Danish Environmental Protection Agency
Ministry of the Environment

25 May 2009

Status and trends of aquatic environment and agricultural practice

Danish monitoring and action programmes in accordance with the Nitrates Directive (1991/676/EEC)

Summary Report to the European Commission

According to Article 10 of Council Directive no. 676 of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources

Danish Environmental Protection Agency
Ministry of the Environment
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1 Content

2 Summary

Since 1985 a number of actions plans have been implemented in Denmark to reduce nitrate leaching. The regulatory measures applied include nutrient-related measures e.g. mandatory fertilizer plans and improved utilization of nitrogen in manure as well as area-related measures such as e.g. wetlands and afforestation. In 1987 the Danish parliament agreed on the first Action Plan for the Aquatic Environment I and in 1998 on the APAE II, which was recognised as the implementation of the Nitrates Directive as announced by the Commission in November 1998. The final evaluation of the APAE II in December 2003 showed that measures already implemented in addition to measures already agreed upon and financed would result in a reduction of the total nitrogen discharges from agriculture of around 149,000 tonnes N per year. This corresponds to a reduction of around 48% of the calculated 311,000 tonnes N in 1985.

In 2004, new goals were set, as the Danish parliament agreed upon Action Plan for the Aquatic Environment III 2005-2015. This plan encompasses broad efforts to reduce agricultural impacts on the aquatic environment and nature. APAE III includes a stronger focus on surplus phosphor in agriculture, which must be halved, compared to 37,700 tonnes P in 2001/2002, with 2015 as the target year. For nitrogen the aim is to reduce leaching from agriculture by a minimum of 13% by 2015 compared to 2003.

The Danish approach to regulating nutrient losses from agriculture has proven successful with high reductions from 1985 to 2003, however also with delays concerning the environmental effect, as well as a recent tendency to a halt in the downward trend, and the Government is starting to explore new modes and means of achieving further necessary reductions.

In 2008 the APAE III was evaluated both on results, adequacy of tools and economic aspects to ensure that activities and expected results are achieved. The results are summarised in the report. The main conclusions are that for a number of instruments implementation and/or effect has not been as anticipated. On this basis, further or different activities are designed, also with a view to further integrate activities with efforts to implement and reach the goals of the European Water Framework Directive (WFD). This framework is under development.

Denmark has about 44,000 farmers and over half of the country is used for agriculture. The agricultural contribution of nitrogen discharges, into the environment has decreased from 311,000 tons in the mid 1980'ties to around 160.000 tonnes per year in 2007. The consumption of mineral fertilisers has decreased from 315,000 tonnes N per year in 1995 to 196,000 tonnes N per year in 2003 to 187,000 in 2006. In the same period the excretion of nitrogen from livestock has decreased from around 270,000 tonnes N per year in 1998 to around 232,000 tonnes N per year in 2003 to 217,000 in 2006.

Regulation is based on research programmes and a dialogue between authorities and the agricultural community. Until now, the regulation has been performed on a national scale. With more attention to the effectiveness of more focused regulation as well as the local goals of the WFD, future regulation is likely to be more targeted specific needs in the local environment, rather than general regulation.

2.1 Watercourses

The results on watercourses are based on 127 sampling stations representing both small and large catchments. Long-term time series and statistical tests show that there have been significant reductions in both flow-weighted nitrate and total nitrogen concentrations since 1989. Evolution of flow-weighted nitrate concentrations between the 3rd period (2000-2003) and 4th period (2004-2007) show that in 32 % of the watercourses, there has been a weak or strong reduction in the flow-weighted annual average NO3-concentration.

2.2 Lakes

The results on lakes are based on data from respectively 93 (nitrate) and 193 lakes (chlorophyll) representing the total Danish lake-population reasonable well (with respect to lake area, depth and nutrient levels). Evolution of nitrate contents, from 3rd to the 4th period shows that in 33% of the lakes, there has been a weak or strong reduction in the yearly mean NO3-concentration.

Evolution of eutrophication shows that in 24% of the lakes there has been a week or strong reduction in summer mean chlorophyll concentration where as in 19% of the lakes there has been a week or strong increase.

2.3 Groundwater

Groundwater monitoring in Denmark is based on information from 75 groundwater monitoring areas typical with each 20-25 monitoring screens. For this reporting to the Nitrates Directive, 1651 monitoring screens/wells from the 75 groundwater monitoring areas are used. Approximately 17 % of the monitoring screens have a nitrate concentration above the maximum admissible concentration (MAC: 50 mg/l nitrate) for drinking water, and almost 50 % of the screens have a nitrate concentration above 5 mg/l. There is thus a large amount, 33% of the groundwater which is affected by nitrate, and at the moment holds contents below the MAC.

The data thus shows that although it is not possible to give an exact significant numeric answer on how much the nitrate has been decreasing in the Danish groundwater since the approval of the Action Plan for the Aquatic Environment in 1987, there are clear indications that there has been a decrease in the proportion of nitrate impacts on groundwater. The fraction of groundwater with very high nitrate concentrations is also decreasing, and the average nitrate contents are just below 50 mg/l in the youngest groundwater

2.4 Estuarine and marine waters

Out of 51 monitoring stations in Danish estuaries, the majority (88%) shows no development in winter nitrate concentration from 3rd to the 4th period. 2% show a strong increase while 2% showing a strong decrease and 8% showing a weak decrease. Out of 82 stations in Danish open marine waters there was an overwhelming tendency for no change for 85% of the stations reporting stable winter nitrate concentrations.

Chlorophyll concentrations have remained stable in both estuaries and in open marine areas during the last reporting periods. There are no long-trends in eutrophication status as determined by chlorophyll concentrations or primary production over the reporting period of 1992 to present.

In the Danish open marine area more stations showed a decrease in winter nitrate concentrations from the 3rd to the 4th period (14%) than from the 2nd to the 3rd period (3%). In Danish estuaries 87% of the monitoring stations showed no changes in winter nitrate concentrations, and while only 2% showed an increase in winter nitrate concentrations, 10% showed a decrease.

These first signs of environmental recovery are most pronounced in the estuaries, but are also apparent in the open waters of the Kattegat, the Sound and the Belt Sea and document significant decreases in nutrient concentrations on a large regional scale resulting from an active management strategy to reduce nutrients from both diffuse and point sources

2.5 Vulnerable zones

Denmark has designated the whole national territory as a vulnerable zone.

2.6 Code of good practice

Denmark has designated the whole national territory as a vulnerable zone. The code of good agricultural practice is enclosed the action programme for the whole national territory and implemented as mandatory measures. There are six Acts and Statutory Orders implementing the Danish code of good agricultural practice administrated by the Danish Ministry of environment and the Danish Ministry of food, agriculture and Fisheries, respectively.

2.7 Action Programme

In 1998 the Danish parliament agreed on Action Plan II and on fulfilment of the Nitrates Directive. The final evaluation of the AAP II in December 2003 showed that measures already implemented in addition to measures already agreed upon and financed would result in a reduction of the total nitrogen discharges from agriculture of around 149,000 tonnes N per year. This corresponds to a reduction of around 48% of 311,000 tonnes N.

In 2004 the Danish parliament agreed upon Aquatic Action Plan III 2005-2015. This plan encompasses broad efforts to reduce agricultural impacts on the aquatic environment and the nature. AAP III address surplus phosphorous in agriculture, which must be halved, compared to 37,700 tonnes P in 2001/2002, with 2015 as target year. For nitrogen the aim is to reduce leaching from agriculture by a minimum of 13% by 2015 compared to 2003. The evaluation of the plan in 2008 showed that on most instruments progress was not as expected. In 2009 the Danish government is working on a new Green Growth strategy to deal with subjects within agriculture and environment, and for example address the problems formerly encountered in achieving expected goals in APAEIII.

2.8 Control and inspection of the farmers

In 2007 the Danish Plant Directorate carried out around 1116 inspections on the spot corresponding to around 1,7 % of all agricultural holdings. Nearly 100% of all Danish farmers must submit an annual fertilisation status account to the Danish Plant Directorate. Control of fertilisation status accounts from year 2004/05 show that 110 farms corresponding to 0.2%, exceeded the farm nitrogen quota by 5-20 kg N per hectare. 26 farms corresponding to 0.05%, exceeded the farm nitrogen quota by more than 20 kg N per hectare. In 2006, 900 inspections were carried out. 8 of these (0,8% of inspected farms) were reported to the police for severe violations of the provisions on rational fertiliser use. 150 of the inspected farms was also controlled regarding the amount of livestock manure applied to the land each year (harmony requirements, LU/ha or kg N/ha). 15 of these (10% of inspected farms) were reported to the police for severe violations of the harmony requirements.

2.9 Cost effectiveness

Measures were evaluated based on their cost-effectiveness. All in all the cheapest measures are wetlands and catch crops. Afforestation and grassland measure are the most expensive, and would be so even if the expected effect on N-leaching had been achieved. The average cost of reducing N-leaching has increased from 2.5 € pr. Kg N in the plan to 5 € pr. Kg N at the mid-tern review of APAEIII.

2.10 Future evolution of water body quality

The nitrogen cycle is complex and the soil nitrogen pool very large. Thus, the full reduction in leaching due to changes in farming practice will not be achieved immediately. It is estimated that the full effect of agricultural measures on nitrogen leaching will be achieved within ten years.

When the full effect of Action Plan II is achieved the total nitrate leaching is expected to be 162,000 tonnes N. Action Plan III has a target of reducing the nitrate leaching further by 13% compared to 2003, corresponding to 21,000 tonnes N. This target is to be attained by 2015.

3 Introduction

According to Article 10(1) of Directive 1991/676/EEC Member States shall, in respect of the four-year period following the notification of the Directive and in respect of each subsequent four-year period, submit a report to the Commission containing the information outlined in Annex V of the Directive. The directive lays down that, at the end of each four-year programme (1995–99, 2000–03, 2004-07, etc), and for each water monitoring report/evaluation of measures associated with this programme a report describing the situation and its development shall be submitted to the Commission by each Member State.

This present report fulfils the Danish obligations report concerning the period 2004-2007. In accordance with the guidelines for Member states report, the report describes the status and trends of the aquatic environment and agricultural practices.

4 Water Quality: Assessment and Maps

4.1 Watercourses

Jens Bøgestrand, National Environmental Research Institute, Aarhus University

Danish streams are generally not liable to eutrophication and nitrate constitutes a major part of total nitrogen during all seasons. Thus the flow-weighted annual mean concentrations are considered fully satisfactory.

Flow-weighted mean nitrate concentrations in watercourses in the period 2004-2007 are shown in map 1, and maximum nitrate concentrations in watercourses in the period 2004-2007 are shown in map 2.

4.1.1 Presentation of monitoring stations

The maps are based on flow-weighted annual mean concentrations at 127 sampling stations representing both small and large catchments. Only sampling stations monitored every year since 1991 have been included. The catchments cover a range of nutrient sources, some of them being only affected by agricultural pollution, others mainly by point sources.

4.1.2 Evolution of nitrate contents

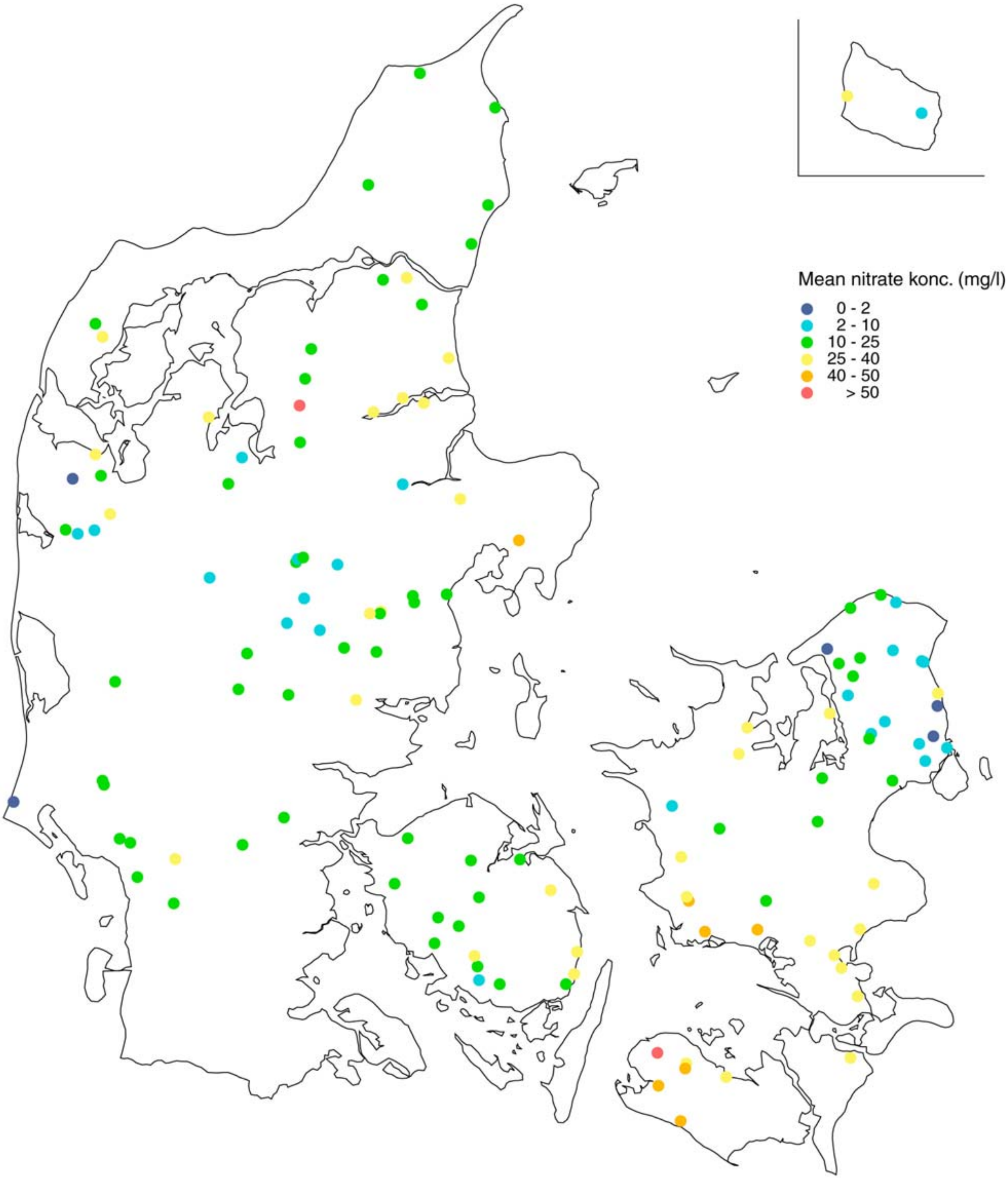
As nitrate concentrations are very dependent on precipitation and run-off, conclusions about changes between to specific periods should be drawn with caution. The use of flow-weighted annual mean concentrations reduces the climate dependency, but does not completely eliminate it. In the previous reporting, most stations showed a reduction in nitrate concentration. In the current reporting, there is a slight overweight of stations with reduction in nitrate concentration. Long-term time-series and statistical tests on flow-weighed concentrations show that there have been significant reductions in both nitrate and total nitrogen concentrations since the implementation of the nationwide Danish monitoring programme in 1989. Evolution of nitrate contents between the two periods 2000-2003 and 2004-2007 are shown in table 1.

Table 1: Evolution in annual average NO_3 concentration from 3^{rd} period (2000-2003) to 4^{th} period (2004-2007)

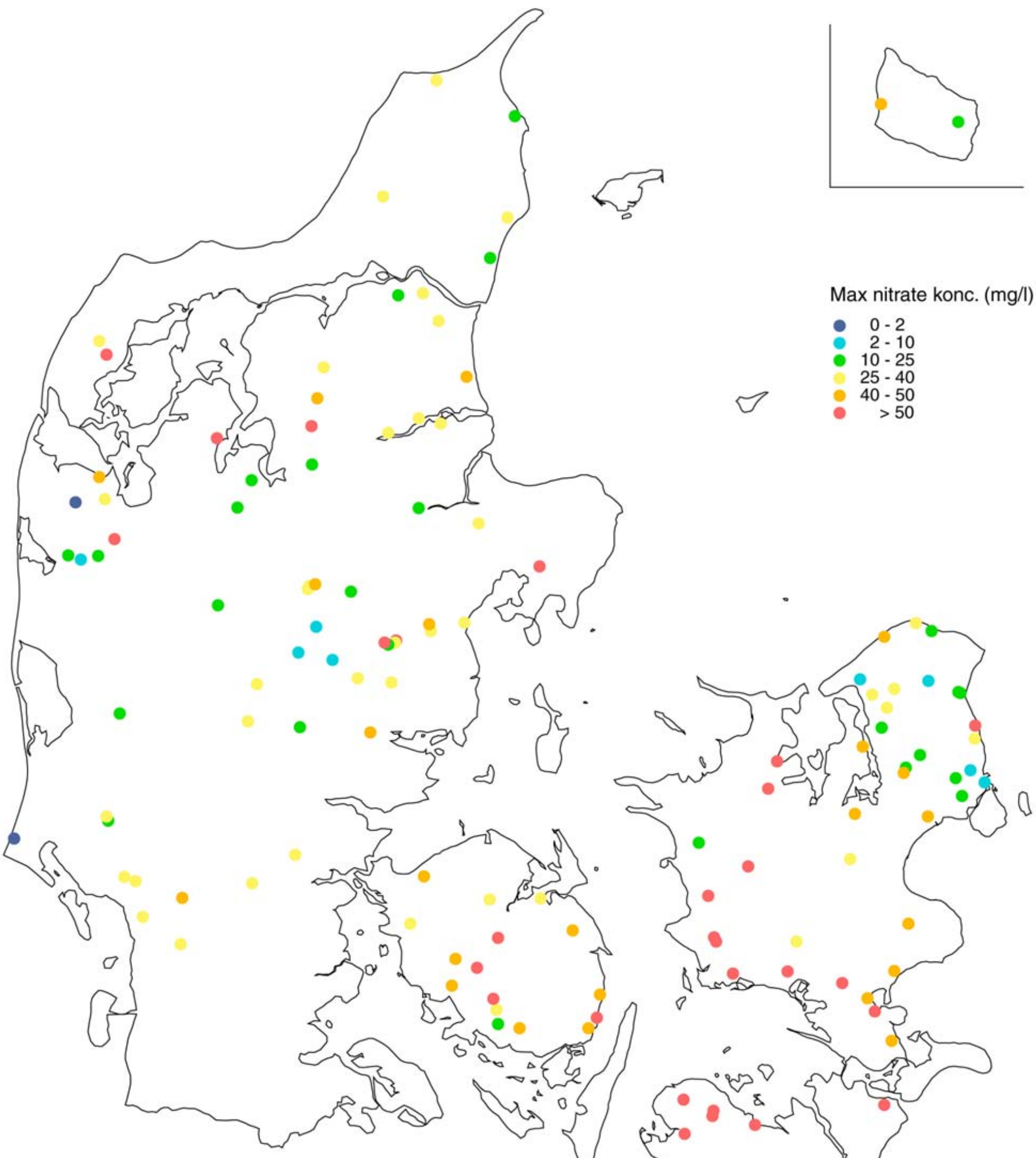
Trend	Percentage of watercourses
Strong increase	4 %
Weak increase	20 %
No change	45 %
Weak reduction	27 %
Strong reduction	5 %

Changes in mean nitrate concentrations in watercourses between the 3rd and 4th period (2000-2003 and 2004-2007) are shown in map 3.

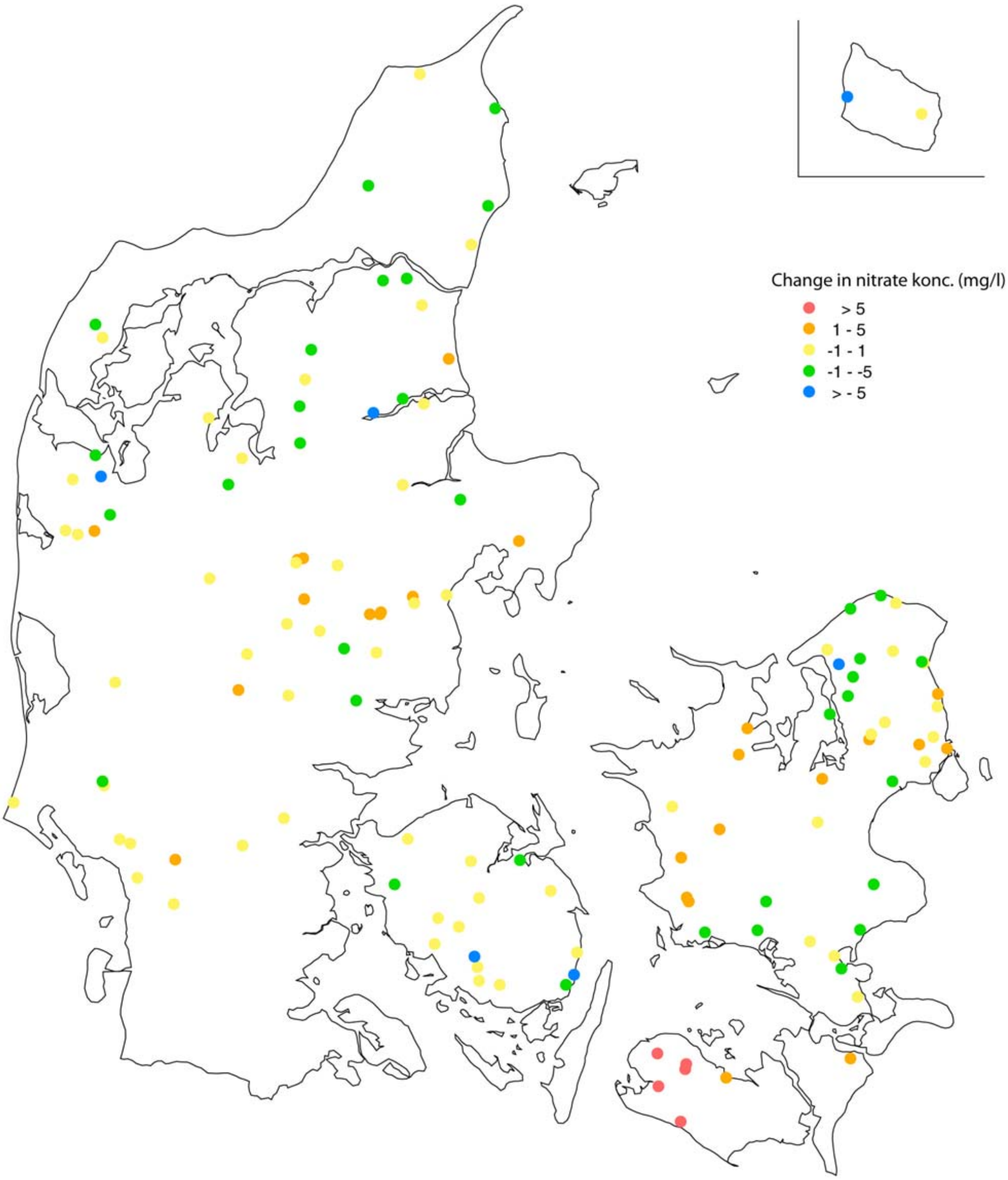
Map 1: Mean NO_3 concentrations in 4th period (2004-2007) (mean.jpg)



Map 2: Max NO3 concentrations in 4th period (2004-2007) (max.jpg)



Map 3: Changes in mean concentration from 3rd to 4th period (2000-2003 to 2004-2007)

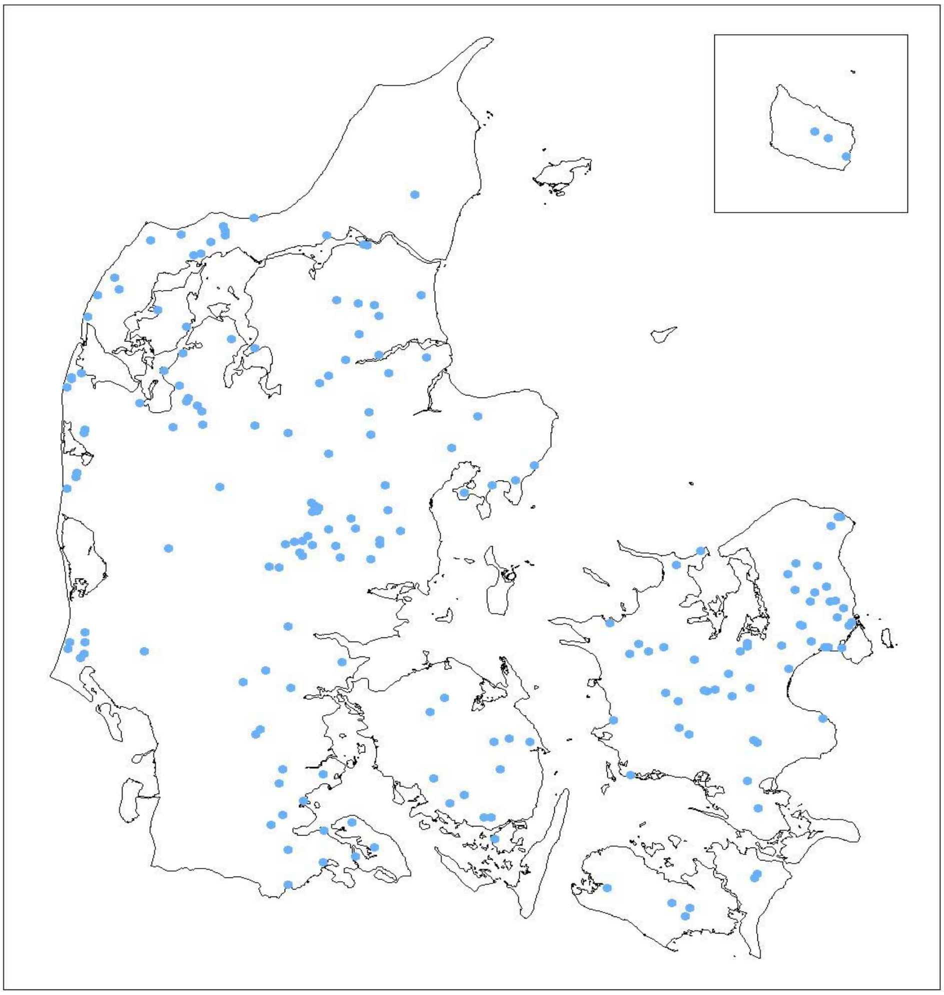


4.2 Lakes

National Environmental Research Institute, University of Aarhus.

