting figure of the MAGIC model and the MAGIC library available at homepages and handbooks might increase this possibility.

Keywords: acidification, county administrative boards, liming

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Abbreviations

Al_{in}	- Inorganic Aluminium
CAB	- County Administrative Board
HaV	- Swedish Agency for Marine and Water Management
IKEU	- Integrated Studies of the Effect of Liming Acidified waters
IVL	- Institute for Water and Air Research/ Swedish Environmental Research Institute
IWRM	- Integrated Water Resource Management
N	- Nitrogen
TOC	- Total Organic Carbon
S	- Sulphur
SLU	- Swedish Agricultural University
VISS	- Water Information System Sweden
WFD	- Water Frame Work Directive
WTH	- Whole Tree Harvest

1 Introduction

Liming of surface water and land has been an important strategy to mitigate the effects of anthropogenic acidification since the 1970s. The state paid about four billion SEK for liming operations in the period 1983-2008, which makes the liming operations one of the largest conservation efforts in Sweden (Naturvårdsverket, 2010). A significant number of surface water are considered affected by anthropogenic acidification. However, the deposition of acidifying sulphur has been reduced by over 90 % since the 1970s (Bertills et al., 2007), which has led to reduced acidity in many lakes. Thus the strategies for remediation of anthropogenic acidification have been changed in manuals and directives.

Several manuals and action plans for liming has existed over the years. The aim of the manuals has been to facilitate the assessment of the presence of anthropogenic acidification and insert relevant measures. The first manual was published in 1989 (Wiederholm, 1989), however at that time a number of waters were already limed and the manual was used sparsely in the assessment (Naturvårdsverket, 2011). The manual that was published 2002 had a focus on keeping pH within target levels, such as pH 6 for waters containing roach or other sensitive species (Naturvårdsverket, 2002). In the most recent manual published in 2007 the MAGIC model (Model of Acidification of Groundwater in Catchments) is used (Naturvårdsverket, 2007). The model categorizes a lake as anthropogenically acidified if the decline in pH is more than 0,4 units compared to a modelled reference state for the year 1860 (Fölster et al., 2011). The new assessment criteria

significantly changed the way of assessing acidification, by initiating a stronger link between chemical and ecological effects thus enabling classification of the acidification status linked to the requirement in Water Frame Work Directive. Moreover the change led to considerable fewer waters being classified as anthropogenically acidified than under the older assessment criteria (Fölster et al., 2007).

1.1 Aim

In this study we examine the liming officer's opinions about several aspects of the liming management, using an inquiry performed in 2010 and semi structural interviews performed 2012-2013. The extensive changes in the guidelines for the assessment of limed waters might have implications for the liming officers who implement them. The tools provided for the assessment of limed waters might need to be adjusted to better meet the needs of the liming officers. Moreover the results obtained by the MAGIC model might not correlate with the prior results obtained with the older liming assessment tools, which might lead to the liming officers opinions not fully coinciding with the newest guideline for assessment of limed waters. This could be seen as a hypothesis that will be investigated further in this study. Thus this study aims primarily to further gain knowledge on how assessments of limed waters are made at County Administrative Boards (CAB). Furthermore, major organizational and economical changes have occurred that affect the conditions of the liming operations since the inquiry was made. A new agency took over the main responsibility for liming in 2011, the funding will decrease and more responsibility will be placed on the county administrative boards (HaV, 2012b). It is therefore appropriate to include these items in the interviews. In addition this study will take the opportunity to ask the respondent's opinions about possible improvements of the liming operations.

More specifically, the purpose is to:

1. Develop knowledge of how assessment of the need for further liming is done at different counties by analysing results from an inquiry performed 2011 and by interviewing the respondents.
2. Analyse which actors each CAB is helped by in order to fulfil their tasks, and to analyse which influence other actors have on the liming operations in Sweden according to the CAB's.
3. Gather opinions about the organisational and economical changes proposed by HaV.
4. Gather opinions and suggest possible improvements of the liming operations.

2 Perspectives of the thesis and general structure

Social, economic and ecological systems are dynamic and they influence and depend on each other. This study considers that relevant ecological, economic and social aspects have to be considered in order to achieve sustainable management of natural resources (in this case the management of anthropogenic acidification).

In this study, the current knowledge of acidification, its effects and remediation alternatives are considered to be the relevant focus of the ecological system.

When it comes to the management of acidification several social and economic aspects are involved. The institutional, economical and organizational aspects are decisive for how acidification assessment and liming operations are performed and perceived. This study will further use these perspectives in its conduction by the background information, theory and questions asked to the respondents. However the main focus is on the ecological values.

The paper constitutes a **background** divided in two themes. The **first theme** represents natural science on this topic. It gives the definition of anthropogenic acidification, the acidification trends in Sweden and presents different aspects that have been shown to affect the acidification process. Moreover it gives some information about the use of the MAGIC model in the acidification assessment and explains the adverse biological effects caused by acidification. The **second theme** of the background gives brief information about some of the current and historical changes that have occurred in liming management. It also presents the complex

relation between the goals of the Water Frame Work Directive, the Swedish Environmental Goal and the interrelated liming management.

The **Method** part explains the different methods that have been used. The **Result and analysis** part presents the key findings of this study. Moreover there is a **Discussion** which deepening the analysis of the most important findings. **The Conclusion and Recommendation** part summarizes the core findings and recommendations.

3 Study Delimitation

This study includes opinions from 8 of the 18 County Administrative Boards that have liming management and will broadly analyse some factors that can affect the liming management. Some economical, ecological and social aspects are chosen for this. It can be seen as a contribution of knowledge and opinions in these specific aspects, but the study does not attempt to thoroughly analyse all factors that can affect the liming management.

4 Background

4.1 Acidification

4.1.1 Definition of anthropogenic acidification

In this thesis anthropogenic acidification refers to the lowering of pH in lakes, rivers, soil, groundwater and precipitation due to atmospheric deposition of sulphur and nitrogen and intensified forestry.

4.1.2 Acidification trends in Sweden

Acidification is one of the most common anthropogenic changes in the industrialised part of the world. The effects are well known and it has caused decreased fish stocks and reduced biodiversity in fresh waters in many parts of Europe and northern America (Lampert and Sommer, 2010). Emission from acidifying compounds began to cause environmental issues during the industrial revolution and the emission of pollutions increased with further expansion of the industrial production (Mylona, 1996). Acidification is caused by deposition of sulphur (S) and nitrogen (N) derived from burning of fossil fuels and other industrial activities as well as farming. The emission of S (which has been the main cause of acidification) peaked in the 1970s and 1980s in Europe, but was significantly reduced during the late 1980s due to emission control measures (EMEP, 2013, Mylona, 1996). The deposition of S decreased with 30-60 % during the 1980s and 1990s in the Scandinavian countries (Moldan et al., 2001). The decreasing pattern stagnated in the 2000s, but the deposition had nearly decreased with 70% in 2011 compared to the levels during the 1990s (EMEP, 2013). Between the period 1990-1999 approxi-

mately 69% of the surface waters in the Nordic countries were recovered from acidification (Skjelkvåle et al., 2001). In 2009 international shipping was the largest individual source of atmospheric fallout of acid compounds in Sweden, but it was reduced by 50% between the year 2005 and 2010 due to sulphur controls of fuel (Naturvårdsverket, 2012). Although sulphur deposition has decreased significantly in recent decades, there will still be a significant adverse effect of anthropogenic acidification on surface waters during more decades to come. Fig 1 shows a map of estimated acidified lakes (red spots) according to the MAGIC library (Fölster and Valinia, 2012).

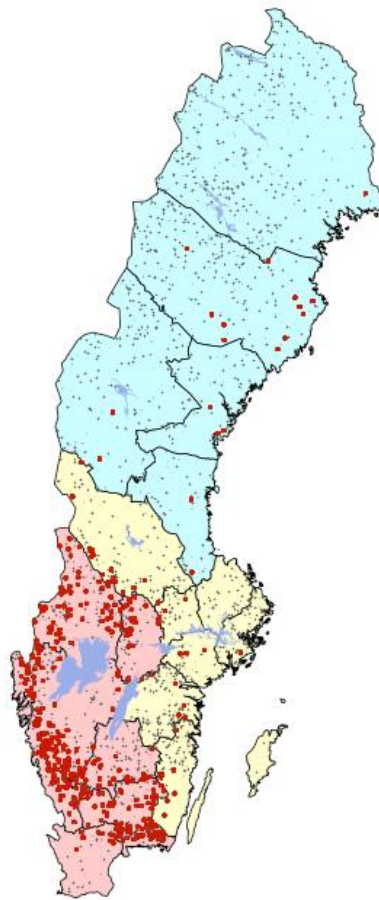


Figure 1: Estimated acidified lakes (red spots) according to the MAGIC library (Fölster and Valinia, 2012). The colours are illustrating three regions of Sweden.

4.1.3 Different aspects effecting acidification processes and the suitability of different remediation alternatives

Acid deposition causes acidification in fresh water by acidifying the soils in the catchments. The atmospheric deposition of acids causes a decrease of pH in soils which leads to a release of inorganic aluminium (Al_{in}) and replacement of base cations by hydrogen (H^+) and Al ions in runoff water. Forest soil was acidified with pH decreases by 0,3-1,0 units during the 1900s (Naturvårdsverket, 2013). Hydrogen ions and aluminium will start to leak to streams and lakes when the soil stock of base cations is reduced and causing acidification in nearby waters.

Liming of lakes, water courses and wetlands has been a widely used remediation method in order to mitigate the adverse effects on aquatic organisms. Unfortunately it will always be a temporary action which regularly needs to be repeated as long as runoff from acidified catchments reaches the aquatic habitats. Another remediation strategy is to restore the acid soils in order to reduce the leaking of acid ions to nearby waters by forest soil liming. Large scale liming operations on soils are however not considered to be socioeconomically profitable due to its costs and low benefits in comparison to liming of waters, despite uncertainty of the time perspective before improvements would appear in waters after forest soil liming (Bostedt et al., 2010).

Delayed recovery from the deposition of acids can further be caused by forestry (Moldan et al., 2013, Aherne et al., 2008), and it is expected to increase due to the intensity of silviculture and extraction of logging residues as branches and tops. The extended use of whole tree harvesting (WTH) decreases the cation exchange capacity (Olsson et al., 1996) and increases the acidity in the soil (Vanguelova et al., 2010), due to the withdrawal of the high quantity of mineral nutrients that are available in branches, needles and foliage. Wood ash contains a high quantity of base cations. Application of it has been recommended by the Swedish Forest Agency in order to reduce the forestry acidifying effect. However, only 12% of the area with WTH was treated with the wood ash application year 2010 (Skogsstyrelsen, 2011). The study conducted by Norström et al (2012) did not

show any change of exchangeable cations in the soil after the application and only small increases of cations in soil solutions. It is difficult to develop guidelines for the distribution of wood ash return due to the patchy spatial distribution of sensitive areas in Sweden (Ågren and Löfgren, 2012) and its diverse effects related to site-specific characteristics (Aronsson and Ekelund, 2004). Acidification of soils has been assumed to decrease the tree growth capacity due to increased concentration of Al_{in} especially when the concentration of Ca^{2+} is low (Sverdrup et al., 1992, Sverdrup et al., 1994). However more recent studies could not link changes in soil chemistry due to acidification with large scale decline of forest growth (Nyberg et al., 2001). This supports the idea that that treatment of lakes and water courses is more socioeconomically profitable than large-scale remediation treatment of forest soils.

Swedish soils often originate from bedrock containing granite and gneiss with a low content of base cations. The weathering rate of these bedrocks will determine what effect atmospheric fallout of acids and forestry methods will have on the available amount of base cations in catchments. It is difficult to estimate weathering rates precisely enough for predicting how long time it will take before the nutrient pools are recovered after forest harvest in silicate mineral dominated soils (Klaminder et al., 2011). More knowledge is needed about how weathering is coupled to plant growth and the water quality. It has been suggested that the symbiotic Mycorrhizal fungi might be able to etch soil mineral grains and directly provide trees with mineral nutrients and improve growing capacity for hosted trees (Jongmans et al., 1997, Hoeksema et al., 2010). Mycorrhizal fungi has also been shown to be an important factor when it comes to the carbon stock in soils (Treseder and Holden, 2013). The fungi might be able to sequester carbon which it used to build the hyphae and when it dies it might be decomposed and converted to organic matter in soils, and together with decomposition of other plant residues it will contribute to the organic compounds available in the soil. Organic compounds consist of numerous organic acids and contribute to natural lowering of pH in streams, lakes and soil water. The concentration of organic compounds are

higher in soil solutions from forest land than moorland (Grieve and Marsden, 2001). Organic compounds in surface water strongly influences other parameters such as the buffering capacity, nutrient concentrations, pH and the bioavailability of toxic metals and organic pollutants (Köhler et al., 1999, Jansson et al., 2001, Ravichandran, 2004, Kukkonen and Oikari, 1991). The concentration of organic compounds is thus a very important factor in aquatic habitats. Increasing concentration of organic acids has further been observed in surface waters since the last two decades which correlate with the recovery from anthropogenic acidification (Monteith et al., 2007, Moldan et al., 2001). This indicate that it might be a link between anthropogenic acidification and the concentration of organic acids in surface waters (Erlandsson et al., 2008).

Seasonal variations such as spring flood or rain events further influence the water chemistry to a large extent. Sometimes more than 50 % of the yearly runoff will reach water courses during three to four weeks (Laudon et al., 2001). Short term acidification can also be caused when cations from sea salt are replacing H^+ ions in inland waters close to coastal areas (Lydersen and Henriksen, 2005). Acidification might also be caused by natural or indirect anthropogenic changes in climate such as forest fires, droughts and changes in precipitation. The variation is further linked to the size of catchment area and the turnover rate of the surface water. Furthermore, it has been showed that there is large spatial variability of acidity among nearby headwaters with similar acidification pressure (Temnerud and Bishop, 2005). Estimation of acidification effects might be difficult due to the large amount of variables that influence acidification, and no matter how complicated models that are developed, these are simplified descriptions of the natures complexity.

4.1.4 Modelling acidification

The Model of Acidification of Groundwater in Catchments (MAGIC) is the most used model for evaluation of acidification. It estimates the supply and removal of acids and alkaline substances in Sweden and Europe. It takes into account the seasonal changes of flow and storage of water in catchment areas. The model aims to

show how atmospheric deposition of acid substances effects forest and surface water (IVL, 2012). The model was developed by Cosby et al (1985), but several refinements and additions have improved the reliability of the conceptual inclusion of physical, chemical and biological processes that are affecting the recovery of acidification.

MAGIC consists of three parts. The first part deals with soil chemical reactions such as exchange of cations on soil particles, dissolution and speciation of aluminium and organic carbon. The second part calculates the mass balances in relation to atmospheric deposition, weathering and net uptake in biomass and leaching. The third part connects the soil chemical reactions with the mass balance calculations (IVL, 2012). Lakes and streams that are contaminated by something other than acidifying deposition or with uncommon bedrock may not be assessed with MAGIC, and sites with large sea salt inputs might further give uncertain results (IVL, 2012, Cosby et al., 2001).

