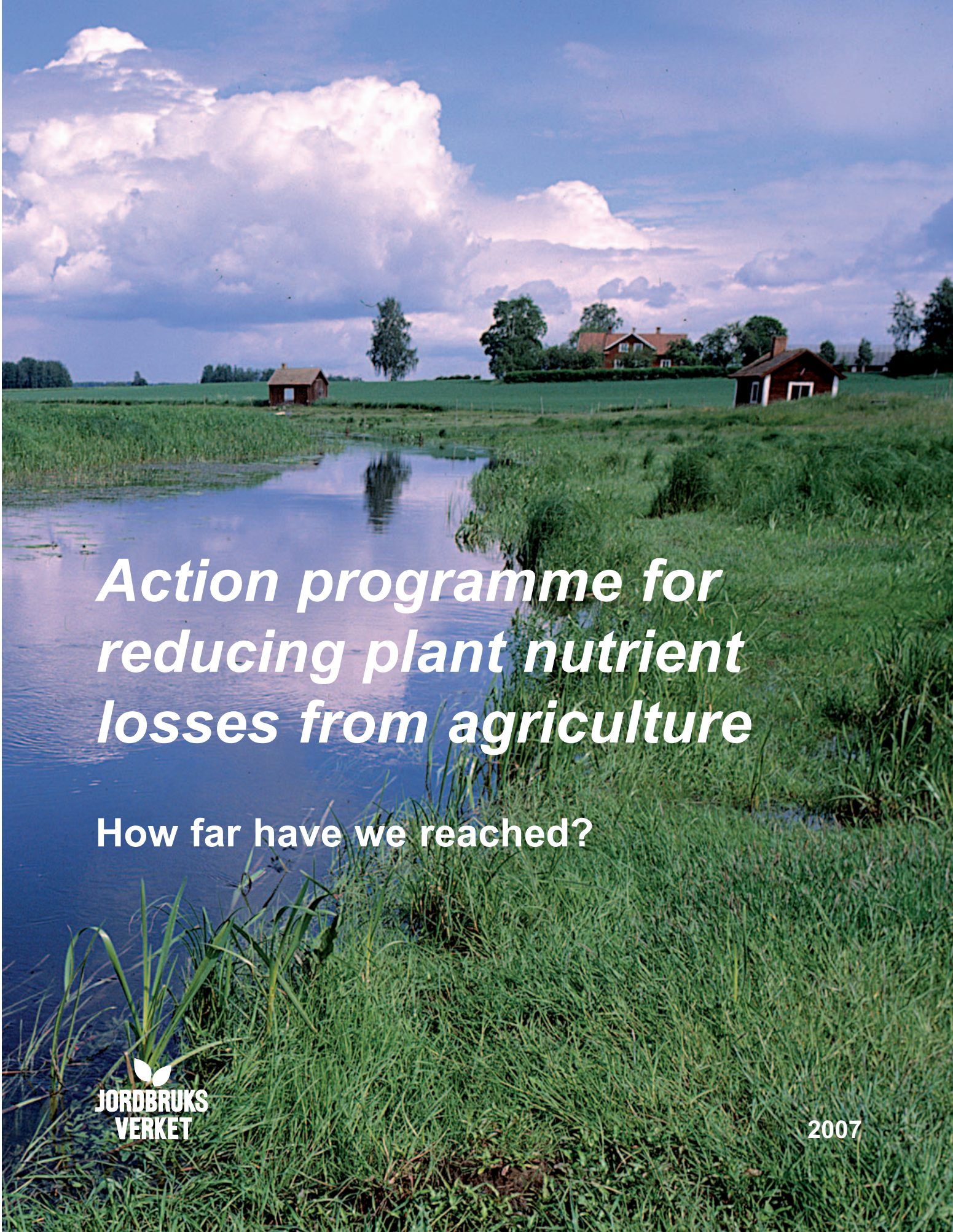


Action programme for reducing plant nutrient losses from agriculture

How far have we reached?

JORDBRUKS VERKET

2007

Introduction

This document summarises the effects of the Plan of Action for Reducing Plant Nutrient Losses from agriculture achieved so far. Our intention is to provide a brief general description of the various measures, including how far those measures have taken us. You may find more detailed information, and some useful tips in the *"further reading"* in some sections of this document.

The programme started in the early 1980s and initially included measures for reducing nitrogen leaching and phosphorus losses. It expanded later to include ammonia losses as well.

The measures in the programme are carried out through legislation, financial means of control, extension service and information, as well as research and development.

The decline of emissions of plant nutrients from agriculture is not solely due to the action programme measures, but also from a number of other external factors. This document takes those factors into account.

This document will:

1 – illustrate the background to, and content of Sweden's action programme.
2 – present the developments in nutrient leaching and losses, and how those can be related to the Action Programme.
3 – try to present the cost and effects of the measures as a whole and individually.
4 – briefly illustrate the changes of nitrogen and phosphorus losses that occur for reasons other than the measures in the action programme.

Cover photo: Lennart Svedlund. Photo this page: Urban Wigert.

Contents

Why an action programme?

The supply of nitrogen and phosphorus to seas, lakes and watercourses may cause eutrophication. Eutrophication is not only a serious threat to our lakes and surrounding seas, but also a reality in several cases. Nitrogen leaching from agriculture through losses from manure to surface water and groundwater can also cause the water to become unfit for drinking.

The current state of the environment is a result partly of years of mistreatment of our environment and partly of the today's emissions. It is important for us to actively strive towards improving the environmental situation for present and future generations.

The agricultural measures based on the action programme contribute both to reach the goals decided in Sweden, like the environmental quality objectives, and to reach international agreements and directives.

How did the action programme come to be?

In 1988, the Swedish Parliament decided on a special action programme for improving the environmental performance of agriculture. This was a result the attention that problems with eutrophication attracted.

At that time, the measures in the action programme mostly concerned areas with intensive agriculture and coastal areas. They focused on adapting plant nutrient supply to its specific need, on limiting pollution and on increasing the share of land under green cover in winter. The action programme has since been expanded to include measures for reducing ammonia losses from agriculture as well, and it has been revised and updated twice. The last revision was carried out in conjunction with the development of the environmental quality objectives.

International agreements and EU directives

In recent decades, Sweden has signed several international agreements aiming to limit environmental pollution. The box below provides some related facts.

Studies including suggestions for measures in the area of plant nutrients

Towards the end of the 1990s, the Swedish Board of Agriculture carried out several studies that contained suggestions for measures to reduce ammonia and nitrogen losses from agriculture.

As regard to ammonia, it was suggested that losses should decline by some 7,300 tonnes from 1995 to 2010. Measures believed to contribute to this target included the covering of slurry stores, swift action to work the manure into the soil after spreading, special techniques for spreading liquid manure, and extension service to farmers.

The proposals for nitrogen concerned the establishment of targets and plans of action for the entire farming sector. It was important that the measures were cost-effective and that they would be well received by the farmers.

Some of the measures proposed by the study were the following:

Facts – EU directives and international agreements regarding nutrient losses from agriculture

The Helsinki Convention, and OSPAR Convention

Convention on the Protection of the Marine Environment of the Baltic Sea Area/Convention for the Protection of the Marine Environment of the North-East Atlantic) Both the Helsinki convention and the OSPAR convention were created with the aim of reducing the pollution of our seas. The goal of the Helsinki Convention is to protect the Baltic Sea from all kinds of pollution, from traffic by road, ship or air. Among other things, the convention attempts to reduce by half the nitrogen emissions caused by humans. The goal of OSPAR is to protect and preserve the marine ecosystems of the North Sea and the North-East Atlantic Ocean.

The Nitrates Directive

(Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources) The Nitrates Directive contains minimum requirements for reducing nitrogen losses (nitrate losses) from agriculture to surface and ground water as well as to coastal water and seas. According to this Directive, each Member State

- Limit the spread of manure before sowing crops in the autumn.
- Introduce environmental support for sowing catch crops and reduced autumn tillage.
- Introduce environmental support for establishing wetlands
- Increase and improve the extension service in counties with the largest leaching of plant nutrients.
- Allow permanent fallow.

Once fully implemented in 2020, the measures are expected to result in a reduction of root zone leaching by 10,000 tonnes of nitrogen. It was also estimated that a natural reduction in arable land and fertilizing intensity would take place during the same period of time and this too was expected to result in reduced root zone leaching.

Sweden's environmental quality objectives

The Swedish Parliament has laid down 16 environmental quality objectives. These objectives form a holistic approach to the task of reducing the environmental load caused by the entire society. The overall goal is to reach a situation and an influence ecologically sustainable in the long run.

One of the objectives, *Zero Eutrophication,* tackles the problem of nutrient losses to land and water.

The environmental quality objectives have been broken down into interim targets, in order to clarify what is needed in various areas to reach the overall objectives. The following interim targets of *Zero Eutrophication* concern agriculture:

- By 2010 Swedish waterborne anthropogenic emissions of phosphorus compounds into lakes, streams and coastal waters will have decreased by at least 20 % from 1995 levels. The largest reductions will be achieved in the most sensitive areas.
- By 2010 Swedish waterborne anthropogenic emissions of nitrogen compounds into sea areas south of the Åland Sea will have been reduced by at least 30 % compared with 1995 level.
- By 2010 emissions of ammonia in Sweden will have been reduced by at least 15 % compared with 1995 levels.

The measures for reducing plant nutrient losses from agriculture are mostly based on the objective *Zero Eutrophication* and its interim targets. To some extent, measures in agriculture also influence the possibility to reach other environmental objectives, for example *Good Quality Groundwater, Flourishing Lakes and Streams* and *A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos.*

The objective reads:

Nutrient levels in soil and water must not be such that they adversely affect human health, the conditions for biological diversity or the possibility of varied use of land and water.

Further reading:

The environmental objectives portal
http://www.miljomal.nu/english/english.php

shall identify areas that are sensitive to nitrate, and draw up an action programme with a view to reducing nutrient leaching from agriculture.

EU:s IPPC-direktiv
(Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control) The IPPC Directive shall, through coordinated measures, prevent and reduce pollution from a number of activities, including large pig and poultry holdings that can cause large losses of nitrate and ammonia.

CLRTAP
(Convention on Long-Range Transboundary Air Pollution) Several countries in Europe, including Sweden, and North America, have signed a protocol of the UNECE Convention on Long-range Transboundary Air Pollution. This protocol applies to emission of several air pollutants, including ammonia.

EU National Ceilings Directive
(Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants) This directive contains provisions for emission limits in the member states for various substances, i.e. ammonia.

What is included in the action programme?

The first action programme for reducing plant nutrient losses, as mentioned above, was drawn up at the end of the 1980s. The most recent change took place when the new environmental quality objectives were laid down in 2000.

What means of control are there for implementing the action programme? The measures in the action programme are implemented through:

- legislation
- financial means of control
- extension service and information
- research and development.

This means that the measures in the action programme consist of compulsory measures, e.g. legislation, as well as voluntary measures such as participating in environmental extension services.

Legislation

Many elements of agriculture and forestry can harm or disturb the environment. Such activities must be carried out with care and consideration. For some agricultural activities and measures there are clear rules, for others there is only general legislation. The rules that apply to environmental matters are collected in the Environmental Code and its ordinances and regulations.

Some rules regarding agri-environmental concerns are for instance, storage capacity for manure, covering of slurry and urine stores and filling them under this cover, limits for the amount of manure that may be added to arable land, special rules on spreading, and rules on keeping a certain share of land under vegetable cover during autumn and winter, so-called “green land”.

Financial means of control

In order to limit the use of some kinds of mineral fertilisers, there is, since the 1980s, a particular tax on the content of nitrogen and cadmium in fertilisers. The money brought with this tax is used for the Swedish rural development programme, and it finances, among other things, measures aimed at water quality management.