4.2.1 Presentation of monitoring station

Map 4: The location of monitoring stations of 193 Danish lakes (map0.eps)



Comments to maps:

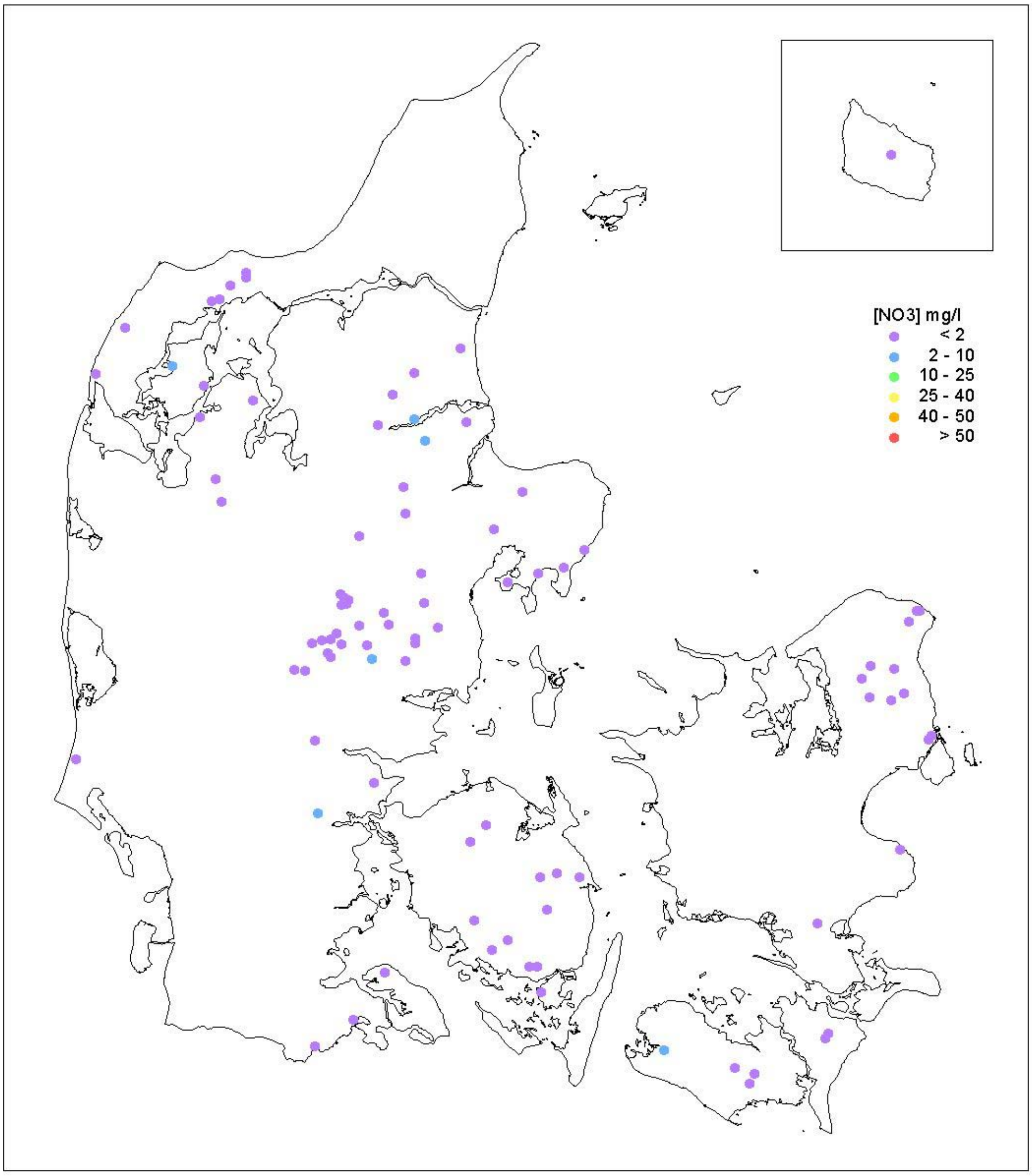
- Based on data from 93 lakes (nitrate) and 193 (chlorophyll) which represent the total Danish lake-population >5 hectares well (with respect to lake area, depth and nutrient levels), with 7 samples per year in one year in the 3rd (2000 – 2003) and 4th period (2004 – 2007).
- Values are based on time-weighted averages (compensating for non-time-equidistant sampling).
- Yearly mean values of nitrate are low in Danish lakes mainly because both denitrification processes and phytoplankton growth removes nitrate efficiently from the lake water in the summer period.

- A map of change in chlorophyll concentrations has not been made since no relations can be found at all between nitrate concentrations in Danish lakes and eutrophication.

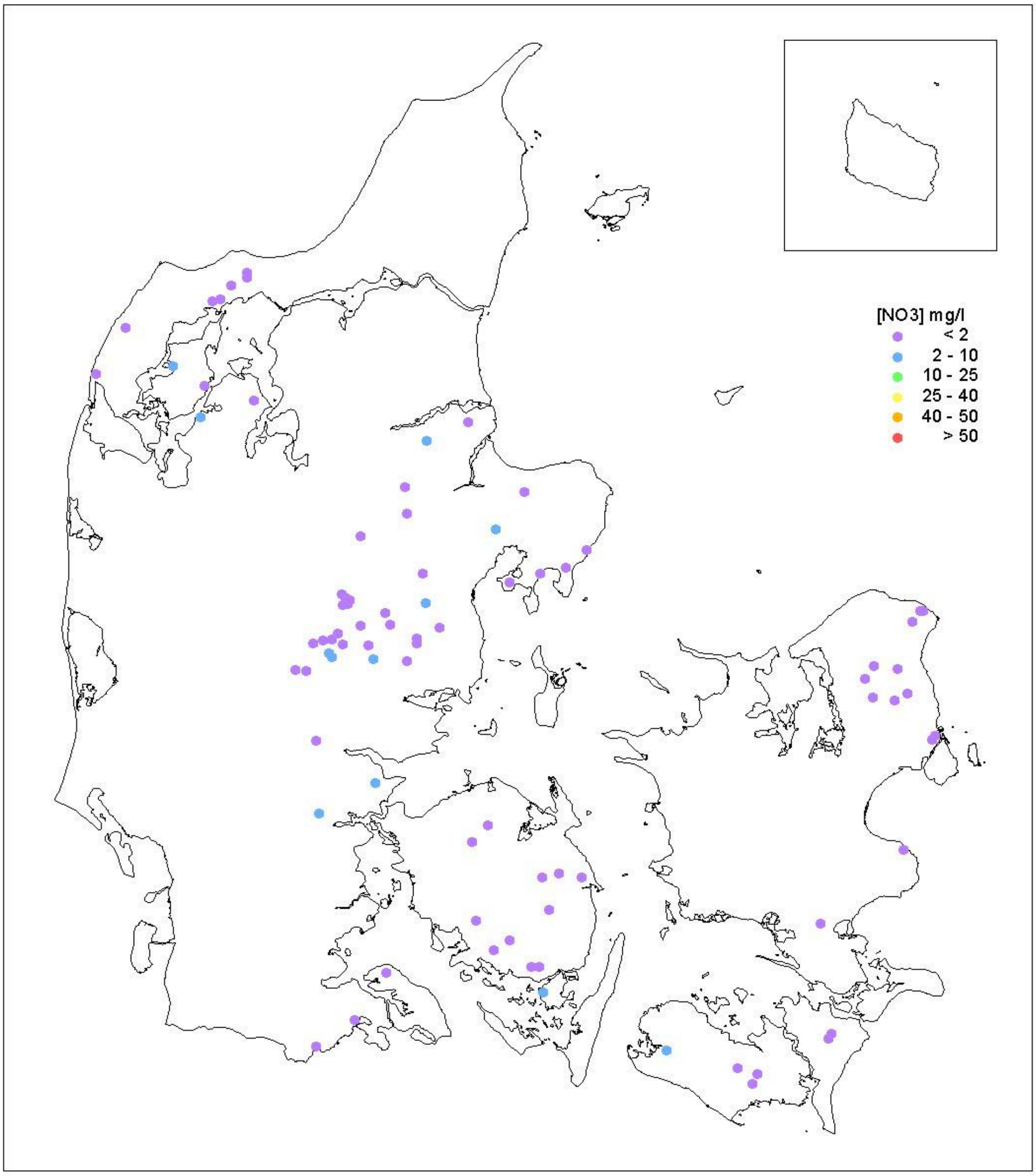
4.2.2 Nitrate concentrations in the 4th period (2004-2007)

Yearly mean nitrate concentrations and winter mean nitrate concentrations in 133 Danish lakes are shown in map2 and map3. Maximum nitrate concentrations are shown in map 7.

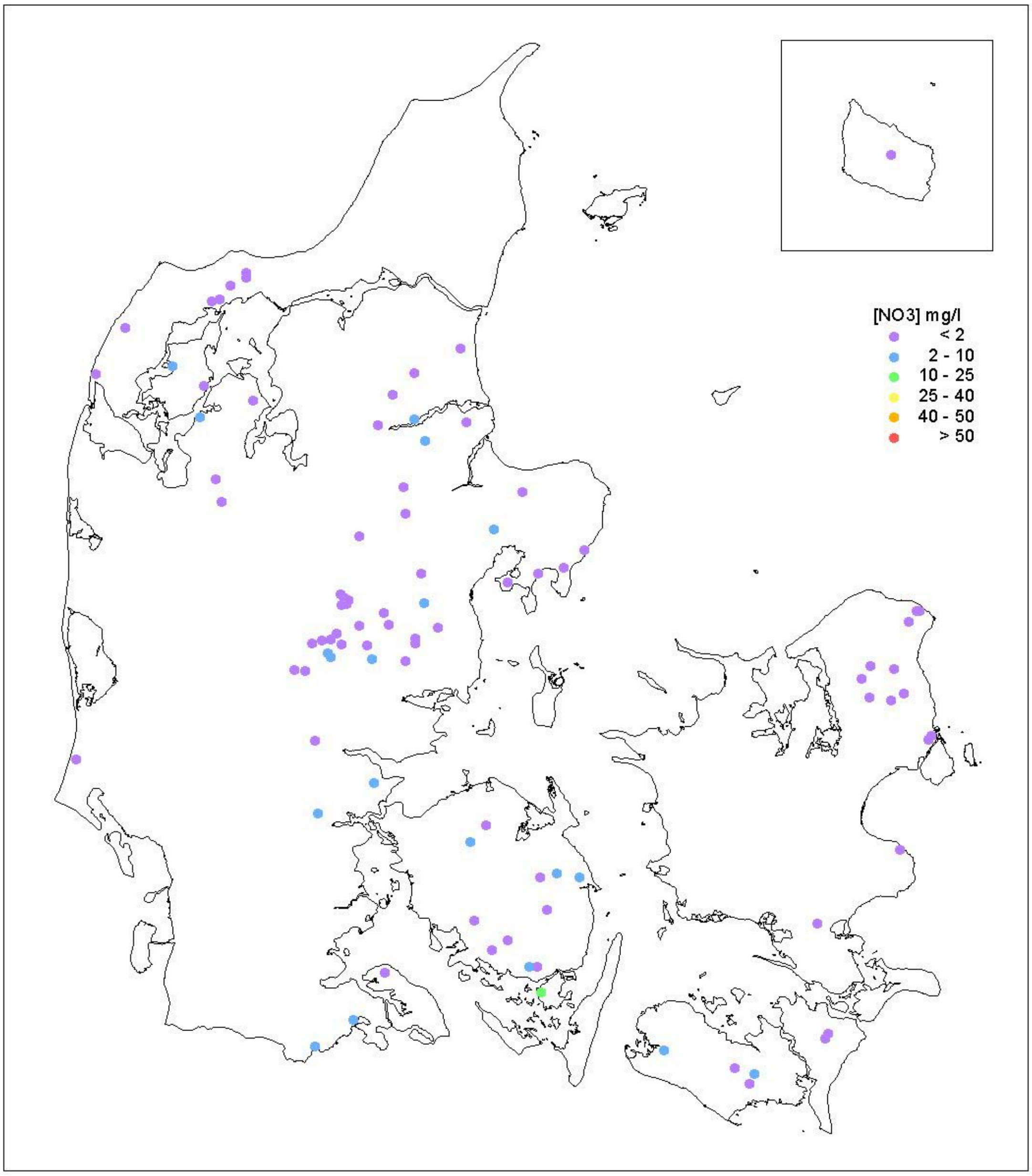
Map 5: Yearly mean nitrate concentrations in the 4th period (2004-2007) (map2.eps)



Map 6: Winter mean nitrate concentrations in the 4th period (2004-2007)(map3.eps)



Map 7: Maximum nitrate concentration in the 4th period (2004-2007)(map4.eps)



4.2.3 Development of nitrate contents

Table 2 and 3 show the evolution in nitrate concentration in the 93 lakes from the 3rd period (2000-2003) to the 4th period (2004-2007) with respect to yearly and winter mean nitrate concentration.

The evolution in the nitrate concentration is very much influenced by the differences in climatic conditions (e.g. precipitation).

Table 2: Change in yearly mean NO_3 concentration from 3rd and 4th period

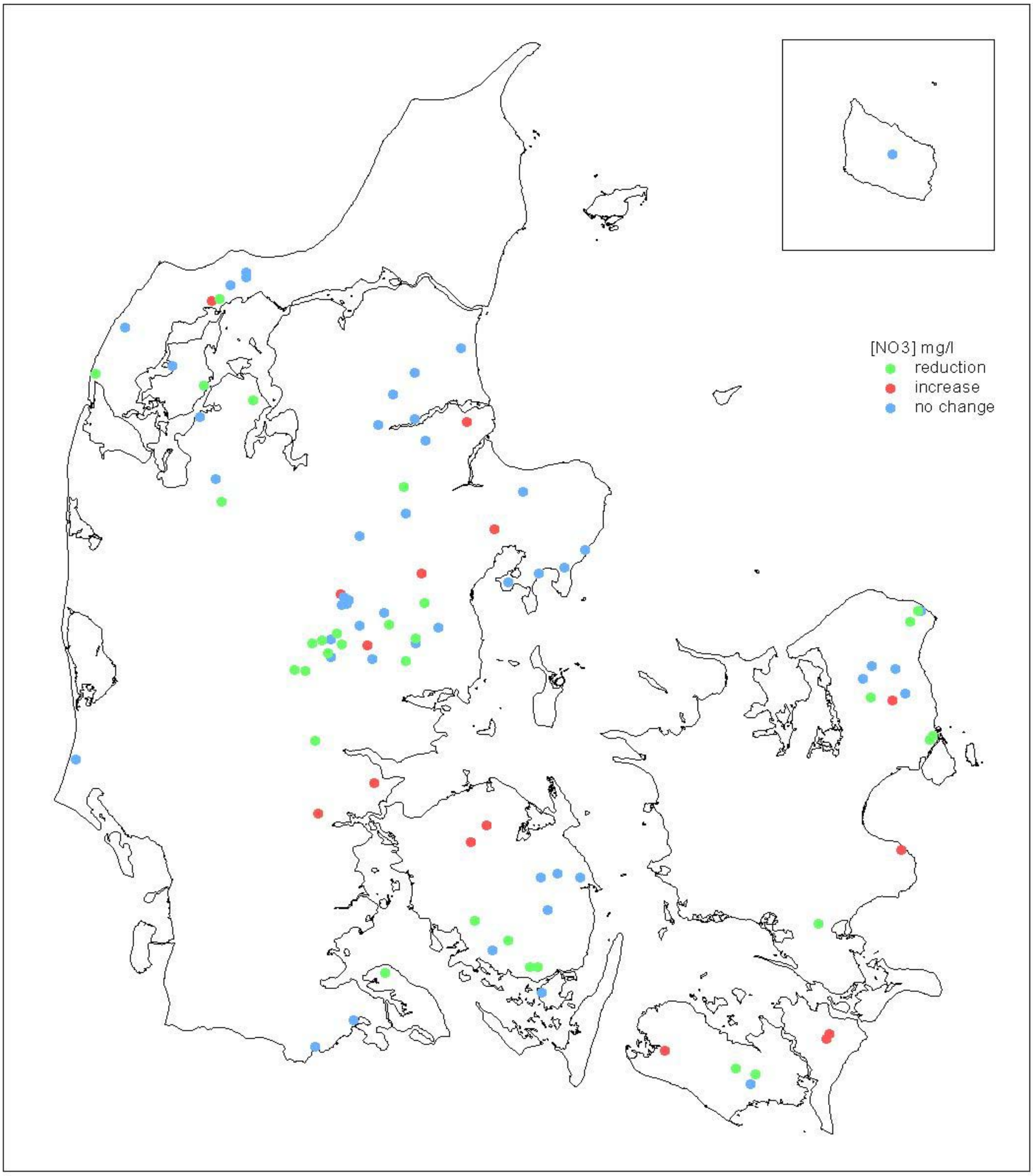
Trend	Number of lakes	Percentage of lakes
increase	15	16
no change	47	51
reduction	31	33

Table 3: Change in winter mean NO_3 concentration from 3rd and 4th period

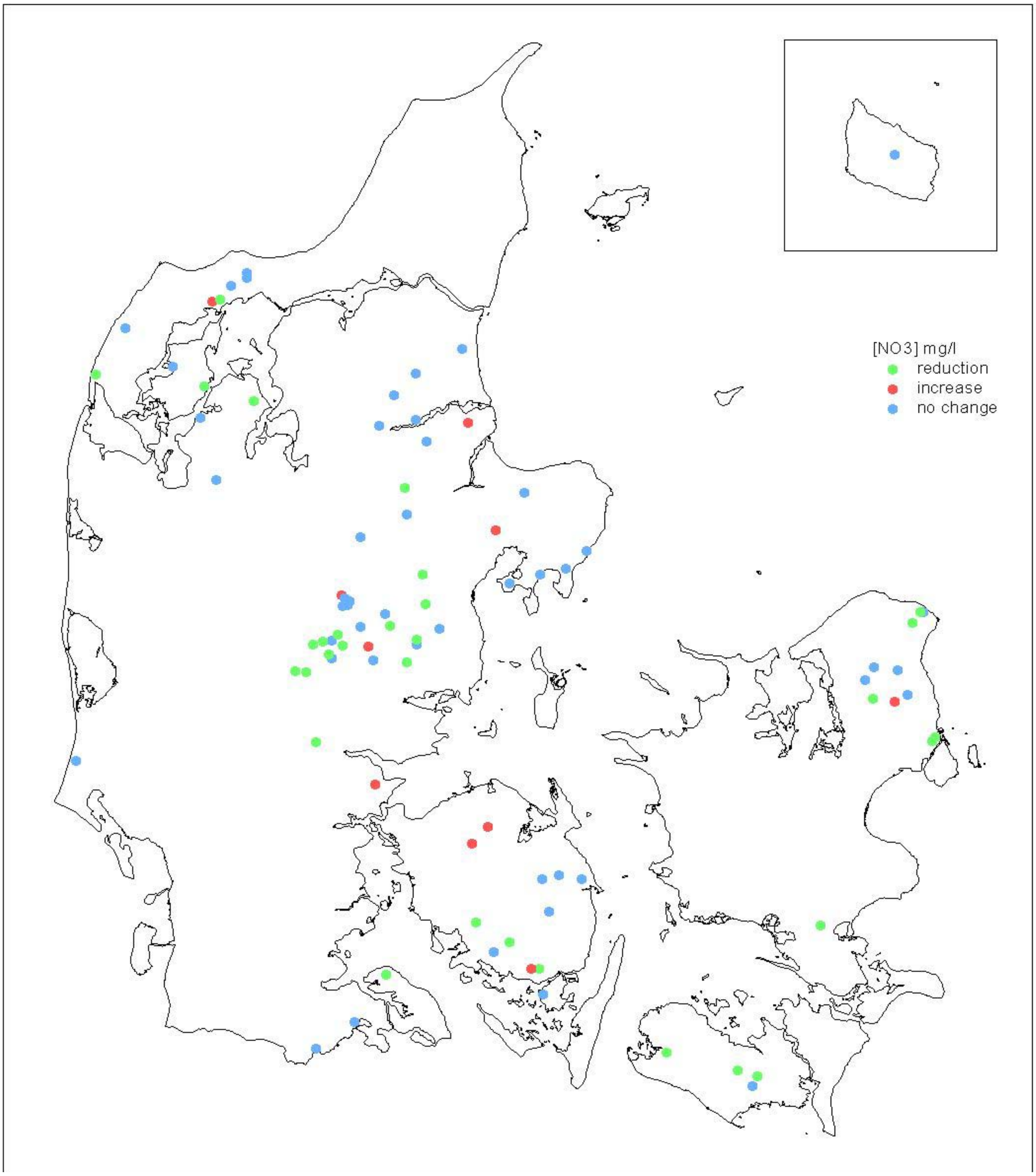
Trend	Number of lakes	Percentage of lakes
increase	10	11
no change	52	56
reduction	31	33

Maps 8 and 9 show change in yearly mean nitrate concentrations and change in winter mean nitrate concentrations respectively from *3rd (2000 – 2003)* to *4th (2004-2007)* period in 93 Danish lakes.

Map 8: Change in yearly mean nitrate concentration from 3rd (2000 - 2003) to 4th period (2004-2007) (map5.eps)



Map 9: Change in winter mean nitrate concentration from 3rd (2000 - 2003) to 4th period (2004-2007) (map6.eps).



4.2.4 Evolution of eutrophication

Classification of eutrophication in Danish lakes:
There is no official Danish quantitative classification of lakes and eutrophication however the classification proposed by Jensen et al. (1998) is applied:

Class[*)]	**I (Ultra Oligotr.)**	**II (Oligotr.)**	**III (Mesotr.)**	**IV (Mesotr./Eutr.)**	**V (Eutrof)**
Chlorophyll (μg l^{-1})	0-2.5	2.5-10	10-30	30-110	>110

[*)] The verbal formulations of the class given in parentheses are approximate

The evolution in the nitrate concentration is very much influenced by the differences in climatic conditions (e.g. precipitation).

Below is shown the evolution in chlorophyll concentrations in the 193 lakes from 3rd (2000 - 2003) to 4th period (2004-2007) with respect to summer mean chlorophyll concentration:

Type	**Number of lakes**	**Percentage of lakes**
increase	36	19
no change	111	57
reduction	46	24

4.3 Groundwater

Lærke Thorling, Geological Survey of Denmark and Greenland

4.3.1 Presentation of monitoring stations

Groundwater monitoring in Denmark is based on information from 75 groundwater monitoring areas typical with each 20-25 monitoring screens (Map 10), 5 agricultural watersheds and about 5500 water supply wells. As a whole they provide the most qualified information on groundwater chemistry and pollution at the national scale. For this reporting to the Nitrates Directive, only the 1651 monitoring screens/wells from the 75 groundwater monitoring areas are used. The groundwater monitoring programme is designed to monitor phreatic groundwater only, and about 75 % of the monitoring is on groundwater dated by CFC to be formed after 1940. There is no monitoring of captive or karstic groundwater.