When the MAGIC model is used to classify the acidity in Swedish water quality assessment, a modelled reference pH for year 1860 is compared with current pH in surface water, and a alteration of 0.4 units from the reference state is currently used as the threshold for acidification (Fölster et al., 2007). The use of pH is considered to be good due to its high correlation with biological effects, but it is sensitive to changes in TOC and CO₂ pressure which might increase the uncertainty of the results.

4.1.5 Biological effects from acidification

A number of chemical and biological factors influence the effect of acidification on the life in lakes and streams. Anthropogenic acidification leads to decreased biodiversity. Sensitive invertebrates and fish have difficulties to maintain viable populations both due to direct changes of the water chemistry, but also because of a change to more acidification tolerant plants and animals who will compete with the indigenous species. However, liming of naturally acid waters will harm the aquatic fauna that adapted to these conditions over thousands of years and is there-

fore a threat to the natural biodiversity (Laudon et al., 1999). Natural acidity is relatively common in surface waters in boreal forest in the Nordic countries due to high concentrations of TOC.

One major effect of anthropogenic acidification is the increased leakage of positively charged, inorganic aluminium (Al_i) to streams and lakes. Al_i can easily react with negatively charged sites on the surface of gills, forming a jelly-like precipitate on the gill surface (Fig 2). This reaction reduces the oxygen uptake and the ionic regulation for gill breathing aquatic organisms (McDonald, 1983). The critical concentration of Al_i for fish and benthic animals depends on several factors such as pH, temperature, total organic carbon (TOC) and ionic strength (Lydersen and Löfgren, 2000). The tolerance further differs depending on the species, strains, life-stage and age. Tolerance limits of Al_i concentrations in humic streams was $<20\mu g L^{-1}$ at pH >5 for brown trout and $<15-20\mu g L^{-1}$ at pH $>5,7-6$ for benthic invertebrates (Andrén, 2012). Liming operations lead to the same process as weathering processes in calcareous soils, which means that the pH increases and the concentration to toxic inorganic aluminium decreases (Naturvårdsverket, 2002).

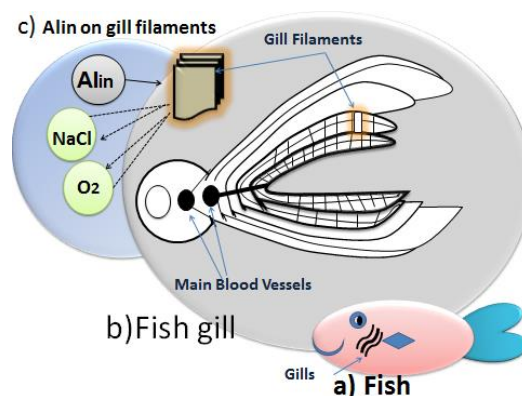


Figure 2: A conceptual model of the toxicity of inorganic aluminium on fish.

The biological monitoring has mostly focused on fish and benthic invertebrates, and in special cases also on crayfish and freshwater pearl mussels. The most common motive for liming in streams is the presence of trout. Roach is the most

sensitive fish species in lakes and is estimated to have disappeared in more than 1100 lakes due to acidification, however several other fish species such as perch has disappeared in more lakes due to its larger distribution (Tammi et al., 2003). River crayfish suffer from impaired adsorption of calcium at pH below 6, which is needed for its construction of the shell. 40% of the stock of river crayfish and about 50% of the population of river pearl mussel is now present in streams that are regularly limed (Naturvårdsverket, 2011).

4.2 Management of acidification

4.2.1 Distribution of responsibilities

The Swedish water monitoring is divided between different actors who have different roles and responsibilities. The Swedish Agency for marine and water management (HaV) was formed in July 2011 and took over the responsibility for the national strategy for water monitoring from the Swedish EPA. County Administrative Boards (CAB's) are responsible for the regional strategy of the liming operations and monitoring while the municipalities have the task to plan and execute the liming. Lime is transported, delivered and disseminated by contractors, furthermore environmental consultants and laboratories are involved in the monitoring (Naturvårdsverket, 2011, Naturvårdsverket, 2010). The large amount of actors involved in the liming operations, demands coordination, as well as a functional criterion for acidification assessment. Regulations and guidelines for regulation of responsibilities and performance were developed primarily for CAB's and municipalities. Universal and joint actions plan and evaluation criteria's for liming have long been missing due to the late regulation of responsibilities. According to § 4 " *CAB should establish a county-wide plan of action plan as the basis for the planning of liming operations in the county*". The plan should contain "*An account of acidification situation, action, action items, reasons for liming, target areas, measurable goals and lime amounts*" (NFS 2001:18). According to the general advice "*Should the county-wide action plan be developed in consultation with the principals*" (NFS, 2001:18). Thereafter should the principals

establish a lime distribution plan for the area within the municipality, and revise it when it is necessary (Naturvårdsverket, 2010).

The CAB has the responsibility to review and approve the plan before it is taken into force. CAB's responsibility for the grants for liming started in 1982 and has continued since then. Liming which occurred before the 1970s was initiated and funded by private actors. During 1970-1980 liming was arranged by AMS (work marked support) (Naturvårdsverket, 2011). However Fisheries Board had the national responsibility for the administration of liming operations during 1977-1982. During this period the majority of applications were from municipalities and fisheries organizations. Swedish EPA got the national responsibility in 1982, but in 2011 the new organization HaV took over the task.

In late 2012 HaV decided to reduce its control of water related tasks performed by CAB, which led to greater freedom for the CAB's to decide what action should be taken to achieve the environmental goals decided by the parliament (HaV, 2012b). HaV will increase the requirements of reporting and follow-up by developing a new accounting system, with particular focus on measures in relation to the environmental goals (HaV, 2012a). In addition, HaV will reduce the grants to CAB from 446 million to 320 million per year, which will go into force 2013.

4.2.2 Implementation of the WFD and the liming assessment

In 2000 the European Union accepted the Water Framework Directive (WFD, 2000/60/EC) as a joint decision to improve and protect waters with the overriding objective to achieve "Good ecological status" for all surface waters and "Good status" for groundwaters in 2015, or 2027 if deadlines have to be extended. WFD is focusing on biological quality factors as the most important for the assessment of the ecological status in surface waters. Physical and chemical variables are considered as supportive variables (WFD, 2000). However the classification of the water status of a site should be determined by the lowest value of the quality elements used.

Sweden had a solid background of assessment methods for evaluating the environmental quality of surface water before the implementation of WFD. A successive change from only using chemical metrics to a combined use of both chemical and biological metrics in monitoring programmes started during the last few decades (Dahl, 2004), well before starting the implementation of WFD. However in order to implement the WFD, Sweden had to further change structure, adjust and increase the monitoring, especially on the biological and hydromorphological quality factors. The use of biological and hydromorphological quality factors were still considered to be insufficient during 2013 despite increased monitoring of these parameters (Vattenmyndigheterna, 2013). Sweden implemented a new environmental code in January 1999 which was replacing rules from 15 old environmental laws. The environmental code contained goals for 16 environmental objectives, with several goals that can be linked to the requirements in WFD (e.g. the goals “only natural acidification, no eutrophication, flourishing lakes and streams and good quality of groundwater). The national law for water regulation SFS 2004:660 was further developed in order to implement the WFD in the Swedish regulation (Miljödepartementet, 2004).

The WFD is further striving for a more integrated water management by including different water resources and managing water on the scale of entire river basins. The WFD was also one of the first European Directives to adopt the requirements of Access to information, Public participation in Decision-making and Access to Justice included in the Åarhus Convention (UNECE, 2001). The WFD is implementing the core elements for IWRM (Integrated Water Resource Management) by applying knowledge from diverse disciplines and insights from different stakeholders (Richter et al., 2013). However the involvement of diverse stakeholders has been a challenge. Difficulties have been argued to be caused by the lack of clear roles, responsibilities and economical restrictions (Hammer et al., 2011). Valinia et al (2012) argued that reference conditions for good ecological status of water need to be assessed by combining both lay and scientific knowledge in order

to implement the two pillars of WFD (good ecological status and public participation). The study further showed that there were great diversities in the opinions of the concept of undisturbed state (Valinia et al., 2012). This underlines the importance of choosing a well proven definition for defining the ecological state of surface water.

According to WFD, all water bodies should be restored to their undisturbed state, accepting only minor deviations (WFD. Annex V), and the Swedish environmental goal has set the target “Only natural acidification”. The Swedish water authority stressed the importance to keep the on-going liming activity in order to not decrease the ecological status of Swedish waters. However, according to the Swedish EPA liming should not be a measure for achieving the environmental goal or to reach the goal of “good ecological status” in the WFD (Naturvårdsverket, 2011). This is because a long term solution of the acidification problem can only be archived by reductions in deposition. According to the guidelines, the status of limed waters should be classified after the water chemistry has been corrected for the liming effect with the ratio of non-marine calcium and magnesium, or by any other method giving equivalent results (HaV, 2013, Fölster and Wilander, 2005).

4.2.3 Liming assessment in Sweden

There have been several different assessment criteria for the liming operations over the years which has been published in handbooks by the Swedish EPA. Sweden assessed the need for liming of surface waters as water with a pH <6.0 and/or with an alkalinity <50 µekv / L in 1989 (Wiederholm, 1989). The handbook published in 2002 divides the acidification assessment into two different purposes. One was a restorative purpose, which was based on biological acidification-related disturbances of fish and benthic fauna. The second was preventive, where liming should commence when the calculated alkalinity had decreased by 25% from estimated natural values (Naturvårdsverket, 2002). Regular sampling was needed in order to perform the calculations, wherein a median value for the various chemical parameters was used to compute the natural alkalinity of surface waters.

The dynamic Model of Acidification of Groundwater in Catchments (MAGIC) is used in the Handbook published in 2010. The model calculates the difference between the current pH and the estimated pre-industrial pH. The software required expertise to run the model, but the pH change can also be estimated by a matching library with previously modelled lakes and watercourses. If acidification calculated by MAGIC is less than 0,2 no liming is needed, if acidification is between 0,2 - 0,4 liming can be reduced unless aluminium concentration exceed 50 mg / l . Table 1 shows how the different assessment criteria for water quality such as liming management, the Swedish environmental goals as well as the requirement of the Water Frame Work Directive (WFD) can be interlinked (NFS, 2008:1).

Table 1: pH criteria's for acidification (NFS, 2008:1).

Acidification limits	pH decrease	Classification (according to WFD)	Environmental Goals (according to Swedish legislation)
1	<0,2	High	No acidification
2	0,2- 0,4	Good	
3	0,4- 0,6	Moderate	Moderate acidification
4	0,6- 0,8	Poor	High impact of acidification
5	>0,8	Bad	very large impact of acidification

5 Methods

5.1 Methods of the inquiry

During 2010 all responsible liming officers in Sweden were asked to participate in an inquiry. Nine liming officers representing nine of the eighteen County Administrative Boards with liming activity choose to participate in the inquiry. The questions and the setup of the inquiry were developed by Katarina Bergander who had previous experience of qualitative studies as well as natural science. Furthermore Katarina was supported by personnel at SLU with expert knowledge of questionnaire development and with expert knowledge on the chemical effects of liming. Katarina wrote a summary text of the inquiry results which are available in Appendix I, and the results are further shown in tables in Appendix II. The results of the inquiry were used to develop questions for semi structured interviews and will further be analysed together with the interview results in this study.

5.2 Motivation for the use of semi structural interviews

Many questions can be answered by surveys and analyses of official data, but social research tools are more appropriate when it comes to include the context of a situation, as well as include experiences and perspectives from respondents (Rubin and Rubin, 2005). An in depth interview or semi structural interview is an appropriate tool when answers on questions might need to be further explained by the respondent. It is especially good when it comes to describe political and social processes. Interviewing is therefore suitable for this study.

5.3 Planning an performance of phone interviews

In this study eight semi structured interviews with liming officers at county boards were performed by phone (Table 2). The participants were chosen to follow up and complement the previously performed inquiry from 2010 (Appendix II). The County Administrative Boards (CAB's) were mainly from the central and southern parts of Sweden. A mail with information about the aim, degree of anonymity and contact for further questions was first sent to nine prospective participants. Eight of them agreed to be interviewed. The given information was developed to fit ethical requirements stated in the report conducted by Vetenskapsrådet (2002). Some of the information was also repeated in the beginning of every interview in order to ensure that the interviewees were properly informed. This study further considers requirements of consent, utilization and confidentiality obligations in its conduct.

Some of the questions from the inquiry of 2010 (Appendix II) were adapted to interview questions in order to evaluate changes in opinions or to gain more knowledge about these aspects. One pilot interview was performed before the real interviews were conducted on a person who previously had worked as a liming officer in order to test the questions. Some adjustments were done after the interview was tested and there were also some questions added after the three interviews in December (see Appendix IV). Moreover, before each interview, previous results from the inquiry were checked and the homepage for each CAB was visited to get an overview of the liming program of the county.

Table 2: Basic information about the interviews conducted and about the interviewee's work related to the liming activities. All interviewees are taking part in the responsibilities related to finances and liming strategy.

Interviewee	Month for interview	Running time	Years active with liming operations	Responsibility	
				money	Liming strategy
Resp. 1	December 2012	23 min	>10	Yes	Yes
Resp. 2	December 2012	27 min	>10	Yes	Yes
Resp. 3	December 2012	36 min	<10	Yes	Yes
Resp. 4	January 2013	57 min	>10	Yes	Yes
Resp. 5	January 2013	48 min	<10	Yes	Yes
Resp. 6	January 2013	51 min	>10	Yes	Yes
Resp. 7	January 2013	40 min	>10	Yes	Yes
Resp. 8	February 2013	60 min	<10	Yes	Yes

5.4 Interview uncertainties

Phone interviews might have drawbacks such as difficulties to create trust and increased risk for lies as well as more limited interview time (Eriksson and Wiedersheim-Paul, 1998). However the drawbacks were limited by well-informed respondents, and follow up questions on unclear statements and well planned interviews. Furthermore, phone interviews limit the effect of body language and facial expression which have both benefits and drawbacks. The interviewer will influence the answers in the way questions are asked and by the interviewee's beliefs on what kind of answer the interviewer expects. However the conductor of this study has not previously worked with liming related work, which might have limited the preconceptions that could influence expressions during the interviews.