Since the mid-1990s, farmers can, among other things, apply for various agri-environmental support schemes that aim at reducing plant nutrient losses from agriculture. The agri-environment support schemes are partly financed by the EU. At the moment, farmers can apply for the following measures:

- buffer zones
- reduced nitrogen leaching (catch crops and spring tillage), and
- construction and management of wetlands and ponds.

The farmer participation has been good for several of these measures. The support for buffer zones and construction and management of wetlands and ponds is available for farmers in all of southern Sweden. Environmental support for reduced nitrogen leaching is available for farmers in the counties of Kalmar, Gotland, Blekinge, Skåne, Halland and Västra Götaland. The new Rural Development Programme commences 2007. It might entail some changes of the environmental compensatory schemes.

Extension service and information

Extension service and information regarding environmental matters is a significant activity within the action programme for reducing plant nutrient losses. This activity is implemented by the Board of Agriculture, the county administrative boards, and extension service organisations. By providing free advice to farmers on environmental matters, we hope to reduce plant nutrient losses. The advice can include aspects like suitable time and conditions for spreading manure, reducing excessive doses and better adjustment of animal feeding to need.

As a result from the studies carried out towards the end of the 1990s, a special extension service project *Greppa Näringen* (Focus on Nutrients)

has been introduced. Within the project large emphasis is put on follow-up and evaluation of the information that is given to the participating farmers. *Greppa Näringen* is carried out in co-operation by the Board of Agriculture, county administrations, extension services and farmers organisations.

Research and development

When the action programme was introduced, funds were also directed towards research and development. These activities include both cropping measures and technical development in the fields of agriculture and horticulture. Research in combination with trials form an important basis for the measures we ought to take in consideration and what financial means of control we are to use for reducing plant nutrient losses. Measures to improve the handling of manure during spreading, the sowing of catch crops, and feeding strategies are examples of implemented projects.

What are the targets of the action programme?

Based on the environmental quality objective *Zero Eutrophication* and its interim targets, the following quantitative targets have been laid down for agriculture. The targets concern nitrogen leaching and ammonia.

- Root zone leaching of nitrogen shall decline by 7,500 tonnes by 2010.
- Ammonia emissions from agriculture shall decline by 7,300 tonnes by 2010.

The reductions take place from the 1995 levels.

The action programme contains no equivalent target for phosphorus. One reason for this is the uncertainty about which measures are most effective for reducing phosphorus losses. Instead of proposing a quantitative target, we have introduced a target aiming at the continued reduction of phosphorus losses to lakes and rivers.

New measures to reach the above goals were proposed in conjunction with the development of the environmental quality objectives. New measures aiming to reduce nitrate leaching are:

- reduction of manure spreading before autumn sown cereals,
- increase the participation in the agri-environment support scheme for the use of catch crops and spring tillage through
- increase the participation to the agri-environment support schemes for the construction of wetlands
- to increase and strengthen the environmental information programmes in the counties where the largest losses of nutrients occur

The area used for arable land and the fertilising intensity was also expected to be reducing, hence contributing to a reduction of root zone leaching.

Follow-up, evaluation, environmental monitoring

Follow-up and evaluation

Data on crop areas, livestock numbers, fertiliser sales, and participation rate in the agri-environment support schemes are some of the information used in the follow-up and evaluation. Much of this data can be sought from the national systems for agricultural aid schemes. Further data can be achieved from Statistics Sweden who carries out a study on the handling of fertilisers in agriculture every two years. This study includes data on the spreading and storing of manure and the use of mineral fertilisers.

Model calculations are a great help for the evaluation of total nitrogen and phosphorus losses from agriculture. Ammonia emissions from agriculture and other sectors are also calculated.

Within the project *Environmental Effects of the Common Agricultural Policy,* environmental effects of the EU common policy are evaluated. One aspect studied in the project is for example how the agri-environment support scheme affects plant nutrient losses from agriculture.

Environmental monitoring

In order to keep an eye on the state of the environment and how it changes, there are monitoring programmes for ground water, watercourses, lakes, and seas. Monitoring programmes are carried out on a national and regional level. To some extent, these programmes can also provide information about effects of measures carried out in agriculture.

To specifically monitor the impact from agriculture on surface and groundwater quality there are two monitoring programmes, *Observation fields on arable land* and *Typical areas within agricultural land.* In the former, field runoff water quality is being monitored and in the latter, water quality in streams is being monitored.

Supervision and self-monitoring

Supervision of agricultural activities

The regulations of the action programme for reduced nitrogen leaching from agriculture are set out in the Environmental Code. Supervision is necessary to make sure that the regulations are complied with. The ordinance on supervision identifies the authorities responsible.

The authority responsible for the supervision shall verify that the rules are complied with, and shall take whatever measures necessary to correct irregularities. In addition, the supervisory authority shall use extension services; information and similar methods to create a situation that can achieve the goals of the Environmental Code. The supervisory authority shall report violations of rules and set conditions that might apply for the particular farm to the police or the office or the public prosecutor, if a violation is suspected.

Supervision is divided into operative supervision and guidance. Operative supervision is aimed directly at the person carrying out a certain activity, for instance when visiting the farm. Guidance shall further reinforce and develop operative supervision. Guidance consists of evaluation, follow-up and coordination of the operative supervision as well as of support and advice to the supervisory authorities that carry out the supervision.

Operative supervision of the regulations regarding nutrient losses is normally carried out by the municipality. An exception is the supervision of operations requiring an environmental permit according to the ordinance on environmentally hazardous activities and health protection, i.e. operations with more than 200 livestock units. The county administration is responsible for the supervision of these operations, even though this responsibility can be transferred to the municipality.

The guidance for agricultural, horticultural and animal husbandry matters in the Environmental Code is responsibility of the Swedish Board of Agriculture. This responsibility comprises, among other things, rules included in the action programme. At the regional level, the county administrative boards are responsible for the guidance to the municipalities in this regard.

Self-monitoring in agriculture

All persons engaged in activities that may have detrimental effect on human health or the environment shall, according to the Environmental Code, practice self-monitoring. Good self-monitoring means that people keep themselves informed about the effects that their operations have on the environment. It is a way of planning and organising work in order to prevent and counteract difficulties. Self-monitoring is also a way of showing the supervisory authority that relevant legislation is implemented.

Further reading:

Plan of Action against plant nutrient losses from Agriculture. Leaflet by the Board of Agriculture, 2006.

Website of the Greppa Näringen (Focus on Nutrients), *www.greppa.nu.*

Environmental code (1998:808)

Ordinance (1998:899) on environmentally hazardous activities and health protection.

Ordinance (1998:915) on environmental consideration in agriculture

Swedish Regulation (SJVFS 2004:62) on environmental consideration in agriculture as regards plant nutrients

Ordinance (1998:900) on supervision in accordance with the Environmental Code

Ordinance (1998:901) on self-monitoring of operators

Swedish guidance (2005:1) on storage and spreading of manure etc.

Changes in nitrogen leaching and losses of phosphorus and ammonia

There are many reasons why there are changes in nitrogen, ammonia or phosphorus losses to the environment from agriculture. Some of the changes are a result of the work carried out within the action programme. For instance, they may result from extension service or rules. Other changes depend on what crops are grown and what kind of livestock production is carried out. One such example is that the general direction of agricultural policy have a large impact on what kind of agricultural production is profitable; this in turn influences the shape of agriculture and its impact on the environment.

Different to point source pollution from large industries, sewage treatment plant losses from agriculture consist of a large amount of smaller sources, such as arable fields and animal housing. In order to estimate the size of these, model calculations and overviews are compiled regularly. Most emphasis has been on the estimations of nitrate leaching. As regards phosphorus, work is being carried out to improve the calculation model in order to better include the most important factors that influence phosphorus losses. Ammonia losses are generally calculated on a biannual basis by Statistics Sweden. The calculations and syntheses make it possible to follow the development of the environmental actions. Another important use of the calculations is the reporting obligations according to international conventions and EU directives.

The following section presents the estimated changes in plant nutrient losses from agriculture. It is primarily the changes that have taken place in comparison to the levels of losses 1995 that are presented. Whenever possible the contribution from the changes that have taken place as a result of the work within the action programme is presented. You can read more about the effects of particular measures in the section *What has the effect of individual measures been?*

Nitrogen leaching

The estimation of nitrogen leaching has been made for the losses directly from the arable land but also for the proportion that is actually reaching the sea. On the way to the sea there is a diversion of nitrogen compounds in the water systems through sedimentation, plant uptake and transformation to nitrogen gas (denitrification). This is called nitrogen retention. In the target for nitrogen it is stated that "the discharges of nitrogen compounds from human activity" to the sea shall be reduced. To get an estimate of the load to the sea that originates from "human activity" on farmland, the starting point is the figure for the leaching from the arable land. From this figure the retention and the leaching that would have occurred if nothing had been grown (background load) is deducted to get the estimate.

In this report only the leaching from arable land is presented as this was the focus when the latest estimates were done. Thus, we are not presenting the changes in the load to the sea. The leaching from arable land is also called root zone leaching, i.e. the nitrogen that has passed beyond the plant root zone in the soil profile at approximately 1 m depth.

During 2005 the Swedish University of Agricultural Sciences (SLU) carried out model calculations of the nitrogen leaching. The calculations show that the nitrogen leaching from arable land has diminished by 7,000 tonnes between 1995 and 2003[7], which is equivalent to a reduction of 12 %. The main reasons for the reduction in nitrogen leaching are introduced measures, better nutrient efficiency in the crop production and a reduced total area of arable land. Through further reductions in arable land area, mainly between 2004 and 2005, it is estimated that the nitrogen leaching has been reduced by a further 2,000 tonnes by 2005. The target for the action programme is a reduction the nitrogen losses from arable land of 7,500 tonnes from 1995 to 2010.

Also in the period between 1985 and 1995 there was a substantial reduction (25 %) of the nitrogen discharges from agriculture. This can be seen in a previous estimate[8], see figure 1. The

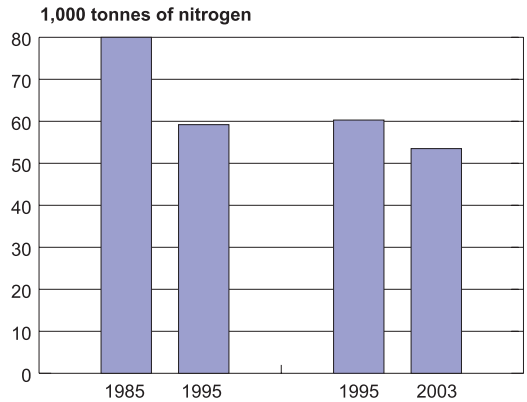


***Figure 1**. Results from two model calculations[9, 10] of nitrogen losses from the root zone of arable land.*

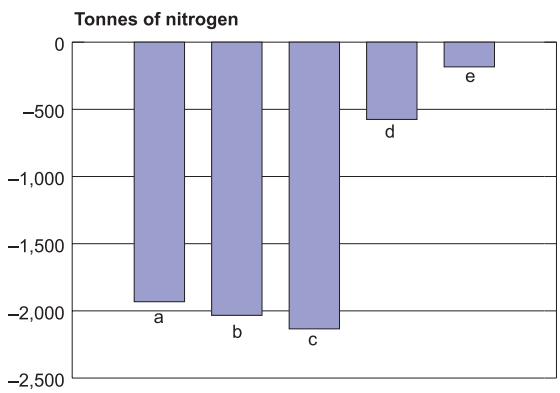


***Figure 2**. Reasons for reduced nitrogen leaching from 1995 to 2003, tonnes of nitrogen (N). a) reduced arable land area b) increased nitrogen efficiency c) growing of catch crops and spring tillage d) spring spreading instead of autumn spreading e) changed crop rotation.*

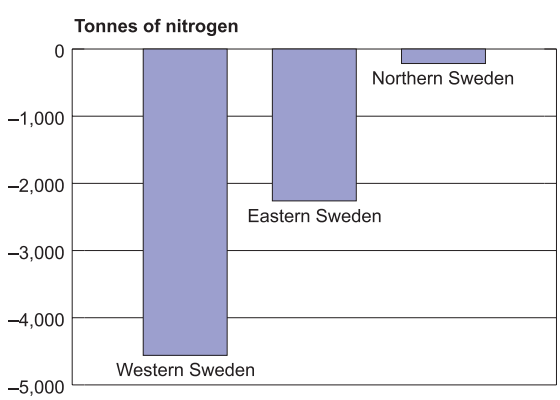


***Figure 3**. Reduced nitrogen leaching (tonnes) in areas affecting Skagerack and Kattegatt (Western Sweden), Baltic Proper (Eastern Sweden) and Bothnian Bay (Northern Sweden).*

result from this and the latest modelling work is not directly comparable because the calculation method has been changed in recent years.