Approximately 17 % of the monitoring screens have a nitrate concentration above the maximum admissible concentration (MAC: 50 mg/l nitrate) for drinking water, and almost 50 % of the screens have a nitrate concentration above 5 mg/l. There is thus a large amount, 33% of the groundwater which is affected by nitrate, and at the moment holds contents below the MAC.

Map 10: Groundwater monitoring areas in Denmark

In the monitoring areas focus has turned towards the upper groundwater over the last 4 years, and about 250 new observation wells are established. The new screens are typically placed 10-20 metre below surface in the upper 5-10 m. of the aquifer. The number of groundwater monitoring points for the present and previous reporting period is shown in table 3.

- Number of groundwater monitoring points

Depths m.b.s	Previous reporting period	Present reporting period	Common points
≤ 5	41	108	35
]5-15]	289	451	266
]15-30]	515	543	455
> 30	421	379	338
Sum	1266	1481	1094

Table 3: Number of groundwater monitoring points grouped by depth to top of screen (metre below surface) for the present (2004-2007) and previous reporting period (2000-2003).

4.3.2 Status for nitrate content in groundwater

Nitrate data for 2004 - 2007 have been pooled and the mean value and maximum value for each monitoring point was calculated. The distribution of monitoring points according to nitrate concentration is presented in 4 quality classes: < 25, [25-40[, [40-50] and > 50 mg/l nitrate. This was done for all points and data was again grouped according to the depth to top of the screen of the monitoring wells. The distribution according to depth is presented in 4 depth classes: ≤ 5,]5-15],]15-30] and >30 metre below ground surface. (Table 4 and 5);

- Mean nitrate concentrations: mg NO3/l

Depths m.b.s	Nitrate <25	Nitrate [25-40[	Nitrate [40-50]	Nitrate >50
≤ 5	62 %	11 %	10 %	17 %
]5-15]	65 %	7 %	6 %	23 %
]15-30]	67 %	10 %	5 %	17 %
> 30	84 %	4 %	2 %	10 %
All	70 %	8 %	5 %	17 %

Table 4: Distribution of mean nitrate concentration of the monitoring points, as grouped by depth to the top of the screens (metre below surface) for the present reporting period 2004-7

- Maximum nitrate concentrations: mg NO3/l

Depths m.b.s	Nitrate <25	Nitrate [25-40[	Nitrate [40-50]	Nitrate >50
≤ 5	57%	5%	13%	25%
]5-15]	60%	8%	5%	27%
]15-30]	63%	8%	6%	23%
> 30	83%	3%	3%	11%
All points	67%	6%	5%	21%

Table 5: Distribution of maximum nitrate concentration of the monitoring points, as grouped by depth to the top of the screens (metre below surface) for the present reporting period 2004-7)

The major part of the screens/wells has a nitrate concentration below 25 mg/l. The share of monitoring points without or with low nitrate contents increases with depths. Almost 40 % of the monitoring points with top of screen less than 5 m.b.s have a mean nitrate concentration above 25 mg/l, compared to only 16 % of the monitoring points below 30 m.b.s. The share of monitoring points with high nitrate concentrations is only a few percents higher if the analysis is done on maximum values. This is due to the relative stable nitrate content in most wells/monitoring points.

The spatial distribution of nitrate through the subsoil is controlled by natural nitrate reduction processes in the aquifers and clayey layers covering the deeper parts of the groundwater. (Figure 1) High concentrations of nitrate in the deeper aquifers are mainly found in the western part of Denmark, where as high nitrate concentrations are found in the upper 5 metres below surface in all parts of Denmark.

The geographical distribution of nitrate is shown in map 11 and 12. The mean nitrate content from the fourth reporting period 2004-7 is illustrated on maps 11, where the monitoring points are drawn last for the respectively highest and lowest nitrate content, and thus on top of the other markings. It is clear that it is possible to make two very different maps. Figure 11a gives an impression of an overwhelming widespread occurrence of nitrate in the groundwater, and figure 11b gives an impression of no nitrate problems at all. If no active choice of drawing order for the monitoring points was taken, any possible combination of map 11a and 11b would be the result.

The fact is that > 50 mg/l nitrate can be found in all oxic groundwater layers in most of Denmark, due to intensive agriculture, but the penetration depths of nitrate varies widely, and primarily gives rise to problems for drinking water abstraction in the western parts of the country. On the other hand, the nitrate present in the very shallow ground waters in the eastern part of Denmark, where clay layers promote near surface runoff, often finds a way to surface waters, and hence contributes to problems with eutrophication. A smaller fraction of nitrate bearing shallow groundwaters in the eastern parts of Denmark reach deeper aquifers and denitrification removes nitrate on the way.

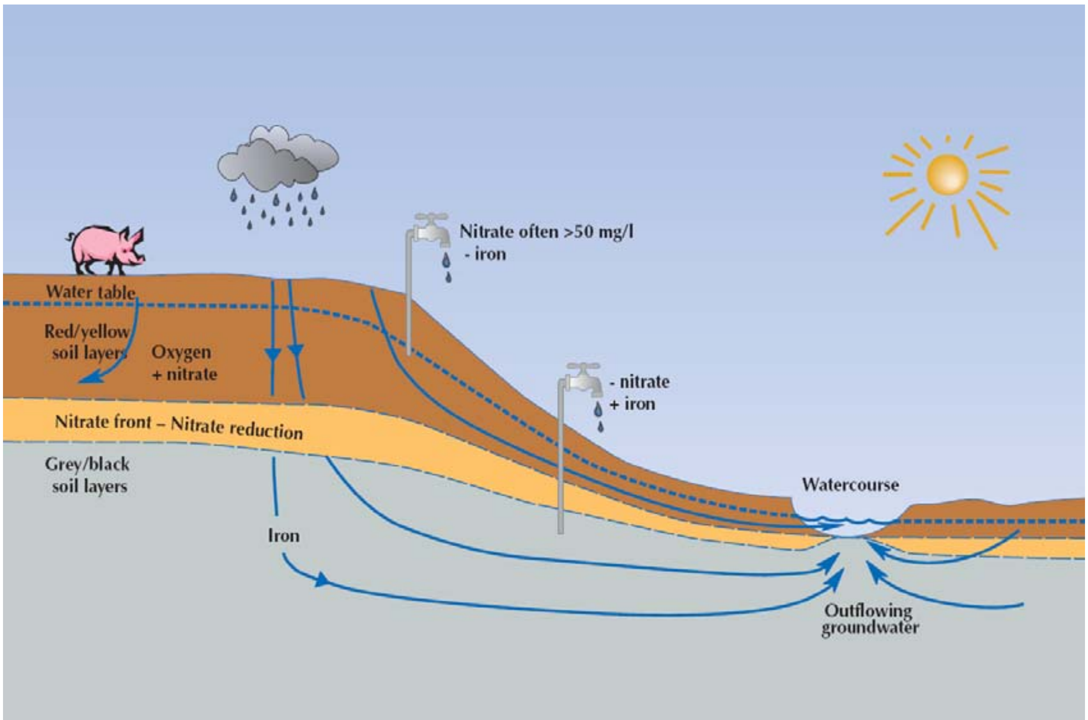
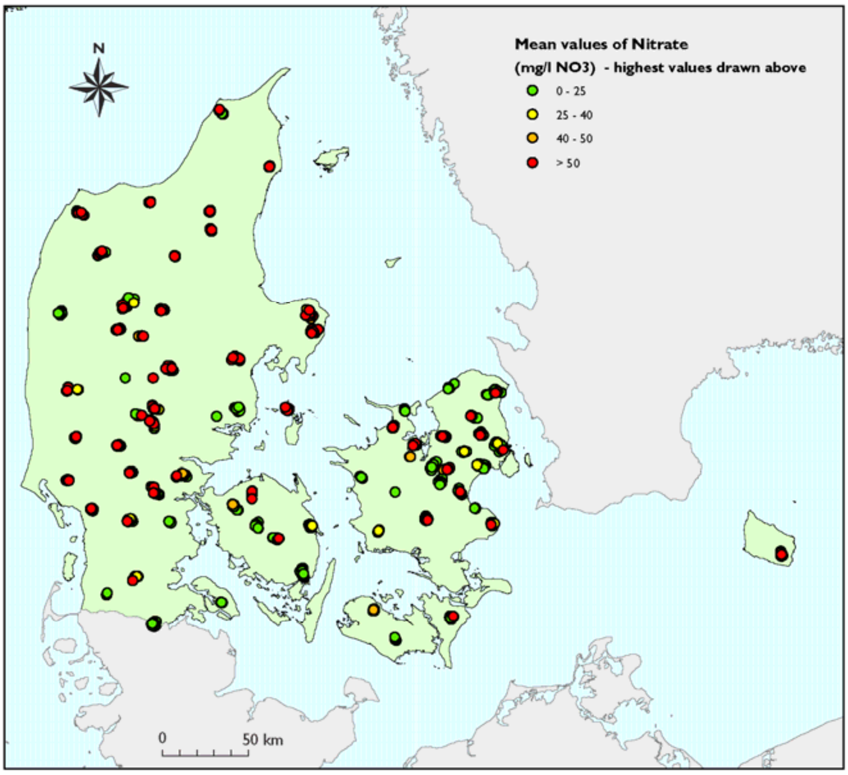
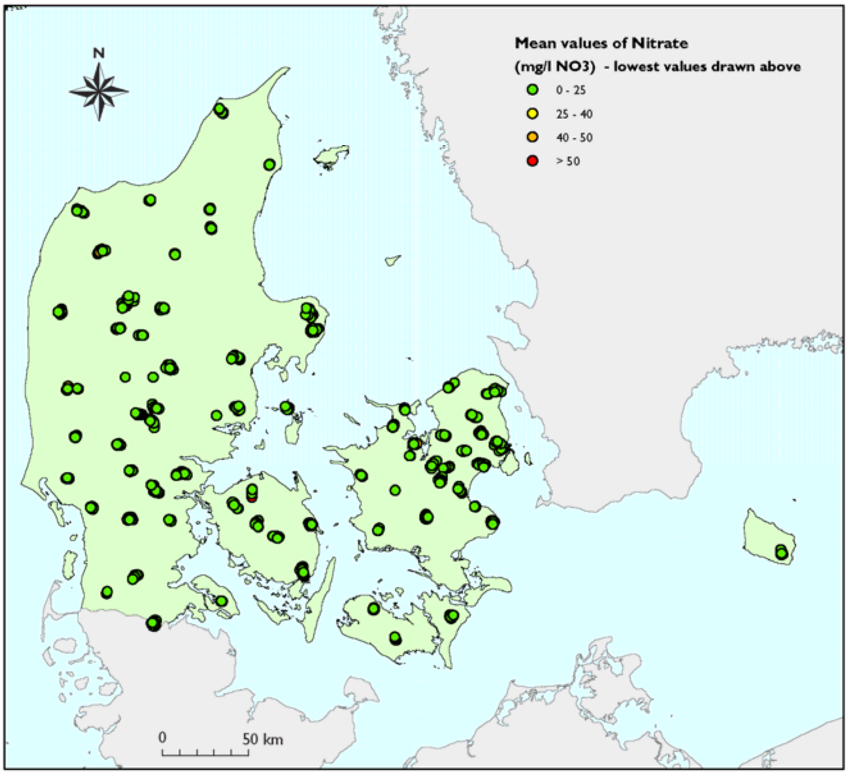
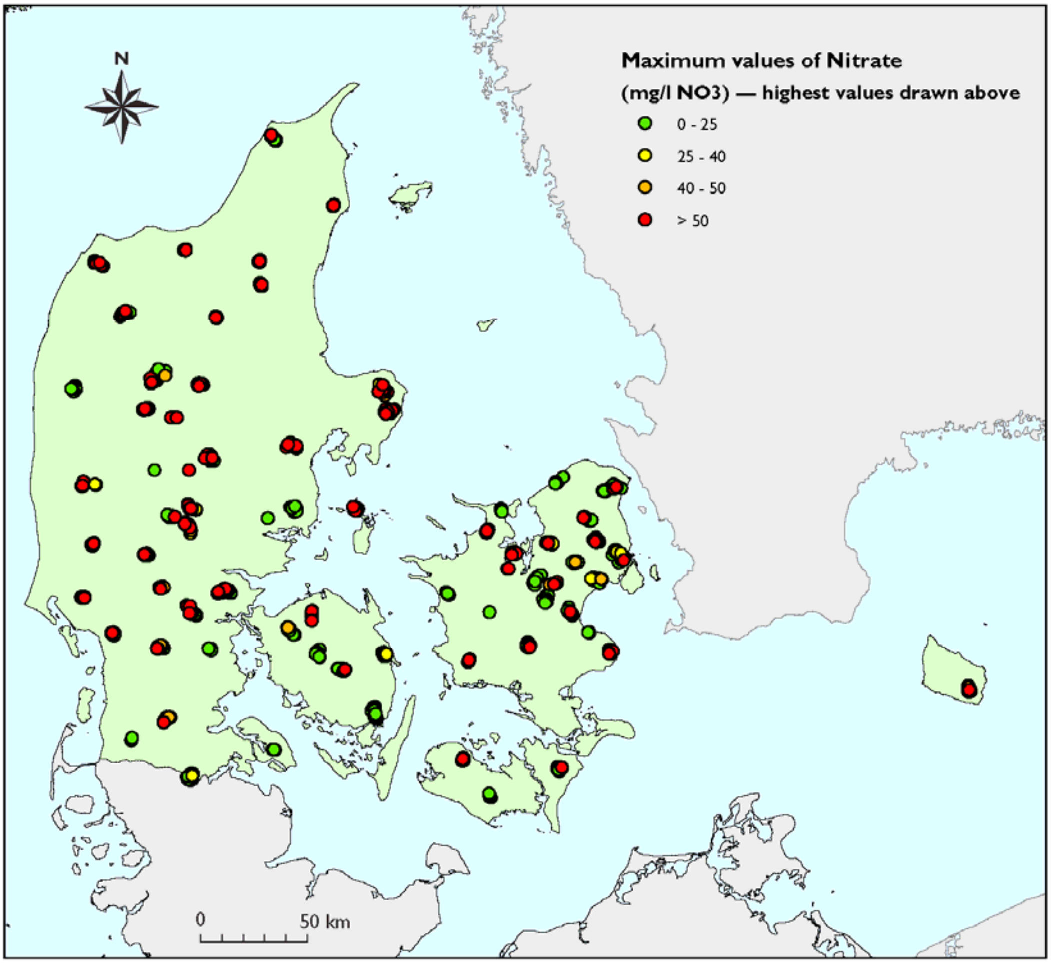


Figure 1: Principle for spatial nitrate distribution in an aquifer.





Map 11: Nitrate in all monitoring points, average values from 2004/2007. The same dataset is shown in two GIS presentations: In figure 3a nitrate values above 50 mg/l are drawn last, in figure 3b nitrate values below 25 mg/l are drawn last



Map 12: Nitrate in all monitoring points, maximum values from 2004/2007. Nitrate values above 50 mg/l are drawn last.

4.3.3 Evolution in nitrate contents in groundwater

Table 7 shows, how that there has been a decrease in the fraction of groundwater with a high average nitrate content (> 40 and > 50 mg/l) from the 3. to the 4. reporting period, both for the max concentrations and for the mean nitrate concentration. This holds for the fractions above 40 mg/l as well as for the fraction above 50 mg/l nitrate.

- Nitrate concentration in groundwater, Percentage of points

Percentage of points	**Previous reporting period**	**Present reporting period**
Exceeding > 50 mg/l		
On max. values. NO_3	23 %	19 %
On avg. values NO_3	17 %	15 %
Exceeding > 40 mg/l		
On max. values NO_3	26 %	24 %
On avg. values NO_3	22 %	19 %

Table 7: Evolution in percentage high nitrate concentrations in common monitoring points between previous period 2000-2003 to present monitoring reporting period 2004-7.

Nitrate data for the 1st , 3rd and 4th reporting periods, (1992-1994, 2000 - 2003 and 2004-7) was pooled and a mean value calculated for each monitoring point for each reporting period. The trend is defined as the difference of the mean values for each point between the periods to be compared. The trend was grouped in 5 classes, as shown in table 8.

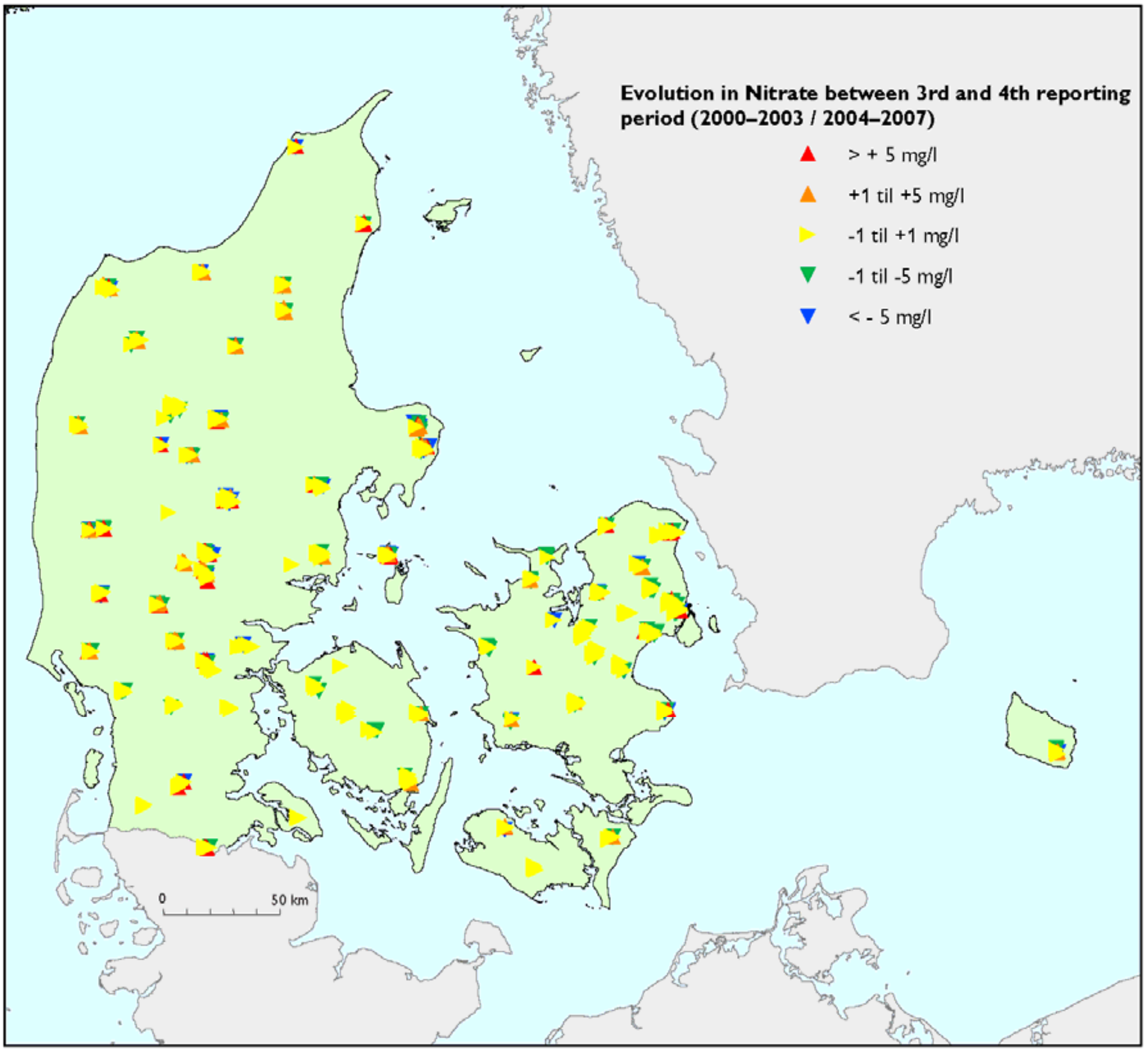
The major part of the monitoring points has trends in nitrate concentration between -1 and 1 mg/l. For obvious reasons this holds for groundwaters where nitrate concentrations are below 1 mg/l, which account for about half of the monitoring points, the stable fraction in table 8. The natural fluctuations from one year to another in the nitrate content in the monitoring wells with contents above 25 mg/l are often more than 5-10 mg/l-year, and these wells are found in table 8 as the large fraction of wells, with increasing and decreasing nitrate contents from one reporting period to another. What is notable and in agreement with the decreasing fractions of monitoring points with high nitrate, is that a larger fraction of points has decreasing nitrate content compared to the fraction with increasing content (table 7).

- **Evolution of NO_3-concentration in groundwater**

Percentage of common points	On max. NO_3	On annual average
Increasing		
Strongly >+5 mg/l	12 %	11 %
Weakly +1-+5 mg/l	9 %	10 %
Stable ±1 mg/l	48 %	54 %
Decreasing		
Strongly <-5 mg/l	20 %	16 %
Weakly -1to-5 mg/l	10 %	10 %

Table 8: Evolution in nitrate concentrations in common monitoring points between previous period 2000-2003 and the present monitoring reporting period 2004-7.

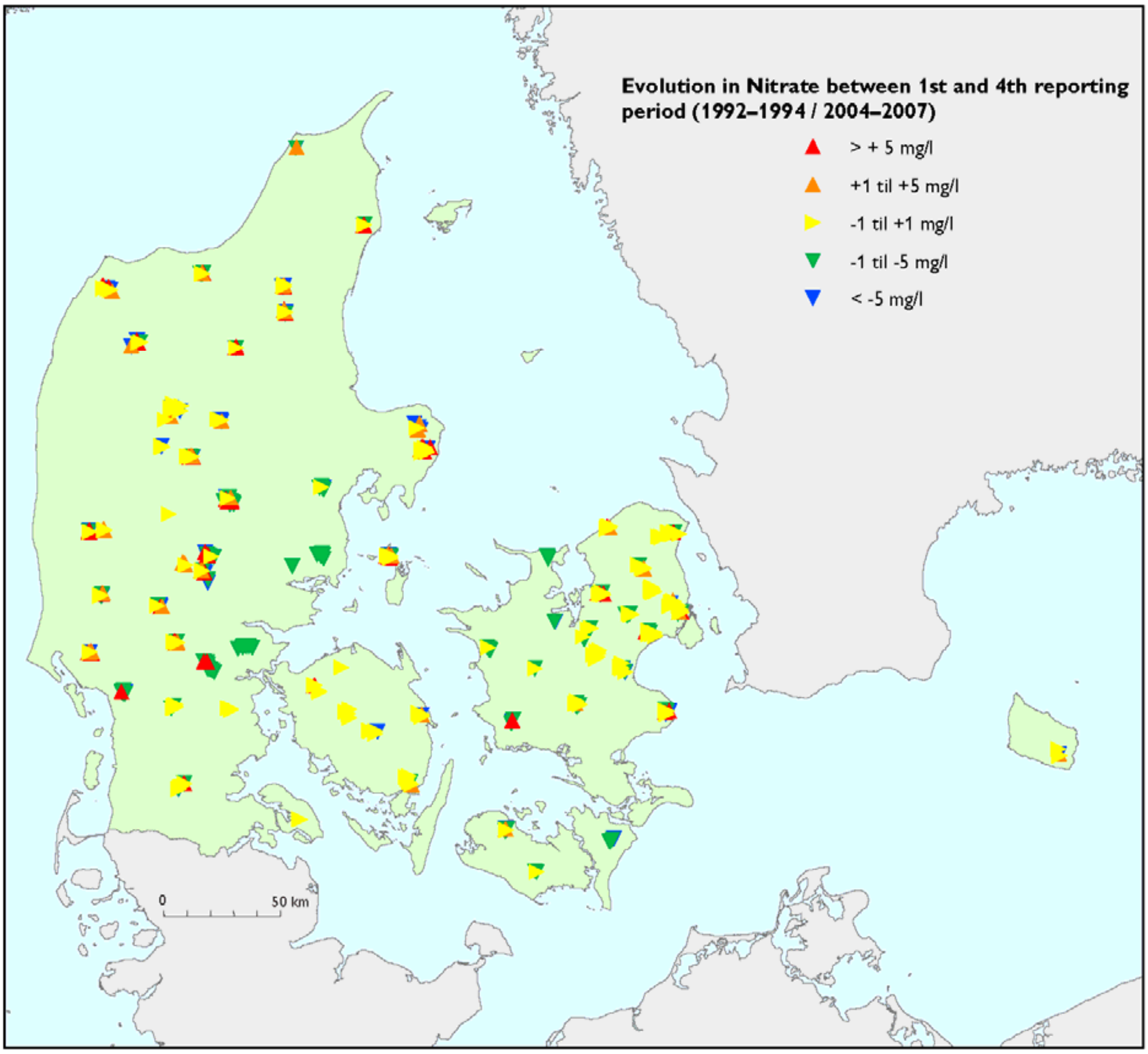
Following the common setup and paradigma for the evolution in nitrate content in this reporting it is difficult to show the larger fraction of monitoring points with decreasing nitrate concentration compared to the fraction of points with increasing nitrate. Map 13 shows a map of the spatial distribution of the trend in nitrate of the monitoring wells from the 3rd to the 4th reporting period, and the stable wells were chosen to be drawn in the top layer.