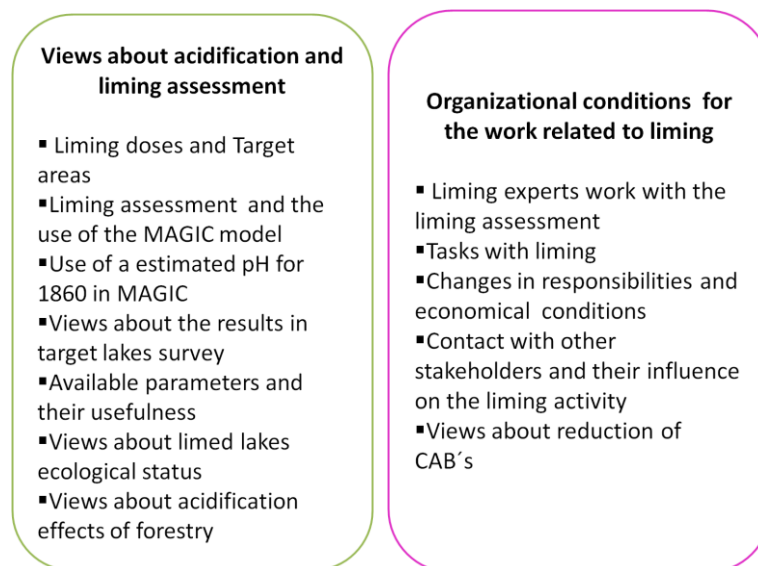
5.5 Handling of the interview material

All interviews was recorded with an Olympus voice recorder DS-2000, transcribed verbatim with help of the DSS player software, and the Nvivo10 software was used for coding of the interview transcripts. The material was categorized into different themes based on the subject areas included in the interview guide (Fig 3).

It might be important to stress that different reviewers will come up with different products after coding of interview transcripts, due to personal perceptions and interpretations. They will however all be true in that sense that they contain information gathered during the interviews (Rubin and Rubin, 2005). The interview material was then added in a excel sheet in order to facilitate an overview of the material. The most important information was put in smaller tables in order to further increase the overview of the material. However during analysing, the original interview transcripts were also used. An inclusion of codes from different degrees of generality can end in data retrieval at different levels, which might decrease the drawbacks of too general or specific coding (Coffey and Atkinson, 1996).

In the final phase, citations from the interviews were edited and translated into English. Repetitions were deleted and some words were adjusted in order to fit grammatically into a readable text. Some of the interviewees were also contacted in order to further increase the reliability of the transcribed material. However this handling might have caused errors in what was said during the interviews.

Figure 3: categorizing of the interview material.



5.6 Final Analyse

Each interview was reviewed in order to improve follow-up questions for the next interview. The transcription and coding was also part of analysing the data as well as the comparison of the different interview results. The interview results were further compared or complemented with the inquiry results. To limit the numbers of pages in this thesis not all interview themes shown in fig 3 will be presented in the results. According to Kvale (1997) the amount of citations should not exceed 50% of the text in a chapter and only the best citations should be used to highlight a position when it is shared by more than one interviewee. The number of citations in this study has been chosen in order to present important aspects as well as general opinions among the liming officers. The amount of citations has further been selected in order to make it possible for the participating liming officers to see parts of their contribution if they wish to do so, yet in balance with confidentiality obligations.

6 Results and Analysis

Below are the results and a brief analysis presented in two parts according to the interview coding shown in Fig 3. The respondents are referred to as shown in Table 2 (Resp. 1-8).

6.1 Acidification and liming assessment

6.1.1 Liming doses and amount of target areas

The liming doses and target areas have progressively been reduced during the last decade and further cutbacks have been initiated during the last years which means that liming doses and target areas have decreased since the inquiry was performed. During the interviews and in the inquiry liming officers were asked about their opinions about liming doses and amount of target areas. It was done since it is important to gain knowledge about what the liming officers think about the decreases of liming doses and target areas and what opinions that underlie this perceptions.

Increase of liming doses

Resp. 6 declared that the newest liming strategy led to too low liming doses in a few cases, which had to be adjusted with larger liming doses. Resp. 3 stressed that their CAB (County Administrative Board) had followed the instructions from HaV (Swedish Agency for Marine and Water Management) and adjusted the liming doses after the acidification load, but sometimes the liming officer was thinking that the reduction was almost too large in some of the projects. Resp. 8 was asked about downstream lakes and answered that some of them might need larger doses,

but they always were very restrictive with doses. In one of the cases the view was linked to a general suggestion from HaV (Resp. 2). *“It is a bit interesting that you are asking that question, HaV has just reviewed our liming assessment and they think that we should double our doses and now when we started to look at it we see that we agree in that thought that we need higher liming doses in the county”* (2). In summary, two liming officers were indicating that the liming doses needed to increase in their county, one person slightly reflected over if it might be the case and a fourth person was mentioning increase of liming doses after questions related to downstream lakes. Moreover, during the oral interviews the opinions about increased liming doses was mostly linked to reliming of specific watercourses and lakes. During the inquiry, the opinions about increased liming doses was also linked to specific watercourses and lakes, but there were also opinions about liming of unlimed waters (Appendix I & II) (Table 3).

Liming doses at steady state

Two persons that thought that the liming doses should be kept in steady state in the inquiry had changed their opinion to decrease during the interview (Table 3). However three other liming officers had changed their opinion from decrease to steady state during the oral interview. These opinions were related to opinions about that the liming doses had reached a level where it was not possible to decrease any more *“As it seems now we are down to levels that should not be decreased more”* (7), and a consideration of negative impacts on the water quality *“We begin to see that we are not able to reduce more now without impact on the performance outcomes”* (5), and a perception of an already optimization of the liming activity *“So we, I think we are at the level that is optimal with this reduction that we did”* (4). The opinions about keeping liming doses at steady state were motivated of the liming officers, and the changes of opinions of “decrease” to “steady state” could probably be linked to the decrease of liming doses between the inquiry and the oral interview.

Decrease of liming doses

About six of the liming officers considered that the liming doses should decrease in the inquiry (2010) and five in the oral interview (2012-2013), due to the dynamic response to the questions in the interview, the answers include several opinions. Four liming officers had the main opinion that the liming doses could further decrease in their county. Resp. 8 concluded that the reduction should be done based on knowledge. *“We like to decrease the liming doses based on knowledge, we will see what we can do”* (8).

Table 3: Answers about amount of liming doses and target areas in the interview and inquiry, the large X represent the main opinion and the small x represents other opinions.

Respondents	Liming doses						Target areas					
	Answers from the inquiry (2010)			Answers from the interview (Dec 2012 - Feb 2013)			Answers from the inquiry (2010)			Answers from the interview (Dec 2012 - Feb 2013)		
	Increase	Steady State	Decrease	Increase	Steady State	Decrease	Increase	Steady State	Decrease	Increase	Steady State	Decrease
1		X				X			X			X
2			X	X					X	X	x	
3	x	X	x	x	x	X	X				X	x
4			X		X			X			X	
5			X		X	x			X		X	
6	x	X		x		X			X			X
7			X		X			X			X	
8			X	x		X			X			X
Total of main opinions		3	5	1	3	4	1	2	5	1	4	3

Amount of target areas at steady state

Most of the liming officers answered that the target areas could be reduced or kept in steady state. There was substantially higher response that indicated that target areas should be kept in steady state during the interview than during the inquiry.

According to Resp. 5 it was not so much changes done of the amount of target areas *“This is something we pointed out 10 years ago when we did the first orderly regional action plan and it is not so much that has been revalued or needed to be revalued”* (5). Resp. 4 stressed that more knowledge about biology was needed in order to make the right decisions and that there were substantial reasons for keep-

ing the current target areas. *“We did a revision and there is a reason for keeping the ones we have” ... “We could maybe end liming in some target lakes if we knew more about the biology, we need more knowledge”* (4). The opinions about keeping the amount of target areas at steady state was motivated differently by the liming officers and no clear link could be drawn by the answers.

Decrease and increase of target areas

The liming officers who answered that target areas could decrease in the oral interview had the same opinion in the inquiry (Table 3). Resp. 1 stressed that the reduction of target areas was a continuous process *“It will be reduced, It has been reduced and it is a continuously process...since we do not have any new liming activity it leads to a decrease since we only take away target areas”* (1). Resp. 6 mentioned that some could be reduced during the next coming years *“We are about to remove and reducethere is some that will disappear during next coming years which are not ready yet”* (6). However Resp. 2 answered that the target areas might need to increase due to new recommendations from HaV *“We might need to increase a bit” ... “It is due to the previously recommendations...and now they have changed the recommendations about what should be limed and what should not”.... “Suddenly it felt current to start to lime again in areas that has been dormant due to the acid peaks in 2009 and 2011”.... “Things are changing”* (2).

6.1.2 The new assessment of limed waters and the use of the MAGIC -model

During the inquiry conducted 2010 (Appendix I & II) the liming officers were asked about how they assessed the task to perform liming assessment plans on all target objects during the year 2010. The majority (6/9) responded that they found the task difficult to perform, while the rest assessed the task as medium or easy. The answers from the interview show that the opinions about the use of the new assessment criteria had not changed in most of the cases. The liming officers specified what they thought was the major issues during the interview.

Difficult to use and time consuming

Resp. 2 had not personally worked with the MAGIC model and only seen the results which limited the answer *“I have not worked with it myself, I have only seen the results and I cannot say more than that. I have had a fast glimpse on it but it did not work”* (2). Resp. 2 further concluded that time was needed to thoroughly understand it. Resp. 5 stated that the use of the assessment criteria was time consuming and complicated which limited the use of it *“It is relatively difficult, it is a complicated system to work with practically without doubt it is nothing we are working with on a daily basis. There is no time for that even if I know the system quite well but I do not have the time for it, it is only in special occasions we do it e.g. when we get an assignment that we must do it or some project where we think it is important”* (5). Resp. 1 had used the model during long time and felt no problem with using it, but this respondent however mentioned that it might be possible to simplify the model. *“I have no problem using it, I know, I think I know that it certainly could be possible to simplify it a lot for other users, but I might be a special user”* (1).

Lack of data and uncertain reliability

Resp. 3 and Resp. 8 further stressed the issue with the lack of basic data that was needed to perform the task. Resp. 3 also reflected over the reliability of the results and mentioned that the available data was not always enough even for the use of the MAGIC library *“The assessment criteria, I think it is a bit difficult since we do not have the basic data. Otherwise it is not so hard even if it is possible to be a bit doubtful of some of the results sometimes, but we do not have the data that is needed for doing MAGIC calculations so then we have to use the MAGIC library instead, and not even then do we have everything that is needed.”* (3). Resp. 8 answered that they conducted simplified equations due to the lack of basic data, but seemed a bit doubtful of these performance. *“It is not difficult to use, the problem is that we do not have the basic data, we do not have data for all chemical parameters that we need and it is still this way. We put quite a lot of energy on doing this assessment, but this year or we started already last year to calculate pH 0-kalk from quite banal grounds there are some simple variants to do the calcula-*

tion, we have to do a complete run of the model, but it takes time to get money for doing all this analyses.” (8).

Implication of changes done with MAGIC and the importance of including biological data

Resp. 6 discussed the changes that had been done with the MAGIC model during the years and what implication that had led to when it comes to the use of the model in the acidification assessment. Resp. 6 concluded that there had been some improvements even if there still were unclear instructions of how the model should be used. *“They have elaborated, worked and changed the model during several years. From the beginning the model worked in one way and then it worked in another way. The results are better or worse. The model needs a lot of data and it further need a lot of understanding of what the data says, it needs quite a lot of time to have time to grasp what the results really says. So it has gone from pretty useless to now 50% accurate. In addition they have change the orientation on how it can be used, they have change it during the years from the beginning we could use it on individual lakes to that we might not use it on individual lakes but now we should do it anyway, but not, so it is still a bit messy even if it starts to be stable”* (6). Resp. 4 replied that the new assessment for limed waters not was difficult to use, but stressed the importance to include the biological data in the acidification assessment.

6.1.3 Use of an estimated pH for 1860 as reference value in the MAGIC-model

The liming officers were also specially asked what they thought about the use of a calculated pH for the year 1860 as the reference state in the acidification assessments. The result revealed that the most of them did not have any explicit negative opinion about the use of the year 1860 as the reference state.

Others responsibility/ year 1860 the best option

Some of the liming officers perceived this kind of things as something that was not within their priority since they have a lot to do and others has the main responsibility to make this decisions. Resp. 6 declared *“I feel that this is not one of the things*

I have put a lot of energy on. I have thought about it, but I have felt that this is nothing I want to put energy on I have enough of other things to do, the scientists and the state can divide among themselves, and then I will do what they say in this aspect, I have enough with other things to do.” (6). Several liming officers discussed implications of using the year 1860, but stressed that there were probably no other year that suited better as reference year, if a year should be chosen. Resp.1 stressed that the use of the MAGIC model and the reference value from 1860 probably was the only possible solution today, on the question if there were other thing that might work better. *“No, not if you think only on reference year, not either when thinking what kind of tool to use for calculate it ...so I must say that the MAGIC is the best, or I might say it feels like the only possible today”* (1). A similar answer were given by Resp.4 who stressed that the use of an estimated pH from 1860 probably gave the closest possible result *“ No, I think it is very ...very difficult I think that how things are now with this model that has been developed and what it has been developed upon is probably the closest that is possible. I actually believe it is good”* (4). Resp. 3 further declared that it was difficult to have an opinion on this matter but sometimes methods have to be chosen and then you had to do the best of it *“I cannot think... it is difficult to say... that I could have any opinion on it actually* (about the year 1860) *No, you have to put your foot down and chose something and then calculate the best as possible”* (3).

Implication of using the year 1860 as reference year and the difficulties of knowing the validity

Several of the liming officers reflected over the difficulties to know if the reference value was valid due to different circumstances such as different concentration of TOC (Total Organic Carbon), changes in land use, population development and other things. Resp. 8 mentioned that the circumstances was a bit different in the region 8 was representing. After a long explanation and description over changes of land use in general in the country the respondent continued *“In that way it is possible to see that 1860 is ok, but if you should have the land use when people went from hunters to live permanent and cultivate the land in large scale then maybe year 1600-1700 would be more appropriate for the conditions in X area”*

(8). Resp. 8 continued discussing the natural acidification process and when it started, and furthermore mentioned that the choice of reference year is difficult and concluded that the goal with the liming assessment is pH values over 6 in any case due to the biological response effect. Resp. 5 was reflecting about the goals with the liming assessment and the reference value in the MAGIC model. The liming officer mentioned that the use of a calculated reference value for 1860 not should be seen as we could go back to conditions that prevailed 1860, but more as an approach trying to deal with the anthropogenic acidification. *“If the acidification (anthropogenic acidification) never happened not in the history or now, if it is what we want to accomplish than pH 1860 is a fairly good way to approach what we want back too, even if no one believe they can come back to the conditions that prevailed 1860 but it not really the way this should be looked upon even if it is described in the form as 1860”* (5).

6.1.4 Target lake survey

A target lake survey was conducted in 2007 and 2008. About 3000 limed lakes and 1800 reference lakes were sampled. One set of samples were collected during autumn 2007 and spring 2008 and the MAGIC library was used (Fölster et al., 2011). The MAGIC library matched the sampled lakes chemistry, lake area and geographic location with similar lakes in order to calculate the acidification status. During the inquiry conducted in 2010 approximately 50% of the liming officers answered that the reliability of the acidification evaluation was moderate, none of them answered that the target lake survey had no reliability or very high reliability (Appendix I & II) (Figure 4).