Figure 2 shows that the reduction between 1995 and 2003 primarily can be explained by a reduction in arable land area, increased nitrogen efficiency in the crop production and the agri-environment support scheme for the growing of catch crops and spring tillage instead of autumn tillage. A smaller proportion can be explained by an increased proportion of manure being spread in the spring and changes in which crops are grown. The increased nitrogen efficiency is due to an increase in yields although the fertilisation rate is the same.

It is estimated that two thirds of the reduction that has taken place between 1995 and 2003 can be accounted to areas that affect the Skagerack and Kattegatt (western sea), whereas a third of the reduction can be accounted to catchment areas feeding into the Baltic Proper, see figure 3. A smaller proportion of the reduction can be attributed to the northern Sweden. In that part of the country the reduction is mainly due to a reduction in cropped area.

What has the latest actions meant?

The reasons for the reduction in nitrogen leaching presented in figure 2 are in some cases related to the measures that were introduced in the action programme in 2000. The reduction in leaching due to the growing of catch crops and spring tillage is a direct consequence of the higher participation rate in the Buffer zone and Wetland and Ponds schemes from 2000. Another measure that was introduced in 2000 was an expansion of the training scheme, including the *Greppa Näringen* (Focus on Nutrients) project and increased focus on a reduction of autumn spreading of manure to cereals The training within *Greppa Näringen* has contributed to increased nitrogen efficiency in cropping in southern Sweden.

The effects of the construction of wetlands are not included in the model evaluation. This is because the wetlands are only having an effect after that the nitrogen has left the arable land.

Out of the measures introduced in 2000, the agri-environment schemes for catch crops and

spring tillage have had a significantly larger effect than what was anticipated, whereas reduction in manure spreading before the sowing of winter cereals has not decreased to the extent that was expected. Due to a reduction in the total area of arable land and changes in crops grown, the nitrogen leaching has decreased more than what we were expecting.

Phosphorus losses

Generally the phosphorus pathways have been less described than what is the case for nitrogen and models for estimating the losses of phosphorus from agriculture are less developed. A method for estimating the amount of phosphorus that is retained in sediments and vegetation in the pathway to the sea (i.e. retention) has been missing. Hence, in the phosphorus case, only the losses from arable land have been estimated and not how much phosphorus that can be expected reaching the sea.

The latest estimations of phosphorus losses from arable land have been made for 1995 and 2000. They show a reduction by 19 % during this period. The reduction is likely to have been overestimated and is probably depending on the model used for the calculations.

New estimations of the phosphorus losses from agricultural land will be carried out using a method that will take better account of different pathways for phosphorus losses. A method to estimate retention has also been developed which enables the estimation of phosphorus load to the sea.

Another indicator of changes in agriculture is to examine the development of phosphorus efficiency. Statistics Sweden is regularly making national nutrient budgets and it indicated an increased phosphorus efficiency in agriculture, see table 1.

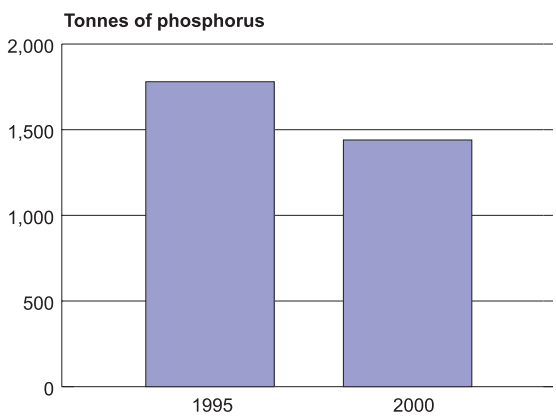


***Figure 4**. Phosphorus losses from arable land 1995 and 2000, tonnes of P.*

Table 1. Phosphorus efficiency in agriculture, 1995–2003, percentage

Year	1995	1997	1999	2001	2003
Efficiency, %	48	56	49	63	69

Ammonia losses

In 2003, some 55,600 tonnes of ammonia are believed to have been released into the air from Swedish sources. According to calculations, emissions have declined by some 13 % since 1995. Since 1995, agriculture has reduced its emissions by some 18 %.

The ammonia reductions that have taken place in agriculture depend to a large extent on the reduction in the number of animals in agriculture. The reduction in animal numbers is believed to have caused two thirds of the total reduction in emissions. Other measures that have resulted in reduced ammonia losses are the change from solid manure to liquid manure, the increased share of slurry stores that are filled under a cover, and the fact that manure is more swiftly worked into the soil after spreading.

Will we reach our current objectives?

Nitrogen

The target set for agriculture within the action programme, i.e. a reduction of the nitrogen leaching by 7,500 tonnes from 1995 to 2010, seem to be achievable. According to the model calculations that have been made, the nitrogen leaching had diminished by 7,000 tonnes already in 2003. In addition, estimations are indicating that the nitrogen leaching may have decreased by a further 2,000 tonnes by 2005.

However, at this moment success is not guaranteed as regards the target of reducing waterborne nitrogen emissions by 30 % to the seas south of the Åland Sea by 2010. In order to reach this target it would be necessary to introduce further measures in several sectors.

Phosphorus

Since the models for calculating phosphorus losses have not been well developed it is hard to estimate what effect the measures in agriculture have had. Although we know that the surplus of phosphorus in crop production is continuously diminishing, with a likely positive effect on phosphorus losses. There are also indications of diminishing trends of phosphorus concentrations in watercourses in intensive agricultural areas in southern Sweden.

For the same reason that it is difficult to estimate the effects from the measures in agriculture, it is difficult to tell how far all sectors have reached altogether in comparison with the national target.

Ammonia

The ammonia target in the action programme is to reduce emissions from agriculture by 7,300 tonnes from 1995 to 2010. According to our estimates, agriculture's emissions have declined by some 10,000 tonnes from 1995 to 2003, thus more than the target. Accordingly this target should be possible to reach.

The ammonia interim target to *Zero Eutrophication* states that ammonia emissions should decline by 15 % from 1995 to 2010. The interim target does not specify any targets specifically for the agricultural sector. The total ammonia losses have decreased by approximately 13 % from 1995 to 2003 and thus the interim target seem to be achievable by 2010.

Further reading:
The web portal of the environmental quality objectives, *http://www.miljomal.nu/english/english.php*

7) Johnsson, H. and Mårtensson, K. 2005. Estimation of the change in nitrogen leaching between 1995 and 2003 and the expected outcome of proposed measures for diminished leaching losses. Report to the Board of Agriculture, Reg nr 23 8051/04. *In Swedish.*
8) Swedish Environmental Protection Agency, 1997. Nitrogen from land to sea. Report 4735. *In Swedish.*
9) Johnsson, H. and Mårtensson, K. 2005. Estimation of the change in nitrogen leaching between 1995 and 2003 and the expected outcome of proposed measures for diminished leaching losses. Report to the Board of Agriculture, Reg nr 23 8051/04. *In Swedish.*
10) Swedish Environmental Protection Agency, 1997. Nitrogen from land to sea. Report 4735. *In Swedish.*


Photo: Urban Wigert.

What can we tell about the costs?

Most measures comprised by the plan have to various degrees resulted in costs for both the farmers and for society. The measures have been beneficial through the reduced pressure on the environment.

In the analyses and proposals for measures cost estimations have been made. These have been done in order to estimate the consequences of the measures and to assess their cost efficiency. Afterwards there has been no follow up or compilation of the cost of all measures. Therefore it is not possible to fully present the costs that have occurred during the implementation of the action programme. However, the costs are available for some of the measures. They concern measures where money has been transferred, i.e. the environmental tax on mineral fertiliser or environmental support. Below, we present the cost which those measures represent for the farm enterprises and for society. Please note that the costs presented here are only a part of the total cost of the action programme.

Environmental tax on mineral fertilisers

There is a so-called fertiliser tax on mineral fertilisers. The tax is imposed on everyone who professionally manufacture fertilisers or import them to Sweden in order to sell them on. They include this cost for the buyers of the fertilisers, i.e. the farmers. In recent years, the rate has been SEK 1.80 per kg nitrogen and SEK 30 for each gram of cadmium above the limit of 5 g cadmium per tonne of phosphorus. The income from this tax is shown in figure 5.

In recent years, a part of this income has been transferred back to agriculture. Among other things, the money has been used for preventive measures like training and information to farmers about agriculture's effect on the environment.

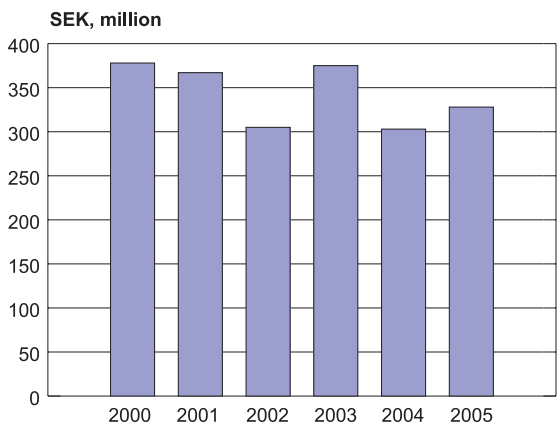


***Figure 5**. Tax income of the environmental tax on fertilisers, million SEK, 2000–2005.*

Agri-environment support schemes

There are three agri-environment support schemes that aim at reducing nitrogen leaching from agriculture. They are the following schemes: *Reduced Nitrogen Leaching* (catch crops and spring tillage), *Buffer Zones,* and *Wetlands and Ponds.* Farmers in all of southern Sweden can apply for participating in the support schemes for buffer zones and the construction and management of wetlands and ponds. The possibility to participate in the reduced nitrogen leaching scheme has during the period 2000–2006 been limited to the counties of Kalmar, Gotland, Blekinge, Skåne and Västra Götaland.

The participation rate has been very different in the three schemes. The participation rate is

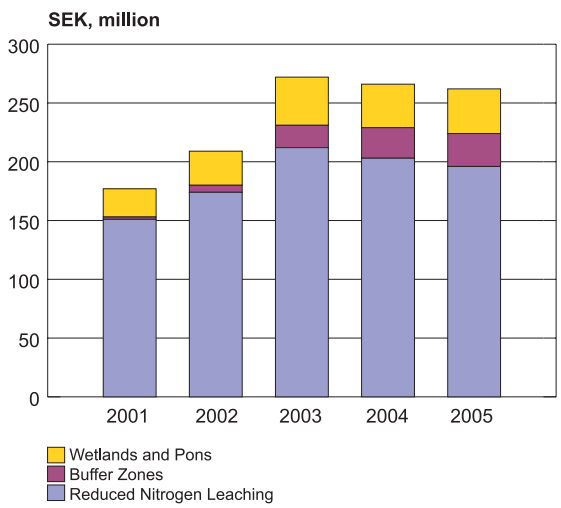


***Figure 6**. Amounts (SEK million) paid to agri-environment support schemes for reducing plant nutrient losses from agriculture in 2001–2005.*

high for the schemes regarding reduced nitrogen leaching and buffer zones, but the scheme for wetlands and ponds has not been as popular as we hoped.