Map 13: Trend of mean nitrate of common monitoring points from the 3. to the 4. reporting period. (2000/03 to 2004/07) Drawn showing the most frequent development class in top layer (no trend).

Map 13 shows the trends between the 1st and the 4th reporting period. Now the tendency of decreasing nitrate concentrations in some parts of the Danish Groundwater is visible.

A more detailed insight into the systematic larger fraction of monitoring points with a decreasing nitrate content compared to the fraction of monitoring points with increasing nitrate can be found in table 8 and 9 where the mean and max nitrate concentrations are used to calculate trends from the 3rd to the 4th reporting period classified according to depth and trend class. Only in the deepest layers of the groundwater where the oldest ground waters are present is there no tendency against an overall decrease in nitrate. The data thus shows that although it is not possible to give an exact *significant* numeric answer on how much the nitrate has been decreasing in the Danish groundwater since the approval of the Action Plan for the Aquatic Environment in 1987, there are clear indications that there has been a decrease in the proportion of nitrate impacts on groundwater.



Map 14: Trend of mean nitrate concentration of common monitoring points from the first to the present reporting period. (1992/04 to 2004/07) Drawn showing the most frequent development class in top layer (no trend)

- **Trends of mean NO_3-concentration in groundwater by depth**

	% of points (mg/l)				
Depth	**< -5**	**-5 to -1**	**-1 to +1**	**+1 to +5**	**> +5**
≤ 5	20%	20%	26%	6%	29%
]5-15]	21%	11%	45%	9%	15%
]15-30]	19%	13%	48%	11%	9%
< 30	7%	5%	72%	8%	8%
All	16%	10%	54%	10%	11%

Table 9: Trends in groundwater NO3 concentrations based on mean values from 3rd to 4th reporting period. (% of sampling points, trends in mg/l nitrate, depth in metre below surface)

- **Trends of maximum NO_3-concentration in groundwater by depth**

	% of points				
Depth	**< -5**	**-5 to -1**	**-1 to +1**	**+1 to +5**	**> +5**
≤ 5	20%	14%	20%	17%	29%
]5-15]	26%	10%	41%	9%	15%
]15-30]	24%	11%	44%	9%	12%
< 30	10%	9%	63%	10%	8%
All	20%	10%	48%	9%	12%

Table 9: Trends in groundwater NO3 concentrations based on maximum values from 3rd to 4th reporting period. (% of sampling points, trends in mg/l nitrate, depth in metre below surface)

The conclusion from the present report is also supported by other findings. CFC age-dating indicates, that the majority of the groundwater containing nitrate was recharged before 1995. As a consequence, a large share of the groundwater samples are older than the start of the action plan from 1987 and thus the beneficial impacts of the plan may yet only be recognised, by careful data analysis.

Figure 2 shows the nitrate content of the groundwater as a function of the estimated age of formation of the groundwater based on CFC dating and chemical modelling. This gives an indirect picture of how much nitrate there was leached to the groundwater as a function of time. Geochemical modelling is used to calculate the original leached nitrate in oxygen free samples, and the red line gives a mean value of the nitrate content recharging to groundwater as a function of time.

Figure 2 shows a tendency towards a decrease in the nitrate content of the groundwater of Denmark over the last 15 years. This is evaluated to be the desired result of the implementation of a series of action plans since 1987. The fraction of groundwater with very high nitrate concentrations is also decreasing, and the average nitrate contents are just below 50 mg/l in the youngest groundwater. The latest data points are sparse resulting a large uncertainty of the data with a CFC age over about 1995.

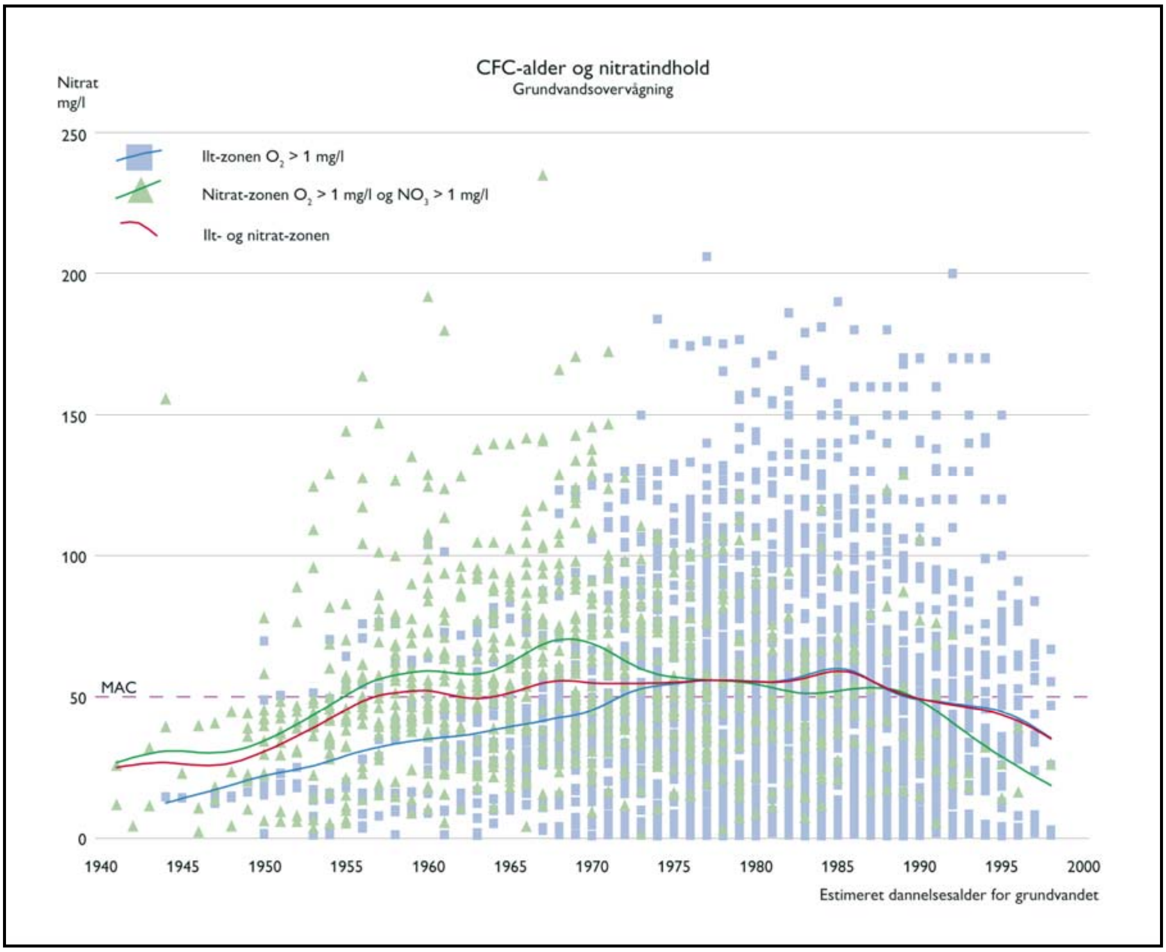


Figure 2: Nitrate as a function of the estimated age of formation of the groundwater based on CFC dating and chemical modelling.. The CFC date is the (mean) date the groundwater in the sample lost contact to the atmosphere. (from Grundvandsovervågning 2007, GEUS, 2007). The red line illustrates a model for the original mean nitrate content in groundwater as a function of the year the groundwater was formed

4.4 Estuarine, coastal and marine waters

Peter Henriksen, Ole Manscher and Ditte L.J. Petersen, National Environmental Research Institute, University of Aarhus

4.4.1 Presentation of monitoring Stations

The number of monitoring points used for evaluation of concentrations and trends from 2nd, 3rd and 4th monitoring periods has decreased slightly for estuarine waters (table 10) and stayed at approx. the same number for winter nitrate measurements in open waters while decreased markedly for summer chlorophyll a measurements in open marine waters (table 11) in Denmark.

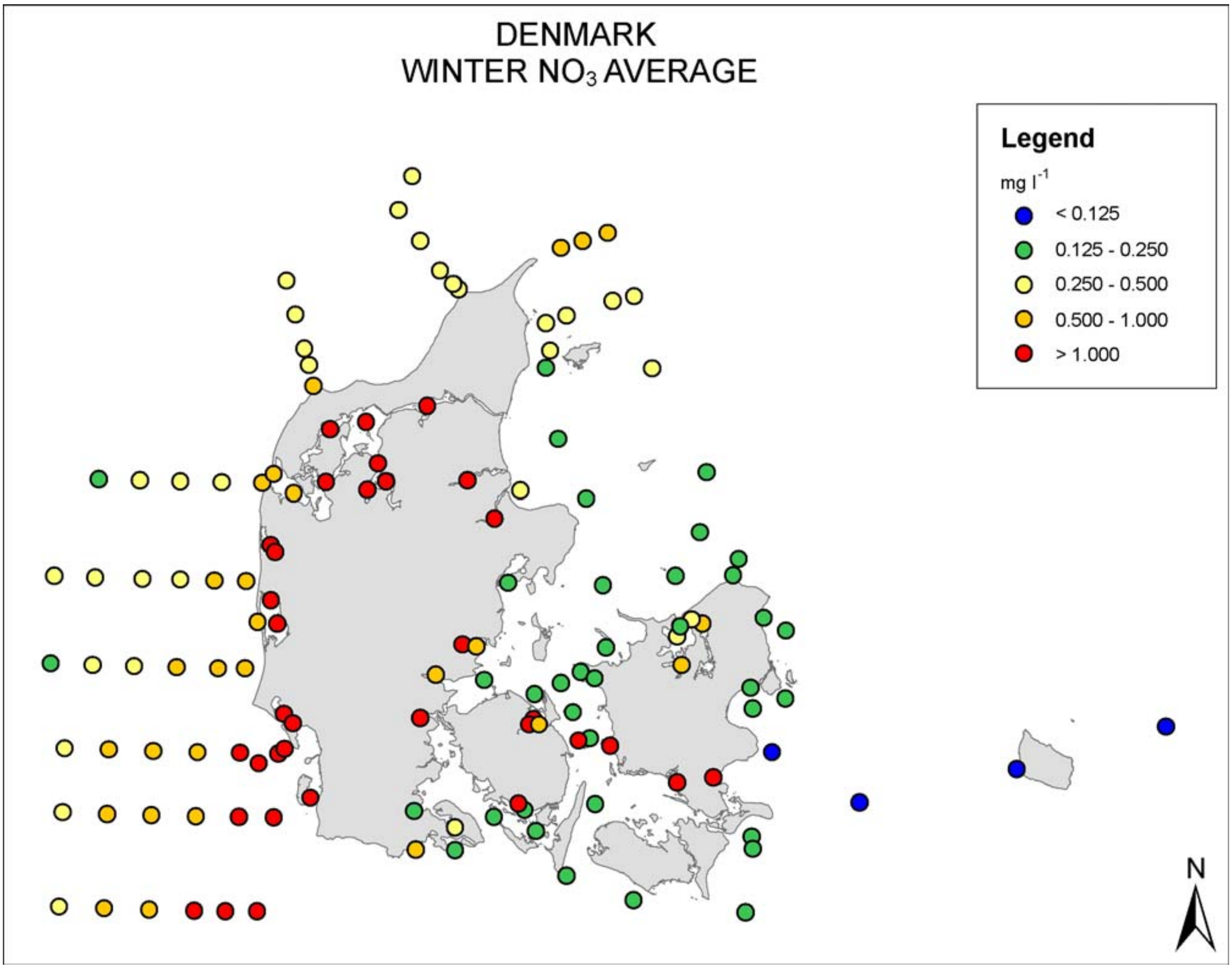
Table 10: Monitoring points for Danish estuaries

Number of monitoring points	2nd period 1996-1999	3rd period 2000-2003	4th period 2004-2007	Common points 3rd and 4th periods
Winter NO_3	56	54	51	51
Summer chlorophyll	55	56	48	48

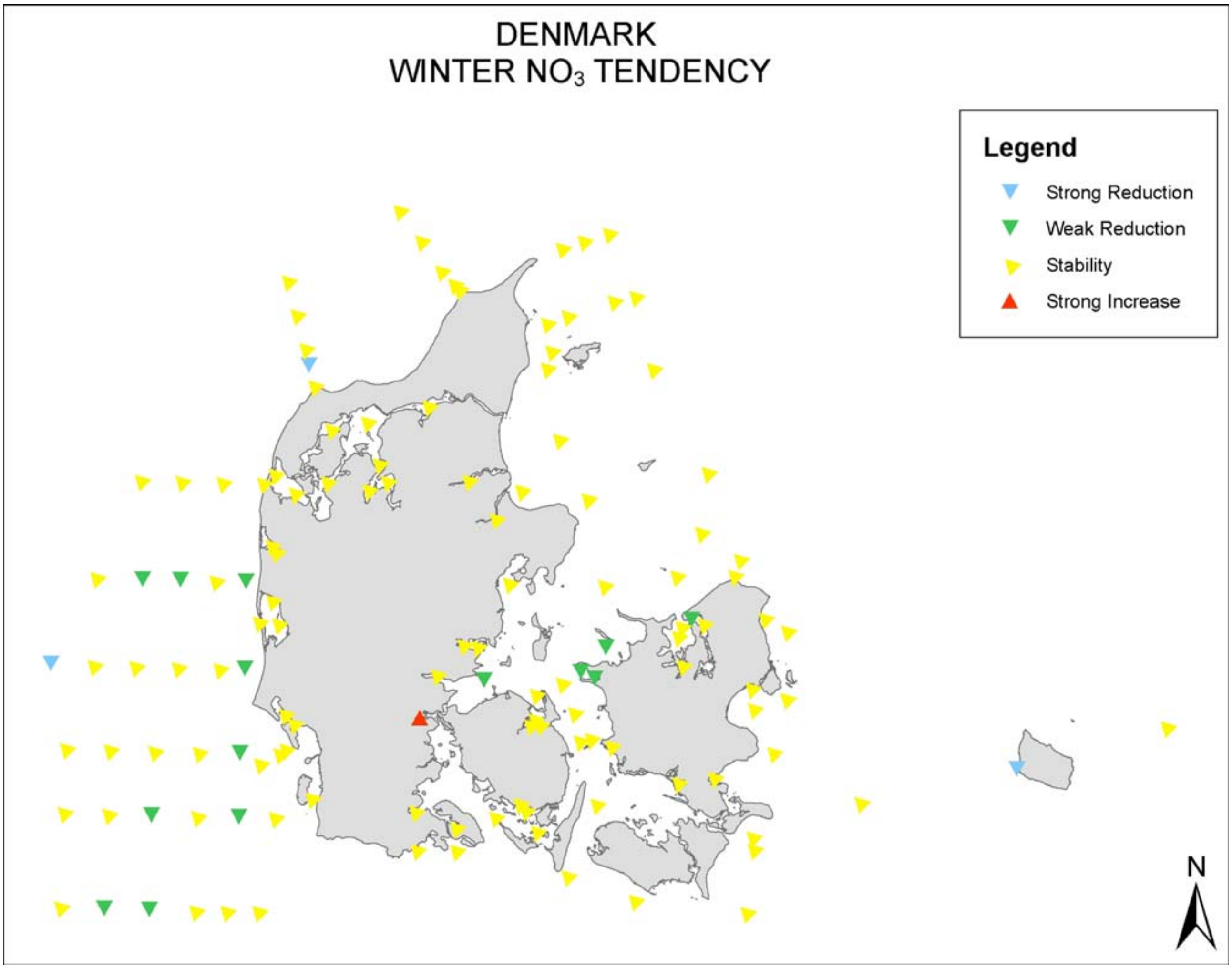
Table 11: Monitoring points for Danish open marine areas

Number of monitoring points	2nd period 1996-1999	3rd period 2000-2003	4th period 2004-2007	Common points 3rd and 4th periods
Winter NO_3	87	87	82	82
Summer chlorophyll	84	81	37	37

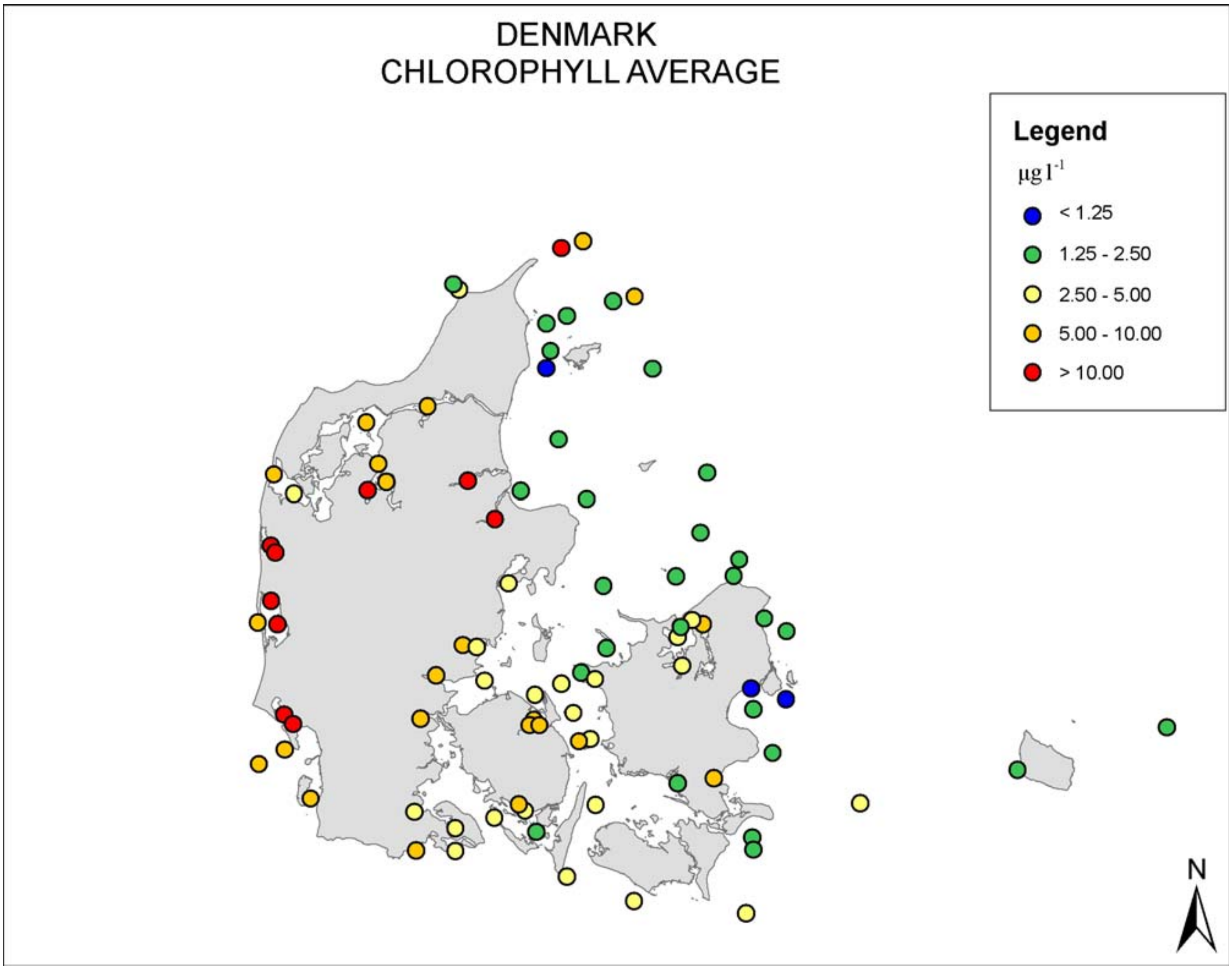
The station locations for the evaluation of nitrate concentrations can be seen in figure 1 and 2, and the station location for the evaluation of eutrophication status using chlorophyll as the indicator can be seen in figure 3.



Map 15: Present surface (0-10 m) winter mean (January-February) nitrate (nitrate+nitrite) concentrations (mg l^{-1}) in Danish estuaries and open waters.



Map 16: Development over time of surface (0-10 m) winter mean (January-February) nitrate (nitrate+nitrite) concentrations in Danish estuaries and open waters.



Map 17: Present surface (0-10 m) summer mean (May-September) chlorophyll-a concentrations (µg l^{-1}) in Danish estuaries and marine areas

4.4.2 Evolution of nitrate concentrations

Evolution from 3rd to 4th monitoring periods (2000-2003 and 2004-2007)

Present concentrations and development over time of surface (0-10 m) winter mean (January-February) nitrate (nitrate+nitrite) concentrations in Danish estuaries and marine areas are shown in figure 15 and 16 and tables 12 and 13 for estuaries/coastal areas and open waters, respectively. The unit is mg NO_3+NO_2 nitrate per litre.

The highest winter nitrate concentrations are observed in semi-enclosed estuaries, and in the German Bight in the North Sea (figure 15). The lowest winter nitrate concentrations are found in the Baltic Proper. The high concentrations in the German Bight and along the Danish North Sea coast are mainly due to contributions from the European rivers to the south-eastern North Sea carried to the north by the Jutland Coastal Current.

Out of 51 monitoring stations in Danish estuaries, the majority of stations (88%) show no development in winter nitrate concentrations from 3rd to 4th period, with 2% of stations showing a strong increase, 2% showing a strong decrease and 8% showing a weak decrease (table 12). Out of 82 stations in Danish open marine waters there was also an overwhelming tendency for no change with 85% of stations reporting stable winter nitrate concentrations (table 13). Concentrations showed slight and strong decreases at 12 and 2% of the stations, respectively.

Table 12: Development over time of surface nitrate concentrations in Danish estuaries. Percentage of points during January-February with mean concentrations of nitrate increasing, stable or decreasing

Trend	Significance	2nd period to 3rd period 1996-1999 to 2000-2003	3rd period to 4th period 2000-2003 to 2004-2007
Increasing	strongly ($p<0.01$)	2 %	2%
	Weakly ($p<0.05$)	13 %	0%
Stable		66 %	88%
Decreasing	strongly ($p<0.01$)	15 %	2%
	Weakly ($p<0.05$)	4 %	8%

Table 13: Development over time of surface nitrate concentrations in Danish open marine areas. Percentage of points during January-February with mean concentrations of nitrate increasing, stable or decreasing

Trend	Significance	2nd period to 3rd period 1996-1999 to 2000-2003	3rd period to 4th period 2000-2003 to 2004-2007
Increasing	strongly ($p<0.01$)	1 %	0 %
	Weakly ($p<0.05$)	1 %	0 %
Stable		94 %	85 %
Decreasing	strongly ($p<0.01$)	2 %	2 %
	Weakly ($p<0.05$)	1 %	12 %

4.4.3 Eutrophication

There are no commonly accepted threshold concentrations for eutrophication variables for marine waters, and the threshold values given for freshwaters are not applicable to marine waters. Mean summer concentrations of chlorophyll-a have been chosen to represent eutrophication in Danish marine waters.

Chlorophyll-a

The highest summer chlorophyll-a concentrations in the uppermost 10 m are observed in the semi-enclosed estuaries and the Danish Wadden Sea, followed by the Belt Sea (figure 3). The lowest summer chlorophyll-a concentrations are found in the Kattegat and the western Baltic Sea.

Assessment

The majority of stations monitored for winter nitrate and show no changes in concentrations from 3rd period (2000-2003) as compared to 4th period (2004-2007). In the Danish open sea area more stations showed a decrease in winter nitrate concentrations from the 3rd to the 4th period (14%) than from the 2nd to the 3rd period (3%). In Danish estuaries 87% of the monitoring stations showed no changes in winter nitrate concentrations, and while only 2% showed an increase in winter nitrate concentrations, 10% showed a decrease.