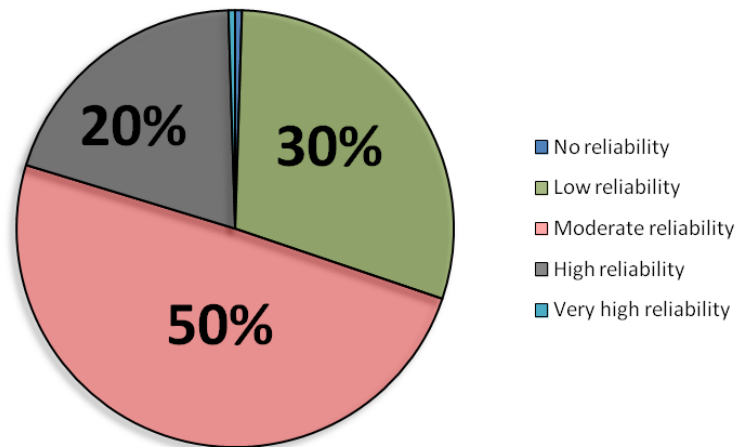


Figure 4: Views about the results from the target lake survey (answers collected during the inquiry 2010). 50% of the liming officers viewed the results as moderate, 30% low reliability and 20% reliability.

The target lake survey was developed as a support for the acidification assessment, but seen by the result gained during the inquiry there were several doubts about the reliability. The liming officers further explained their opinion during the interview.

Difficulties caused by low sampling frequency, problems with reference lakes and changes in precipitation

Some of the liming officers explained that they had used the target lake survey during the latest acidification assessment. Resp. 4 described the use of target lake survey during their latest acidification assessment. The interviewee explained that the target lake survey contained two alternatives for the lakes either no acidification or affected by acidification, there were a possibility to do an uncertainty assessment on the two alternatives. When Resp. 4 looked at the uncertainties and delta pH was the outcome in most of the lakes that delta pH were less than 0,4 which gave very uncertain results. It was difficult to know if the lakes could be terminated from lime. These uncertainties made it difficult for Resp. 4 to use the target lake survey in the acidification assessment. Resp. 4 further stressed that the uncertainties might be linked to low sampling frequency and problems with reference lakes. “ *We had so many lakes that got delta pH lower than 0,4 so then it might be the case that it might be needed more frequent sampling and more close reference lakes in order to obtain a better acidification assessment that is what I*

believe now when I look back on the acidification assessment” (4). Problems with reference lakes were also mentioned by Resp. 8 which led to difficulties in about 50% of the cases. “I can say, at least it has to do with that it only were two lakes that were reference lakes and they were located long away from each other and they gave divergent results so it were difficult to use the result in about 50% of the cases” (8). Resp. 8 further mentioned that the precipitation was low during autumn 2007 and the spring 2008 which caused too low pH and alkalinity to be representative for the region.

Reliability of target lake survey

Resp. 1 confirmed the answer “ high reliability” in the inquiry by answering that the evaluations in the target lake survey was in line with the opinion that they held before and they continued to have. In contrast Resp. 3 answered that there were some strange results in the target lakes survey and concluded that the target lake survey suited best for general assessments in the region. *“We used it as a base when we did acidification assessments for the action plan, but there were some weirdness we could conclude, the model became better and better , but I have always believed that the model suits best for general assessments of a region than to use it on individual waters.” (3).* Resp. 3 further mentioned that one lake got an unlimed value between pH 6,6-6,7 in the target lake survey, but the measured unlimed pH was 5, which made the result from the target lakes survey unreasonable for that lake. The opinion about the suitability of using the target lake survey for general assessment was shared with another liming officer. Resp. 5 further replied that it was not possible to accept the results in the target lake survey without an own evaluation since some of the results were totally wrong. *“...at least you have to be very careful we noticed when we looked at this material when we did the regional action plan then we went through the whole assessment in the report and did our own assessment of how accurate it was and sure the most of them seem to be quite reasonable but some of them is totally wrong so it is not possible to just accept all the results in it, it is a question about what the purpose is that determine how good or bad it is” (5).*

6.1.5 Available handbooks and reports

A general question was asked about what the liming officers thought about the available handbooks and reports regarding liming. The question was asked since the handbooks and reports are developed as a tool for the liming assessment and it is important that they give adequate support to the liming officers.

Positive opinions/ Reports are written in a certain way

Most of the opinions about the available handbooks and reports about liming were positive. The Resp. 7 concluded *“Yes they have, it is good that there are published handbooks. I think it has worked in a good way”* (7). Resp. 2 indicated that handbooks and reports often was written in a certain way *“They are as they always are, they have to be read a lot of time in order to understand them orderly”* (2). When Resp. 2 was asked about special improvements the respondent further mentioned that people have different way to think but that the persons who write the reports and handbooks were doing their best. *“No, it is probably how people think simply, so I believe they are doing as good as they can, it is not so damn easy”* (2).

Some material is difficult

Resp. 5 answered that the written material was comprehensive and useful but that the descriptions about how to assess acidification was difficult. *“....I think they have been good and useful in a lot of different ways, it is in principle possible for anyone to understand quite well the liming procedure. So I think they have been very good, but then I think that some of the descriptions about how to assess acidification is correct but quite difficult to understand when it is time to do the calculations”* (5). Resp. 5 further suggests increased descriptions about the calculations and education or more tools to make it easier. Resp. 5 stressed that it had been improvements in the descriptions but it was still a bit tediously to do acidification assessment for all the limed lakes. Resp. 5 mentioned that the acidification assessment took a lot of days and more things could be done to help this process.

Missing information and differences in opinions

Resp. 6 replied that they not always agreed upon all procedures in the handbooks. *“They have been the base and support for our assessments, then it is not always*

we agree sometimes we do stuff a little bit different, but they are handling out the money so they have the right to tell us what to do, but then we sometimes think we have better ways so then we have to argue for our opinion” (6). The liming officer further stressed that more information about IKEU (Integrated Studies of the Effects of Liming Acidified Waters) was needed.¹ Furthermore more research and support was needed when it comes to the acidification assessment such as termination of liming activities and monitoring.

Lack of data hindering the use of the newest handbook

Resp. 8 mentioned that the handbooks were good to have in order to coordinate and perform fairly equivalent acidification assessments in all regions in Sweden. However, it was visible that Resp. 8 used an older version of the handbook in some of their assessment at the homepage for the liming assessment. A specific question was asked about it. *“It is the criteria before the MAGIC model from year 1999. There is the handling of the acidification assessment before the MAGIC-model and the newest acidification assessment”* (8). When the respondent was asked if this report was the best one Resp. 8 replied *“No I do not think so, but we had the background data to work according to it”* (8).

6.1.6 Available parameters and their usefulness

Questions about available parameters and usefulness of parameters were asked in the inquiry and in the oral interview. Available and reliable data is very important for the assessment of limed waters. Lack of data and doubts of the liming assessment has been mentioned of several liming officers in other sections. In this part are specific parameters investigated.

¹ IKEU (Integrated Studies of the Effects of Liming Acidified Waters) is a national monitoring program for long-term effects of liming.

The inquiry showed that available parameters for the conduction of liming assessment were varying in high extent between different regions in Sweden (Appendix II). Table 4 are showing the summed estimations of the usefulness of the different parameters according to the inquiry results, however seen in Appendix II there are great variations between different opinions. Furthermore, according to some responds in the inquiry was some of the grading done according to different parameters availability and not their usefulness.

Table 4: Summed estimation of the usefulness of different parameters. (inquiry results).

Parameter	Total grading points
Alkalinity and measure of water colour before liming	30
pH before liming	29
Data of current fish and crayfish stocks	28
Survey data of lost fish and crayfish stocks	27
Measured inorganic aluminium in reference waters	27
Base cations and sulphate before liming	26
Measured inorganic aluminium in limed waters	25
Other biological parameters	25
Data of benthic invertebrates before liming	14
Other Data	11

Usefulness and limitation of chemical parameters

Alkalinity and some measure of colour and pH before the liming started were considered as the most useful parameter in the inquiry (Table 4). During the oral interview the usefulness of these parameters were further confirmed by some of the liming officers. Resp. 7 mainly used alkalinity and in Resp. 7 opinion this was the best parameter. Another liming officer (Resp. 2) concluded that the use of pH and the other chemical parameters was the fastest approach. However other liming officers stressed the limitations of chemical parameters. When Resp. 4 was asked about the most unreliable parameter the respondent stressed the importance of correct sampling of chemical parameters, and especially the difficulties with sampling in streams. On one side, water chemical sampling could say a lot if there were regular sampling, the sampling point was located at the right spot and if the time for sampling was optimal. However the liming officer replied that there was occasions when this was not the case, especially in running waters due to the high variability of water flow. Resp. 4 concluded that biological parameters gave a more reliable result in streams. “ *It does not give a good picture since it can vary so incredible, the water chemistry, it gives the values for one occasion that day*

you are out and get the results, while the biological parameters actually reflecting the state during a longer period” (4).

Low availability and limitation of biological parameters

Some of the liming officer stressed that the availability of different parameters were low. Resp. 1 declared that the chemical parameters were most available, but other data was used when it was present. *“It is not so much we have really it is mostly the chemical parameters that are available except some other special things in order to perform acidification assessment we use the chemical parameters and other things that we have available” (1).* Resp. 5 also answered that the different biological parameters seldom were available, but also stressed that biological parameters only were useful to show changes over time. Moreover there were limitations with historical biological data collected from interviews and literature due to this the evaluation of acidification were mainly done with the acidification assessment criteria's. Limitations with historical biological data was also mentioned by Resp. 8 who mentioned that there basically were no biological data until the mid-70s and this data were mainly survey data of fish. The survey data of fish could be questioned due to the way it was produced *“...There were fish consultants who went out to the cottages with a species list and pictures of fishes to point on if the species had been present, yes or no, and then there was enormous amount of species, which did not correlate with the reality....” (8).*

Reliability of fish data

However despite the critic of fish data mentioned in previous section, the usefulness of both present and historical fish data was stressed by several liming officers both during the inquiry and in the oral interviews. Data of current fish stock and survey data of lost fish stock were rated as the third and fourth highest in the inquiry (Table 4). During the oral interview Resp. 3 replied that both present and historical data of fish especially roach, but also other acidification sensitive species was useful *“When it comes to the assessment of acidification, I think that presences of roach and other acidification sensitive species are useful, and historical data can be very useful” (3).* Furthermore Resp. 4 stressed that the usefulness

of different parameters was different in lakes and rivers and concluded that data of current fish stocks was very important for their assessment in lakes. Resp. 6 also found data of current fish stocks to be reliable especially when long time series were available. *“Fish is quite reliable...In general over several years I think they give good results...and the water chemistry cannot be argued against.”* (6).

Diatoms and benthic invertebrates

Some of the liming officers were talking especially about diatoms as a useful parameter during the oral interviews. Resp. 8 was keen on plankton such as diatoms, but stressed further that long time series were available for fish and benthic invertebrates. *“I start to think that the use of diatoms seems to be a good tool for assessment, but we have not used it for so long yet, it has been fish and benthic invertebrates and I think that both of them are quite good. The problem is that these parameters are found in special habitats and there are other types of water that can be affected, so that’s the problem with these parameters. On the other side it’s here we have long time series and that is very important when it comes to interpreting changes over time”* (8). Resp. 2 mentioned that plankton might be a reliable parameter, but did not say anything more about the parameter.

Resp. 6 indicated a high reliability to diatoms and a low reliability to benthic invertebrates when the liming officer was asked about the less reliable parameter. The respondent mentioned that they did not agree on the methods in the national standard for benthic invertebrates and that there were no visible differences in samplings after liming or termination of liming activity. The results from benthic invertebrates were moreover contradicting the results obtained by diatoms. Resp. 6 explained the possible reason for the low reliability of benthic invertebrate data *“It is not the standard. It’s about the consults, they who perform the task, they should have the right species knowledge and do the grouping in the same way according to available species and then there are a lot of different index who reacts in different ways depending on who made the species assessment, we can get very different answers when one person is replaced”* (6).

Handling of contradicting results

Some liming officer described different ways to handle contradicting results, and diatoms was also mentioned as a tool in this aspect. Resp. 3 added diatom sampling in the assessment program two years ago on locations where biological data were missing and on locations with contradicting results, and confirmed a feeling of high reliability of diatoms “ *I have a feeling that diatoms might be a little bit more reliable and easier to use for acidification assessment*” (3). Resp. 3 further concluded that the results seemed to correlate well with the water chemistry. The measurement of aluminium was in addition increasing in the county Resp. 3 was representing. However it was not enough and more measurements was needed at other locations. Resp. 5 further highlighted the measurement of inorganic aluminium as an important support parameter in the acidification assessment and stressed its usefulness for estimating the risk for negative impact on aquatic species. Resp. 8 CAB (County Administrative Board) had increased the sampling of inorganic aluminium since three years back. However there were some uncertainties in the results of the analysed concentrations. Resp. 8 dealt with the situation by changing laboratory for the analyses to validate the accuracy of the measured concentrations. Resp. 3 mentioned that the historical data of roach in lakes were contradicting to some of the MAGIC estimation of prelimed pH, Resp. 3 dealt with the issue by own choice and estimation and performed estimation of unlimed pH and delta pH. Resp. 5 did also use calculated unlimed pH associated with species that occur naturally in order to deal with insecurities of the MAGIC results. Similar methods were also mentioned by Resp. 4 and Resp. 8. There were few contradictions in the results from different parameters in Resp. 1 county, but the liming officer replied that the assessment criteria's mostly had been used on lakes and more contradictions might occur when the criteria's were applied to water courses.

6.1.7 Assess ecological status in limed waters

The Water Framework directive (WFD) has the goal to reach good status until 2015 in all surface water. Liming has been an important tool for the conservation of biological diversity in lakes and rivers, but can also cause adverse effects on naturally occurring species if natural acidified waters are limed. The fulfilment of

the Swedish environmental goal “only natural acidification” are not influenced by liming (Naturvårdsverket, 2012). The liming has only a temporary effect and is only a tool to keep up the water quality until acidifying substances stops to deteriorate the water quality and the ecological status. The water status gained after liming is a modification of the water quality with no permanent effect. According to the guidelines, the chemical status should be adjusted with the ratio of non-marine calcium and magnesium. When it comes to the biological quality factors are the liming of the water in most cases improving the living conditions for sensitive species, which cannot be denied. An interrupt of liming could lead to a deterioration of the water quality thus not compatible with WFD.

Difficult to answer

All liming officers were asked about their opinion about liming water that was reaching good status according to the environmental criteria's in the Water Framework directive (WFD). Most of the respondents stressed that the question was strange and difficult to answer. The question can be considered as quite diffuse and not well developed. The question was not changed during the interview period and the liming officers were answering the question from different perspectives. It might also be stressed that the liming officers had different enrolment in the work with WFD, some have main responsibilities while other did not explicit took part in the work (Table 5).