Figure 6 above shows the amounts (SEK million) paid each year within the three schemes during 2001–2005. The agri-environment support scheme is a part of the Swedish Rural Development Programme and is financed by national funds as well as funds from the EU.

Amounts paid for training

The county administrative boards are responsible for the training programmes for farmers. These programmes contain the theme for the training and provide the of extension services offered to farmers in the county they cover. There is no charge for the participating farmers; the activity is financed through the Swedish Environmental and Rural Development Plan. This, in turn, is financed partly by the Swedish Government and partly by the EU.

Funding for courses, farm walks, extension service, information material, etc. are paid to the counties by the Board of Agriculture. The diagram below shows the sums paid (SEK million) for training in the area of plant nutrients. The costs include the work for the preparation of the courses and the information material, which is carried out by the Board of Agriculture as well as all administrative costs.

The project *Greppa Näringen* (Focus on Nutrients) is a part of the training programme. Figure 7 shows the proportion of funds going to *Greppa Näringen. Greppa Näringen* is also partly financed by the revenues from the environmental tax on mineral fertilisers.

Amounts paid for research and development

Research and development projects give important input to develop training and appropriate rules. The Board of Agriculture has been funding projects concerning plant nutrient losses.

During the years the number of projects and available funds have been somewhat varied. The last few years the Board of Agriculture has received less funds towards research and development projects for plant nutrient losses. Figure 8 shows the amount that has been paid for research and development projects through the Board of Agriculture in the last nine years.

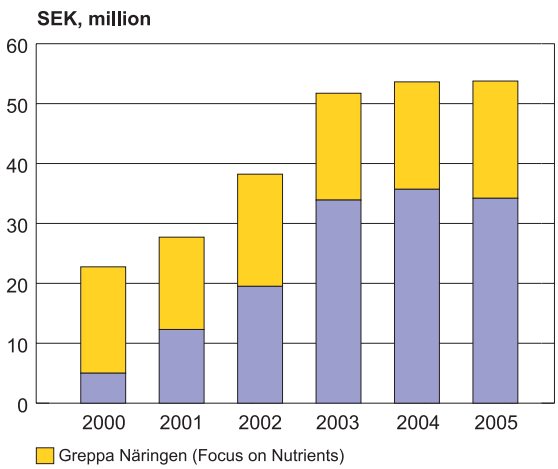


***Figure** 7. Costs (million SEK) for training in the area of plant nutrition during 2000–2005. The relative part of the total funds going to the project Greppa Näringen (Focus on Nutrients) is included in the presentation.*

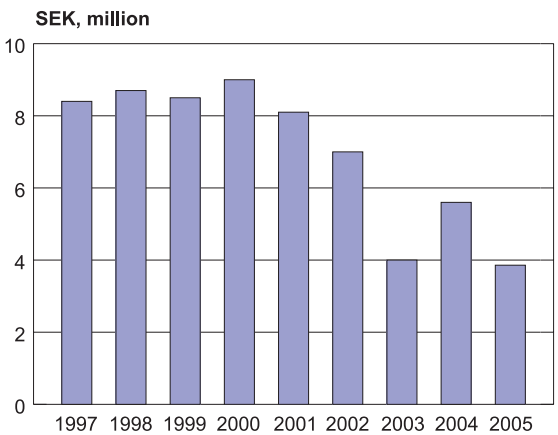


***Figure 8**. The diagram shows funds granted to research and development in the area of plant nutrition during 1997–2005.*

Are the changes visible in the environment?

Time might be needed to show the changes in the environment

How quickly the effects of a measure can make a tangible impact on the physical environment depends on the elements considered and the conditions of the place in question. The natural systems are often slow to respond and some time elapses before clear results from the measures in agriculture become evident.

Another reason why the direct effects of measures in agriculture may be difficult to notice is that the environmental monitoring targeting the effects is relatively limited, e.g. through the measurement of the content of nutrients in a watercourse. In a catchment with different soil types and sources of pollution is it also difficult to distinguish the proportion of agriculture contributing to the pollution of a particular watercourse.

It is difficult to distinguish whether the pollution derives from agriculture or from other sources. The atmospheric deposition of nitrogen originates from various sources, from Sweden and from other countries, and the proportion coming from agriculture is only a small proportion. Monitoring capable of distinguishing the proportion of depositions coming from Swedish sources does not currently exist.

Lower concentrations of nutrients in watercourses in southern Sweden

Can we therefore see any changes in the environment as a result of the work towards reducing losses of nitrogen, phosphorus and ammonia? Yes. There are studies that indicate a positive trend in reduced levels of, for instance, nitrogen in watercourses.

Environmental monitoring programmes

Sweden has a series of environmental monitoring programmes for water quality in lakes, watercourses and ground water. Some of these programmes are focussed on monitoring the effects of agriculture on surface and ground water quality.

Photo: Lennart Svedlund.

They are called *Monitoring Fields on Arable Land* and *Typical Areas on Agricultural Land.*

In the monitoring fields, measurements are taken from water drainage runoff. There are currently 10 monitoring fields. The typical areas consist of small catchments dominated by agriculture located at various places in Sweden. They represent a variety of soil and farming practices and thus function as sample areas. In these catchment areas is measured the quality of the water draining in the watercourse. Currently about 20 areas are monitored, but the number of areas has varied and has decreased over the years.

What are the trends in the Typical Areas?

The sampling in the monitoring fields and the typical areas have been carried out for a sufficient number of years to be able to notice trends in the leaching. A statistical analysis of the trends in typical areas during the year 2002 showed a significant downwards trend in nitrate concentration in 7 out of 24 typical areas and in further 13 areas it showed the tendency of downward trend[11]. However, in one typical area the losses of nitrate were increasing. The transport of phosphorus showed a significant downward trend in 8 areas whereas the concentrations of particle phosphorus showed a significant decrease in three areas but an increase in two.

In 2006 a new analysis was carried out but the number of typical areas considered was lower. The trends were the same, i.e. statistically significant downward trends of nitrogen concentrations in the water in several areas and of phosphorus in a few cases[12]. No area showed an increasing trend for nitrogen. There were some areas where the analyses showed a statistically significant trend for increased phosphorus transports[13].

Results from monitoring of water courses

Data from the environmental monitoring of watercourses has in some cases indicated that the measures for agriculture have had an effect. In 2005 water quality data from 12 watercourses in areas dominated by agriculture[14] (at least 30 % agricultural land) were analysed. The analysis showed significant decreases of nitrate and so called other phosphorus (the difference between total P and phosphate-P) in some watercourses. The decreases were most marked in Skåne where the figures were one up by 2 % annually (1983–2003). The changes were very likely due to the measures taken to reduce leaching.

In south-central Sweden the decreases were not as clear but in these areas the catchments were not dominated by agriculture and the nitrogen concentrations were lower. In some cases there were tendencies to increased concentrations of phosphorus in the watercourses.

Further reading:

Website of the, Soil Science Department, Swedish University of Agricultural Science, *www.mv.slu.se*

Nitrogen leaching in small agricultural catchment areas (2004), K. Kyllmar. Agraria 485. Doctoral thesis. SLU

Monitoring fields on arable land. Technical report No. 93. G. Johansson and A. Gustafson. SLU. 2005. *In Swedish*

Nitrate concentration and trends in agricultural watercourses, B. Ulén and J. Fölster. SLU. 2005. *In Swedish*

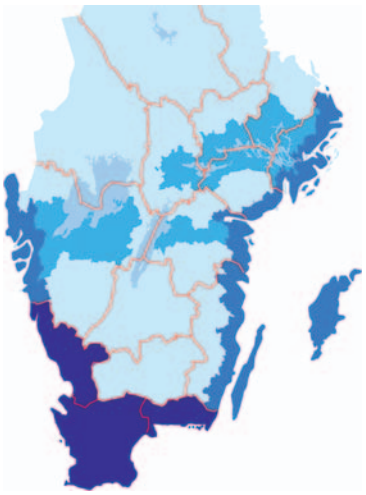
11) Nitrogen leaching in small agricultural catchment areas (2004), K. Kyllmar. Agraria 485. Doctoral thesis. SLU.
12) Typical areas on agricultural land – Statistical analysis of time series for transport of nitrogen and phosphorus. Technical report No. 112. K. Kyllmar. Section for water management. SLU. 2006.
13) Nitrogen leaching in small agricultural catchment areas (2004), K. Kyllmar. Agraria 485. Doctoral thesis. SLU.
14) Nutrient concentrations and trends in agriculturally dominated water courses. B. Ulén and J. Fölster. SLU. 2005.

What has the effect of individual measures been?

This section presents the implementation of the measures for reducing nutrient losses in closer detail. The main focus this chapter is the statistical data relevant to each of the measures. Please note that some of the measures can only show estimates of the plausible effects they would have in reducing nutrient losses.

Legislation

Several measures in the action programme are enforced by law with specific rules. Some of these rules are the result of international directives, and some are based on national targets for achieving the environmental quality objectives.



- The counties of Skåne, Halland och Blekinge
- Coastal areas, and the Gotland och Öland islands
- Agriculture areas in the counties of Östergötland, south of the lake Vänern, as well as the area arond the lakes Mälaren and Hjälmaren

Nitrate vulnerable zones

In some areas of Sweden, the environment is particularly vulnerable to nutrient leaching from agriculture. These areas have been identified as nitrate vulnerable zones according to the EU nitrates directive[15]. The areas designated as Nitrate Vulnerable include the counties of Skåne, Halland, Blekinge and Gotland, the entire coastal area from the Norwegian border to the Stockholm Archipelago, the areas around Lake Mälaren and Lake Hjälmaren, central parts of Östergötland county and the areas south of Lake Vänern (see map).

Since those areas are considered particularly vulnerable to nitrogen losses, the rules aiming to reduce such losses are stricter in the designated vulnerable areas.

Rules on storage capacity of manure

Good storage capacity for manure allows good practice for spreading manure at a time when it is most beneficial both financially and environmentally. The ordinance on environmental consideration in agriculture provides general rules on storage capacity. Such capacity is measured in time i.e. how many months of manure produced should be stored in the purpose built facilities before spreading. The rules may vary depending both on geographic location and on the type of manure in question. Table 2 summarises the rules in the ordinance.

15) Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources

Table 2. Rules on manure storage capacity expressed as the number of months of manure produced on the farm to be stored, based on the number of animals on the farm, animal species and on the location in Sweden[6]

	Skåne, Halland, Blekinge and Gotland as well as Öland and vulnerable coastal areas		Other vulnerable areas		Other areas	
Number of livestock units[1]	Bovines, horses, sheep and goats	Other animals	Bovines, horses, sheep and goats	Other animals	Bovines, horses, sheep and goats	Other animals
100–	8 months	10 months	8 months	10 months	8 months	10 months
10–100	8 months	10 months	6 months	6 months 10 months[2]	6 months	6 months 10 months[3]
2–10	6 months	6 months	6 months[2]	6 months[2]	Inga generella bestämmelser	Inga generella bestämmelser
1	No general rules	No general rules	No general rules	No general rules	No general rules	No general rules

1) For a definition of a livestock unit, please see table 3.
The rules on storage capacity applies: 1) from 1 July 2007 2) from 1 July 2013.

Table 3. Definition of livestock units

One livestock unit equals:

- 1 dairy cow (also dry dairy cow)
- 6 calves, one month or older. A calf is a cattle of an age up to six months. Calves up to one month of age is included in the mother
- 3 other cattle, six months of age or older
- 3 sows, including piglets up to 12 weeks of age. Cowered gilts are counted as sows.
- 10 pigs or boars, 12 weeks of age or older
- 1 horse, including foal up to six months of age
- 10 breeding mink females, including pups up to eight months of age and breeding males.
- 100 rabbits
- 100 laying hens, 16 weeks of age or older. Breeding hens are counted as laying hens
- 200 pullets up to 16 weeks of age
- 200 broilers
- 100 turkeys, geese or ducks, including chickens, goslings and ducklings up to one week of age
- 15 ratite of the species Ostrich, Emu or Rhea, including chickens up to one week of age
- 10 sheep or goats, six months of age or older
- 40 lambs or goat kids up to six months of age

For other animal species, one livestock unit is equivalent to the number of animals having a yearly excretion of 100 kg of N or 13 kg of P in fresh faeces or urine. When determining the number of animals, the alternative from N or P that results in the lowest number of animals shall be used.