The nitrogen load to the Danish marine waters and the resulting winter concentrations of nitrate are closely correlated to run-off from land (Ærtebjerg et al. 1998). The runoff from land varies by a factor of 2-3 depending upon if it is a wet year or a dry year. For example, nutrient loading to marine waters around Denmark has varied from a low of about 50,000 tonnes of N during the low freshwater flow years of 1996 and 1997 to about 130,000 tonnes during the wet year of 1994 (Dahl & Josefson 2009). This annual variation in nutrient load due to changes in climatology (freshwater discharge) strongly influences the reported trends. Therefore, probably the main reason that nitrate concentrations decreased sharply for 1st period (1992-1994) to 2nd period (1996-1998) was due to the 2 dry years of 1996 and 1997 strongly influencing the mean concentrations.

Changes in nitrogen concentrations following the reduction measures that have been taken in Denmark to reduce nutrient loads are partly masked by large interannual variations in freshwater discharge. If we make a climate correction and remove the influence of river runoff from land with the resulting N loading (figure 3) then DIN (Dissolved Inorganic Nitrogen: nitrate + nitrite + ammonium) concentrations have significantly decreased both in Danish estuaries and in open marine waters (Dahl & Josefson 2009). The very low runoff-corrected concentrations in Danish estuaries during 2007 were caused by high run-off events during June and July which only has minor influence on the concentrations in the fjords.

These first signs of environmental recovery are most pronounced in the estuaries, but are also apparent in the open waters of the Kattegat, the Sound and the Belt Sea and document significant decreases in nutrient concentrations on a large regional scale resulting from an active management strategy to reduce nutrients from both diffuse and point sources (Carstensen et al. 2004).

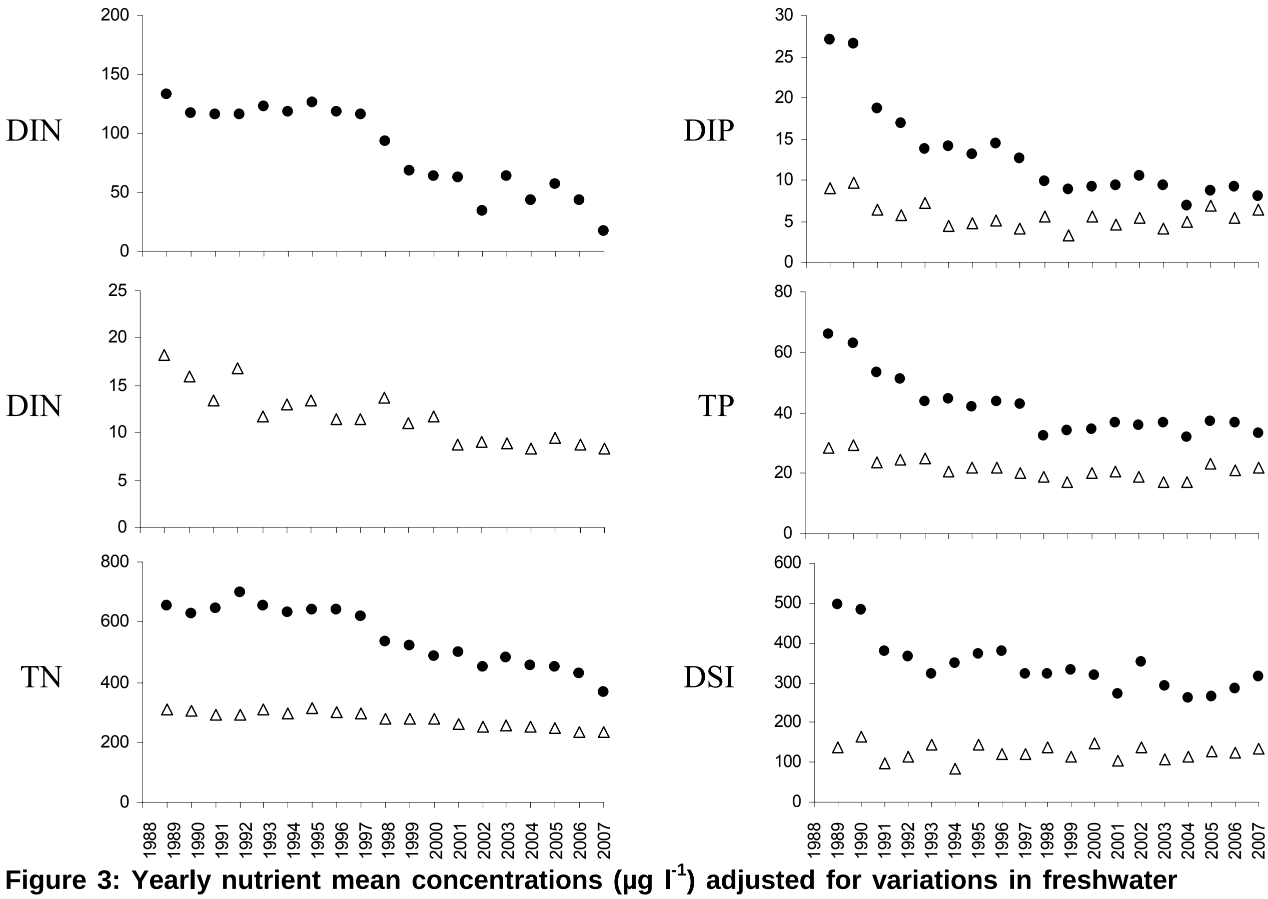


Figure 3: Yearly nutrient mean concentrations (µg l^{-1}) adjusted for variations in freshwater discharge from year to year (Dahl & Josefson 2009). Yearly means for estuarine stations (circles) and open-water stations (triangles) for the surface layer. Open waters are the Kattegat, the Sound and the belt Sea. DIN = Dissolved Inorganic Nitrogen (nitrate + nitrite + ammonium). DIP = Dissolved Inorganic Phosphorus (phosphate). TP = Total Phosphorous. TN = Total Nitrogen. Dsi = Dissolved Silicate

The phosphorus load and concentrations have also decreased significantly in Danish estuaries during the period 1989 to 2007. Nitrogen continues to be the nutrient potentially most limiting to phytoplankton biomass, although the number of days with co-limitation from both nitrogen and phosphate has significantly increased (Dahl & Josefson 2009).

Chlorophyll concentrations have remained stable in both estuaries and in open marine areas during the last reporting periods. There are no long-trends in eutrophication status as determined by chlorophyll concentrations or primary production over the reporting period of 1992 to present, which is consistent with our national reporting (Dahl & Josefson 2009).

4.4.4 References

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Dahl, K. & Josefson, A. 2009: Marine områder 2007 – Tilstand og udvikling i miljø- og naturkvaliteten. Danmarks Miljøundersøgelser. 248 s. - Faglig rapport fra DMU nr. 707 (in Danish).

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Rasmussen, M.B, Andersen, J., Ærtebjerg, G., Carstensen, J., Krause-Jensen, D., Greve, T.M., Petersen, J.K., Hansen, J., Josefson, Christiansen, T., Ovesen, N.B., Skjøth, C.A., Ellermann, T., Henriksen, Markager, S., Hansen, O.S., Dahl, K., Fossing, H., Risgaard-Petersen, Larsen, M.M., Pedersen, B., Dahllöff, Strand, J., Christensen, P.B., Conley, D., Axe, P., Druon, J.N. Hansen,
J.W. 2003. Marine områder 2002 – Miljøtilstand og udvikling. Danmarks Miljøundersøgelser. Faglig rapport fra DMU nr. 467 (in Danish).

5 Vulnerable zones

According to Article 3(1) of the Nitrates Directive waters affected by pollution and waters which could be affected by pollution if action pursuant Article 5 is not taken shall be identified by the Member States in accordance with the criteria set out in Annex 1 of the Directive.

According to Article 3(2) Member States shall designate as vulnerable zones all known areas of land in their territories which drain into the waters identified according paragraph 1 and which contribute to pollution.

Denmark has designated the whole national territory as a vulnerable zone.

6 Development, promotion and implementation of code of good practice

Henriette Hossy and Signe Kromann-Rasmussen, Danish Environmental Protection Agency

In the following the code of good practise and its development, promotion and implementation is described. The code is implemented a long side other initiatives and often together with the Action Programme, because of the way the implementation has been designed in Denmark. This means that there is some overlap between this chapter and the chapter on the Action Programme, because some measures are part of both.

6.1 Data concerning the territory of Denmark

Table 14: Data concerning the territory of Denmark 1)

	Reporting Period		
	Previous period Average of 2000-2003	**Current period Average of 2004-2007**	
Total land area 1)	43 098		km²
Agricultural land	26 580	26 815	km²
Agricultural land available for application of manure2)	24 390	24 851	km²
Permanent grass	1737.86	1878.79	km²
Perennial crops3)	1956.44	2506.14	km²
Annual use of organic N from livestock manure4)	270	228	thousand tons
Annual use of organic N from other sources than livestock manure5)	2,4	2,56)	thousand tons
Annual use of N from fertilizer (mineral N)	226	195	thousand tons
Number of farms	53001	47326	
Number of farms with livestock	36398	31158	
Cattle	1,84	1,57	million heads
Pigs	12,37	13,46	million heads
Poultry	20,50	17,10	million heads
Other (horse, sheep and goat)	0,18	0,21	million heads
Other (mink, fox, chinchilla)	2,28	2,59	million heads

1) Without territories which are not part of the European Union (Greenland and the Faroe Islands)
2) Not all permanent pastures and set aside land receives manure
3) Does not include data for Christmas trees
4)This figure refers to Nitrogen in livestock manure (excreted Nitrogen minus losses in housing and storages)
5)This figure refers to all other forms of organic nitrogen applied to soil

6) Average of 2004 and 2005

Sources: Statistics Denmark, the Danish Plant Directorate, NERI (Status rapport on APAE)

6.2 Nitrogen discharges to the environment

The agricultural contribution of nitrogen discharges into the environment as shown in table 15 is estimated using the average of three different model calculations. Data for the previous period is from the final evaluation of Action Plan for the Aquatic Environment (APAE) II and data for the 4th period is based on the midterm evaluation of APAE III in 2008.

It should be noted that about 10-15% of agricultural contribution of nitrogen discharges could be considered as the natural background contribution. The figures do not include contributions from atmospheric deposition and scattered dwellings. Furthermore, processes such as retention in rivers and lakes, and loss of nitrogen in delivery pathways are not taken into consideration.

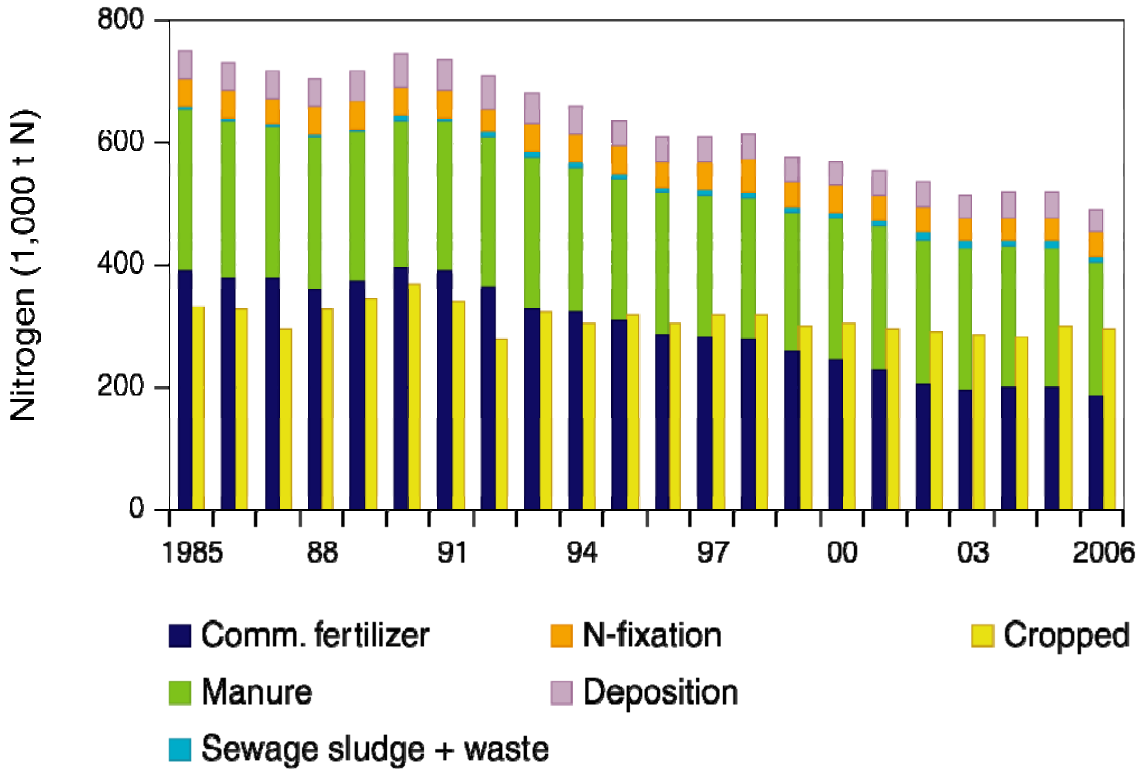
Table 15: Nitrogen discharges into the natural environment

Sources	2nd period (1996-1999)		3rd period (2000-2003)		4th period (2004-2007)	
Tons N	1996	1999	2000	2003	2004	2007
Agricultural contribution	219 000	192 000	179 000	162 000	162 000	157.000
Urban wastewater	6 386	5 134	4 654	4 528	4027	3623
Industrial wastewater	2 582	804	897	752	500	500

Table 16: Development from 2003 to 2007 in fertilizer consumption, the year refers to the harvest year.

Consumption of fertilizer	2003	2004	2005	2006	2007
Nitrogen	1000 tons N	1000 tons N	1000 tons N	1000 tons N	1000 tons N
Mineral fertilizer	196	202	201	187	190
Animal manure	232	230	227	219	237
Total	428	432	428	404	427
Phosphor	**1000 tons P**	**1000 tons P**	**1000 tons P**	**1000 tons P**	**1000 tons P**
Mineral fertilizer	13,6	14,5	14,6	13,0	13,4
Animal manure	51,5	49,3	46,8	44,3	45,9
Total	65,1	63,8	61,4	57,3	59,3

Figure 4: Danish field balances for nitrogen



6.3 Measurements of nitrate in water leaving the root zone (by Ruth Grant)

In five of the six Agricultural Monitoring Catchments water samples are collected regularly at 32 sites. The samples represent the root zone water (1 m depth – 30 samples per year) and the upper groundwater (1.5–5 m depth – 6 samples per year). The measured concentrations are shown as annual average values for loamy and sandy soils, respectively, for the period 1990/91-2005/06.

Generally, measured data for nitrate leaching from the root zone cannot be used directly for estimating the effect of a single variable because of the variability between monitoring fields. However, the data are used for development and testing of the nitrate leaching model, N-LES3. This model is then used for calculating the leaching from all the fields in the catchment based on the agricultural practises and for scenario analyses. The measurements are also used for statistical trend analysis as shown below.

6.3.1 General trend for nitrate concentrations in water leaving the root zone

There is a high annual variation in measured concentrations due to variations in rainfall and temperature. Therefore, a long time series and a large number of measuring points are needed to detect any statistically significant trend. Such data series are now available from the Danish Monitoring Programme. A statistical trend analysis showed that the nitrate concentrations in water leaving the root zone with 95% probability have decreased with 1.7

and 4.3 mg NO_3 l^{-1} per year for loamy and sandy soils, respectively, during the period 1990/91-2005/06.

In 2006 the annual flow weighted concentrations on sandy soils were higher than in the previous years. This may be caused by the low percolation in 2006 (36-62% lower than the average percolation during the monitoring period) resulting in less dilution of the root zone water. This has also resulted in a less steep trendline than presented in 2005.

The trend analysis showed a decrease in nitrate concentrations of about 29% (11-44%) and 45% (32-59%) for loamy and sandy soils, respectively, during the period 1990/91-2005/06. The trend lines of figure 2 show that the nitrate concentrations, when corrected for annual variations, have decreased to about 63 and 80 mg NO_3 l^{-1} for loamy and sandy soils, respectively.

In the upper ground water (1.5-5.0 m), nitrate concentrations are lower than in the root zone water, indicating that nitrate reduction and denitrification take place in the uppermost layer of the soils. The variations in groundwater concentrations between the years follow the same pattern as for root zone water but with a time lag of about one year. In 2006 the upper groundwater concentrations were 22 and 45 mg NO_3 l^{-1} for the loamy and sandy sites, respectively.

The general conclusion to be drawn from the Agricultural Catchment Monitoring Programme is that:

- Nitrate in soil water (1.0 m below soil surface) have decreased steadily since the beginning of the 1990s, and is now approaching the limit of 50 mg nitrate l^{-1}.
- Nitrate in the upper groundwater (1.5-5.0 m below soil surface) is reduced to a level below the limit of 50 mg nitrate l^{-1}.

6.4 Code of good practice

Pursuant to Article 4(1) of the Nitrates Directive Member States shall:

- Establish code or codes of good agricultural practice to be implemented by the farmers on a voluntary basis and containing provisions covering at least the items mentioned in Annex II, A of the Directive.
- Set up where necessary a programme, including the provision of training and information of the farmers, promoting the application of the codes.

Pursuant to Article 5(1) and (4) of the Nitrates Directive Member States shall:
Establish action programmes in respect of designated vulnerable zones, and the action programmes shall consist of the following mandatory measures:

- The measures in Annex III.
- Those measures which the Member States have prescribed in the code(s) of good agricultural practice established in accordance with Article 4, except those which have been superseded by the measures in Annex III.

The code of good agricultural practice, according to Article 4 of the Directive, is in Denmark a part of the action programme for the whole national territory, in accordance with Article 5, and subsequently implemented as mandatory measures. It is implemented through a sequence of national action plans, the Action Plans for the Aquatic Environment.

As Denmark has designated the whole national territory as a vulnerable zone, the code of good agricultural practice apply to the whole territory, according to Article 5.

It should be noted that the Danish code of good agricultural practice pursuant to Article 4 of the Directive, including detailed references to Statutory Orders implementing the code, was formally submitted to the Commission on December 17, 1993.

The Action Plans for the Aquatic Environment (APAEs) encompass comprehensive regulations regarding the aquatic environment and have been the key tools in reducing the load of Nitrogen from diffuse pollution on the environment. They precede the implementation of the Nitrates Directive, as the first plan was adopted in 1987. For each APAE a number of strict goals are set for the reduction of nitrogen and phosphorous discharges.

The APAEs are described in detail under chapter 5 on principal measures in the Action Programme. However, a number of elements included in the APAEs are described below, as they are a part of the Code of Good Practise.

There have been several revisions of the environmental regulation through the APAEs since notification of the EU Commission on 17 December 1993. The regulation has however followed the same framework as the 1993 code of good agricultural practice. Table 5.3 shows the number and date of notified Acts and Statutory Orders implementing the Danish code of good agricultural practice and dates of revisions.

6.5 Implementation of the code of good agricultural practice

The Danish code of good agricultural practice pursuant to the Nitrates Directive consists of the measures listed in Annex II and III of the Directive.

Table 17: Measures pursuant to the Nitrates Directive concerning good agricultural practice and the provisions in Danish legislation implementing the measures.

Nitrates Directive (91/676/EEC)	**National legislation**
Annex II, A, 1)	Article 25 of Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. No. 1695 19.december 2006
Annex II, A, 2)	Article 26 (2) of Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. No. 1695 19.december
Annex II, A, 3)	Articles 25 and 26 of Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. No. 1695 19.december 2006
Annex II, A, 4)	Article 69 (1) of Statutory order on Water sources, no. 789 of June 21, 2007
Annex II, A, 5)	Articles 6 to 22 of Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. No. 1695 19.december 2006
Annex II, A, 6)	Article 26 (1) of Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. No. 1695 19.december 2006. And Article 21 of Consolidated Act no. 757 of 29 June 2006 on Farms' use of Manure and on Plant cover.
Annex II, B, 7)	Articles 6 and 18 and 21-22 of Consolidated Act no. 757 of 29 June 2006 on Farms' use of Manure and on Plant cover. And Articles 7 and 26 of Statutory Order no. 975 of 25 September 2006 on Farms' use of Manure and on Plant cover.
Annex II, B, 8)	Article 23 (1) of Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. No. 1695 19.december 2006 Catch crops:

	Article 18 of Consolidated Act no. 757 of 29 June 2006 on Farms' use of Manure and on Plant cover. And Article 26 of Statutory Order no. 975 of 25 September 2006 on Farms' use of Manure and on Plant cover.
Annex II, B, 9)	Articles 21 to 23 of Consolidated Act no. 757 of 29 June 2006 on Farms' use of Manure and on Plant cover And Articles 27 to 28 of Statutory Order no. 975 of 25 September 2006 on Farms' use of Manure and on Plant cover.
Annex II, B, 10)	Measures concerning irrigation are superseded by the measures in Annex III, 1. 3
Annex III, 1.1	Article 25 of Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. No. 1695 19.december 2006
Annex III, 1.2	Articles 6 and 7 of Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. No. 1695 19.december 2006. And Article 17 of Statutory Order no. 975 of 25 September 2006 on Farms' use of Manure and on Plant cover.
Annex III, 1. 3	Consolidated Act no. 757 of 29 June 2006 on Farms' use of Manure and on Plant cover And Statutory Order no. 975 of 25 September 2006 on Farms' use of Manure and on Plant cover. i: a) Articles 5-9. Act 757/2006 Articles 7-12. Statutory 975/2006 ii: a) Article 6 (2). Act 757/2006 b) Article 6 (1). Act 757/2006 Articles 7 (1-3) plus Annex 1 (column 2+3). Statutory 975/2006, c) Articles 10 and 12. Act 757/2006 Articles 14 to 20. Statutory 975/2006 d) Articles 13 and 14. Act 757/2006 Articles 21 and 22. Statutory 975/2006
Annex III, 3	Articles 27 to 30 plus annex of Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. No. 1695 19.december 2006.

The Danish versions of Statutory Order and Act are to be found at www.retsinformation.dk. In the table is referred to the act and statutory in force in 2007.

Table 18: Number and date of notified Acts and Statutory Orders implementing the Danish code of good agricultural practice pursuant to the Nitrates Directive and dates of revisions

	Date of first publication	Dates of main revisions
The Environmental Approval etc. of Livestock Holdings Act (Approval of Livestock Holdings Act)	20. December 2006	
Statutory Order on Professional Livestock, Livestock Manure, Silage etc	15. December 1992	13. July 2006 15. July 2002 10. December 1998 19. December 1994
Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc.	19. December 2006	11. October 2007

	Date of first publication	Dates of main revisions
Statutory Order on permission and authorisation of animal husbandry	19. December 2006	18. June 2007 11. October 2007
Statutory order and Act on Water sources	23. June 2001	18. August 2004 28. May 2003 21. June 2007
Act on Water Supply	8. June 1978	17. January 2007 26. February 1999
Act on Environmental Protection	13. June1973	22. December 2006 25. August 2001 22. September 1998 24. January 1989 8. March 1985 16. December 1982
Statutory Order on Plant Cover, Crop Rotation and Fertilisation Plans as well as Fertiliser Status Accounts in the Agricultural Sector	10. December 1992	22. July 1996 4. February 1994
Act on Farms' use of Manure and on Plant cover. And	1. July 1998	15. May 2006 09. June 2004 25. March 2003 06. June 2002 19. December 2001
Statutory Order on Farms' use of Manure and on Plant cover.	13. August 1993 (Revised annually before the next growing season)	14. March 2008 16. July 2007 25. September 2006 19. July 2005 13. July 2004 15. July 2003 18. July 2002 17. July 2001 4. July 2000 12. July 1999 8. July 1998 15. July 1997 22. July 1996 20. July 1995 12. July 1994
Statutory Order on Nitrogen Prognosis	Statutory Order no. 228 of 29 March 1994 (Annual revision)	11. March 2008 14. March 2007 15. March 2006 17. March 2005 15. March 2004 17. March 2003 18. March 2002 15. March 2001 23. February 2000 22. March 1999 12. March 1998 13. March 1997 25. March 1996 5. April 1995
Statutory Order on financial assistance for environmental management of wetlands	22. September 2005	22. Sept. 2007
Statutory Order on financial assistance for preservation and maintenance of wetlands	14. June 2007	10. March 2008
Statutory Order on financial assistance for set-aside bufferzones	8. June 2007	

6.5.1 Introduced or modified elements

Table 19 presents an overview of the elements introduced as part of the code of good agricultural practice and implemented through the regulation outlined above as a part of the Action Programme I-III (the APAEs).