Table 5: liming officer's involvement in work related to WFD and the Swedish environmental goals. (Inquiry results with adjustments)

Liming officer	Work tasks with WFD or the Swedish environmental goal
Resp. 1	Swedish environmental goal
Resp. 2	-
Resp. 3	WFD/ Swedish environmental goal
Resp. 4	WFD
Resp. 5	-
Resp. 6	WFD
Resp. 7	-
Resp. 8	WFD/ Swedish environmental goal
-Resp. 9	WFD

Error margins and liming effects on downstream lakes

Resp. 1 replied that if the status classification was considered to be done within error margins they would primary continue to lime, but if the classification was performed outside error margins liming should not be conducted. Resp. 7 on the other hand was thinking about liming for downstream effect and replied that lim-

ing could continue if liming was done to achieve good status in acidified waters downstream “ *I depends on what values to be achieved or if there are important areas downstream, then I think it could be limed*” (7)

Liming to reach good status

Resp. 5 stressed that the system used for the criteria's in WFD also was a bit blunt like the criteria's in the liming assessment which made it difficult to clearly say that a lake with good ecological status not should be limed. The liming officer had not worked with classification and was not fully familiar with the system but stressed that there was a lack of biological data to further evaluate the status of the water. Resp. 5 concluded that liming was a tool to reach good status in the region “.....*good status has been applied when it has been limed and the water chemical targets has been achieved, we do not have biological data to further evaluate it so then is the liming a tool to reach good status which can be discussed but it is the way we have handled it.....*” (5).

Liming should not be used to reach good status

Resp. 3 concluded that liming should not be used if the water had good status. According to Resp. 2 should the liming operation be performed when there was a need to be done and when it was good reason to do so regardless of the status classification, but on the other hand was the liming officer critical to assess a water as good status if the water could not maintain good status without liming “*I think that the status should not be good if it cannot be maintain a good status independently but it is a personal opinion*” (2).

Impossible to reach good status if the acidification status is bad

Resp. 8 reasoned that if the acidification status was bad, then the status could not be classified as good “*It is so that if the acidification status is not good, the lake can't get good status, or if the biology is perfect or OK then the chemistry pulls down to moderate status at least. So if the water has lower than god status when it comes to acidification, the total status is deteriorated to moderate ecological status*” (8).

The importance of national agreements and motivation for the status classification

Resp. 4 stressed the importance of that the reason for status classification carefully should be motivated and described in the VISS system.² According to Resp. 6 it was said from the beginning that limed waters should be classified as “good status at risk” and either it could continue on the same path or change guidelines and classify limed lakes as “moderate status”. However the respondent concluded that a national agreement was important in these matters *“It depends on how things has been done since it was said from the beginning that limed waters should be classified as good status at risk and then you may continue at that path...in other case the strategy must change so limed waters are classified as moderate status but these are something that must be agreed upon nationally”* (6). Resp. 6 further argued that if the liming was conducted in a correct way should the water quality not be so bad so it could be classified as “bad status” on the other hand it could not be classified as good without measure. In accordance to Resp. 5, Resp. 6 was also critical to the assessment criteria for the status classification and pointed out that assessment criteria for the biology might not be good enough to evaluate if liming was the cause of bad ecological status.

6.2 Organizational condition for the work related to liming

6.2.1 Liming officers work with liming

The time available for liming officers to perform tasks linked to the liming management was varying in large extent. During the oral interview Resp. 6 and Resp. 7 responded that they worked 80% of their time with liming. Resp. 5 was working between 50-100%. Resp. 4 and Resp. 2 worked about 50% with the liming activity, while Resp. 1 worked 40% and Resp. 3 worked 10-20% and Resp. 8 15-20%.

Amount of persons involved

The County administrative boards (CAB) suffers in varying extent of acidification and the respondents time spent on liming related tasks should further be related to

² VISS (Water Information System Sweden) is a database of all large lakes, rivers, groundwater and coastal water in Sweden.

the amount of other persons working with liming at the CAB's. Resp. 3 and Resp. 6 indicated the largest amount of involved personnel. Resp. 3 explained that the involved personnel were working with varying proportions of their time, *"We are four persons who are working with liming and biological restoration, but with varying proportion of our time"* (3). Resp. 6 further stressed the issue with what should be included in the definition of work with liming *"Yes, I am the responsible person for the liming and with biological restoration included there is two persons more or three if liming effect assessment are included, it's depend on what is included but say two persons more"* (6). The difficulty to define the work with liming was also shown by Resp. 8 *"Actually two, but three might be said"* (8). Resp. 1 and Resp. 4 indicated that they were the only person who was working with liming at their CAB's while Resp. 2 only had some administrative help.

Time spend on work related to liming

In the inquiry the answer on the amount of persons involved in the work with liming was quite similar except the answer of Resp. 1 (Table 6, Appendix II). However the answers about working time with liming was in the most cases higher in the interview than in the inquiry. The liming officers did not indicate any general increase of the working time between the inquiry and the interview. It was probably due to that more tasks were included in the answers from the interviews than during the inquiry. Furthermore were the liming officers indicating that the work with liming was varying from time to time which made it difficult to clearly estimate the average time spent.

Table 6: Time spend on work related to liming and amount of people working with liming at CAB. Answers from the interview (conducted in dec 2012- feb 2013 and the inquiry conducted in 2010 (Annex II).

Liming officer	Answers from the inquiry (2010)		Answers from the interview (Dec 2012 - Feb 2013)	
	Respondents Working time with liming %	Numbers of people working with liming	Respondents working time with liming %	Numbers of people working with liming
Resp. 1	90	6	40	1
Resp. 2	30	2	50	1 (2)
Resp. 3	20	4	10-20	4
Resp. 4	40	1	50	1
Resp. 5	100	5	50-100	5
Resp. 6	55	1	80	2-3
Resp. 7	60	2	80	2
Resp. 8	10-15	2	15-20	2-3

Some of the liming officers indicated that there was too little time for working with liming, Resp. 2 considered 50% as too little time to perform liming assessment. *“I think we have too little time. The person who had this job earlier only worked 50% with liming and it is not enough time for doing the liming assessment.”*(2). Resp. 3 commented that a large number of participants in the liming assessment did not ensure that there was enough time to perform the tasks *“One can possibly think, we are four persons but totally if we count the percent of every position then it is not so much work, so we do not have possibility to control and examine in detail as much as we might would like”* (3). However Resp. 1 indicated that restrictions of available time were no limitation for the work with liming *“I spend the time needed... it’s a bit different depending on different occasions so it’s difficult to give a general answer”* (1). According to the inquiry 67% of the respondents were dissatisfied with the workload in relation to the amount of staff and the rest thought it was moderate (Appendix II). The question was not separately asked in all of the interviews, but most of the respondents answered that they would perform more biological and chemical assessment if they had more resources which indicate that more time is needed if these tasks should be performed more thoroughly.

Administrative work take the most time

According to the inquiry conducted in 2010 65% of the average work time with liming was dedicated to administrative tasks (Appendix II). Tasks with acidification assessment and adjustment of liming strategy and liming doses were given much lower work time in most of the cases. The interviews (conducted between Dec 2012 and Feb 2012) indicated that the administrative related tasks continued to take a lot of the time. Resp. 4 responded that the administration took the most of the time, but chemical sampling and liming monitoring was also time-consuming. *“I put most of my time on the administration of e.g. government grant for liming, then are liming, liming monitoring and water chemical sampling taking a lot of time”* (4). A similar answer was given by Resp. 6. Resp. 5 stressed that the post that was called administration includes a lot of things and Resp. 2 concluded that the administration part was a fixed post which could not be cut down which might

be possible with other tasks. However several other tasks was mentioned to be important such as the management, monitoring and evaluation of data, follow up and identify needs or possibilities to cut down liming doses.

6.2.2 Contact and influence of other stakeholders

During the interview the liming officers were asked about their contact with other stakeholders and their influence on the liming activity. A few of the liming officers worked part time at other institutions and gained direct contact with another institution by this way. The liming officers mentioned several different actors. Resp. 7 mentioned that different municipalities, other County administrative boards (CAB's) and Swedish Agency for Marine and Water Management (HaV) were important stakeholders. *"Yes it is the municipalities of course they are the principals for the liming and we do have contact with HaV and the other county CAB's of course"* (7). All liming officers mentioned the municipalities as important stakeholders, seven of eight liming officers mentioned HaV and five of eight were mentioning people at CAB's (at their own or at other CAB's) as stakeholders they had contact with, furthermore five of eight mentioned consults or entrepreneurs.

Municipalities

Different involvement among the municipalities

Resp. 2 said that they had contact with the municipalities by phone, mails and annual meetings. However since the municipalities sometimes had poor economic resources, shortages of time and knowledge gaps in the topic it sometimes lead to that the CAB almost took the whole burden of the tasks. *"It is the municipalities who are the principals and have the responsibility and we have a more overall responsibility in the county, but since they often have shortage of resources, time and knowledge it becomes us who take the whole burden"* (2). Resp. 2 as well as Resp. 7 stressed that the participation of the municipalities was varying in high extent, some was very active and other had to be pushed to respond to important questions regarding their liming activity. Resp. 2 further reflected about that the

difference of involvement probably depended on interest and available time at the municipalities.

Resp. 8 described different ways to interact with different stakeholders. For example, the liming officer participated together with landowners and liming entrepreneurs in yearly meetings held and prepared by one municipality. During the meeting was the perceived progress of the liming activity described by the CAB. Resp. 8 stressed that this meeting was a good opportunity to meet other important stakeholders such as the landowners. Resp. 8 was asked if the municipalities were very active in the county. Resp. 8 concluded that in this specific case the municipality was an important initiator, but Resp. 8 would not like to say that the municipalities was very active and stressed that the CAB accounted for the main part of the activity. Resp. 8 further held a similar opinion as Resp. 7 and Resp. 2 about that the municipalities had to be encouraged and helped to perform their tasks. *“That is an exaggeration, but in this case we meet the principals and landowners and I think that is important. No I would not like to say that our municipals are very active. Actually it might be us who account for the most activity in the county, they are doing what they should but they have to be encouraged and they get quite good help from us to do what they should”* (8).

Resp. 6 meant that the municipalities had a large impact on the liming activity since they were paying most of costs and had the role as principals. However since the municipalities felt they did not have the expertise, they relied on the expertise from CAB and were listening a lot to their advice. Resp. 6 explained further that it could be considered as a symbioses relationship *“It is a bit strange. They are in charge of the decisions but they often think it is very good if I take the decisions, and I am in charge of the money and I will judge if they do the right things so it’s like a symbioses relationship between us. You can almost say it is 50/50 influence between us and the municipality. And then of course we have the HaV that have a large impact, since they take the overall decision about the money”* (6).

CAB's and municipalities do not discuss the relimed waters

Resp. 5 had daily contact with the municipalities who was responsible for all sampling in the county, but according to the liming officer nobody was really influencing which waters that were limed. *"The municipalities... what is limed today and have been limed since long back in time... it is only reliming we have not had any new liming since I do not know when... so it has not been discussed basically nothing at all today. We keep the one we have started to lime and then there is not so much discussion about it"* (5). Resp. 3 held a similar position and also stated that nobody really had influence on which water that was limed. However the liming officer also mentioned that when it came to the shutdown of liming activities they were the main decision makers. Furthermore sometimes municipalities request liming of unlimed lakes which also was the case this year but if no money was received from HaV no reliming would occur.

Cabs, HaV and other stakeholders

Resp. 4 described the review of their action plan as an example of influence of HaV and other CAB's. *"It is obvious...as an example we had, when we did the action plan for 2010-2015 the latest plan. It has been reviewed by HaV together with a liming officer from another CAB. And I must say what has been the most important in this case that we had communication between HaV and this other CAB"* (4). The liming officer further explained that this kind of communication was very important when there was need to solve problems in target areas and receive feedback, suggestions and recommendations on adjustments of the action plan. The liming officer could also contact other liming personnel at other CAB's in order to get support in emerging issues. Resp. 8 was mentioning the importance of internal dialog within the unit and with other units at their CAB as an important contact. The liming officer continued to explain that it was important to reach consensus in some values. *"We have a dialog internally of course it is some that need to be managed. It needs to be consensus when it comes to values and things like that with other units at CAB. It is important to have consensus, at least in overarching values"* (8).

Resp. 5 told that they had contact with entrepreneurs in some cases. When Resp. 5 was asked about their contact with entrepreneurs the liming officer explained that this contact was mainly conducted when municipalities and entrepreneurs was disagreeing regarding questions of principle. *“ It is mostly when... when it comes to special things...in general when municipalities and entrepreneurs not quite agree or in more principal questions then we usually step in and say our opinion”* (5). Resp. 2 did not either have so much contact with the entrepreneurs but sometimes it happened that they went out to see so things worked.

Resp. 6 sometime used consults to do evaluations of the sampling and establish liming plans however it was not so much contact during the past year. Resp. 8 also used consults especially for biological monitoring e.g. diatoms. The liming officer stressed that the consult not had any influence since it was on request of CAB they performed the tasks however their performance was particularly significant for the assessment performed by the CAB. Resp. 6 had further contact with fish clubs who often stressed particular lakes which they had interest in but their opinion seldom led to changes in the liming activity *“They highlight individual waters which they have particularly interest in. And we usually go there and watch, but usually their opinions do not lead to any changes, but however we take into account what they have seen, but in term of influence it usually do not lead to so much”* (6).

HaV was also mentioned as an important stakeholder by several liming officers however it's contribution was often not described in depth during to the questions focusing on the general influence of optional stakeholders. This might be caused by that HaV was mentioned in several other aspects during the interview, furthermore was the interviewer asking following question in favor of explanations of other stakeholders. Seen above was Resp. 4 describing a case of important communication with HaV and Resp. 2 also stressed that HaV was affecting the liming activity in high extent due to their influence of available money and their role of making recommendation of adjustments. Furthermore did Resp. 6 indicate that the

CAB might have more insight of local aspects which they have to take into account when they are considering the changes that are recommended by HaV *“Then of course we have the HaV they have a large impact since they take the overall decision about the money. But we have to consider the local knowledge ...sometimes HaV have objections about the management of individual liming objects”* (6).

6.2.3 Changes of responsibilities and economical decrease

In October 2012 the Swedish Agency for Marine and Water Management (HaV) presented the decision to change the structure of the decision-making regarding what actions to be taken in order to achieve the environmental goals decided by the parliament. HaV stated that they would increase the freedom for the County administrative boards (CAB's) to make the crucial decisions. However the requirements of reporting would increase with a development of a new accounting system, and furthermore the grants for the Swedish environmental goals were reduced. The preliminary budget was set to 320 million a decrease of 126 million from previous year (HaV, 2012a). However, during the decision in February the grant was set to 310 million (HaV, 2013). According to the report about the new strategy HaV was suggesting a higher appropriation for the environmental goals, but the parliament rejected the suggestion.

Opinions of the new structure of the decision making

In the interviews the liming officers were asked about their opinion and reaction on the planned changes. Most of the liming officers were doubtful about the decision. The responds should be seen from the point of view that the question was asked to the participants during the end of 2012 and the beginning of 2013 before anyone clearly knew the outcome of the decisions. The unclear outcome of the decision was mentioned by several liming officers. According to Resp. 3 was the decision changed a bit and HaV should probably continue to give quite clear directions about the allocation of the money even if things was still unclear. *“ Yes, it was what was said when they didn't want to give us money, but what I have understood during the discussions that has taken place, it seems like they have changed and*

will continue to point quite clear on what we should do with the money we get, but we have not got the decision yet so we do not know how yet” (3). Resp. 1 did not expect that the decision about giving free hands to the CAB to decide all the decisions would come into force. According to Resp. 1 it would be better if HaV continued to take the overall decision about the distribution of money. “My spontaneous reaction is that I do not think that the CAB should do these trade-offs themselves. And I do not expect that this will happen. I do not think that this should be especially appropriate. It is better if HaV continue to distribute and valuate where the money will make the most benefit” (1).