Figures 9 and 10 present the changes in storage capacity for dairy cows, other cattle and pigs during the last few years. The storage capacity is expressed in months.

Many farms with dairy or beef production nowadays have a larger storage capacity than the minimum requirement of 8 months set out in the ordinance. In 2005 manure from more than 40 % of the dairy cows was stored in units with a capacity of 10 months or more. For beef producers this trend was taken even further. Today more than 60 % of the beef cattle produced on farms are provided with more than 10 months of storage capacity.

In 2003, for example, more than 50 % of the manure from dairy cows was kept in storages with a capacity of 10 months or more of product. This is a definite increase compared to 1999 and 2001 when the corresponding figure was 40 %.

Approximately 70 % of all slaughter pigs are produced on farms with more than 100 livestock units. These farms are encompassed by regulations requiring at least 10 months of manure storage capacity. Accordingly most pigs are kept on farms with this storage capacity. Few pigs are kept on farms with less than 8 months of storage capacity. The storage capacity on pig farms has changed little the last few years.

Storage facility may differ depending on the type of manure to be stored, for example solid, semi-liquid or slurry. There is a general trend for an increasing use of slurry and deep litter manure and decreasing use of solid manure and urine. Figure 11 presents this development for cattle and pigs. When the manure is handled as slurry the ammonia losses are usually lower compared to a solid manure handling system, it is for example easier to take measures to reduce the

Photo: Håkan Alfredsson.

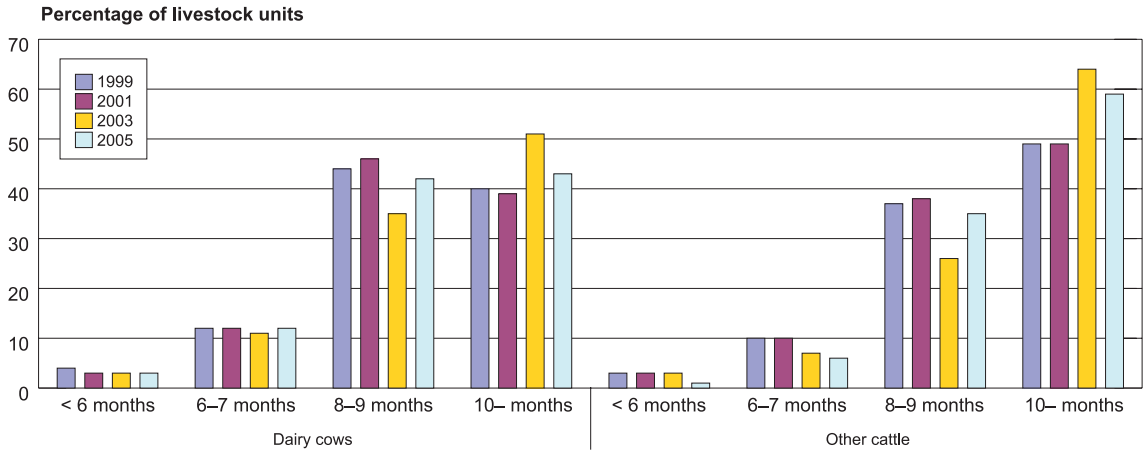


Figure 9. *The diagram shows the distribution of storage capacity (in months) of manure from dairy cows and other cattle as percentage of the total number of animals in the two groups during 1997–2005. Source: Statistics Sweden.*

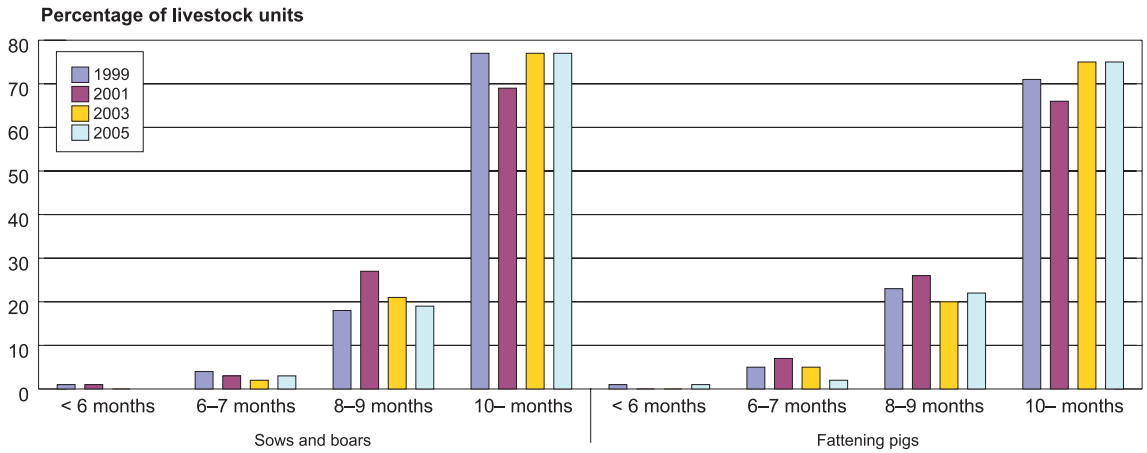


Figure 10. *The diagram shows the distribution of storage capacity (in months) for manure from pigs, as percentage of the total number of either sows and boars or pigs for slaughter, in 1997–2005. Source: Statistics Sweden.*

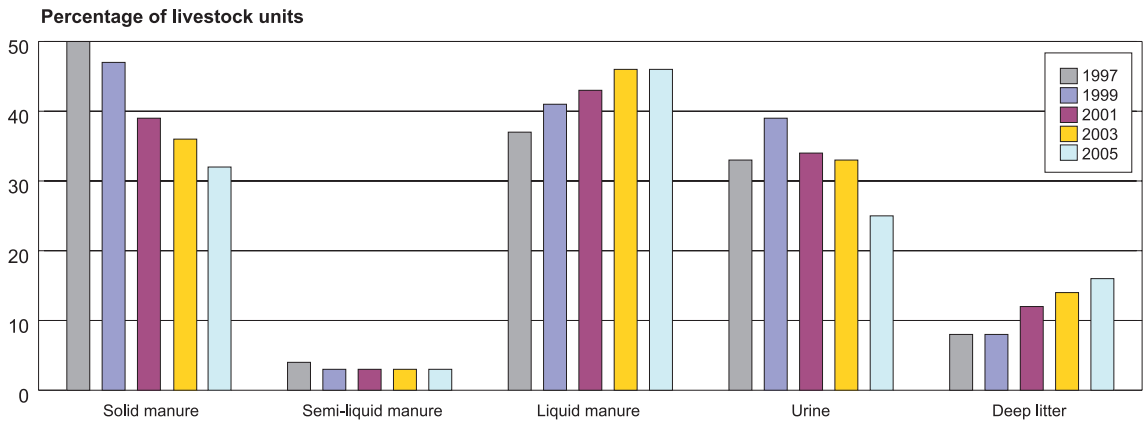


Figure 11. *The diagram shows how the handling of manure from cattle and pigs has changed between 1997–2005, based on the number of livestock units producing the manure. Note that the bars sum up to more than 100 % in any given year, since the same livestock unit produces, for instance, both urine and solid manure. Source: Statistics Sweden.*

losses. An increased proportion of manure handled as slurry is one of the contributing factors to the reduction of ammonia losses from agriculture. To avoid plant nutrient losses from slurry stores, the containers must be designed in such a way to prevent any runoff or leaching to the environment from taking place.

Rules on covering of slurry stores

For most of southern Sweden (Götaland and parts of Svealand) there are rules stating that farms with more than 10 livestock units shall store slurry or urine with some kind of covering technique. The aim of this rule is to reduce the ammonia losses from stored manure in the areas of Sweden most in need of reduction of such losses from farming to minimise air pollution. In addition to the rules on covering, there is also a requirement for slurry stores to be filled from below the surface to minimise ammonia losses (se Facts).

The rules on the covering of slurry stores and filling from below the surface were introduced in 1995 in the three southernmost counties, and in 1997 in the remaining counties. As a natural consequence, the degree of covering has increased gradually since then. Figure 12 shows the development of the share of covered slurry stores for slurry and urine.

The predominant covering technique since

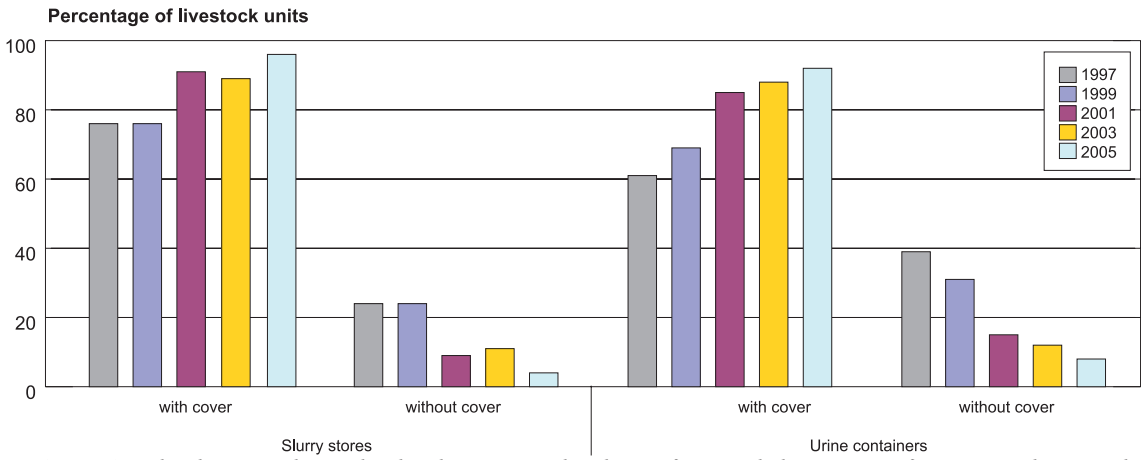


***Figure 12**. The diagram shows the development in the share of covered slurry stores for storing slurry and urine, based on the number of livestock producing the manure in the period 1997–2005. Source: Statistics Sweden.*

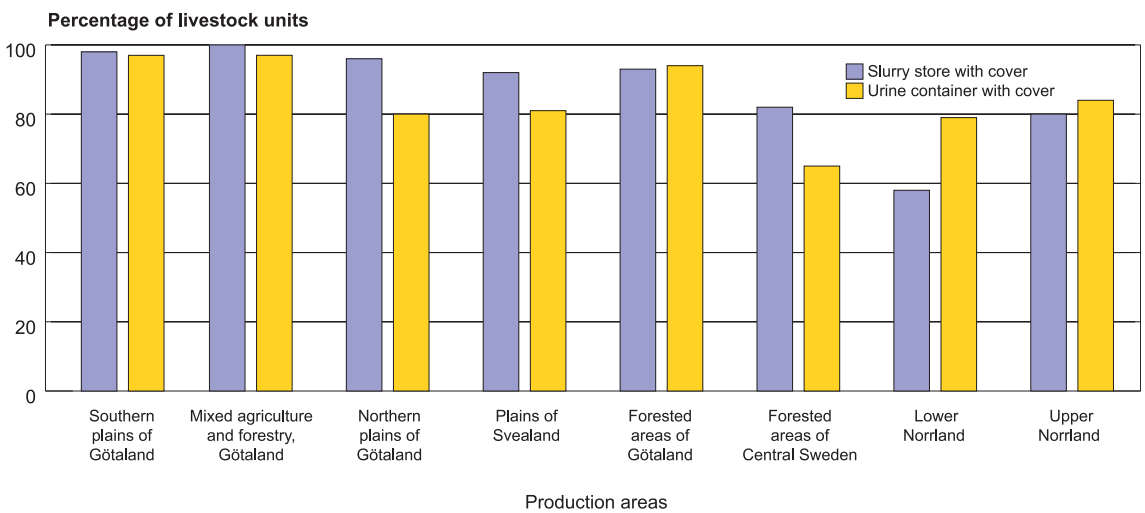


***Figure 13**. The diagram shows the covering of slurry stores based on the number of livestock units that the manure comes from, in various Swedish production areas in 2003. The abbreviations are explained in the map to the right. Source: Statistics Sweden.*

Facts

The rules on the covering of slurry stores and filling from below the surface apply generally to farms with more than 10 livestock units in the counties of:

- Stockholm
- Uppsala
- Södermanland
- Östergötland
- Jönköping
- Kronoberg
- Kalmar
- Gotland
- Blekinge
- Skåne
- Halland
- Västra Götaland

And in the flat country in the counties of:

- Värmland
- Västmanland
- Örebro

2005 for slurry is floating crust. 96 % of the slurry being covered is covered this way. Solid covers are used as a cover for 4 % of the slurry.

