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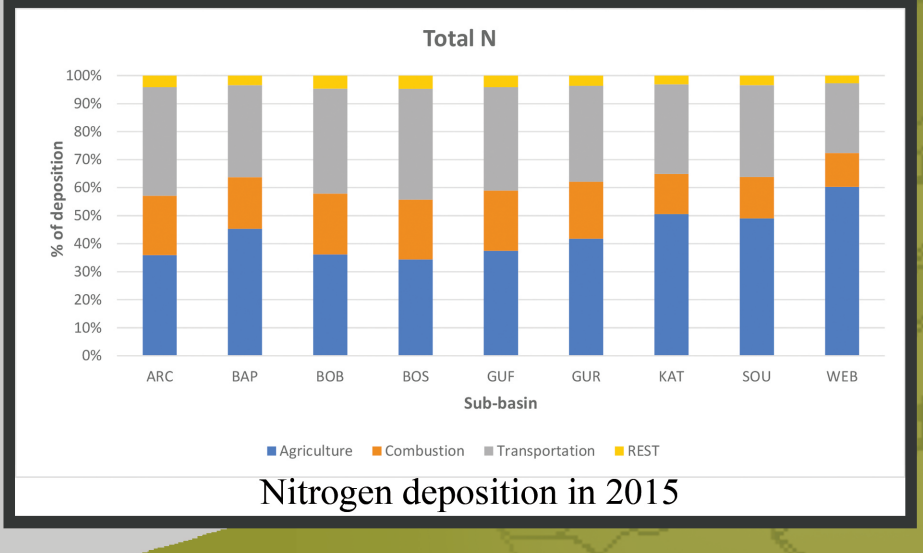
TECHNICAL REPORT
MSC-W 3/2017

Contributions of emissions from different countries and sectors to atmospheric nitrogen input to the Baltic Sea basin and its sub-basins

Jerzy Bartnicki
Anna Bendictow



Nitrogen deposition in 2015

msc-w

EMEP/MSC-W report for HELCOM
EMEP/MSC-W TECHNICAL REPORT 3/2017

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Jerzy Bartnicki and Anna Benedictow

Meteorological Synthesizing Centre-West (MSC-W)

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Contents

1. Introduction 3
2. Atmospheric nitrogen emissions in 2014 5
2.1 Emissions from all EMEP sources 6
2.2 Emissions from Denmark 8
2.3 Emissions from Estonia 9
2.4 Emissions from Finland 10
2.5 Emissions from Geramany 11
2.6 Emissions from Latvia 12
2.7 Emissions from Lithuania 13
2.8 Emissions from Poland 14
2.9 Emissions from Russia 15
2.10 Emissions from Sweden 16
2.11 Emissions from Belarus 17
2.12 Emissions from France 18
2.13 Emissions from the Netherlands 19
2.14 Emissions from the United Kingdom 20
2.15 Emissions from ship traffic on the Baltic Sea 21
2.16 Emissions from ship traffic on the North Sea 22
3. Contributions to nitrogen depositions from the countries and sectors 21
3.1 Contributions from Denmark 23
3.2 Contributions from Estonia 26
3.3 Contributions from Finland 29
3.4 Contributions from Germany 32
3.5 Contributions from Latvia 35
3.6 Contributions from Lithuania 38
3.7 Contributions from Poland 41
3.8 Contributions from Russia 44
3.9 Contributions from Sweden 47
3.10 Contributions from Belarus 50
3.11 Contributions from France 53
3.12 Contributions from the Netherlands 56
3.13 Contributions from the United Kingdom 59
3.14 Contributions from the Baltic Sea 62
3.15 Contributions from the North Sea 62
3.16 Contributions from all EMEP sources 63
4. Contributions to sub-basins of the Baltic Sea 66
4.1 Archipelago Sea 66
4.2 Baltic Proper 68
4.3 Bothnian Bay 70
4.4 Bothnian Sea 72
4.5 Gulf of Finland 74
4.6 Gulf of Riga 76
4.7 Kattegat 78
4.8 The Sound 80
4.9 Western Baltic 82
4.10 The entire Baltic Sea basin 84
5. Conclusions 87
References 88

1. Introduction

The main goal of the present report, as specified in the contract, is the calculation of the "blame matrices indicating contribution from different countries and sectors to the deposition (modelled actual) of nitrogen to the different sub-basins of the Baltic Sea in 2014". There are two deliverables for HELCOM from this project: 1) the summary report and 2) the excel file with three blame matrices, for deposition of oxidised nitrogen, reduced nitrogen and total (oxidized + reduced) to nine sub-basins of the Baltic Sea.