Table 19: Overview of elements regulating nitrogen use and discharge

Elements introduced or modified as regards:		
1.	periods of spreading;	• No liquid manure from harvest to February 1 or perennial crops to March 1 • Solid manure from harvest to October 20 only on fields with winter crops • Limits to use of Silage effluent between harvest and November 1
2.	spreading on sloping soils;	• No application in a manner which risks run off into lakes and watercourses • No application in a 20 m buffer strip along watercourses, lakes and inlets
3.	soaked, frozen and snow-covered soils;	• No application in a manner which risks run off into lakes and watercourses
4.	proximity of watercourses;	• 2 meter mandatory bufferzones along all watercourses, as well as lakes
5.	effluent storage works;	• Storage restrictions and capacity and quality of manure storage • Distance to water bodies and nature sites • Precautions when handling slurry is tightened
6.	limitation and splitting of nitrogen inputs;	• See also Chapter 5 on the Action Programme • Nitrogen quota for fields and farms, calculated prior to the growth season and reported in annual fertilizer accounts • Nitrogen quota is 10% under the economic optimum • Burning of Manure in approved plants • Fluent manure, separation of dry and wet components to allow burning • Tightening of utilization rates for manure • Increased demands for utilisation of mink and poultry fluent manure • Compulsory correction of calculation of manure production on farms (Type 1) • Tightening of livestock density rules. • Environmental approvals
7.	method of spreading (and uniformity) of chemical fertilizers and manure;	• Manure must be worked into the soil within 6 hours • See also 2 and 3
8.	crop rotation, permanent crop maintenance;	• Crop rotation plan for all fields individually with nitrogen use • Specification for calculation of a nitrogen quota for grass is changed with a change in the number of grazing animals required.
9.	vegetation cover in rainy periods;	• Catch crops
10.	fertilization plans and spreading records;	• Fertilizer and manure accounts • Publication of all Fertilizer accounts
11.	runoff and leaching connected with irrigation;	• Fields with irrigation are allowed a higher nitrogen standard
12.	other preventive measures.	• Demands for use of the high nitrogen standard for wheat changed

Re. 1 Periods of spreading

Provisions of periods of spreading livestock manure are implemented in Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. no.1695, 2006.

Liquid manure shall not be applied to the soil from harvest to February 1. However, from harvest to October 1 liquid manure can be applied to already establish wintering grassland and fields, which will be planted with winter rape in the winter to come. Exempted is application from harvest until 15 October on areas of seed grass for which a contract on delivery of seeds in the coming season has been entered with a seed-growing company.

Solid manure shall only be applied from harvest till October 20 on fields that are subsequently planted with winter crops.

Silage effluent shall not be applied to the soil from harvest until November 1, unless it is applied to areas covered with vegetation or areas subsequently planted with winter crops.

From September 1 to March 1, liquid manure may not be applied to perennial crops, which are not harvested every year.

Liquid manure and solid manure applied to areas without vegetation shall be incorporated into the soil within 6 hours after application.

Re. 2 and 3. Spreading on sloping, soaked, frozen and snow-covered soils

A general provision on prohibition of application of livestock manure and the like in such a way that risk of run of into lakes and watercourses are caused is implemented in Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. no.1695, 2006.

Livestock manure, silage effluent and waste water from cleaning livestock housing, equipment and the like shall not be applied in such a way and on such land that livestock manure, silage effluent or waste water are likely to run onto lakes and watercourses, including drains, during thaw or heavy rain.

The risk of run of is among other things dependent on proximity to watercourses, sloping of the field, nature of the soil surface, water-saturation and the amount of fertiliser application. For example could application of livestock manure on a thin layer of ice or snow - depending on the circumstances - be a violation of the regulation.

Areas where livestock manure under normal conditions may not or can not be applied, e.g. sloping ground or hilly areas, may not be included in calculations of the available area for application of livestock manure when complying with the livestock density requirements described below.

In 2008 provisions against the spreading of manure on slopes is prepared in the revised Statutory Order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. no.1695, 2006, where it is noted that “liquid manure shall not be applied on slopes with a gradient of more than 6° against watercourses, lakes and inlets in a buffer strip on 20 m”

Re. 4. Proximity of watercourses

Provision on proximity of watercourses is implemented in Statutory order on Water sources, no. 789 of June 21, 2007. The Consolidated Act on watercourses and the 2-meter wide cultivation-free strips was put into force in 1992.

Cultivation, soil management, planting, ground alteration, placing of fence and construction of buildings within the rural zone must not be made in a 2-meter wide cultivation-free strip along natural or in regional planning high objective watercourses and lakes. The provision applies however not for isolated lakes under 100 m^2. The competent authority can when planning the maintenance of public watercourses carry out planting along watercourses to limit water weeds like the bank owners can be ordered to maintain shadowing vegetation.

Re. 5. Effluent storage works

Provisions on effluent storage works are implemented in Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. no.1695, 2006.

Animal housing and similar enclosures for animals shall be designed in such a way that ground water and surface water is not polluted. They shall have floors made of a material, which resists humidity. The floors shall be constructed to resist the effect of animals and the tools used at the premises. A system shall be established for appropriate drainage and collection of all liquid wastes.

Drain from animal housing, manure yards and silage stocks, and from cesspools and pumps wells shall be placed in impermeable closed pipes. Drain and connected wells shall be installed by authorised sewer contractors in accordance with prescriptions for drains laid down in the building regulations. Drains which will be subjected to pump pressure shall be constructed to resist such pump-pressure impacts. Drains from animal housing and the like shall lead to containers for liquid animal manure.

In 2008 precautions in handling slurry was tightened to avoid discharge of slurry, among others a timer must be installed at the slurry pump to stop it from possible overload.

Wastewater from washing of products used in connection with the livestock production, milking machines, fodder utensils etc., may be led to a container for liquid livestock manure or to a separate container.

For properties with livestock production or storage of livestock manure, the *capacity of manure storage* facilities must be sufficient to ensure that land application may take place in accordance with the provisions on application of livestock manure an silage effluent, and that utilization of the nutrient content fulfils the requirements laid down in the Act on Farms' use of manure and on plant cover. However, the storage capacity must correspond to no less than six months' supply. Sufficient storage capacity will normally correspond to at least nine months' supply; this figure is, however, normally at least seven months' supply for cattle farms in which at least 2/3 of the livestock units are cattle and where the animals are outdoors in the summer grazing season.

Supply is calculated as the manure quantity produced in question on the basis of animals in stable, together with quantities otherwise supplied to the facility, for instance washing water and silage effluent. When carrying out calculation manure stored in accordance in the field under specific conditions, as descried below, may be deducted. Where special conditions prevail, for instance beef cattle grazing outdoor most of the year, the storage capacity must as a minimum correspond to the period where the cattle is stalled.

The capacity of facilities used solely for storage of silage effluent and wastewater must be sufficient to secure environmentally sound land application.

The storage capacity requirement can be fulfilled by means of written agreements on supply of livestock manure for storage at another property, or delivery to common biogas plants, manure treatment facilities or storage facilities (manure contracts). Such agreements must be valid for at least five years. The municipal council may lay down detailed rules on the wording of agreements.

Solid manure must be stored in manure yards designed in accordance with the description below, or in closed containers placed in paved areas which are impermeable to water as specified below, and with drain to manure effluent taken or the like.

Manure yards shall be designed so that surface water from surrounding areas and roofs cannot run into the manure yard area. Manure effluent shall be drained off through outlet pipes designed for that purpose. Drains from manure yards and silage stocks shall be arranged so that liquid may drain off from the lowest point(s), that clogging is avoided, and that the discharge capacity per hour corresponds at least to 100 mm rain. The drain shall lead to a container that meets the requirements.

The sidewall of the manure yard shall as a minimum consist of a 1 m high wall or a border layer at least 2 m broad. The manure yard floor and bordering layer and the surface cover at the entrance to the manure yard shall be inclined at least 3 per sent towards the outlet. The municipal council can permit other forms of bordering resulting in a similar safe collection of manure effluent. Manure yard floors and sidewalls shall be made of material, which resists humidity and be constructed so that they can resist the effects both of vehicles and tools used for filling and emptying, and of the manure stored in the manure yard.

Compost with a dry matter content of 30% or more can, however, be stored in the field, provided the compost stored are covered by compost canvas or an air-tight material. The stocks shall comply with the distance requirements for location of animal housing, manure yards etc., and may not present risks of pollution of groundwater or surface water.

For farm holdings located in villages, the local council may in special cases permit storage of solid manure in field stacks, provided that proof is given that manure cannot be stored near the animal housing facilities in an environmentally sound manner. A permit shall be accompanied with conditional terms for location, design and operation of the field stack ensuring that risks of pollution of groundwater and preventing discharge into watercourses (including drains), lakes, and the sea. Field stacks shall comply with the distance requirements.

Silage which release liquid, including silage of beet leaves, beet waste and untended grass, shall be stored in silage sites or silage tanks. Silage sites must comply with requirements corresponding to the provisions applying to manure yards with border layer. The requirements also apply for silage sites for storage of silage, which does not release liquid. The floor of silage tanks shall be made of a material, which resists humidity. They must furthermore be constructed of durable materials and be able to resists the impacts of the tank content and of filling and emptying. They must be designed so that silage effluent con only drain off through outlets designed for this purpose.

Containers for liquid manure, silage effluent and wastewater shall be made of durable materials and be able to resist humidity. The containers shall be dimensioned in accordance with the contents load and be able to resist the impact of possible forces affecting walls and floor, including effects of stirring, covering, and emptying.

Where the municipal council detects a likely risk of a container cracking, bursting or similar, the local council shall order that remedial action be taken or possibly ban operation of the facility. And where one of the containers specified above is located in a manner which means that disruptions of operation or accidents can entail serious damage to water abstraction plants watercourses, and lakes, the municipal council may order that special measures be taken.

Re. 6. Limitation and splitting of nitrogen inputs

The nitrogen crop demands are calculated every year and are 10 % under the economic optimum the amount of nitrogen applied in 2003/04 (cf. APAE III). The nitrogen demand is calculated on the background of previous crop, soil type and irrigation, demand for using the grass quota is a minimum of 1.9 LU/ha for full quota. The crop nitrogen quota is corrected every year based on the precipitation during winter, soil samples measuring available N and temperature. (Act 757/2006 and Statutory 975/2006).

In 2006 it became allowed to burn manure and processed manure in approved plants and withdraw the nitrogen from the fertilizer account. This also includes processed manure (dry matter) and for unprocessed manure with a major part of dry matter

In 2007 a new Environmental Approval Act for Livestock Holdings was put into force, an approval system that is covering all livestock holding for more than 75 LU. With this system a level of allowable nitrate leaching was made to all the country's vulnerable watercourses depending on the denitrification capacity.

In those Nitrate vulnerable areas with low denitrification capacity the demands for the Livestock holdings when applying for approval can be tighten more than the general harmony rules. Meaning that the farmer at some areas only is allowed to apply e.g. 0.7 LU/ha.

Table 20. Reduced number of LU/ha when in Nitrate vulnerable areas with low denitrification capacity

Denitrification capacity, pct.	Very vulnerable recipient	Vulnerable recipient	Robuste recipient
0 – 50	50 %	85 %	Harmony rules
51 – 75	65 %	Harmony rules	Harmony rules
76 – 100	Harmony rules	Harmony rules	Harmony rules

Livestock density requirements (harmony rules).

The harmony rules have been revised several times since notification of the provisions to the EU Commission. The Danish provisions on applied manure to the land are calculated on the basis of animal numbers, cf. Annex III, 3, and the provisions are differentiated in tree categories depending on the type of husbandry: pig, cattle and other types of husbandry.

Provision on the amount of livestock manure applied to the land each year; including the animals themselves are implemented in Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. no.1695, 2006.

The harmony rules has been tightened for poultry and fur: 1.7 LU per hectare per year on till 1 August 2004, hereafter 1.4 LU per hectare per year and the efficiency of slurry is tighten up for fur and poultry (from 65% to 70%).

At farm holdings, the quantity of livestock manure applied must not exceed an amount corresponding to 1.4 livestock units per hectare per planning period (1 August-31 July), where 1 LU = 100 kg N ex storage.

At farm holdings with cattle, sheep, or goats, however, livestock manure produced on these farms may be applied in quantities corresponding to 1.7 livestock units per hectare per planning period.

Harmony rules	Demand (from 2004)
All agricultural holdings	1.4 LU per hectare per year
Cattle, sheep, and goats	1.7 LU per hectare per year.
At farm holdings where at least 2/3 of the livestock are cattle	2.3 LU per hectare per year.

The quantities of livestock manure applied to land are calculated on the basis of the quantities of produced livestock manure at the farm adjusted for changes in the manure stored at the beginning and end of the relevant planning period (1 August to 31 July), cf. Act on Farms' use of Manure and on Plant Cover, and the quantities supplied and received during the planning period. Manure dropped by grazing animals shall be regarded as applied if dropped in areas which can be included in calculations as harmony areas. Corrections for storage fluctuations shall be calculated in the basis of 100 kg N per livestock unit.

Calculation of the areas to be available to the farmer for application of livestock manure has since the provision was introduced been deducted areas without fertilisation requirements and areas to which livestock manure cannot be applied under normal circumstances. A calculation of harmony areas shall be made for each planning period. The following areas shall be discounted when making this calculation: areas with crops for which no fertilisation standard exists, and areas where livestock manure may not be used or cannot be applied under normal circumstances. The nutrients in livestock manure, silage effluent, and wastewater shall only be applied to crops with nitrogen standards or a guide standard for phosphorous and potassium according to Act on Farms' use of Manure and on Plant Cover and the Statutory Orders issued pursuant to this Act.

If a livestock holding has quantities of livestock manure, including manure received from other holdings, greater than the quantities which can lawfully be applied to the land held by the livestock holding written agreements shall ensure that excess livestock manure is received by:

- a registered enterprise, cf. Act on Farms' use of Manure and on Plant Cover,

- a biogas plant,
- a common plant,
- a processing plant,
- as processed livestock manure or
- as burning of manure in approved plants

Processed livestock manure declared in accordance with the Act on Farms' use of Manure and on Plant Cover and may be supplied if reported in accordance with the same Act. Supply of manure from biogas plants, common plants, processing plant shall require a written agreement.

The number of livestock units supplied shall be calculated on the basis of the quantities of nitrogen supplied, cf. Act on Farms' use of Manure and on Plant Cover, so that the balance between livestock units and nitrogen contents correspond to the relevant manure production.

The farm owner shall be able to document compliance with the harmony rules (livestock density requirements).

Documentation in the form of an agricultural tenancy agreement shall include information on the size of the area; the names, addresses, and VAT nos. of the parties to the agreement; the start date, end date, or term of notice of the agreement's period of validity; and the date on which the agreement was entered into.

Documentation in the form of an agreement shall include information as specified in Act on Farms' use of Manure and on Plant Cover in force at the time in question.

Re. 7 Methods of spreading (and uniformity) of chemical fertilisers and manure

Provision on methods of spreading livestock manure is implemented in Statutory order on Livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc.

Liquid manure and solid manure applied to areas without vegetation shall be incorporated into the soil without delay, and within 6 hours after application. If for unforeseeable reasons this cannot be done, the liquid and/or solid manure shall be worked into the soil as soon as possible.

Re. 8: Crop rotation and permanent crop maintenance

Agricultural holdings shall for each growth season draw up crop rotation plan and fertilisation plan on cultivated areas and set-aside areas as specified in Act on Farms' use of Manure and on Plant Cover in force at the time in question .

The crop rotation plan should for each field describes the composition of the planned composition of crops and plant cover. The crop rotation plan and fertilisation plan shall be drawn up to the 21 April in the harvest year where the farmer submit application for support under the single payment scheme within the common agricultural policy. For derogation farms the crop rotation plan and fertilisation plan shall be available for the authorities the 1 of September.

Adjustments of the plan due to change of crop, correction in accordance to the nitrogen prognosis, or raise of the farm nitrogen quota in accordance with dispensation by the Minister of Food, Agriculture and Fisheries as a result of drifting or leaching of fertiliser because of extreme weather conditions, should be noted in the plan prior to action according to the adjustment. Other adjustments should be noted in the plan 7 days after action, at the latest. The crop rotation plan and adjustments should be dated.

Re. 9. Vegetation cover in rainy periods

In Statutory order on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. no. 1695, 2006 is stated to ensure vegetation cover when applying nitrogen: The nutrients in livestock manure, silage effluent and wastewater shall only be applied to crops with nitrogen standards or a guiding standard for phosphorus and potassium according to the Act on Farms' use of Manure and on Plant Cover.

Provision on catch crops is implemented in the Act on Farms' use of Manure and on Plant Cover no.757, 2006. In 2004/05 the general rule that an area corresponding to 65% of an agricultural holding's arable land should be established with a plant cover was brought to an end. And the rules concerning catch crops were in 2005/06 tightened, where farmers applying below 0.8 LU/ha must establish catch crops at 6% of the owned and leased area and the N-quota of the following crop will be reduced with 17 kg N/hectare. And the farmers applying more than 0.8 LU/ha must establish catch crops at 10 % of the owned and leased area and the N-quota of the following crop will be reduced with 25 kg N/hectare. Winter green fields may, if they constitute 100% of the cultivated area alone or together with catch crops, replace the requirement for catch crops. The percentage of the area must be calculated from "the catch crop basis area" which includes set-aside land and areas with annual crops with no nitrogen assimilation in the autumn, which does not include grassland. Only farms with more than 10 hectares have an obligation to sow catch crops.

The amount of applied manure (> or < 0.8 LU/ha) is calculated according to Statutory order on Livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc. However in this calculation other organic fertilisers than livestock manure is included where 100 kg N is equal to 1 LU. Calculations are done on the basis of the fertilisation status account. Applied urea is not included in calculating the catch crop provision. This also goes for urea as part of mixture products.

Catch crops are defined as a specific high nitrogen assimilation that shall be undersown the harvest crop. Catch crops must not be ploughed up, defoliated or in other ways destroyed prior to 20 October, and furthermore a spring-grown crop must succeed the catch crop. The purpose of establishing catch crops is to obtain an effective assimilation of nitrogen in the autumn. The fertiliser standard of catch crops is 0 kg N per hectare.

Catch crops
Undersown grass, cruciferous and chicory
Grain cereals and grass sown prior or after harvest, but no later than 1 August
Cruciferous sown prior or after harvest, but no later than 20 August
Grass for seed

Transfer of excess areas with catch crops from a maximum of four immediately previous planning periods can be included in compliance with the area to be established with catch crops. The area established with catch crop in each of the four immediately previous planning periods should be complied with.

Re. 10 Fertilization plans and spreading records

The fertilisation plan should be drawn up prior to 21 April in the harvest year:
1) the agricultural holding's planned total nitrogen quota, including the nitrogen quota for each individual field as well as the individual field's demand for phosphorous;
2) the planned consumption of nitrogen in livestock manure and other organic fertilisers than livestock manure at the holding;
3) the planned consumption of mineral fertiliser at the holding.

Adjustments of the plan because of change of crop, correction in accordance to the nitrogen prognosis, or raise of the farm nitrogen quota in accordance with dispensation by the Minister of Food, Agriculture and Fisheries as a result of drifting or leaching of nitrogen due to extreme weather conditions, should be noted in the plan prior to action according to the adjustment. Other adjustments should be noted in the plan 7 days after action, at the latest. The fertilisation plan and adjustments should be dated.

The rules on the agricultural sector's consumption of fertilisers have through a period of years been very well incorporated in the agricultural sector's management of fertilisers. Agricultural holdings, which delivers livestock manure, and agricultural holdings which make the most of the farm nitrogen quota have established routines to calculate nitrogen content of livestock manure and to avoid situations where deliverance of livestock manure is not possible but also to calculate the amount of mineral fertiliser to be applied within the farm nitrogen quota. It is the presumption that planning of production of livestock manure will be maintained despite the fact it is not compulsory to draw up fertiliser plans and spreading records.

Fertilisation status account

A register for farmers who are entitled to purchase artificial fertilisers without tax is established and administered by the Danish Plant Directorate. Registration is compulsory for livestock farms with more than a total of 10 LU or with more than 1 LU/ha and farms that receive more than 25 tonnes of manure on a yearly basis. The term manure in this text includes al kinds of manure, slurry, deep-litter etc. if not specified otherwise. Other farmers can register voluntarily. Almost all Danish farmers are registered. Linked to the registration are a number of rules regarding the use of nitrogen fertilisers, which the individual farmer must obey.

The Danish Plant Directorate publish every year on the internet an instruction for the farmers, which include standard permissible use of nitrogen for all individual crops, the standard nitrogen contents in livestock manure from different types of livestock and the required minimum utilisation rate. On the basis of this information, the farmer is required to calculate the maximum permissible amount of nitrogen that can be used on the farm - also termed the farm nitrogen quota – and the quantity of nitrogen in manure and slurry that has to be utilised (compulsory utilisation rates). The farm nitrogen quota and the content of nitrogen in livestock manure shall be calculated in accordance with stipulated standards.

By the 31st of March, after the growth season has passed, an annual fertilisation account containing key-figures on the use of nitrogen and the farm nitrogen quota is prepared by the farmer and submits to the Danish Plant Directorate for registration and control. The fertilisation status account covers a year, which is defined as the period from 1 August to the next 31 July.

In 2006 the Danish regulations make it compulsory for farmers to submit the fertiliser account integrated with the Central Husbandry Register (CHR), which is the central database, used for registration of holdings and animals. The integration with the CHR has led to a very dependable registration of animal units and the use of manure in the fertiliser accounts, due to the fact that information on animals on the farm is printed in the fertiliser accounts in advance.

Furthermore, the Danish Plant Directorate has taken action to co-ordinate the Fertiliser Register with the Central Husbandry Register on pigs, in order to ensure, that all pig holdings compulsory to make fertiliser accounts, are indeed also submitting to it.

All fertilizer account for 2006 and 2007 is as well publish at the internet for the public, where it is possible to enter an address and get information on the consumption of fertilizer at a specific farm or as a total overview of the consumption of fertilizer in Denmark.

The fertilisation account shall include:

1) composition of crops and farm nitrogen quota;
2) use of nitrogen fertiliser expressed in livestock manure, mineral fertilisers as well as other organic fertilisers;
3) the compulsory utilisation on nitrogen content in livestock manure;
4) storage of livestock manure, mineral fertiliser and other organic fertilisers from one year to the next;
5) information on livestock manure contracts;
6) information on livestock density
7) area with catch crops
8) information about using the derogation

The nitrogen standards for crops and the standards of nitrogen content in livestock manure is renewed annually and the required minimum utilisation rate of livestock manure have been tightened several times according to APEAs.

Elements concerning the calculation of the farm nitrogen quota

The yearly amount of nitrogen permitted to be used on a farm is restricted by the farm nitrogen quota. On the basis of the composition and distribution of crops and the crop-specific nitrogen standards each farmer calculates the nitrogen quota for his farm. Any surplus application of nitrogen fertilisers compared to the quota is regarded as a violation of the rules.

The nitrogen standard quota depends predominantly on the specific crop, but also on the type of soil in which it is grown, the pre-crop, precipitation, and irrigation. Nitrogen standards are expressed as an amount of nitrogen measured in kilograms per hectare. The nitrogen crop demands are calculated every year and are 10 % under the economic optimum the amount of nitrogen applied in 2003/04.

As different amounts of nitrogen residues remain after the harvest of a crop, this is taken into account when the standard of the following crop is stipulated. Consequently the individual standards are differentiated with regard to the residual effect of the pre-crop, e.g. the lowest standard applies when winter wheat succeeds clover and Lucerne; the highest standard is when winter wheat succeeds cereals or set aside areas.

In Denmark soil types differ significantly. In general, soils in the western part of the country are characterised as sandy loams whereas in the eastern and southern parts fertile humus and clay soils are more predominant. Even at farm level the soils can also be very heterogeneous. Because of varying abilities to retain nutrients the different soil types are divided into four categories with different nitrogen standards for the same crop.

If the farmer has an opportunity to irrigate, this is taken into consideration when the specific norm is set. In general the standard is increased when irrigation is possible.

Finally the farm nitrogen quota is adjusted every year according to meteorological data. In years with much precipitation the quota is increased because leaching of nitrogen is closely linked to the precipitation. This means that in some years the adjustment will be negative and in other years positive. The adjustments are stipulated in Statutory Order on Nitrogen Prognosis.

The nitrogen standard set for any crop is calculated on the basis of an expected normal yield (standard yield). If a farmer expects higher yields than the standard, he is given a possibility to increase the nitrogen standard by a fixed factor given in the table showing the nitrogen standards. To do so the farmer has to show documentation for higher yield in precious years. Such documentation should be in form of invoices for sale of the crop and fertiliser plans showing the acreage's cultivated with the crop in question. A higher expected yield is calculated as an average over the last 5 years yield for that specific crop.