The picture is different with urine. In 2005 more than 70 % of the urine was being covered under a floating crust, and around 23 % under a lid.

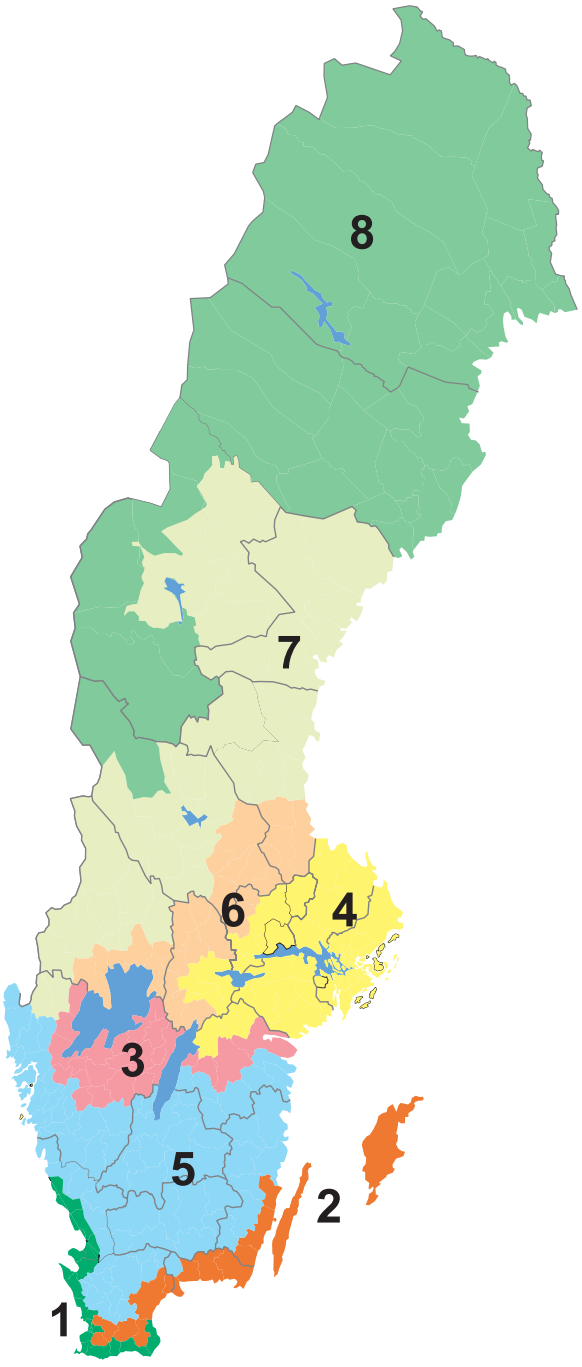
Given that the general rules for covering concerns farms in southern Sweden, it is in this part of the country where the highest proportion of covered stores are found. The degree to which slurry stores for slurry and urine are covered differs across the country. The degree decreases slightly the further north we get. Figure 13 shows the covering for the various production areas in Sweden. The production areas in Sweden are presented on the map in figure 14. 90 % of the covered slurry stores for slurry and urine are filled from below the cover.

Quantitative restrictions on the spreading of manure

In order to keep a sustainable balance between import and export of plant nutrients from manure, the first action programme included rules limiting the number of animals and the available acreage for manure spreading on the farm in question (i.e. rules on livestock density). The rules have applied to all farms with more than 10 livestock units.

Since the rules on livestock density were introduced in the mid-1980s, animal husbandry has become more intensive. This higher intensity causes the animals to produce more nutrients. At the same time, the amount of phosphorus removed with the crops has increased slightly, but not to a degree that justifies a general increase in

Figure 14. Sweden divided into production areas.



1. Southern plains of Götaland
2. Mixed agriculture and forestry, Götaland
3. Northern plains of Götaland
4. Plains of Svealand
5. Forested areas of Götaland
6. Forested areas of Central Sweden
7. Lower Norrland
8. Upper Norrland


Photo: Hans Nilsson

supply. In order to reach a better balance between supply and removal of phosphorus in agriculture, the Board of Agriculture made an overhaul and revised the rules in 2004.

From 1 January 2006, the rules on livestock density have been replaced by a limit on the supply of phosphorus from manure and other organic fertilisers. This limit is 22 kg total phosphorus per hectare per year, calculated as a five year average for the available spreading area, which is deemed sufficient for most Swedish cropping systems.

Overall, the status of phosphorus in the soil in Sweden on arable land is good. Only about 13 % of arable land has a low content of phosphorus and is placed within the bottom phosphorus classes[16] I and II. The areas of southern Sweden with high livestock density have the highest levels of phosphorus in the soil. In these areas there is no need for additional fertilising or extra supply of phosphorus with mineral fertilisers.

16) Phosphorus classes are measured with the acetate lactate method (P AL); Class I (very low) < 4.0 mg P $^{-1}$ soil, Class II (low) 4.0–8.0 mg P g^{-1} soil, Class III (moderate) 8.1–16.0 mg P g^{-1} soil, Class IV (high) 16.1–32.0 mg P g^{-1} soil and Class V (very high) > 32.0 mg P g^{-1} soil.

Rules on the spreading of fertilisers in winter

During the period from 1 December to 28 February any manure or other organic fertilisers shall be incorporated into the soil on the same day. This prohibits spreading when the soil is frozen or covered with a thick layer of snow.

In addition, in vulnerable zones – according to the Nitrates Directive – there is a prohibition of winter spreading of mineral fertiliser (1 November–15 February), manure and other organic fertilisers (1 January–15 February) and in addition, there is a prohibition against spreading on frozen or snow-covered ground.

The present rules allow the spreading of manure in December as well as after 15 February in vulnerable zones. There is reason to question the usefulness of applying manure in December. In some cases it is not appropriate to apply manure at this time of the year. In other cases fertilising does not necessarily have to cause increased nitrogen leaching. Whether leaching occurs or not, that would depend, amongst other things, on elements such as climate, soil type and type of manure.

However, in general, there is not much spreading of manure in December in Sweden. Therefore, leaching due to spreading in

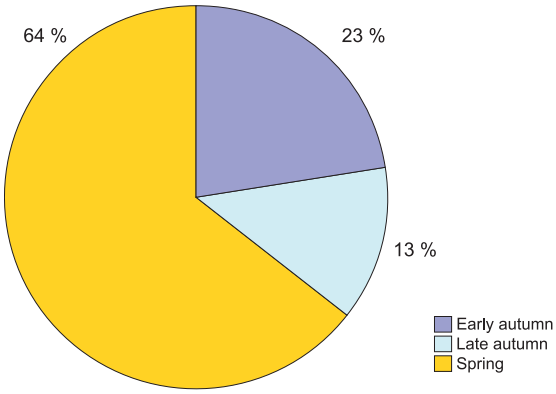


***Figure 15**. The diagram shows the share of cereals area fertilised with manure that is fertilised at different times of the year in 2005. The diagram shows times of spreading for all of Sweden. Source: Statistics Sweden.*

December is judged to be small. In addition, the requirement to incorporate the fertiliser into the soil that applies to the spreading of manure or other organic fertilisers in December decreases the risk of surface runoff of manure from the ground.

The prohibition against winter spreading probably has only a small effect on nitrogen leaching. The reason is that there would probably not be any major spreading anyway at this time of the year. Figure 15 shows in what time of the year Swedish farmers chose to spread manure during the growing season 2004–2005.

Figure 16 presents the time of the year in which manure has been spread for cereals in the last few years in counties regarded as particularly vulnerable to nitrogen losses.

Spreading of manure in autumn

One of the measures that were suggested in the revision of the action programme in 2000 was an increased effort to try and reduce manure spreading before winter cereals. Winter cereals do not have a large nutrient uptake during the autumn and when manure is spread before winter crops are sown the nitrogen efficiency is usually low and the risk for leaching is high. Solid manure can provide good plant nutrient efficiency if spread in late autumn and incorporated into the soil.

It is especially important that slurry and urine, containing a high content of available nitrogen, is spread during the seeding period in the spring. If slurry and urine is spread on winter cereals it should be spread on the growing crop in the spring or early summer. The change in spreading time was thought to be achieved through information services and through the requirements for storage capacity.

To conclude spring spreading practices have not generally increased to the degree that was intended when the measure was first introduced in the plan.

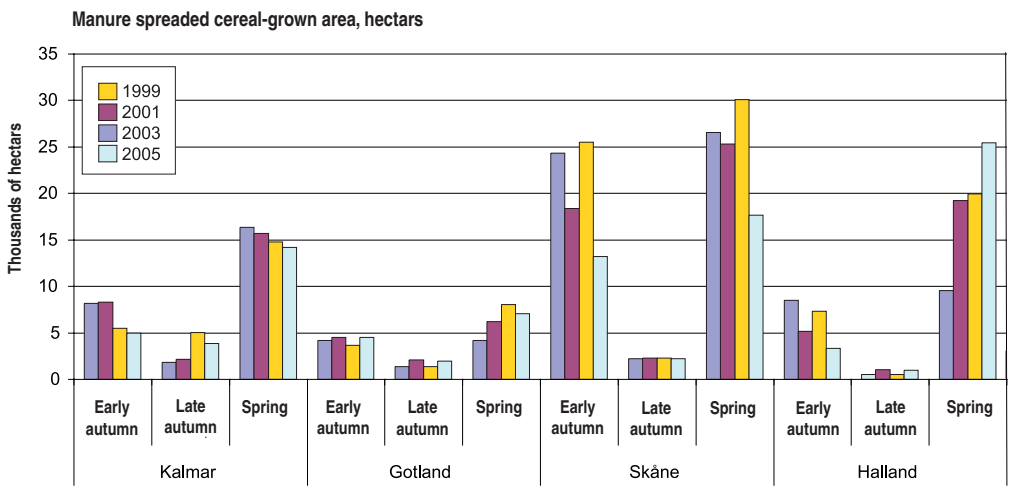


***Figure 16**. The diagram shows the distribution of manure spreading over the year as hectars of the cereal-grown area fertilised with manure, during the period 1999–2005. Four counties considered as particularly vulnerable to nitrate loss have been chosen. Source: Statistics Sweden.*

Rules on spreading techniques in growing crops

The kind of spreading technique chosen can have a large effect on the proportion of the nutrient losses, especially ammonia losses. The provinces of Skåne, Halland and Blekinge have, since 1998, special rules for certain spreading techniques in order to reduce the ammonia losses related to the spreading of slurry in growing crops.