Resp. 2 was holding a similar position as Resp. 3 and Resp. 1 and believed that HaV would continue to keep control in higher extent than was mentioned in HaV’s press release. In other case the decision might lead to a fight about money between different water related measures. *“I was present at this liming conference when they dropped this cutting plan. It would lead to a fight about money and what they should be used for, but it seems like they in some way will control more than what has been written in the press release” (2).* Resp. 5 stressed that the change of decision structure could lead to large risks with increased variations of how the money was handled as well as ineffective money management. According to Resp. 5 should the central authority control and determine the performance since the environmental strategies was established of the parliament and government. The liming officer concluded *“Personally I think that it is an objectionable action to leave free hands to the CAB, it will only increase the variation in how this money is handled. If there is a strategy from the parliament and government how to pursue environmental work in Sweden then it is reasonable that central authorities control and determines the strategy from the parliament and government....it feels very strange with the whole action and I think there are large risks to do it this way” (5).* Resp. 3 did also stress the importance that HaV as a central government should continue to take their responsibility and not make it easy for them by letting the CAB’s fight internally about the allocation of money. *“I think it is weak of HaV, if this comes into force. It is their responsibility actually as an authority to*

manage the management then they have to take care of it and not only make it easy for themselves and letting the county fight internally” (3).

Resp. 4 mentioned that they had revised their liming activity and decreased the liming doses and wished that the decrease of appropriation should not prevent them from implementing their liming activity as planned. Furthermore they progressively decreased the liming doses regardless of if there were a decrease in the appropriation or not. *“Since we already have revised our liming activity and decreased it so much I hope we can implement the liming activity as planned. We will see, but it is always something that we have done every year ...looked if we can decrease the amount... how does the water chemistry looks like. So it is something that we are already doing every year regardless if there is a decrease in the appropriation or not” (4).* Resp. 7 was not surprised about the decision made by HaV and also talked about the previously large decreases of liming and further stressed the possible risks having to reduce the doses at levels where it could harm the biological values.

Resp. 6 believed that the increase of accounting would rather affect other measures than the liming activity. Moreover it could perhaps be nice with some more discretion over the money, but on the other hand they already had sufficient freedom and it would probably not matter in any high extend. Resp. 6 continued further to reflect over if it could perhaps lead to that CAB increased the administrative grants to the municipalities and then progressively let them assess more from year to year. *“It is more about if we in that case would like to increase the administrative grant to the municipalities and maybe let them assess some more from year to year” (6).* However in contradiction Resp. 6 also mentioned that the roles probably would be kept in the same way.

Most of the liming officers were unsure if the new distribution of money and decision making would affect their work and the distribution of work among different stakeholders. Resp. 5 did not think that it would affect the work, but noted that it might cause an enhanced role of the CAB in the regional work with the environ-

mental goals, which might cause an increased priority of regional matters. Resp. 3, Resp. 2 and Resp. 1 did not think it would cause any large change of stakeholder roles, only the role of HaV in such case. The referral of the new regulation (HVMFS-XXX) that was presented by HaV in December was mentioned by Resp. 8 who found that the roles of stakeholders were clarified by the new regulation.

6.2.4 Improvement opportunities and wishful thinking about investments in the liming management

All liming officers were asked about how their current work with the acidification assessment could be improved and what they would like to invest in if they had unlimited resources to put on the liming management. The first questions were asked in order to capture the opportunity to gather opinions of possible improvements of the liming management. The second question was asked in order to broadening the perspectives and invite for further wish thinking that might not seem to be realistic. This chapter will present some of the concluding remarks on this topic, but some of the answers have instead been presented in other chapters.

More learning and more user friendly tools

Several liming officers wished for more education and more user friendly tools for the liming assessment. Among others Resp. 1 stressed the importance of further education at least for the County administrative boards (CAB's). The liming officer further expressed the need of simplified tools to make the liming assessment more manageable especially for CAB's with small resources and low number of liming objects. *"There is probably many questions that are important, but if you only look at the acidification assessment, then it is very important to continue to educate at least at CAB level and continue to think about the possibility to simplify the tools to make it more available for those who don't have the possibility to put so much time on it as I have, because there are large variations in how much resources the CAB's have and many CAB's have very few liming objects which means they have very little time to work with the liming and the system should be adapted according to that"* (1). The need of more education was also explained by Resp. 3 who wished for more hand-on tutorials. The liming officer mentioned that there had been learning opportunities at the national liming meetings and that

CAB's who had more time working with the liming assessment shared knowledge among other liming officers during these meetings. Resp. 4 did also stress that the learning outcome of the national liming meetings was very important and this had worked very good, but also mentioned that learning also was created by being out in the real world sampling biological and chemical data.

The need for simplified tools was also further mentioned by Resp. 2 and Resp. 5. Resp. 5 concluded that the shortage of time and handling of large datasets created a risk for miscalculations. *"It takes a lot of time to work with large datasets and recalculate ions and milligram and milliequivalence and so on....so there are also large risks of counting errors, which are not good, it's a bit on the way at that direction and there is a lot more that could be done to ease this process for the liming officers"* (5). More improvements was mentioned by Resp. 6 who was working with changing the structure on the data handling, but also wished for better guidance from HaV and more time to work with the liming assessment.

More sampling and more available data

Resp. 7 wished to have more opportunities to be out more in the field and collect more data. If there were unlimited amount of money should the sampling events increase remarkably and the monitoring would lead to more knowledge of the biological values such as allocation of crayfish in the county. This was also mentioned by Resp. 8 who would increase the sampling events but also improve the liming management by adapting the management to specific conditions in individual waters. Resp. 1 stressed that an increase of resources not would lead to large changes in the liming management, but if they had more money it could lead to an increase of analyze and more calculations. Moreover did Resp. 6 answered that more resources could be used to put more time on the liming assessment, which would increase the reliability of the assessments and make it possible to consider all collected data in the liming assessment.

7 Discussion

7.1 The complexities of the liming assessment

Acidification is rather well known and rigorously researched and experienced by many people e.g. by the loss of biodiversity. Still, the estimation of current, future and historical patterns of acidification and its biological effects is complex and difficult to predict due to the large number of processes involved. This is illustrated in many ways in this study e.g. by the liming officers sometimes got contradicting results when comparing results from different parameters. New knowledge and perspectives are appearing continuously such as acidification by forest harvesting and changes in TOC concentrations. Furthermore new regulative directives, economic and organizational conditions are shaping the conditions for the liming assessment.

There is a history of conflicting perceptions of what should be considered as natural and anthropogenic acidification. Moreover there has been a lack of consensus of how to perform the liming management which not has been eased by the absence of national guidance during the beginning of the implementation of liming activities. Many waters lack sufficient data to ever know the exact conditions prior liming. Therefore decisions of liming doses and termination of liming activities must carefully be assessed with criteria which enable the best decisions for the future water quality.

7.2 The governance structure of the assessment of the limed waters

Another important question is further at what level the decisions about the liming management should be taken. The question about level for the decisions is not only relevant in the case of the liming management. These are important questions in all environmental assessments. Do we want uniform decisions for important environmental resources governed at national level or do we want diverse decisions governed at regional or local level? The management of environmental resources has both large effects for the current population, but also for the future availability of environmental resources. To manage natural resources require dealing with several perspectives at local, regional and global scale as well as in current and future needs and effects. Ideally, the choice of measures should be taken at the level of governance with best capacity to encompass all costs, benefits and perspectives. This requires cooperation and dialogue between different agencies as well as the public. It further requires sufficient coordination and a transparency of how measures are conducted. Moreover, measures need to be implemented in a practice of impartiality in order to mitigate vested interests and maintain trust among the broad public.

The discussion about relocations of some of the decision making between governance levels shows the complexity of defining the best level for different measures in the management of environmental resources, such as the liming management. This study showed that the majority of the participating liming officers did not have a positive opinion about the suggested changes in the decision making and reduced liming budget. Some of the liming officers stressed that the changes might lead to a fight about money and viewed the change as an increased risk of ineffective money management as well as increased variation among CAB's. In addition they were considering the risk of having to reduce liming doses to concentrations leading to adverse biological effects. The liming officer's opinions should be seen from the perspective that they was asked in a process of change and did not know the outcome. However, with these perspectives the current institutional arrangements seems more appropriate. On the other hand it does not seem to be the level

of decision making that is the crucial problem stressed by the liming officer. It might be an uncertainty in how to reach sufficient coordination and tools to regulate competing interest that are problematic.

Furthermore, seen by the liming officer's responds it seems unlikely that there is a broad interest by municipalities to take more responsibility of the liming management today. However, there might be potential to increase their influence and in a better way use their local knowledge. It has further been discussed that people who live in a catchment could define proper targets for catchment areas. Other studies have shown that local stakeholders have great knowledge of nearby ecosystems (Olsson and Folke, 2001). However, there is reason to expect that different stakeholders hold different opinions about the best way to manage resources. The involvement of diverse stakeholders can be difficult especially since it might increase the difficulties to define clear roles and responsibilities among stakeholders and agencies. Although the difficulties, the involvement of diverse stakeholder is important since the incorporation of several perspectives in the decisions ideally increases the resilience of the management of environmental resources. However in the worst case it could lead to adverse effects caused by vested interests and power struggles. It is not appropriate to only focus on local decision-making if not sufficient coordination and impartiality can be insured, which might be difficult. So should some actors take more responsibility than others in the management of natural resources, and in that case should it be experts, governments or stakeholders? Sustainable management of resources is a responsibility as well as a right, of all. Should the liming management be governed by a top down process or should it be facilitated by broad participation and deliberation? In my opinion both are needed. Decisions should be made where the capacity to encompass the benefits and drawbacks are the best, which suggests that different partial decisions can be made at different levels.

7.2 The performance of the liming assessment

This study found that the liming officers have great knowledge about liming and its effects. However, the knowledge was diverse and several of them wished for more education. This study shows that the assessment of liming is complex and difficult. The assessment will most likely be influenced by individual perceptions and by collective opinions among groups such as CAB's or other constellations. The current guideline as well as older ones is further important tools that influence the perceptions held by the liming officers.

7.2.1 The new assessment criteria with the MAGIC model

The study confirms that several liming officers used data from the target lake survey as support for decisions. But some of its results have been considered highly unreliable, and the majority of the interviewed liming officers made their own calculations of delta pH. The liming officers had a perception of uncertainty of the MAGIC model both in the survey and the oral interviews. Several liming officers stressed that there was a shortage of data in order to effectively use the newest assessment criteria's which might be the major cause of the low perception of reliability. One other cause might be that the assessment criteria's was considered complex and time-consuming, which might lead to that not all liming officers have time to orderly put time to grasp the results. In addition the liming officers found unreasonable results for some individual lakes in the "target lakes survey" which might decrease the perception of the overall reliability of the results. One of the liming officers further mentioned that the model had been changed and that there had been several different approaches on how it should be used and how the results should be interpreted. This might further increase the insecurity of the model. The majority of the liming officers stressed the complexity of choosing a reference year for the MAGIC model. One the other hand the majority of liming officers was positive of using an estimated pH for 1860 as reference value in the MAGIC-model.

7.2.2 Biological parameters

Liming officers expressed a high confidence in fish data both in the inquiry and in the oral interviews. Moldan et al (2013) showed that a modelled historical pattern of acidification with the MAGIC model correlated well with information of historical fish population. Loss and damage of fish populations have long been the major issue caused by acidification and its negative effect on fish gills has been well studied (Lydersen et al., 1994, Andrén, 2012). However doubts about fish data especially historic survey data were also mentioned by the liming officers, as well as doubts about benthic invertebrates. Mant et al (2013) study showed that liming overall has a significant effect on the abundance of fish species, and abundance and richness of invertebrates, but results were mixed and there were cases where the abundance of invertebrates decreased. There are also risks that liming cause negative effects on fish communities by creating boundary conditions between limed and unlimed sites with enhanced aluminium toxicity (Erlandsson et al., 2011). Liming of naturally acid water might further decrease or change the species abundance by disadvantaging naturally occurring acid resistant taxa (Norberg et al., 2008). Angeler and Goedkoop (2010) further speculate if liming disturbs the formation of stable trophic relationships in the food web in lakes. This might further complicate the use of biological parameters as estimation of the long term recovery in limed waters. Moreover the study further showed that limed lakes had the fewest links between different trophic guilds, thus had lower complexity than circumneutral and acidified lakes undergoing an independent recovery process (Angeler and Goedkoop, 2010). Despite uncertainties of biological parameters, they are important tools in the assessment. By giving information of the occurrence of different species taxa it gives direct information about the long term living condition for aquatic organisms. Several liming officers had further a perception of high reliability of diatoms and had increased the sampling during the last years. Andrén and Jarlman (2005) study further confirm a strong connection between species composition of diatoms and acidification.

7.2.3 Chemical parameters

The inquiry result further indicated opinions about high reliability of historical pH and alkalinity measurement. The reliability of current measurement of these data was further confirmed during the oral interviews, although some of the respondents stressed the importance of correct sampling and difficulties with sampling in running waters. The high reliability of chemical parameters might further be linked to the high availability of these parameters compared to the biological parameters.

7.3 Implications of organizational structures and involved stakeholders

7.3.1 Working with liming

An important result of the inquiry and the oral interviews was that the majority of the liming officers work time was spent on administrative tasks. This probably limited the time for the assessment of limed waters. Moreover in the inquiry, 67% of the responding liming officers were indicating that the staff was too small in relation to the workload. The shortage of personnel was not mentioned in the same degree in the oral interview as in the inquiry. On the other hand the respondents reported more work time related to liming in the interview than in the inquiry. It might be reason to look if there are ways to improve the administrative process around the liming management in order to make it possible for the liming officers to put more time on other tasks. The inquiry and the oral interviews did not fully grasp what the administrative tasks contained. However among other the administrative task contained economical responsibilities dealing with budgets and procurement with entrepreneurs and consults.

7.3.2 Stakeholders

The study gained some knowledge about the stakeholders that the county administrative boards (CAB's) consider to be involved in the liming management. One striking result is that several liming officers considered the involvement of the municipalities to be low even if they have been valued as one of the most important stakeholders. Some of the liming officers mentioned that local knowledge

is important in the liming assessment. It might be reasonable to see the municipalities as a source for local knowledge and perspectives. All liming officers seems to have regularly contact with the municipalities, but it might be good to further ask the municipalities how they perceive the meeting and if there is anything that can be done in order to increase their participation. Moreover it could be a good idea to arrange a meeting with the municipalities to further discuss the relimed lakes, which not seem to be discussed today. This paper further acknowledges that there might be wisely to further ask other stakeholders about their opinions.