Elements concerning livestock animal manure

A large percentage of the nitrogen contents of applied livestock manure must be included in the overall use of nitrogen on the farm. As part of the nitrogen, contained in the manure applied to the fields, is not released during the first year following the application, some of this will be made available for plant utilisation during the following years. This residual effect of manure applied during previous years is also part of the calculation of the overall use of nitrogen on the farm and is included in utility rate. The compulsory minimum utilisation rate of livestock manure stipulated in Statutory Order on Farms' use of Manure and on Plant Cover is shown in table 6.

Table 21: Compulsory minimum utilisation rate of livestock manure

Type of livestock manure	Minimum utilisation rate
Pig slurry	75 %
Cattle slurry	70 %
Mink and poultry slurry	70 %
Liquid manure	65 %
Deep litter	45 %
Other kinds of livestock manure	65 %

In general the nitrogen production from different species of livestock is calculated on basis of standards with respect to the housing system. An increased utilisation of fodder compared to the standard utilisation or standard fodder can lead to decrease in the contents of nitrogen in the manure. Two types of corrections are possible. Type 1 is used to correct productivity e.g. milk production. Type 2 is used if both data on productivity and composition of fodder are available. From 2005 it became compulsory to correct the standard content of nitrogen in type 2.

Table 22: Required minimum utilisation rate of other organic fertilisers

Type of organic fertiliser	Minimum utilisation rate
Sludge from urban areas	45 %
Composted household waste	20 %
Potato juice	50 %
Juice from production of grass pellets	40 %
Urea	100 %
Waste from gardens and parks	0 %
Other types of organic manure	40 %

6.5.2 Training and information of the farmers

In Denmark the farmers' training is a 3½ years long education with a mix of practical training and schooling. The farmers' training is based on 9-10 years compulsory basic education. The education is split up in 3 modules where the student must attend the school in periods from 2-6 month and in between get practical training at different farms.

The student has to complete courses in for example ecology and nature-preservation, where knowledge about the cycle in nature and the possibility for establishment of small biotopes is lectured. During the training to farmer the student also has to acquire a pesticide spraying certificate, according to the Danish Ministry of Environment. It is not allowed a person to purchase a farm of more than 30 hectares or raise loans to purchase a farm at favourable interest rates, if he is not a skilled farmer.

During the training to farmer the students learn about good agricultural practice. There are also courses after the training. However, this is not so widespread because the topics of after-training courses are included in the basic training of the farmer.

Table 23: Practical training and schooling of farmers

Module				Aim with this module
Module 1 a and 1 b	2-month schooling	12-month practical training	5-month schooling	The student is introduced to basic skills of farming e.g. safety to himself and the environment.
Module 2	12-month practical training	6-month schooling	6-month schooling	After satisfactory completion of the education the student is now a skilled farmer.

Good agricultural practice reflects as a minimum the environmental legislation compulsory to Danish agriculture. This means complying with the common Danish rules on environment, hygiene and animal welfare, laid down in as in legislation implementing the action programme under the Nitrates Directive well as in other legislation.

6.5.3 Voluntary measures

According to Article 5(5) of the Nitrates Directive the Danish action programme includes voluntary measures.

The measures agreed upon in APAE II, 1998 covers four different schemes of voluntary measures:
- Reestablishment of wetland areas
- Afforestation
- Environmental Sensitive Areas (ESA)
- Forestry

The total area covered by the voluntary measures and the area under the four different schemes are shown in table 1. The prognosis for the final evaluation of APAE II was that a total of around 154,000 hectares were covered by voluntary measures.

Table 24: Areas on which farmers were estimated to enter agreements on voluntary measures (Action Plan II, Midterm evaluation), areas on which farmers have entered agreements on voluntary measures (Final evaluation) and future goals for agreements on voluntary measures

Measure (Hectares)	**Agreement** **Action Plan II 1998-2003**	**Adjustments** **Midterm evaluation 2001-2003**	**Final evaluation** **Action Plan II 2003** (prognosis)	**Agreement** **Action Plan III 2005-2009**
Wetlands	16,000	8,000-12,500	2,900	4,000
ESA-areas[1]	88,000	30,000	25,500	50,000 + 4,000[2]
Forestry	20,000	18,000	14,200	11,400
Organic farming	170,000	156,000	111,500	No goal[3]
Total	300,000	220,000	154,000	

1: Only schemes with effect on nitrogen leaching.
2: The 50.000 ha are from 10m wide buffer zones along watercourses and lakes, while the 4,000 ha are other measures in ESA-areas for example establishment of wetlands. The 50.000 ha buffer zones has primarily an effect on the leaching of phosphorus as it is a relocation of set-aside-land.
3: There is no area-related goal in Action Plan III concerning organic farming, but organic farming will receive 27 Million Euro in support in the period 2005-2009. 1 Euro = 7,45 DKK

At the end of 2003, the wetland-areas was 2,700 hectares and projects of further 2,100 hectares have been approved for financial support and will be established in near future, the ESA were 22,000 hectares, the afforestation-area was 14,200 hectares and 103,700 hectares were converted from conventional agriculture to organic agriculture.

Table 25: Overview of voluntary measures in APAEIII

	2004-2009			**2010-2015**		
	Area (ha)	**Reduced N-leaching (tons N)**	**Reduced P-surplus (tons P)**	**Area (ha)**	**Reduced N-leaching (tons N)**	**Reduced P-surplus (tons P)**
Afforestation[1)]	11.400	450		11.400	450	
Wetlands	4.000	1.050				
ESA-areas (grass) and ESA-areas (wetlands) [1)]	4.000	400				
Demand for establishment of voluntary buffer zones	30.000			20.000		

In APAE III further goals were set for achievement of reductions through voluntary measures, as seen in table 25. The measures were evaluated in fall 2008, an outline of the results are presented in chapter 7.

Reestablishment of wetland areas

Reestablishment of wetlands remove nitrate from passing water streams, thereby resulting in reduction of nitrates leaching to the marine environment. Under APEAII app. 2.700 hectares of wetland was established.

This measure is a continuation of the measures taken under APAEII, with a demand for nitrogen removal of kg N/hectare/year. The farmer receives remuneration for costs for reestablishment of wetlands. Some are established with a one-off payment from the Danish Forest and Nature Agency, while others are established with an annual support pr. hectare from the Ministry of Food, Agriculture and Fisheries. For 2004 and 2005, there was only money left on the budget for annual payments as the one-off payment had proved most popular. The economic framework for the two years and establishment of around 4000 hectares wetlands were 160 million DKKR (app. 20 million EURO). In addition the former regions covered 30 % of the costs of the project.

Table 26: Area with re-established wetlands and area approved for reestablishment of wetlands 2002-2007 (data from Danish Forest and Nature Agency)

	Area with wetlands (ha)					
	2002	2003	2004	2005	2006	2007
Re-established wetlands	663	1.881	2.839	3.509	4824	5343
Wetland approved for reestablishment	3.844	3.240	4.638	3.332	3949	3396
Total	**4.507**	**5.121**	**7.477**	**6.841***	**8773**	**8739***

*reduction in total area compared to former year is due to annulment of some approvals of wetlands.

The Danish Forest and Nature Agency has registered 8739 ha approved wetlands at the end of 2006, of which 5343 ha were established.

Under APAE III, there is a further measure for establishment of wetlands under ESA , with a budget from 2004 to 2009 of 375 mio. DKKR. Here the demand for nitrogen removal is 100 kg N/ha/year. The costs for projects are 12.000 DKKR for construction and 51.500 DKKR for running costs (the ESA supplement). Paid over 20 years this results in app. 3.600 DKKR/ha/year.

Table 27: ESA wetlands (Data from Danish Food Industry Agency)

	Area with wetlands * (ha)				
	Old agreement	**New APAEIII agreement**			
	2004	**2005**	**2006**	**2007**	**2005-07**
Re-established wetlands	284	20	38	0	58
Wetland approved for reestablishment		55	544	623	1222
Total	284	75	582	623	1280

*N reduction is presumed to be 265 kg N/hectare for wetlands established in 2004 and 100 kg N/hectare for for wetlands implemented from 2005-07

A future goal of further reestablishment of 4,000 hectares wetland is agreed upon by Action Plan III.

Afforestation

Planting of forest on arable land reduces nitrate leaching, as the leaching from forests is less than from arable land. The estimated goal for APAE II was to plant trees on 20,000 hectares arable land within the period 1998-2003. The estimate was not obtained, as the result for 2003 were a total afforestation area of 14,200 hectare.

In APAEIII the expectation is increased afforestation of 22800 hectares from 2004 to 2015. Sources for afforestation are:

1. Private afforestation with subsidy
2. Public afforestation (the record for local government afforestation is not complete)
3. Private afforestation without subsidy (these numbers are only an estimate)

The average subsidy for approved private afforestation projects were in 2006 33.000 DKKR/hectare (29.000 DKKR/ha for projects with open areas) in areas appointed favourable for afforestaion and 28.000 and 24.000 DKKR for areas not appointed. For public afforestation costs were 40.000 DKKR/ha plus costs of land.

From 2004 to 2007 around 8.100 hectares of afforested land were established.

Environmental Sensitive Areas/ESA-agreements

In addition to wetlands on areas designated as environmental sensitive farming areas, different measures may be taken which has a positive effect on nitrate leaching. The highest reduction in nitrate leaching is expected to result from the following ESA-agreements:

- Reduction of the general nitrogen application level (farm nitrogen quota) to 60% of the quota at farm level,
- Distrait by rye grass in cereal crops,
- Stop for agricultural use of the land,
- Changed drainage.
- Grazing
- Pesticide free buffer zones
- Cultivation without pesticides
- Additional catch crops and cover
- Grassland

Financial support is provided through Statutory Order no. 225 from 1997 and no. 193 from 1999

Table 28: Other ESA agreements than wetlands (2004 to 2007)

	Increase in area (hectare)				Ceased 5-year agreements (hectare)				Net increase	N-leaching reduction	
	2004	2005	2006	2007	2004	2005	2006	2007	2004 -07	Kg N/ha	Tons N
Grazing	-	-	-	13.853					13.853	0	0
Reduction of Nitrogen application quota at farm level	6.735	713	0	-	868	800	869	1.245	3.654	16	58
Changed drainge	0	0	0	-	78	150	957	372	-1.546	48	-74
Pesticide free buffer zones and	10	4	0	-	51	7	13	12	-73	0	0
Cultivation without pesticides				-	388	393	253	301	-1.335	0	0
Additional catch crops and cover	365	472	0	-	1.702	1375	1.603		-3.843	25	-96
Grassland	17.464	13.577	5	-	5.175	15.068	8.324	8.119	-5.639	0	0
Total	24.575	14.766	5	13.853	8.262	17.793	12.019	10.049	4.568		-112

Data from Danish Food Industry Agency

6.5.4 Organic farming

Conversion of conventional farming to organic farming, where use of commercial fertilisers is abandoned, has resulted in an estimated nitrate reduction of 33 kg N per hectare in APAEII. The final evaluation of APAE II showed that a total of 103,700 hectare had been converted from conventional farming to organic farming in the period 1998-2003.

Organic farming is not a direct measure under APAEIII, however it may influence targets as N-leaching increases when organic land area falls, as has been the case between 2003 and 2006. In 2007 a slight increase has been registered. The result is estimated to be an increase in N-leaching of 900 tons.

A number of organic farms receive support as part of schemes for cultivation of land without pesticides.

6.5.5 Buffer zones

Uncultivated bufferzones along watercourses and lakes withholds phosphorous from the catchment area, mainly by protecting the banks from erosion.

In APAEIII it was agreed to establish 30.000 hectares of 10 meters broad uncultivated buffer zones along each side of natural and measured watercourses and lakes before 2009 and additionally 20.000 hectares before 2015. In the agreement it is assumed that these buffer zones are established by voluntary replacement of set-aside, and special ESA subsidies have been established to support the establishment of buffer zones.

7 Principal measures in the action programme

Pursuant to Article 5(1), (4) and (5) of the Nitrates Directive action programmes shall establish action programmes in respect of designated vulnerable zones, and the action programmes shall consist of the following mandatory measures:

(a) the measures in Annex III;

(b) those measures which Member States have prescribed in the code of good agricultural practice established in accordance with Article 4, except those which have been superseded by the measures in Annex III.

Member States shall moreover take, in the framework of the action programme, such additional measures or reinforced actions as they consider necessary if, at the outset or in the light of experiences gained in implementing the action programmes, it becomes apparent that the measures referred to in paragraph 4 will not be sufficient for achieving the objectives specified in Article 1. In selecting these measures or actions, Member States shall take into account their effectiveness and their cost relative to other possible preventive measures.

In Denmark the Action Programme is implemented in the Action Plans on the Aquatic Environment (APEA) described in detail below.

7.1 Agricultural activities, development and nitrogen assessment

Table 29: Data on agricultural activities, development and nitrogen assessment

		Period		
		Previous (2003)	**Current (2007)[1]**	
Total land area		43 098		km2
Agricultural area		26 580	26 815	km2
Agricultural area available for manure application		24 301	24 783	km2
Evolution in farming practices				
	Permanent pasture	3684	3612	km2
	Permanent crops	1776	1966	km2
Manure N excretion per animal category[1]				
	Cattle	85,254	91,986	ktonnes/y[2]
	Pigs	96,100	100,112	ktonnes /y[2]
	Poultry (and mink, 2007)	7,366	10,547	ktonnes /y[2]
	Other (without mink , 2007)	7,459	2,929	ktonnes /y[2]

[1] From the fertilizer status accounts for the 2006 harvest season

[2] Kilotonnes N per year

7.2 Action programme

7.2.1 Vulnerable zones

Denmark has designated the whole national territory as a vulnerable zone. The code of good agricultural practice, according to Article 4 of the directive, is enclosed the action programme for the whole national territory and implemented as mandatory measures. The Danish action programme pursuant to the Nitrate Directive also contains the voluntary measures as well as training and information of the farmers.

7.3 The Action Plans on the Aquatic Environment

An Action Plan for the Aquatic Environment was already put in place in1987, preceding the Nitrates Directive (91/676/EEC). However as a result of the evaluation of the APAE I, the Danish Parliament agreed upon Action Plan on the Aquatic Environment II (Action Plan II) and hereby fulfilling the Nitrates Directive (91/676/EEC). Action Plan II focused especially on root zone nitrogen discharges from arable land. Below is an overview of the three main Action Plans and further initiatives taken to strengthen their implementation.

Date of first publication/ revision	Sub-components of the Action Programme	Principal measures taken under the APAE
1985	NPo Action Plan to reduce N- and P-pollution	• Target: general reduction of N and P • Minimum 6 month slurry storage capacity • Max. stock density 2 LU/ha • Various measures to reduce runoff from silage clamps and manure heaps • Mandatory to establish a floating antural crust or artificial cover on slurry tanks • Ban on slurry spreading between harvest and 15 October on soil destined for spring crops
1987	Action Plan on the Aquatic Environment I (Action Plan I)	• Target: 49 % reduction of nitrogen leaching compared to the mid 1980s • Minimum 9 months slurry storage capacity • Ban on slurry spreading from harvest to November 1 on soil destined for spring crops • Mandatory to incorporate manure within 12 hours after application • Winter green fields required (percentage increasing from 45% to 65% through the period) • Mandatory fertiliser and crop rotation plans
1991 1994 1996	Action Plan for Sustainable Agriculture (implemented to strengthen APAE I) 10-Point Programme for Protection of the Groundwater and Drinking Water Follow-up on the Action Plan for Sustainable Agriculture	• Target: 49 % reduction of nitrogen leaching compared to the mid 1980s • Ban on slurry spreading from harvest to February 1st, except grass and winter rape • Compulsory fertilizer and manure accounts • Statutory utilisation rates for nitrogen in manure (pig slurry: 60 %, cattle slurry: 55 %, deep litter: 25 %, oother types 50 %) • Winter green fields required (percentage increasing from 45% to 65% through the period) • Maximum limit on the plant-available nitrogen applied to different crops, equal to economic optimum.
1998	Action Plan on the Aquatic Environment II (Action Plan II)	• Target: 49% reduction of N-leaching compared to the mid 1980s • Mandatory catch crops (6% and 10% of the total area of the farm property depending on the amount of manure used per hectare). Catch crops included in fertilizer plan. • Nitrogen standards norms with maximum limit on the plant-available nitrogen applied to different crops lowered to 10 % beneath economic optimal application rate. • Livestock density demands at 1,7 LU/ha for cattle and 1,4 LU/ha for pigs

2001 2001 2003	Midterm evaluation of Action Plan on the Aquatic Environment II Action Plan for reducing Ammonia Volatilization from Agriculture Final evaluation of Action Plan on the Aquatic Environment II	• Increased utilisation rates for manure through the period from APAE I to final rate in 2002 (pig slurry: 60 to 75 %, cattle slurry: 55 to 70 %, deep litter: 25 to 45 %, other types 50 to 65 %) • Improved animal feeding practice to improve utilization of feed • Tax on DKK 5 per kg nitrogen in fertilizer (farms are exempted if they register in the manure register – compulsory for most farms, but not possible for nonfarm nitrogen fertilizer users) • Reduced fertilisation norms to grassland and restrictions on additional N-application to bread wheat (2000) • Ban on slurry application by broadcaster spreader (2001) • Mandatory covering of all dung heaps • Slurry spread on bare soil must be incorporated within 6 hours (2001) • Optimisation of manure handling in animal housing • Ban on ammonia treatment of straw • Subsidies for: Forestation, conversion to organic agriculture, reduced nitrogen use in vulnerable areas, and establishment of Wetlands
2004 2008	Action Plan on the Aquatic Environment III Midterm evaluation of the of Action Plan on the Aquatic Environment III will consider further initiatives needed.	• Target: 13 % reduction of nitrogen leaching in 2015 compared to 2003 and 50 % reduction of phosphorous surplus in Danish agriculture by 2010. • Mandatory catch crops increased to 10 and 14 % • 50.000 ha 10 m. bufferzones along streams and lakes before 2015 • Improvement of utilisation of nitrogen and phosphorous in feed. For phosphorous encouraged by a tax on mineral phosphorous added to feed. • Based on research result further increase in utilisation rates for manure • 300 m. protection zones around ammonia sensitive habitats • Strengthen and increase organic farming • Establish more wetland and support environmentally sensitive farming.

7.3.1 Action Plan on the Aquatic Environmental I & II

By agreement on Action Plan on the Aquatic Environmental I in 1987 (Action Plan I) the Danish Parliament for the first time agreed upon specific goals for reduction of nutrient discharge to the environment from the tree largest nutrient sources in Denmark: Agriculture, urban sewage treatment plans and industries. The goal was to reduce the total discharge of nitrogen with 50% and phosphorous with 80%. This was to be achieved through a differentiated effort where agriculture e.g. had to reduce the nitrogen discharge 49% where as sewage treatment plants and industries had to reduce the nitrogen discharge 60%.

The yearly nitrogen discharge from the root zone of arable land and the direct discharges from stable and storage facilities had, according to the action plan, to be reduced from around 260,000 to 133,000 tonnes N per year, corresponding to a reduction of 49%. The reduction target of 127,000 tonnes N consisted of 100,000 tonnes discharged from the root zone and 27,000 tonnes directly discharged from stable and storage facilities. At the same time direct phosphorous discharge from stable and storage facilities should be reduced from around 4,400 tonnes to 400 tonnes per year. Because of large uncertainty about the scale of phosphorous discharges from arable land this was not included in Action Plan I.

Nitrogen discharge from municipality sewage treatment plants had to be reduced from 18,000 to 6,600 tonnes N per year, while phosphorous discharge had to be reduced from 4,470 to 1,220 tonnes per year. Point source discharges from industries had to be reduced from 5,000 to 2,000 tonnes N per year and from 1,250 to 200 tonnes phosphorous per year.

In 1987 when Action Plan I was agreed upon the total yearly discharges should be reduced from around 283,000 tonnes nitrogen and 10,120 tonnes phosphorous corresponding to a 50% reduction of discharges of nitrogen and 80% reduction of discharges of phosphorous. The deadline for these reductions was 3 years. However, it became quickly clear that is was not possible to obtain the goals within this time frame, and the deadline was postponed until 1 January 1993.

Concerning agriculture the point of departure for Action Plan I was a total reduction of nitrogen discharge of 260,000 tonnes. However, a recent scientific evaluation showed that the discharge from agriculture in mid 1980'ties were considerable larger than firstly estimated and in the magnitude of 311,000 tonnes N per year.

Therefore, the benchmark for the evaluation of the agricultural nitrogen discharge, as part of the final evaluation of the Action Plan II in December 2003, was 311,000 tonnes N per year. The evaluation showed that measures already implemented in addition to the measures agreed upon and financed by Action Plan II would result in a reduction of the total nitrogen discharges from agriculture (root zone and stable and storage facilities) of around 149,000 tonnes N per year. This corresponds to a reduction of around 48% of 311,000 tonnes N. Considering the calculation uncertainty the nitrogen discharge reduction goal of 49% is obtained.

The measures and results of these two action plans are described in the Danish reports on the 1st period (1991-95) submitted to the EU Commission in 1996. The supplementary measures implemented as a result of Action Plan II (1998) is described in the Danish report on the 2nd period (1996-1999) submitted to the EU Commission in 2001. The final result of APAE II is described in the Danish report on the 3rd period (2000-2003) submitted to the EU Commission in 2001

7.3.2 Agreement on Action Plan III in 2004

2 April 2004 the Danish Parliament agreed upon the Action Plan for the Aquatic Environment III (Action Plan III). Action Plan III will continue the development started by the two first action plans for the aquatic environment. The aquatic environment must be further improved through reductions in discharges of nitrogen and phosphorous; nature conservation must continue to be improved; and nuisances experienced by neighbours to agriculture must be limited. Therefore, this Agreement encompasses broad efforts to reduce agricultural impacts on the aquatic environment, nature, and neighbours.

- Agriculture's *excess phosphorous* must be halved compared to the 32,700 tonnes P in 2001/2002. A reduction of the excess phosphorous of 25% by 2009 will be achieved through a tax of DKK 4 per kg of mineral phosphorous in feed and through general improvement of the phosphorous balance by 3,000 tonnes on the basis of new knowledge acquired through research programme. In the period from 2009 to 2015 there will be a further 25% reduction.

- Close to 30,000 hectares of *10-metre crop-free buffer zones* along rivers and lakes before 2009 and a further 20,000 hectares before 2015 will be established. The buffer zones will be established by voluntary transfers of set-aside land along lakes and rivers. In order to support the establishment of crop-free buffer zones through siting set-aside land, an additional subsidy under the agri-environmental measures for crop-free buffer zones established along rivers and lakes will be introduced. The buffer zones will retain phosphorous from other areas and they will protect banks along rivers and lakes, and in this way the discharge of phosphorous will be reduced.
- In accordance with the element mentioned above, a further financing will be allocated in the period 2004-2009 including the expected EU co-financing to special initiatives under the *Agri-environmental measures* targeted towards phosphorous and nitrogen. Besides being spent on establishing crop-free buffer zones, the funds are expected to be spent on establishing wetlands under the agri-environmental measures and general set-aside of agricultural land. In order to achieve a higher degree of integration of protection of the aquatic environment and nature, and because several wetland projects have not been able to meet the relatively high nitrogen requirements in projects under the Action Plan for the Aquatic Environment II, the requirement for removal of nitrogen is reduced to 100 kg N per hectare for future wetlands under the agri-environmental measures.
- *Nitrogen leaching* from agriculture is to be reduced by a minimum of 13% by 2015 compared to 2003. The structural development, including setting aside land, improved feed utilisation, and the implementation of the new EU agricultural reform are expected to lead to a reduction in nitrogen leaching from agriculture of approx. 11,200 tonnes N before 2015. In addition, afforestation in the range of 20,000-25,000 hectares will contribute to reducing nitrogen leaching by approx. 900 tonnes N.
- Regulations regarding *catch crops* will be tightened. From 2005-2009, catch crop requirements will be introduced corresponding to 6% of the catch crop basis for farms using livestock manure, corresponding to less than 0.8 LU/ha, and 10% for farms using livestock manure, corresponding to more than 0.8 LU/ha. From 2009-2015, the catch crop requirements will be tightened to 10 and 14% respectively. In the future, maize will be included as a catch crop. Cruciferous catch crops sown before 20 August are equal to grass crops and other catch crops with a large potential for nitrogen accumulation.
- Determination of requirements for the establishment of *winter green fields*. Winter green fields may, if they constitute 100% of the cultivated area alone or together with catch crops, replace the requirement for catch crops.
- A general tightening of requirements for *utilisation rate of nitrogen in livestock manure* with 4.5-5 percentage points concurrently with research creating a basis for this. This will be assessed in the evaluations in 2008 and 2011. This initiative is expected to contribute to reducing nitrogen leaching by approx. 2,900 tonnes N.
- Establishment of a further approx. 4,000 hectares of *wetlands* in 2004 and 2005.
- In the 2008 evaluation, the effect of the *afforestation* initiatives will be assessed in relation to the reduction in nitrogen discharges to surface water and groundwater.
- The requirements for utilisation rate of nitrogen in *mink manure* will be tightened so that they reach the same level as the current utilisation requirements for cattle manure.
- Initiatives already adopted that are targeted towards a reduction of *wastewater discharges* from sparsely built-up areas in the open country will contribute to reducing nitrogen discharges.