Figure 17 shows the changes in spreading techniques in recent years. The diagram shows an increase in areas fertilised with a technique that reduces ammonia losses, while areas fertilised with a more traditional technique, like broadcast spreading, have decreased during the same period.

Rules for working manure into the soil

The incorporation of manure into the soil reduces ammonia losses and can, under certain times of the year, be of importance for the reduction of surface runoff. To reduce the ammonia losses the manure needs to be incorporated into the soil quickly. In the counties of Skåne, Halland and Blekinge, this must be done within four hours if the manure is spread on bare soil. This rule applies all the year round.

In the country as a whole the manure is usually incorporated into the soil quickly, within four hours from the spreading. Nonetheless, a large share of the manure is spread on growing crops, making it impossible to incorporate it in the soil unless special techniques, like slurry injectors, are used. The figures 18 and 19 the show the change during 1999–2005 for solid and slurry and for various intervals.

With regard to urine, almost all spreading takes place on growing crops, and so it is very rarely incorporated into the soil.

Rules on land under green cover during autumn and winter

The rules on a minimum share of land under green cover during autumn and winter, colloquially referred to as green land, were introduced in 1992. Those rules apply to several measures aimed to reduce leaching from Swedish agriculture. Research shows that nutrient leaching occurs with less frequency in land under vegetable cover than in tilled land. The rules establish that 60 % of the arable land in the counties of Skåne, Halland and Blekinge, and 50 % in the remaining counties in Götaland, shall be autumn or winter grown.

The share of land under green cover during autumn and winter is much higher today than when the rules were first introduced. This increase could be seen as a result of agricultural policy. In the years after the introduction of the rules, agricultural policy has, amongst other things, led to periodic increases in grassland, fallow, and other untilled arable land. In 2001, environmental aid for growing catch crops was introduced, which also resulted in an increased share of green land.

Diagram 20 shows the development of the land-

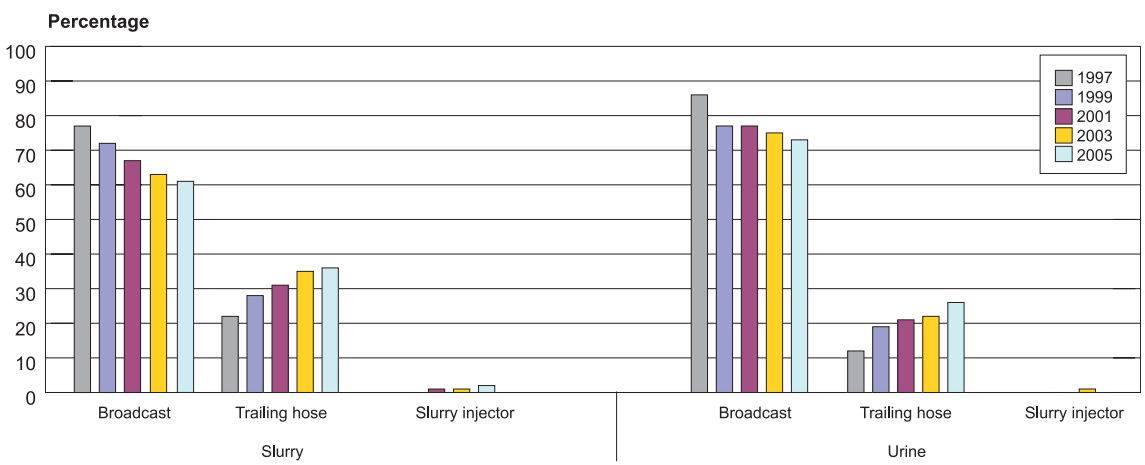


***Figure 17**. The diagram shows the distribution of spreading techniques used for slurry and urine. The proportions are presented as a percentage of the spread for each type of manure during the period 1997–2005. Source: Statistics Sweden.*

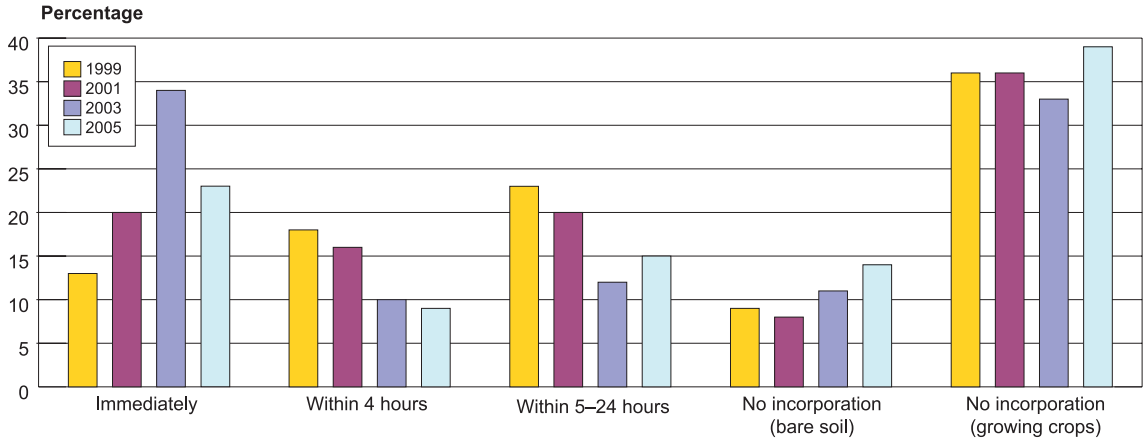


***Figure 18**. The diagram shows how the time for incorporating solid manure into the soil has changed during the period 1999–2005. The data is presented a percentage of fertilising that uses solid manure. Source: Statistics Sweden.*

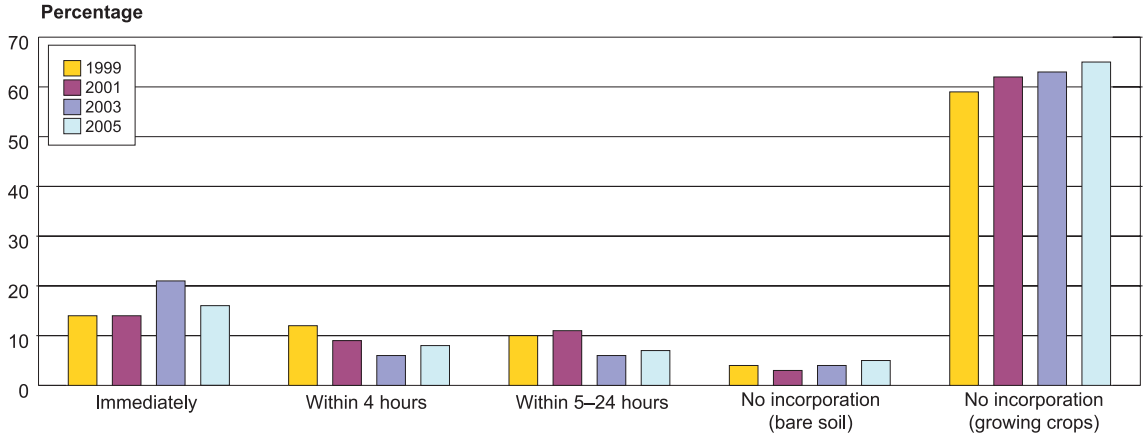


***Figure 19**. The diagram shows how the time of working slurry into the soil has changed during the period 1999–2005. The data is presented in per cent of fertilising that uses slurry. Source: Statistics Sweden.*

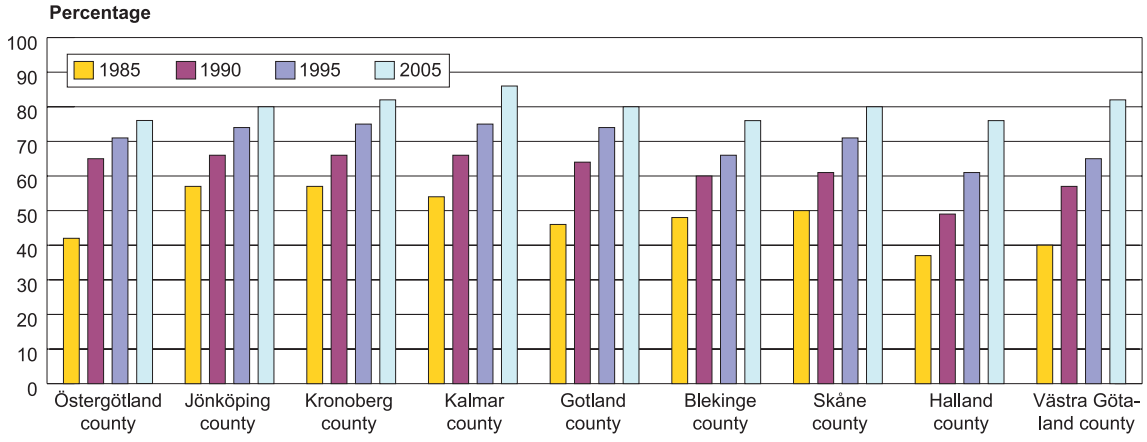


***Figure 20**. The diagram shows the change in land under green cover during autumn and winter as a percentage of the total arable area between 1985 and 2005. The diagram only applies to the counties comprised by the rules on a minimum share of autumn or winter grown land.*

share under green cover during autumn and winter during 1985–2005. The diagram only includes the counties to which the rules apply. The figures do not include the share of late autumn tilling of stubble fields, which may also be a way to fulfil the rules.

Supervision of agricultural operations

It is mainly the responsibility of the municipalities to carry out the supervision of farms and livestock keeping. In 2004 a survey was conducted to assess how the municipalities had carried out the operative supervision during 2003. The municipalities were asked to answer questions about, among other things, supervision of farms and animal keeping. Figure 21 shows what kinds of supervision the municipalities carried out.

From the answers received it was noticeable that more than half of the municipalities' time was spent on supervision was devoted to inspections. The rest of the time was distributed on information and guidance and other, e.g. on administration, training, and commenting on proposals circulated for consideration.

According to the municipalities, farms with livestock are inspected much more frequently than farms without livestock. Also, animal keepers businesses that do not count as farms, e.g. horse keeping, dog kennels etc., are in most cases inspected at least every four or five years, as opposed to farms without animals which are in most cases rarely or never inspected. The largest proportion of annual inspections concern animal-related activities requiring compulsory notification or the obtainment of an environmental permit

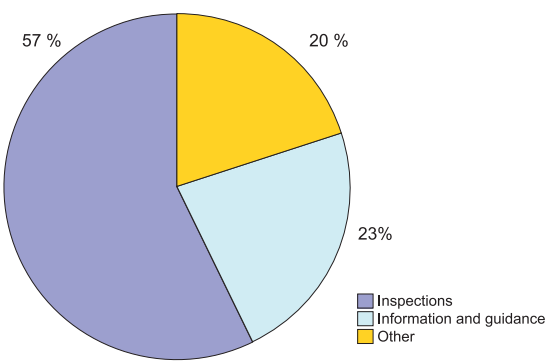


***Figure 21**. Distribution of the municipalities' time spent on farm supervision*

for. According to the municipalities, the environmental supervision is to a large extent coordinated with the animal welfare supervision, which could explain why it is above all livestock farms that are inspected.

What then, are the municipalities looking for during an inspection? According to their replies, first, the rules on the storage of manure are the most common subject of inspection. Second are the rules on livestock density and on spreading of manure. The rules on green land have been inspected the least. Table 4 shows the number of inspected activities and which rules the municipalities paid the most attention to.

The municipalities were also asked about how many cases they handed over to the office of the public prosecutor or to the police in 2003. The total number of cases related to the storage of manure, livestock density, the spreading of manure, and land under green cover during autumn and winter amounted to 34. Hence inspections seldom result in a report to the prosecutor or the police.

Table 4. Number of inspected activities in 2003 with regard to the specific rules

Storing of manure	8,200
Livestock density	6,400
Spreading of manure	5,500
Green land	4,200

Environmental support scheme

Measures intended to reduce nutrient runoff to our waters are above all the environmental payment schemes for reduced nitrogen leaching, buffer zones, and wetlands and ponds.