7.3.4 WFD and liming management

The question about liming in order to reach good ecological status received different answers among the liming officers. This is not so strange since there have been several official approaches during a short period. In the handbook published in 2002 it is written that liming is a tool to reach good ecological status according to the requirements in WFD (Naturvårdsverket, 2002). However in the handbook published 2010 it is written that liming not should be seen as an action that leads to good ecological status (Naturvårdsverket, 2010). In contrast it is mentioned in a recent scientific article that liming might be advocated as a tool in WFD “programmes of measures (Mant et al., 2013). One of the liming officers mentioned that it is important with national agreements about these matters and another liming officer stressed the importance of the motivation for the status classification. There might be reason to further strengthen the guidelines and the agreement for how limed waters should be classified since there seem to be difference approaches for how water is classified in different regions.

7.4 Importance of tools for the assessment

The importance and benefit of offering adequate performance support tools to those who perform complex and difficult tasks are stressed by several recent studies (Coulson-Thomas, 2013a, Coulson-Thomas, 2013b, Arciniegas et al., 2013). This paper has collected experiences and opinions from eight liming officers who seemed highly motivated to perform liming assessment in their county. The published liming handbooks, the “target lakes survey” and the MAGIC model can be

seen as available performance support tools. However the study shows that several liming officers wished for more education and more user friendly tools for the liming assessment. One of the most complex tools is the MAGIC model and the MAGIC library. Although a few liming officers stressed that they did not have difficulties using it, the majority thought the new liming assessment was difficult, complex and sometimes unreliable. In this case it is advisable that the classification tools for limed waters are made more user-friendly for the liming officers and other stakeholders. Better tools for calculations of unlimed chemistry and an improved MAGIC library could be developed in order to increase the reliability.

The MAGIC model contains several aspects effecting acidification such as; flow and storage of water in catchments, weathering, soil chemical reactions, leaching and dissolution and speciation of aluminium and organic carbon and atmospheric deposition. The complexities of the current assessment of limed waters might further limit the possibility for other stakeholders and the public to take part. Some liming officers mentioned that the municipalities lacked time and knowledge to participate orderly. More effort should be put to make people understand the model with focus on what it is, what it does and why it should be used. This could increase the possibility to receive relevant and thoughtful feedback and increase the dialogue with other stakeholders as well as the public. This approach might further straighten the resilience of the liming management if it causes an incorporation of multiple perspectives and includes public participation which is in line with WFD. Several conceptual models of the MAGIC model is available in scientific papers, however it should be possible to present the core processes related to the calculations in a way that people that do not have any previous knowledge can understand it. At present there are no educational and interesting figure of the MAGIC model and the MAGIC library present in reports, guidelines or at homepages.

8 Conclusion and Recommendation

Today the liming management cause large costs, it influence a large quantity of stakeholders and effects the ecosystems in large extent which makes it worthwhile to further invest effort to improve the liming management in several aspects.

The liming officers need more education and more user friendly tools for the liming assessment. However the acidification process is complex and new information and perspectives are continuously emerging. Therefore the tools need to be developed in a way so that new knowledge can be incorporated smoothly without leading to complications for the liming officers. Moreover the administrative tasks take a lot of time. Perhaps there is a need for an improved performance support tool.

The study further concludes that there might be a need of more data to conduct the current assessment of limed waters. In addition the classification (according to WFD) of limed waters might need to be discussed. When it comes to the changes in the decision making and decrease of money it is important to take into account the risks of negative impact mentioned by the liming officers. Moreover there might be reasons for the CAB's to further ask the municipalities if there is anything that can be done to increase and improve their involvement in the assessment of limed waters. At last, it might be possible to present the MAGIC model and MAGIC library more approachable e.g. with an educational conceptual model at homepages and in reports. This might increase the possibility of public participation.

9 Acknowledgements

The contribution of the liming officers has been the most important for the conduction of this study and I would like to thank all the liming officers who carefully answered and explained their opinions and perceptions during the interviews. Thank you so much for your contribution.

Moreover, I would like to special thank Jens Fölster for offering me to work with an interesting project and for good advice, guidance and critical analysis during the writing process. I am very thankful for your support. Also thanks to Salar Valinia for comments on the draft and for introducing the Olympus voice recorder DS-2000. Thanks also to Hans Peter Hansen who lent his recorder for this project.

Another important contributor was Stefan Löfgren who participated in a pilot interview and suggested changes which greatly improved the outcome of the interviews. Furthermore I would like to thank Stephan Köhler who from the beginning investigated whether there were any available projects at SLU, and Kevin Bishop for the examination of the thesis.

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Appendix I

PM- Enkätundersökning

Bakgrund

Nedfallet av sur nederbörd startade i samband med industrialiseringen runt 1860. Detta har orsakat en omfattande försurning av vattendrag och sjöar i Sverige vilka har haft drastiska effekter på akvatiska miljöer. Flora och fauna har minskat av för låga pH och utlakningen av tungmetaller till vattendragen har ökat vilka i sin tur påverkar vattenfaunan. Sedan 1980-talet har EU-baserade konventioner om utsläppsbegränsningar minskat nedfallet av försurande ämnen. Bistånd och forskningsanslag till övervakning av mark- och vattensystemen har möjliggjort större kunskap om hur tillståndet har sett ut och hur det förändras av föroreningar. Detta möjliggör också hur medel ska sättas in för att motverka en fortsatt försurning av de europeiska vattnen.

En lösning sedan 1970-talet har varit att kalka vatten och våtmarker för att höja pH och ge ekosystemen en chans att återhämta sig från försurningen. I början var målet att få pH i alla sjöar och vattendrag över 6.0. Under 1990-talet ifrågasattes syftet med kalkningen då forskning pekade på förekomsten av naturligt sura sjöar som på grund av naturliga processer hade pH under 6.0. På så sätt riskerar fortsatt kalkning i dessa områden att förstöra naturligt sura ekosystem (Bishop, 1997). Idag strävar man efter mer målspecifik kalkning där anpassning sker efter eventuellt naturligt lågt pH eller alkalinitet.

Beslut om kalkning görs länsvis. På länsstyrelser och kommuner görs expertbedömningar av tillståndet i vattendrag och sjöar gällande försurningsgraden. Expertbedömningarna ligger sedan till grund för huruvida vattenmagasinen behöver eller inte behöver kalkas eller om kalkningen ska minska successivt i området (Naturvårdsverket, 2010).

Då det under flera år har saknats en allmängiltig handlingsplan och gemensamma bedömningsgrunder för expertbedömningarna har olika län olika utgångspunkter för sina bedömningar. T ex kan fokus i vissa fall vara på pH före och efter kalkning, i andra fall har man i första hand koncentrerat sig på fiskfaunan. År 2007 publicerade Naturvårdsverket nya bedömningsgrunder för kalkningsverksamhet och tre år senare introducerades en ny handbok för kalkning. För att utveckla dessa gjordes åren innan en omfattande målsjöundersökning vilken man använde för att försurningsbedöma alla målsjöar.

De främsta skillnaderna mot den tidigare handboken var nya pH-gränser, nya bedömningsmetoder och gränsen för när kalkning ska upphöra. Tidigare baserades många expertbedömningar på pH uppmätt i slutet av 1970- och början 1980-talet, eftersom försurningen ansågs accelerera som mest vid andra hälften av 1970-talet. Idag sker bedömningen bland annat genom att jämföra förindustriellt pH med det uppmätta och på så sätt skilja antropogen försurning mot naturlig. En grundläggande del är att använda modellverket MAGIC för att på ett bättre sätt få en uppfattning av pH innan industrialiseringen. MAGIC har utvecklats på basis av målsjöundersökningen och kan beräkna förindustriellt pH, antingen genom att använda existerande indata, eller baserat på referenssjöar.

Det finns nu ett behov av att följa upp omstruktureringarna inom kalkningsverksamheten med en kvalitativ undersökning av hur förändringarna uppfattas och tas emot av de kalkansvariga. Denna rapport syftar till att ge en uppfattning om den nuvarande känslan hos de anställda angående bedrivningen av expertbedömningar och deras egna erfarenheter av kalkningen och dess verkningar. Studien kommer sedan vara underlag för utvecklingen av enhetliga riktlinjer för expertbedömningar som kan användas över hela landet oberoende försurningshistorik.

En första enkätundersökning gjorde för att ge en översikt över det nuvarande läget inom kalkningsverksamheten. Syftet med enkäten var att skissa en bild av nuvarande arbetsstyrkan kring kalkningen, försurningsläget i länen samt hur försurningsbedömningar görs och uppfattas av de anställda. Därefter gjordes ett antal djupintervjuer som mer detaljerat skulle ge en bild av hur bedömningar utförs och uppfattas. Dessutom var målet att se vilka förbättringar som kan göras, både vad gäller försurningsbedömningar, arbetsförhållanden och kommunikationen mellan olika instanser.

Metoder

Enkätundersökningen blev underlag för 8 djupintervjuer. Urvalet baserades på geografisk utspridning och informanternas erfarenheter. Djupintervjuerna var semistrukturella och följde en intervjuguide med ämnen som diskuterades (Bernard, 2006). Således var intervjuerna öppna och gav utrymme för informanterna att på egen hand utveckla ämnena med en viss ledning av intervjuaren. Under intervjuerna triangulerades ämnesvalen för att på så sätt skapa större förståelse för expertbedömningarnas genomförande och utvecklandet av riktlinjer.

Resultat

Enkätundersökning

Av de 18 kalkningslänen svarade 9 stycken på enkäten, varav en var testpilot. Geografiskt sett dominerade de södra och mellersta delarna av Sverige.

Nuvarande arbetssituation

Respondenterna hade olika akademiska bakgrund, oftast med biologi som inriktning (67%). Andra inriktningar var exempelvis ekotoxikologi, miljöadministration och vattenfrågor. Bland de svarande var det stor bredd i hur länge man arbetat med kalkning, från 3 till 33 år (5/9 svar).

I genomsnitt arbetar 2.8 personer med kalkning på länsstyrelserna. Av dessa har upp till 1 person heltidsanställning för uppgiften (exklusive biologisk återställning och kalkeffektuppföljning). Fördelningen av arbetet med kalkningen varierade. Det var stor variation i hur mycket av de svarandes arbetstid som ägnades åt kalkning. Arbetstiden låg mellan 20% och 100% med ett medelvärde på 47.5%. Andra arbetsuppgifter handlade främst om miljöövervakning, kalkeffektuppföljning, miljömål och vattenförvaltning. Den mesta arbetstiden med kalkning går åt till att administrera verksamheten. Andra uppgifter inom kalkningen, såsom försurningsbedömningar och justeringar av kalkningsstrategier och kalkgivor tar mindre tid i anspråk. Å andra sidan ansåg en majoritet (67%) att bemanningen är för låg i jämförelse med arbetsbördan, resten tyckte arbetsbördan var lagom. Inga av de svarande tyckte arbetsbördan var för liten.

Kalkningsverksamheten i länet

I länen idag bedöms kalkningen i viss mån vara klar eller uppnått jämvikt: Ungefär hälften av de svarande anser att kalkdosernas omfattning behöver minska, och resten anser att de borde ligga på samma nivå. Återhämtning och minskad försurningsbelastning gör att doserna i många fall förväntas trappas ner successivt. I andra fall har kalkningen skett i överkant i vissa sjöar och i underkant i andra, vilket gör att behovet för tillfället är stort i vissa sjöar medan mycket lite i andra. Fortfarande finns dock sjöar som lagts som avvaktande men som visat att de ännu inte återhämtat sig. I ett län upplevde man att kalkdosen skulle kunna minska ifråga om de målsjöar som direktkalkas och som uppnår de kemiska målen, medan målsjöar som kalkas för nedströms effekt i målvattendrag borde fortsätta kalkas på samma sätt som tidigare.

Antalet målobjekt förväntas minska eller ligga på samma nivå, främst på grund av många vilande områden som förväntas kunna läggas ner inom en snar framtid. Den nya åtgärdsplanen från 2010 har medfört att ett antal sjöar och vattendrag har börjat utfasats. I ett fall gav målsjöreferenserna osäkra indikationer på vattenkvaliteten vilket föranleder varför en ny målsjöinventering ska göras i detta län innan fler beslut kan tas. I ett av länen saknades det tillräckligt med biologisk effektuppföljning för att kunna ta ett beslut om utfasning av målpunkter.

Enbart i ett av de svarande länen kommer antalet målobjekt och kalkdos troligtvis att öka, trots minskad försurningsbelastning. Detta på grund av önskemål på nykalkningar och förstärkning av olika projekt.

Försurningsbedömningar av kalkade vatten

Enbart en av de svarande tyckte att försurningsbedömningarna i samband med de nya åtgärdsplanerna var enkel att göra. I övrigt var inställningen hos resterande svarande (88.9%) att försurningsbedömningarna var lagom till svåra att utföra. Anledningarna var många: modellverktyg bedöms vara otillförlitliga, komplicerade och tidskrävande, och avsaknad av viktiga kemidata gör att bedömningen inte går att göras, vare sig med eller utan MAGIC. I ett fall ledde detta till att försurningsbedömningar inte hade utförts på ett tag. Ett av problemen att samla in kemidata är finansiära.

Ur enkäten visar det sig att tilltron till MAGICs bedömningar överlag är tveksamt. Endast i två fall bedömdes MAGIC modellen prediktera ett rimligt försurnings-

läge. Övriga 78% bedömde MAGICs beräkningar att ha medel till låg tillförlitlighet. En svarande vars län främst hade försurade vattendrag hade ingen större användningen av målsjöinventeringen. I vissa fall saknas de data som krävs för att kunna köra MAGIC, vilket gör användningen komplicerad och problematisk om länsstyrelsen dessutom inte kan finansiera provtagningar för de värden som behövs. Utöver otillräckliga data upplever många av de svarande att MAGIC modelleringar ofta inte stämmer överens med egna mätvärden och historiska uppgifter. Dessutom har man erfarenhet av att MAGIC simulerar pH som känns orimliga. Ett allmänt intryck är att det är säkrare att gå på egna erfarenheten när man ska göra en försurningsbedömning.

Tillgången på data är viktig för bedömningarna av försurning, både av anställda och i MAGIC. I allmänhet på länsstyrelserna vara pH, alkalinitet olika former av uppgifter på fisk och kräftförekomster (historiska anteckningar/enkäter och uppgifter strax innan kalkning) de kategorier av data som länen oftast hade tillgång till. För målvattendragen var det i allmänhet mer sällan som det fanns tillgång på data, men för dessa objekt fanns det relativt sett mer data på aluminium i kalkade och okalkade vatten samt övriga biologiska data. Till stor del motsvarade tillgången på data även den användbarhet man hade av de olika typerna. De mest användbara var pH mätningar före kalkningen startade, samt olika typer av data på fisk och kräftförekomster. I ett fall uttalades det även specifikt att användbarheten likställdes med tillgängligheten, det är dock svårt att uppskatta om detta även gäller i de andra fallen. Flodpärlmussla och kiselalger i rinnande vatten anges som bra parametrar. En kommentar är att försurningstillståndet som det bedöms genom parametrar inte kan säga något om påverkan, men att data däremot kan vara bra till att sortera bort opålitliga MAGIC-simuleringar.