- A technical adjustment of the system to determine *crop nitrogen standards* will be made so that, as a main rule, the norms will continue to be laid down without regard to protein content. However, the norm reduction will be subject to a maximum of 10% below the management economical optimum, as laid down in the Action Plan for the Aquatic Environment II, but the total nitrogen quota will not be allowed to exceed the 2003/2004 quota after adjustments for the effect of crop displacement.
- With a view to protecting ammonia-sensitive habitats designation of *300-metre buffer zones* around all raised bogs, all lobelia lakes, all – to start with - heaths larger than 10 hectares, and all endangered and low-nutrient dry grassland larger than 2.5 hectares, as well as all endangered heaths, dry grassland, and other particularly vulnerable types of natural habitat in the Natura 2000 sites. The total area where buffer zones are designated constitutes just over 7%, corresponding to just over 180,000 hectares. Within this buffer zone and within the area itself, no extension of livestock farms can take place if such an extension would lead to increased ammonia discharges in natural areas vulnerable to ammonia. Application of new technology may be used in such an assessment. Final designation of these areas will take place through the natural planning by counties up to 2009.
- The *research programme* under the Action Plan for the Aquatic Environment III - including reduction of nutrient losses and odour emissions. Limitation of nutrient discharges in a regional context is included in the programme as a separate element. Knowledge about the development and spreading of odours and instruments to limit odours from livestock production will be important elements in limiting nuisances experienced by neighbours. Research into odours is closely related to the development of technologies and knowledge about reduction of ammonia volatilisation. Limiting ammonia volatilisation, e.g. the potential for adding acid to manure, will also be included in the manure research programme, so will experiment projects regarding manure separation and biodegasification, etc.
- In addition, a *new research programme* will be carried out with regard to organic agricultural production - the so-called FØJO III.
- The Manure Action Plan builds upon the recommendations made in the report from the "Nabogeneudvalget" (committee on nuisances experienced by neighbours) of 29 January 2004. It should be noted that the first phase of the Manure Action Plan has already been implemented since the *tightened distance requirements* entered into force on Saturday 20 March 2004. Local authorities have been instructed to be extremely aware of avoiding future odour nuisances in their case administration.

Evaluation in 2008 and 2011

The third APAE was evaluated in fall 2008, the results are described in chapter 8.

7.3.3 Nitrates Directive

Denmark is obliged to submit a four-year action programme for the implementation of the Nitrate Directive. The Parties to this Agreement agree that the Action Plan for the Aquatic Environment III as well as the results achieved under the Action Plan for the Aquatic Environment II are included in the four-year action programmes and that Denmark will continue to meet the requirements for correct implementation of the Nitrate Directive.

8 Evaluation of the implementation and impact of the action programme measures

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8.1 Percentage of farmers visited each year by the supervising authorities or there delegates (programme and code of good practice)

The provisions laid down in Statutory Order 1695/2006 on livestock and animal husbandry of more than 3 livestock units, livestock manure, silage etc.is controlled and farmers inspected by the environmental authorities of the local municipalities.

Every agricultural holding with professional livestock must be inspected by the municipality environmental authority at least every six years which means that at least 16.5% is inspected at the spot each year. On top, every pig farmer with a storage capacity of 6-9 months production of livestock manure, must be inspected every tree years which means that 33% is inspected at the spot each year. Furthermore large livestock holdings granted an environmental permit in accordance with the IPPC Directive (96/61/EEC) must be inspected by the municipality environmental authority every second year.

The provisions of Act 757/2006 on Farms' use of Manure and on Plant cover including 975/2006 Statutory Orders on Farms' use of Manure and on Plant cover and on Nitrogen Prognosis is controlled and farmers inspected by the Danish Plant Directorate.

The Danish Plant Directorate also carries out inspections on the spot. Inspection on the spot covers control of crop rotation planning including plant cover and catch crops, fertiliser planning, fertilisation status account but also the provision regarding application of the amount of livestock manure to the land each year (harmony rules) laid down Statutory Order 1695/2006.

In 2007 the Danish Plant Directorate carried out around 1116 inspections on the spot, regarding the orders mentioned above, corresponding to around 1,7 % of all agricultural holdings.

Provisions on crop rotation, fertiliser planning and winter plant cover are implemented in Act on the Agricultural Sector's Consumption of Fertiliser and on Plant Cover including the annual revised Statutory Order on Agricultural Sector's Consumption of Fertiliser and on Plant Cover and annual revised Statutory Order on Nitrogen Prognosis.

In 2007 the Danish Plant Directorate carried out 262 inspections on catch crops. 14 of the 262 inspections on crop rotation planning was reported to the police for non-compliance with the requirements on 6% / 10% catch crops, corresponding to 5,3%.

Provisions on rational fertilisation use taking into account physical, climatic conditions and irrigation among other parameters are implemented in Act on the Agricultural Sector's Consumption of Fertiliser and on Plant Cover including the annual revised Statutory Order on Agricultural Sector's Consumption of Fertiliser and on Plant Cover and annual revised Statutory Order on Nitrogen Prognosis.

Nearly 100% of all Danish farmers must submit a yearly fertilisation status account to the Danish Plant Directorate. Control of fertilisation status accounts from year 2004/05 show that 110 farms corresponding to 0.2%, exceeded the farm nitrogen quota by 5-20 kg N per hectare. 26 farms corresponding to 0.05%, exceeded the farm nitrogen quota by more than 20 kg N per hectare.

The Danish Plant Directorate also carries out inspections on the spot regarding fertilisation status account. Inspection on the spot supports the control carried out on the basis of the yearly submitted fertilisation status accounts. At the inspection on the spot compliance with the requirements of fertilisation status accounts and requirements regarding use of fertilisers are controlled. In 2006 900 inspections were carried out. 8 of these (0,8%) were reported to the police for severe violations of the provisions on rational fertiliser use. 150 of the inspected farms was also controlled regarding the amount of livestock manure applied to the land each year (harmony requirements). 15 of these (10%) were reported to the police for severe violations of the harmony requirements.

8.2 Main points of difficulty in the implementation

The implementation of the Action Plan on the Aquatic Environment III was evaluated in fall 2008. The main points of difficulties are listed from these reports on the effect of the programme, for the economic evaluation please see chapter 8.

The evaluation looked at the expected and obtained effects from different instruments dealing with both nitrate and phosphorous leaching.

Table 30: Expected and achieved outcomes of the APAEIII 2004-2009

	Expected		Achieved		Prognoses	
	2004-2009		*2004-2007*		*2008-2009*	
	Area (ha)	*Tons N reduced leaching*	*Area (ha)*	*Tons N reduced leaching*	*Area (ha)*	*Tons N reduced leaching*
Wetlands	4.000	400	app. 2.400	600	1600	380
Agri-environmental schemes	4.000	1.050	app. 340	75		20-120
Catch crops	40.000	2.100	13.000	420	-	-
Increased efficiency rates – mink		100		130	-	-
Increased efficiency rates – general						
Forestation	11.400	450	app. 8.200		3.200	-
Organic farming				-340		
Agricultural development		7.200		300		

Below are comments in the areas where developments have not been as expected. Initiatives to address the problems are briefly described in 9.3, as these are still being developed.

8.2.1 Agri-environmental schemes

The agri-environmental schemes includes both wetlands in addition to the separate wetland schemes mentioned in table 30, buffer zones, set aside, and additional agreements on less use of nitrate, catch crops, grasslands, grazing, pesticides use and irrigation.

For wetlands the projects expected to be in place by 2009, are estimated to give a reduction of nitrate leaching of about 150-250 tons N pr. Year. For the other schemes the result is not as expected, the main reason is considered in the economic midterm evaluation described in 9.3, as the lack of economic incentive to the farmer, compared to the costs of production, establishment, control, etc.

8.2.2 Forestation

Though forestation has reached the expected level in terms of the area forested, the effect has not been as anticipated, because of a mechanism in the current nitrogen quota system, which doesn't deduct the amount of nitrogen formerly used on cultivated land, which has been forested from the total amount of nitrogen allowed at a national level. Therefore the nitrogen might just be used somewhere else, and consequently forestation doesn't result in the anticipated reduction of N leaching.

8.2.3 Catch crops

The total area with catch crops is smaller than expected because farmers are allowed to opt for a 100% winter green fields instead of laying out catch crops, or reduced area of catch crops, if the winter green field leaves a smaller area than the area required for catch crops. The effect of the winter green field doesn't replace the catch crop effect.

8.2.4 Other developments anticipated or included in the estimated effect of the APAE III

APAE expects a negative development in agricultural land and calculates an effect of this. The effect of the CAP has not been as expected, it has resulted in more land being registered for use and after the health check, most set-aside land has also been cultivated again. Even though the amount of land taken out for roads, urbanisation etc. has been as expected, there has been no effect because the current system for application norms have not deducted the nitrogen from the total allowed amount of nitrogen use, and therefore will be used somewhere else.

Organic farming has decreased in the evaluated period, but the trend has now turned and an increase is expected over the next years. It is estimated that the average effect of organic farming is a reduction of 17 kg N pr ha, this means that the fall in organic area during the period is estimated to result in an increased leaching of 340 tons N.

Table 31: Development in organic farming 2003-2007 (Data from Danish Plant Directorate)

	2003	2004	2005	2006	2007
Authorized farms	3.510	3.034	2.892	2.662	2.607
Organic farmland including under conversion	165.148	156.881	147.482	141.019	145.393

8.2.5 Instruments targeting phosphor

Two instruments targets phosphorous leaching and phosphorous surplus in agriculture. First APAE has a target of 50.000 ha buffer zones. A survey was done in 2008 that showed that the 10 m. buffer zones along water courses and lakes had not been layed out voluntarily as expected, actually the number of hectare of buffer zones from 2004 had decreased. The survey also showed that the 50.000 ha buffer zones would encompass the cultivated land near all watercourses and lakes.

Second a phosphor tax targets the phosphor surplus. The surplus is expected to be reduced with 25 % as expected, but the effect of the tax is difficult to see, among other because the price level for phosphor has increased dramatically.

8.2.6 Increased efficiency rates for manure

For efficiency rates, the evaluation considers whether there are still possibilities within the existing technological framework for increasing efficiencies. There is no target for this, but an obligation to analyse this as part of the evaluation. The result of the analysis shows that for cattle and pig, a further increase would equal a tightening of the application norms. However for other types of manure the estimated possibilities for increase in efficiency and the consequent effect on fertilizer use are outlined in table 31.

Table 32: Efficiency rates for manure existing and estimated possibilities for increases in the evaluation

	Existing efficiency demand	Possible efficiency rate based on fertilizer effect	Difference	Reduced fertilizer use
	[%]	[%]	[%-point]	
Pig slurry	75	75	0	-
Cattle slurry	70	70	0	-
Slurry from fur bearing animals	70	=pigs	+5	240
Poultry slurry/manure	70	80[2]	+10/30[3]	2.400
Liquid manure	65	85	+20	480
Solid manure	65	55	-10	
Deep litter	45	50	+5	1.250
Other manure	65	65	0	-
Liquid fraction from separation[1]	85	85	0	-
Slurry from biogas plants[4]	-	Min. 80	+5	340

[1] An individual efficiency rate for the liquid fraction, where the nitrogen in the fibre fraction is incinerated and thus removed from use
[2] The total effect of N in the manure is calculated for sold manure, deep litter and slurry together.
[3] The 10% are the difference for poultry slurry, the 30% are the difference for poultry manure as a whole.
[4] There is currently not a separate demand for an efficiency rate, but an advice to use the efficiency rate fro pig slurry. Calculated form the estimate that 5% of slurry are delivered to biogas plants.

If an estimate that 33 % of the used fertilizer result in N leaching, the effect of the reduction in fertilizer use of 4.700 tons N, gives a reduction in n leaching of 1.600 tons N.

8.3 Envisaged evolution and local or general proposals

The Danish government had foreseen a development of the current programme for the implementation of the Nitrates Directive, the Action Plan for Aquatic Environment III (APAE III), through a fourth Action Plan (APAE IV). The APAE IV was expected to ensure that as a minimum the goals of APAE III were met, and moreover to establish a framework to ensure a common approach to the implementation of the commitments under the EU Water Framework Directive (WFD) and the Nitrates Directive.

This process was foreseen to commence after the midterm evaluation of APAE III in December 2008, which would establish whether progress was being made towards the goals in the plan, as well as coincide with the formulation of the River Basin Management Plans (RBMP) for the implantation of the WFD and the subsequent programme of measures.

During autumn 2008 the Danish Government decided to initiate an all-encompassing process to create a new and integrated approach to regulation and strategies concerning agriculture and environment – a strategy and plan for Green Growth. This will replace

APAE IV, and will be the platform for the future Action Programme to be agreed. A number of the difficulties listed above are particularly addressed in the Green Growth platform, as the activities in the water area are based on the critiques raised in the evaluation.

9 Individual cost-effectiveness studies carried out on certain practices

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The economic analysis for the Action Programme under the Nitrates Directive in Denmark estimates the costs for the first period with focus on the years 2004-2007 of Action Plan for the Aquatic Environment III (APAEIII). The analysis has been carried out by the Institute of Food and Resource Economics at University of Copenhagen (FOI) in cooperation with The National Environmental Research Institute under University of Aarhus (NERI) (Jacobsen et al. 2009). The analysis is based on the midterm technical evaluation regarding the effect on N-leaching (Waagepetersen et al., 2008). The evaluation is based on historic figures for 2004-2007, supplemented with a prognosis for 2008-2009 in order to compare the results with the expected costs and environmental effects for 2004-2009. This means that some numbers are a little different than elsewhere in the report, but with a focus on cost effectiveness, this should provide a qualified picture of the costs of the measures.

In the analysis the costs are divided into the costs to the public and government institutions (state and EU) and the costs to the agricultural farms. It is basically assumed that the subsidies in terms of area payments to farmers are equal to the economic loss for the farmer. In cases where the subsidies exceed the economic loss for the farmer, the costs to society will be smaller than the compensation paid. The benefits from the different measures are not estimated and subsequently not included in the estimate. As FOI carried out a cost estimate for the APAEIII in 2004 - after the final program was decided - it is possible to conclude whether the cost level has been higher or lower than anticipated and whether the measures have been as cost-effective as anticipated (Jacobsen, 2004).

NERI and The Faculty of Agricultural Sciences at University of Aarhus (FAS) have in 2008 published a mid-term evaluation of the effect of APAEIII on the aquatic environment from 2004 to 2007. It is concluded that the effect of APAE III is lower than anticipated with respect to N-leaching (Waagepetersen et al., 2008). The expected reduction in N-leaching was 11.300 tonne N of which 4.100 would com from specific measures and 7.200 tonne would come from changes in feeding and a decrease in the agricultural area as a result of set-a-side land and area required for roads and houses.

In the midterm review it is concluded, that the total reduction in N-leaching is 1.200 tonne for the period 2004-2007, and that the effect is around 1.700 tons N for the period 2004-2009.

In table 1 the effect and the costs of each measure are described. The measures include wetlands (based on a one-off payment), wetlands and grassland as voluntary schemes under the rural development program (RDP), afforestation schemes, catch crops requirements and measures to increase the N efficiency rate of animal manure from mink.

The annual costs over the lifespan of the measures (20 years) have been estimated to €10 millions. The estimate in the midterm review is an annual cost of €9.4 millions. The cost effectiveness has deteriorated as several of the cheap measures have not been successful. Furthermore the effect of several measures, e.g. afforestation and grassland measures, have not provided any decrease in N-leaching. The overall cost efficiency has therefore changed from 2.5 € to 5.5 € per kg N leaching reduced. The cost of reducing 1 kg N leaching has therefore doubled.

Table 33: Cost effectiveness for the measures in APAE III (2005-2009)

	Plan			Midterm evaluation		
	Reduction in N-leaching	**Total cost**	**Cost effectiveness**	**Reduction in N-leaching**	**Total cost**	**Cost effectiveness**
	Tonne N	*Million €/yrs*	*€ / kg N.*	*Tonne N*	*Million €/yrs*	*€ / kg N*
Wetlands	1.050	1.6	1.6	980	2.4	2.5
ESA-areas (grass)	70	0.9	13.4	0	1.0	---
ESA-areas (wetlands) [1)]	330	1.6	5.4	200	1.0	4.8
Afforestation[1)]	450	4.1	9.2	0	4.4	---
Catch crops	2.100	2.0	1.0	420	0.6	1.4
Mink	100	0.1	0.7	130	0.1	0.5
Sum of measures	**4.100**	**10.4**	**2.5**	**1.730**	**9.4**	**5.5**
Other measures	7.200	---	---	-40	---	---
Total effect	11.300	10.4	---	1.690	9.4	---

Comments : 1 € = 7,45 DKK.

1) Annual cost for afforestation and wetlands is based on 6 pct. interest and 20 years

Sources: Jacobsen et al. (2009)

In addition, the anticipated effects of free measures from the impact of agricultural policy, have not provided the expected decrease in N-leaching, as the higher prices received for agricultural goods have meant that less land than expected has been taken out of production. The introduction of the Single payment scheme has also increased the agricultural area as more land has been included in the statistics than before.

Looking at each individual measure, afforestration has become slightly more expensive than anticipated. The target for afforestation will be reached, but the environmental effect will not be achieved, as the nitrogen has been applied on other fields. As the effect on N-leaching is zero the cost-efficiency has not been calculated.

Agreements on wetlands following the principle used in APAEII, where there was a one-off payment and a high effect on N-leaching, have achieved the expected target both in terms of area and costs. The wetlands under the RDP have a smaller effect on N-leaching per ha as more areas have been included and the minimum effect was set at 100 kg N per ha as oppose to 200 kg N per ha in APAEII. The costs per ha are also lower, but in spite of this these wetlands cost almost twice as much per kg N as the other wetlands.

The grass measures have not reduced N-leaching, so even if the costs pr. ha are as expected, the cost pr. Kg N is high.

The total costs related to catch crops have been lower than expected as the area with catch crops is lower than expected. A number of farms have instead used the option of having 100% green crops (e.g. winterwheat and barley), which has been allowed to replace the required catch crops. The cost per kg N is higher than expected.

All in all the cheapest measures are wetlands and catch crops. Afforestation and grassland measure are the most expensive, and would be so even if the expected effect on N-leaching had been achieved. The average cost of reducing N-leaching has increased from 2.5 € pr. Kg N in the plan to 5 € pr. Kg N at the mid-tern review of APAEIII.

Sources:

Jacobsen, B.H. (2004). Vandmiljøplan II – økonomisk slutevaluering. [Economic evaluation of Action Plan on the Aquatic Environment II]. Report no. 169. Danish Research Institute of Food Economics.

Folketinget (2004) (Aftale om Vandmiljøplan III) [Agreement about Action Plan on the Aquatic Environment III] April 2nd 2004

Waagepetersen, J.; Grant, R., Børgesen, Christian, D. og Iversen, T.M. (2008). Midtvejsevaluering af Vandmiljøplan III. [Midterm evaluation of the Action Plan on the Aquatic Environment III]. FAS and NERI University of Aarhus.

Jacobsen, B.H.; Hasler, B. and Hansen, L.B. (2009). Økonomisk midtvejsevaluering af Vandmiljøplan III [Economic midterm evaluation of Action Plan on the Aquatic Environment III]. Note. Institute of Food and Resource Economics, University of Copenhagen and National Environmental Research Institute, University of Aarhus.

10 Forecast of future evolution of water body quality

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According to Annex V(4e) of the Nitrates Directive a summery of the assumptions made by Member States about the likely time scale within which the waters identified in accordance with Article 3 (1) are expected to respond to the measures in the action programme, along with an indication of the level of uncertainty incorporated in these assumptions must contained in the information in reports pursuant to Article 10.

10.1 Forecast in time of future evolution of nitrogen content

10.1.1 Effect on nitrogen soil leaching

The nitrogen cycle is complex and the soil nitrogen pool can be very large. Thus, the full reduction in leaching due to changes in farming practice will not be achieved immediately. It is estimated that the full effect of agricultural measures on nitrogen leaching will be achieved within around 10 years, with the effect being greatest at the outset (Iversen et al, 1998). In contrast, the re-establishment of wetlands will have an immediate effect.

When the full effect of APAE II is achieved the total nitrate leaching is expected to be 162,000 tonnes N.

Action Plan III has a target of reducing the nitrate leaching further by 13% compared to 2003, corresponding to 21,000 tonnes N. This target is to be attained by 2015. The expected effect of Action Plan III is shown in table 7.1. The table shows the expected area and the expected effect on nitrogen surplus and nitrogen leaching for the different measures agreed upon in Action Plan III as well as the total area and effect on nitrogen surplus and nitrogen leaching. The estimations on reduction in nitrogen surplus and reduction in nitrogen leaching are estimated the period 2005-2009 and 2010-2015, respectively as well as for the total period 2005-2015. APAE III will be evaluated in December 2008 and 2011 and adjusted, if necessary. The final evaluation of the Action Plan takes place in 2015.

10.1.2 Effect on river concentration and marine loading

On average, only 30-40% of the nitrogen leaching from fields reaches Danish watercourses and rivers, among other reasons because considerable nitrogen removal takes place in the groundwater.

Part of the nitrogen leaching from fields will reach the watercourses rapidly via drains and other forms of sub-surface flow, while part of the leaching will pass the groundwater magazines, and not reach rivers until years later.

Measures implemented in Action Plan III regarding nitrate leaching are expected to reduce the riverine loading by 8,400 tonnes N in 2015 as compared to 2003. The expected effect of Action Plan III on transport of nitrogen in watercourses is shown in table 7.1. The table shows the estimates as a result of reduced nitrogen leaching and as a result of denitrification as well as the total estimated reduction of transport of nitrogen. The estimates are shown for each of the measures agreed upon in Action Plan III as well as the total estimated effect in watercourses.

10.1.3 Effect on specific water bodies

The Danish Action Plan III on the Aquatic Environment is a national plan. It is therefore not possible to predict the effects on specific water bodies.

Table 1 Expected effect of Action Plan III (2005-2015) on agricultural area concerned, nitrogen surplus, nitrogen leaching and transport of nitrogen in watercourses.

	2015 Area		2005-2009 Estimated reduction		2010-2015 Estimated reduction		2004-2015 Estimated reduction		Estimated reduction of transport of nitrogen in watercourses[2)]	
	Hectare	**N-surplus** Tonnes N/year	**N-leaching** Tonnes N/year	**N-surplus** Tonnes N/year	**N-leaching** Tonnes N/year	**N-surplus** Tonnes N/year	**N-leaching** Tonnes N/year	**As result of the reduced N-leaching** Tonnes N/year	**As result of denitrificatio n** Tonnes N/year	**Total** Tonnes N/year
Structural development		8,600	4,000	8,600	4,000	17,200	8,000	2,800		2,800
CAP-reform		9,800	3,200			9,800	3,200	1,120		1,120
Re-establishment of wetlands	4,000	150	50			150	50	18	1,000	1,018
Further use of ESA-schemes	4,000	150	50	150		300	50	18	350	368
Tightened rules for catch crops[1)]	240,000	2,100	2,100	2,500	2,500	4,600	4,600	1,160		1,610
Tightened utilization rate of mink manure		200	100			200	100	35		35
Afforestation	22,800	900	450	900	450	1,800	900	315		
Utilization rates of manure				9,600	2,900	9,600	2,900	1,015		
Buffer zones										
Total		21,900	9,950	21,750	9,850	43,650	19,800	6,930	1,350	8,280
Total, rounded		22,000	10,000	22,000	10,000	44,000	20,000	7,000	1,400	8,400

1) Total area with catch crops. The reduction of nitrogen surplus includes a residual effect corresponding to the reduction in nitrogen leaching. 2) The nitrogen removal in fresh water system is not included.

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[i] Sweden (Remark (2) 4 c)