The environmental payment for reduced nitrogen leaching implies that the farmer can receive compensation when growing catch crops between the main crops. When catch crops are grown, some of the nitrogen in the ground is picked up by the catch crop instead of being transported to the watercourses. The growing of catch crops is the single most important measure to reduce nitrogen leaching from arable land. On average, catch crops are

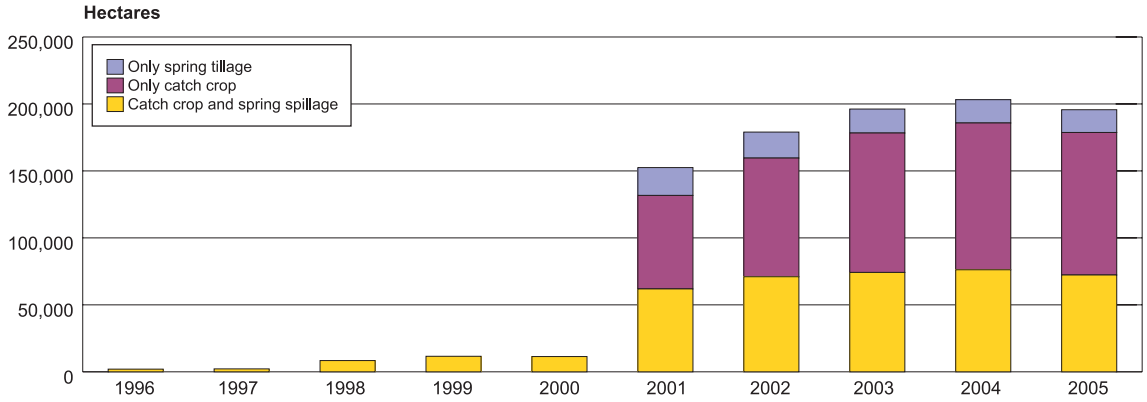


***Figure 22**. The diagram shows the development in number of hectares in the environmental aid for reduced nitrogen leaching during the period 1996–2005. This scheme is open for farmers in the counties of Kalmar, Gotland, Blekinge, Skåne and Västra Götaland.*

estimated to reduce losses in southern Sweden by 30 % if ploughed up in late autumn, and another 10–20 % if the field remains untilled until spring. The farmer can also receive the aid if he chooses to till his land in the spring when the risk of nutrient runoff is lower than in the autumn.

The payment for reduced nitrogen leaching has had a great effect since it was first introduced. Above all, the participation rate increased dramatically after the revision of the prerequisites for the scheme in 2001, see figure 22. The revision introduced the possibility to choose to either enter both schemes or one at the time. Today nearly 200,000 hectares of arable land are included in the scheme. When the scheme first was introduced the target was 50,000 hectares.

Model calculations of the root zone of nitrogen leaching show a reduction of 7,000 tonnes from arable land. It is estimated that 2,100 tonnes from these are a consequence of the reduced nitrogen leaching scheme.

The aim of the scheme for buffer zones is above all to decrease the losses of phosphorus from arable land to watercourses. In 2005 about 9,400 hectares of buffer zones were included in the scheme, much more than the target of 5,500 hectares. As previously mentioned, there are difficulties in calculating the effects of the measures on phosphorus. Thus, it is hard to estimate to what extent the buffer zones have contributed to reduced phosphorus losses.

The action programme aims to the create 8,000 hectares of wetland by 2010. The rate of farmers participating to the scheme for wetlands and ponds has been lower than expected during the period 2000–2006. Until 2005, 3,100 hectares of wetlands were created and another 300 hectares have also been created with the aid of other schemes since 2000. The purification effect of wetlands from nitrogen varies significantly. In previous estimations the purification effect has been thought to be around 175 kg of nitrogen per hectare per year. Evaluations show that wetlands created under the wetlands and ponds scheme have had a much smaller effect. Higher nitrogen purification through better financial support for the planning of new wetlands is prioritised.

Environmental tax

The environmental tax on nitrogen applied to mineral fertilisers changes the economically optimal fertilising rate to a lower level. In 2000 it was estimated that if the tax was removed the higher economically optimal fertilising rate would result in increased nitrogen leaching of 1,800 tonnes per year. Today the effect of the tax is estimated to be between 1,000 and 2,000 tonnes per year.

Figure 23 shows that the sales of mineral fertiliser nitrogen are steadily decreasing. The tax probably had a limited effect on this development. It is probable that other reasons such as the extension service and fluctuations in agricultural policy provided a more efficient contribution towards a better adapted use of fertilisers and towards a lowered usage of mineral fertilisers as a cultivation supplement. We think that the foremost

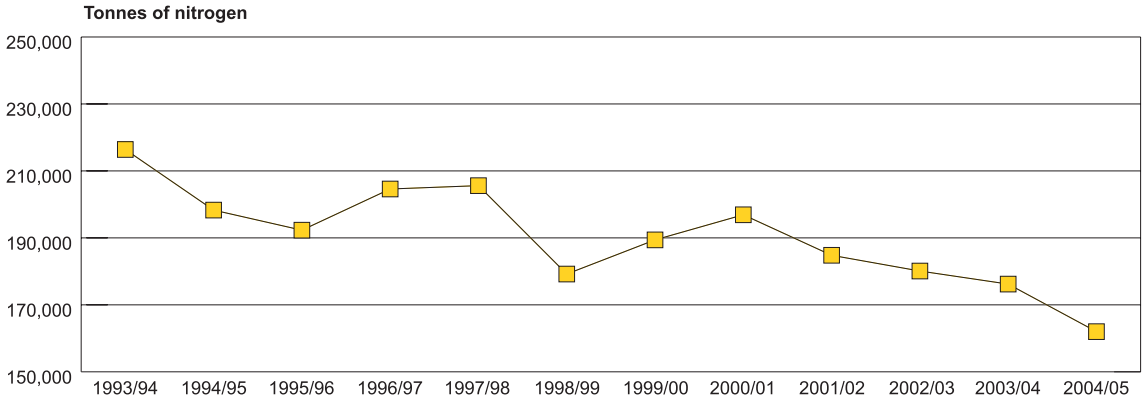


***Figure 23**. The diagram shows the trend in sales of nitrogen in mineral fertilisers during the period 1993–2005.*

reason for the decrease in sales of mineral fertiliser from 2004 to 2005 is due to the decreased acreage of cereals. This reduction is reinforced by the fact that more than half the decrease in acreage relates to winter wheat, which usually receives larger doses of fertiliser than cereals sown in the spring. Low cereal prices in recent years may also have contributed to a certain caution in the use of fertilisers in cereals. A lower price lowers the economically optimal fertilising rate.

Extension service and information

Farmers are offered the possibility of using environmental extension services and information within the training scheme in the Rural Development Programme. *Greppa Näringen* (Focus on Nutrients) is a special project that aims to increase the nutrient efficiency and reduce the nutrient losses in areas of intensive agriculture, in south and central–south Sweden.

The training has probably made a contribution to the increased nitrogen efficiency in agriculture, although, the entity of its overall impact is difficult to quantify.

An estimate the effects of training in relation to the quantity of nitrogen losses within the project *Greppa Näringen* in 2005 was carried out within the project. Through the evaluation of plant nutrient balances and extension service concerning about 3,100 cereal or livestock farms participating in the project *Greppa Näringen,* calculations show that the annual nitrogen leaching from these farms has decreased by about 460 tonnes. In addition, we estimated that the wetlands created following the extension service of *Greppa Näringen* reduced nitrogen leaching by 80 tonnes. If we assume that half of these 80 tonnes can be attributed to the extension service provided, the annual effect of this service would amount to 500 tonnes of reduced nitrogen leaching. We also think that the training has given farmers knowledge that has not yet been implemented in practice. It sometimes takes time before things are suitable to change. It is estimated that the total effect from this knowledge will be somewhat larger than the level it has reached until now. Table 5 presents the effect from *Greppa Näringen* has gradually increased since the launch in 2001.

Table 5. Estimations of the effect of extension service in *Greppa Näringen* on nitrogen leaching (tonnes)

Year	Estimated effect	Future effect	Sum
2001	100	–	100
2002	200	–	200
2003	350	–	350
2004	500	250	750

Further reading:

Plan of Action against plant nutrient losses from agriculture. Leaflet from the Board of Agriculture. 2006.

Swedish Regulation (SJVFS 2004:62) on environmental considerations in agriculture regarding plant nutrients. *In Swedish*

Fertilisers in agriculture. Statistiska meddelanden, Statistics Sweden. *In Swedish*

Ordinance (1998:899) on environmentally hazardous activities and health protection. *In Swedish*

Nitrogen and phosphorus balances for agricultural land and the agricultural sector in 2003. Statistiskt meddelande M1 40 SM 050. Statistics Sweden. *In Swedish*

Facts about fertilisers in agriculture

(Fertiliser Survey by Statistics Sweden)

The Farm Register is the basis for the selection of participating farms. The Fertiliser Survey was carried out via telephone interviews with some 4,000 farmers since 1988 and has been carried out almost every other year ever since. The overall ambition of the survey is to cover all of Sweden, to include both mineral fertilisers and manure, to provide information at a regional scale and for individual crops so it can be used in the following ways:

- as a basis for the extension service on plant nutrients
- as a basis for calculating nutrient leaching of air and water
- as follow up on the objectives regarding the environmental effects of agriculture.

The purpose of the survey is partly to obtain regional data on fertiliser use in various crops, and partly to obtain data on handling, storage, and spreading of manure from various species. It also tries to shed some light on other related environmental issues, for instance the use of fallow, preceding crops, etcetera.

Photo: Urban Wigert.

Factors outside the action programme affecting plant nutrient losses

Within the action programme, large efforts are made to reduce plant nutrient losses from agriculture to the environment. Changes in society and the current EU agricultural policy on Common Agricultural Policy (CAP) reforms help this work. In some ways, the changes in CAP is beneficial for reducing plant nutrient losses from agriculture. In addition, work based on certain EU directives, e.g. the Water Framework Directive, may affect the efforts to reduce plant nutrient losses in the future.

Agricultural policy

One effect of the latest EU CAP-reform is a change in what is cultivated. In Sweden, the reformed CAP was implemented mainly in 2005. What we have seen in the short time since then is that the cereal acreage is decreasing, above all in the less favoured agricultural areas, while grassland, pastureland and the cultivation of oilseeds are increasing. The decreased acreage of cereals and the increased acreage of grassland, pasture and set aside land may lead to reduced nutrient losses. Decreased cereal acreage could mean less use of mineral fertilisers. The reduced area of arable land has reduced nitrogen leaching by 1,900 tonnes between 1995 and 2003, according to calculations made by SLU. The decreased area of arable land in 2004–2005 is estimated to have reduced nitrogen leaching by an additional 2,000 tonnes.

However, we need to remember that the data on which these trends are based only covers a short period of time, and the trends may change. What we know for certain is that the future direction of agricultural policy will affect the possibilities to reach the goals set to reduce plant nutrient losses from agriculture, as well as the eutrophication of our waters. For example, it would be interesting to foresee the impacts of a widespread change if production from traditional to bioenergy crops would occur. It might result in more arable land taken into use and a subsequent increase of the overall nutrient losses from agriculture.

The EU framework directive on water

The EU has a framework directive for measures in the area of water policy[17], usually called the Water Framework Directive (WFD). This is ongoing work and action plans for identified risk areas should be ready in 2009. In accordance with this directive, the water should reach good status by no later than 2015.

Depending on what areas are identified as risk areas, and on what measures are included in the action plans, the implementation of the WFD will most likely influence the work of limiting and reducing plant nutrient losses from agriculture.

17) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

Photo: Eva Sjöberg.

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SJV offset, Jönköping
Layout: Kraft&Kultur AB, Stockholm