För försurningsbedömningarna används oftast en sammanvägd bedömning av olika data. Ett fall hade inte mycket annat än målsjöundersökningen att gå på, detta var samma län som inte hade försurning i sjöar utan främst i vattendrag och som inte heller hade haft de prover och värden som behövdes för att göra en försurningsbedömning. Här görs bedömningarna främst på biologiska data. En annan svarande uttryckte det som en självklarhet att man jämförde pH_{okalk} med $pH_{före}$ och efter kalkning.

De senaste försurningsbedömningarna som gjordes i samband med kalkningsplanerna har generellt sett inte påverkat verksamheten i de svarande länen. I några län har ett antal områden lagts vilande, i andra har kalkdosen minskat och i ett tredje län har kalkdosen för vissa målområden ökat. Indikationer gavs på att försurningsbedömningarna känns osäkra och att de därför har baserats på t.ex. biologiska data snarare än MAGIC.

För förbättra arbetet med försurningsbedömningar behövs bland annat mer utbildning och workshops. Förslag på utbildningsteman är t ex skogsbrukets bidrag till försurning och fiskbestånds variation i olika sjöar. Dessutom vill man få mer information om kalkdatabasen och uppdatering på forskningsläget kring försurning och kalkning. Förslag kom på en utbildningsdag/seminariedag, men en annan föreslog en utbildningsdag minst var tredje år.

Behovet av mer resurser framhävs, bland annat i form av tid och biologisk och vattenkemisk effektuppföljning. Även enklare verktyg såsom modellverktyg och hjälp med modelleringar efterfrågas. Flera behöver mer biologiska och vattenke-

miska data och användbara referenser såsom data från okalkade vatten. Förbättring av MAGIC eller liknande modeller efterlyses också.

Diskussion och sammanfattning

I allmänhet upplevs inte försurningsbedömningarna förändrats nämnvärt sedan den senaste versionen av bedömningsgrunderna kom ut. Vissa förändringar har dock skett i kalkdosmängd, men i två fall var detta främst på grund av resultat från effektuppföljning, nya pH-mål och biologiska data. Vissa väntar fortfarande på bättre underlag från inventeringar för att kunna verkställa förändringar.

I enkäten togs både funderingar och kritik mot de nya bedömningsgrunderna och metoderna upp. Dels yttrades behov av ökad tid och resurser för att göra försurningsbedömningar och jobba med kalkning. Den större delen av de svarande ansåg att kalkningsverksamheten på länsstyrelsen var underbemannad. Kritik riktades även mot verktygsmodellen MAGIC. Medan vissa av de svarande var mer eller mindre starkt kritiska till MAGIC, menade andra att det fortfarande behövdes mer data och längre tidsserier för att kunna använda den på ett tillförlitligt vis. Enbart målsjöinventeringen är inte tillräcklig för att få pålitliga resultat.

Tilliten till och användbarheten hos olika typer av data skulle kunna vara påverkad av ens bakgrund såsom att t ex biologisk/ekologisk bakgrund ger upphov till en större tillit till biologiska data istället för vattenkemiska data. Detta stämde enbart i vissa fall, och som en informant påpekade har tilliten mycket att göra med tillgängligheten på data. Dessutom tillkommer det att ha förtroende till de som utför provtagningen.

Enkäten gjordes för att ge en överblick och inblick i verksamheten kring kalkning och försurningsbedömningar idag. Tyvärr gör det låga antalet svarande det svårt att få en generell uppfattning av försurningsbedömningarna. Särskilt geografiska förhållanden kan påverka hur försurningsbedömningarna uppfattas och utförs, t ex med tanke på att den största delen av sur nederbörd faller i sydvästra delen av Sverige samt att de flesta naturligt försurade sjöar finns norrut.

Appendix II

Inquiry result (Swedish and English)

Table 7: Inquiry results (in Swedish). The respondents working time with lime related tasks.

Arbets tid med kalkning							
Administration		Försurningsbedömningar		Justering av kalkningsstrategi och kalkgivor		Total arbetstid med kalkning	
Antal resp.	%	Antal resp.	%	Antal resp.	%	Antal resp.	%
1	5	5	5	1	5	1	10-15
1	20	1	10	4	10	2	20
1	30	1	20	1	20	1	30
1	40	1	30	2	25	1	40
1	60					1	55
3	70					1	60
						1	90
						1	100

Table 8: Inquiry results (in Swedish). a) Staffing in relation to work load. b) Respondents background.

Bemanning i förhållande till arbetsbörda	%	antal resp.	Inriktningar på studier	Antal
Låg	66,7	6	Geokemi	0
Lagom	33,3	3	Biologi	6
Hög	-	-	Annan inriktning	3

Table 9: Inquiry results (in Swedish). Respondent's opinion about the liming assessment.

Åsikter om kalkningsverksamheten					
	Minska	Ligga på samma nivå	Öka		
Kalkdosernas omfattning bör	5	4	-		
Antal målobjekt bör	5	3	1		
	Enkel	Medel	Svår		
Uppgiften att försurningsbedöma samtliga målobjekt enligt de nya regionala åtgärdsplanerna	1	2	6		
	Obf.	Låg	Medel	Hög	M. Hög
Tillförlitlighet på försurningsbedömningar gjorda enligt bedömningsgrunder baserade på målsjöundersökningen	-	3	5	2	-

Table 10: Inquiry results (in Swedish). Rating of usefulness of different parameters.

Användbarhet av parametrar				
Gradering av användbarhet	1	2	3	4
	Antal resp.	Antal resp.	Antal resp.	Antal resp.
pH-mätning före kalkning	-	2	3	4
Alkalinitet och något mått på vattenfärg före kalkning	-	1	4	4
Baskatjoner och sulfat före kalkning	1	2	3	3
Uppmätt oorganiskt aluminium i kalkade vatten	1	2	4	2
Uppmätt oorganisk aluminium i referenssjöar	0	3	3	3
Mätdata på fisk och kräftförekomst innan kalkning	2	1	1	4
Muntliga/Enkätbaserade uppgifter om förlorade fisk och kräftbestånd	1	2	2	4
Uppgifter om nutida bestånd av fisk eller kräftor	1	-	5	3
Bottenfauna före kalkning	2	3	2	-
Övrig biologiskdata	1	-	4	3
Övrig Data	-	1	1	2

Table 11: Inquiry results (in English) available parameters. (-/ means no answer or an answer that cannot be represented as a number).

Interviewee	pH before liming		Alkalinity and measure of water colour before liming		Base cations and sulphate before liming		Measured inorganic aluminium in limed waters		Measured inorganic aluminium in reference waters		Measured fish and crayfish presence before liming		Survey data of lost fish and crayfish stocks		Data of current fish and crayfish stocks		Data of benthic invertebrates before liming		Other biological data		Other Data	
	Lakes	Rivers	Lakes	Rivers	Lakes	Rivers	Lakes	Rivers	Lakes	Rivers	Lakes	Rivers	Lakes	Rivers	Lakes	Rivers	Lakes	Rivers	Lakes	Rivers	Lakes	Rivers
Resp. 1	-	95%	90%	95%	-	5%	0%	80%	-	100%	-	80%	-	20%	-	90%	0%	80%	-	5%	-	-
Resp. 2	5%	0%	5%	0%	0%	0%	10%	0%	5%	0%	0%	30%	30%	70%	70%	0%	0%	20%	70%	-	-	
Resp. 3	85%	80%	85%	80%	5%	5%	55%	0%	0%	50%	50%	90%	-	80%	85%	2%	2%	-	10%	-	-	
Resp. 4	-	-	-	-	-	0%	0%	0%	0%	-	-	-	-	-	-	-	-	-	-	-	-	
Resp. 5	20%	20%	70%	70%	1%	1%	2%	30%	70%	90%	80%	20%	10%	95%	100%	0%	0%	60%	5%	0%	0%	
Resp. 6	85%	42%	80%	40%	1%	0%	20%	0%	10%	5%	2%	70%	98%	55%	100%	1%	0%	10%	98%	-	-	
Resp. 7	-	90%	-	90%	5%	0%	50%	100%	0%	-	30%	10%	10%	60%	100%	0%	10%	10%	-	-	-	
Resp. 8	-	5%	-	5%	0%	5%	25%	-	25%	-	5%	5%	5%	-	90%	-	5%	25%	90%	90%	10%	
- Resp. 9	100%	100%	100%	100%	0%	0%	0%	0%	0%	1%	0%	0%	0%	40%	96%	0%	0%	0%	0%	0%	0%	

Appendix III

Covering letter (Swedish)

Förfrågan att delta i en telefonintervju

Hej!

Hösten 2011 gjordes en enkätstudie kring kalkningsarbetet i olika län av SLU på uppdrag av Naturvårdsverket. Nu planeras en intervjustudie per telefon som återkopplar till denna enkät. Intervjustudien syftar också till att ta fram mer fördjupad kunskap om förurningsbedömningar, arbetsprocesser och förbättringspotential av kalkningsverksamheten samt att följa upp enkätstudien. Syftet med studien är att ge underlag till en fortsatt utveckling av relevanta verktyg för bedömning av förurningspåverkan i kalkade vatten. Den kommer också ge underlag till en mastersuppsats i ämnet miljövetenskap på SLU.

Det är viktigt att så många kalkningshandläggare som möjligt kan medverka i intervjustudien för att resultatet ska bli så representativt och användbart som möjligt. De som medverkar kommer att få ett sammanfattande dokument med resultat skickat till sig efter att studien är slutförd.

Allt material som samlas in kommer att behandlas konfidentiellt, varken län eller respondenter kommer att namnges i arbetet. Intervjuerna kommer att spelas in för att säkerställa korrekta citat. Det går bra att avbryta en påbör-

jad intervju eller att avstå från att svara på frågor. Intervjun innehåller inte frågor som bedöms ha känslig karaktär.

Intervjun beräknas ta mellan 30 -60 minuter. Jag kommer att höra av mig till er via e-post och föreslå tider för intervjuerna

Du är också välkommen att höra av dig om du har några frågor om intervjustudien!

Mvh Rebecka Karlsson

mail : 

tel. XXXXXXXX

Appendix IV

Interview guide (Swedish)

Arbetsprocess

=* Hur jobbar din organisation med kalkningsbedömningarna?

Delfrågor som ställs om de inte avverkas på annat vis

=Beskriv Processen och Tidsramar

=Hur många Personer är involverade i Processen?

Hur stor del av din tid ägnas åt kalkning i relation till andra arbetsuppgifter?

*Vilka arbetsuppgifter med kalkning lägger du Mest/Minst tid åt?

- Administration
- Försurningsbedömningar
- Justering av kalkningsstrategi och kalkgivor

+ Har du kontroll över pengarna för kalkningsverksamheten

+ Har du kontroll över kalkningsstrategin i ditt län

+Vilka andra Aktörer har du kontakt med i ditt arbete med kalkningsfrågor?

+Hur stort inflytande skattar du att dessa aktörer har när det kommer till vilka ytvatten som blir kalkade?

- Kalkdoser
- Försurningsbedömningar
- Val av/ Tillgängliga Parametrar

Försurningsbedömningar av kalkade vatten

*+ Hur ser du på kalkdosernas omfattning?

- Dagsläget och i framtiden?

*+ Hur ser du på antalet målobjekt i länet?

- Dagsläget och i framtiden?

Minska	Ligga på samma	Öka
Vad ligger till grund för din åsikt?		

*Tycker du att det är lätt eller svårt att använda den nya försurningsbedömningen?

- Vad gör det lätt /svårt?
- Har du ändrat åsikt sen enkäten gjordes?

*Den där målsjöundersökningen som gjordes 2007-2008, tycker du att bedömningsgrunderna baserade på målsjöundersökningen är tillförlitliga?

- Vad gör den tillförlitlig/otillförlitlig?
- Tror du att din åsikt har ändrats sen enkäten gjordes?

+Hur ställer du dig till kalkning av ytvatten som bedöms ha god status enligt miljökvalitetsnormerna i vattendirektivet?

+Hur ser du på skogsbrukets betydelse för försurningen i länet? ³

+ Anser du att det är lämpligt att ett beräknat pH för år 1860 används som referenstillstånd i försurningsbedömningarna?

- Varför anser du att det är det bra/dåligt? Vad tycker du i så fall skulle fungera bättre?

= Har de olika handböckerna och rapporterna från Naturvårdsverket varit till hjälp vid bedömning?

Vad bör förbättras i dessa dokument?

* Vilka biologiska och kemiska parametrar tycker du är mest/minst tillförlitliga och användbara för att försurningsbedöma vatten.

1. Ev. specificera

³ Question asked to Resp. 4-8

= Har du fördjupad/ expertkunskap för någon specifik biologisk eller kemisk parameter?

* Vilka biologiska och kemiska parametrar finns tillgängliga för försurningsbedömningarna i målsjöar och vattendrag?

+ Minns du något specifikt tillfälle då bedömningsgrunderna stred mot annan tillgänglig data? Hur hanterade du det?

+ Kan du komma på och beskriva ett fall då tillgången av underlag för bedömning av kalkningsdos var mycket låg/otillförlitlig. Hur hanterade du det?

Försurningsarbetet i framtiden

”Under slutet av 2012 beslutade HaV att styrningen av vattenarbetet ska minska vilket kommer leda till en ökad frihet för länsstyrelserna att besluta vilka insatser som ska sättas in för att nå riksdagens miljömål (HaV, 2012b). HaV kommer att öka kraven på redovisning och uppföljning genom att utveckla ett nytt redovisningssystem, som särskilt kommer fokusera på åtgärder i relation till miljömålen (HaV, 2012a). Dessutom ska HaV minska sitt bidrag till länsstyrelserna från 446 miljoner till 320 miljoner per år, vilket kommer att träda ikraft 2013.⁴⁵”

+ Hur är din spontana reaktion kring detta?

+ Tror du det kommer påverka dina arbetsuppgifter?

+ Tror du länsstyrelsens roll kommer ändras i relation till andra aktörer när det kommer till kalkningsverksamheten?

+ Det finns ett förslag på att minska antalet länsstyrelser från 21 till 11. Tror du att det skulle vara bra eller dåligt för kalkningsverksamheten?⁶

* Hur skulle ditt arbete med att försurningsbedöma kalkade vatten kunna förbättras, utifrån de nuvarande resurserna som finns till förfogande.

+ Om du hade obegränsade resurser hur skulle du vilja att kalkningsverksamheten utvecklades i ditt län i framtiden.

Har du något annat att tillägga?

⁴ <http://www.havochvatten.se/download/18.45b0847b13a1135746af73f/1349189125898/ny-atgardsstrategi-for-havs-och-vattenmiljon.pdf>

⁵ <http://www.havochvatten.se/om-oss/press-och-media/visa-nyheter/visa-pressrelease.html?url=-290745163%2Fpressrelease%2Fview%2F799519>

⁶ Question asked to Resp. 4-8