The present report has been prepared by one EMEP Centre only – MSC-W and it differs from the annual reports (Bartnicki et al., 2016), which involves three EMEP Centres. It is focused on the contributions of main emission sources to nitrogen deposition into the Baltic Sea. The analysis of contribution of main emission sources to nitrogen deposition to the Baltic Sea in the latest available year – 2014 is extended compared to annual reports. Extended means, that not only emissions from the individual countries are taken into account as emission sources, but also selected groups of emission sectors in each of the contributing country. This extension resulted in a large number of additional runs of the EMEP/MSC-W model performed for this project.

The selected groups of emissions sectors aggregations of individual 11 SNAP sectors used in the EMEP MSC-W model for nitrogen oxides emissions and ammonia emissions. The selected group of sectors are combustion and transportation for nitrogen oxides emissions and agriculture for ammonia emissions. They represent the main sources of nitrogen emissions. The remaining emissions are relatively much lower, but they are also taken into account in the analysis presented here.

It should be stressed that all results presented here are based on the emission data and the calculations of the EMEP/MSC-W model version presented to the Second Joint Session of the Steering Body to the EMEP and the Working Group on Effects, which took place 13-16 September 2016 in Geneva and was accepted there by the EMEP Contracting Parties.

The latest available EMEP/MSC-W (Simpson et al. 2012) model version rv4.9 has been used for the deposition calculations. This version is described in the EMEP Status Report 1/2016 and the results of model verification for 2014 can be found in the Supplementary material to the EMEP Status Report 1/2016. The model was run in 50 km×50 km in the EMEP domain. Meteorology, emissions, boundary conditions and forest fires for 2014 have been used as input. In addition, the SO_2 emissions from the Holuhraun eruption in 2014 were included in the emission inventories, which is a significant source of natural SO_2 emissions. For the first time, Dimethyl sulphide (DMS) emissions are created 'on-the-fly' e.g. they are meteorology dependent. However, the improvements in parameterization of sulphur emissions have practically no limited effect on calculated nitrogen deposition.

Analysis of this model version performance and comparison of the model results with measurements can be found in Supplementary Material to the EMEP Status Report 1/2016.

Annual nitrogen depositions in 2014 resulting from different emission sources were calculated for the entire Baltic Sea basin and for its nine sub-basins. These nine sub-basins are listed in Table 1.1, in alphabetical order, together with their abbreviations and surface area in km^2.

Table 1.2. The sub-basins of the Baltic Sea used for computing atmospheric nitrogen deposition in this report listed in alphabetical order. The abbreviations and areas of sub-basins of the Baltic Sea and the entire Baltic Sea basin are also shown.

Sub-basin	Abbreviation	Area in km^2
Archipelago Sea	ARC	13405
Baltic Proper	BAP	209258
Bothnian Bay	BOB	36249
Bothnian Sea	BOS	65397
Gulf of Finland	GUF	29998
Gulf of Riga	GUR	18646
Kattegat	KAT	23659
The Sound	SOU	2328
Western Baltic	WEB	18647
Baltic Sea basin	**BAS**	**417587**

There are large differences in the sizes of individual sub-basins. The area of the largest one – Baltic Proper is almost two orders of magnitude higher than the area of the smallest sub-basin – The Sound. The areas of the remaining sub-basins are within a factor of two range. The locations of individual sub-basins are presented in Fig. 1.1.

Fig 1.1. Locations of nine sub-basins of the Baltic Sea listed in Table 1.2 and used for all nitrogen deposition calculations presented in this report.

2. Atmospheric nitrogen emissions in 2014

In the latest EMEP report for HELCOM (Bartnicki et al., 2016), the following main emission sources (countries and ship emissions) with the largest contribution to annual 2014 nitrogen deposition were identified: Germany, Poland, Denmark, Sweden, Finland, Russia, Latvia, Lithuania, United Kingdom, France, The Netherlands, Belarus, ship emissions from the Baltic Sea and ship emissions from the North Sea. Contributions of the above sources to atmospheric nitrogen deposition into the Baltic Sea basin are shown in Fig. 2.1.

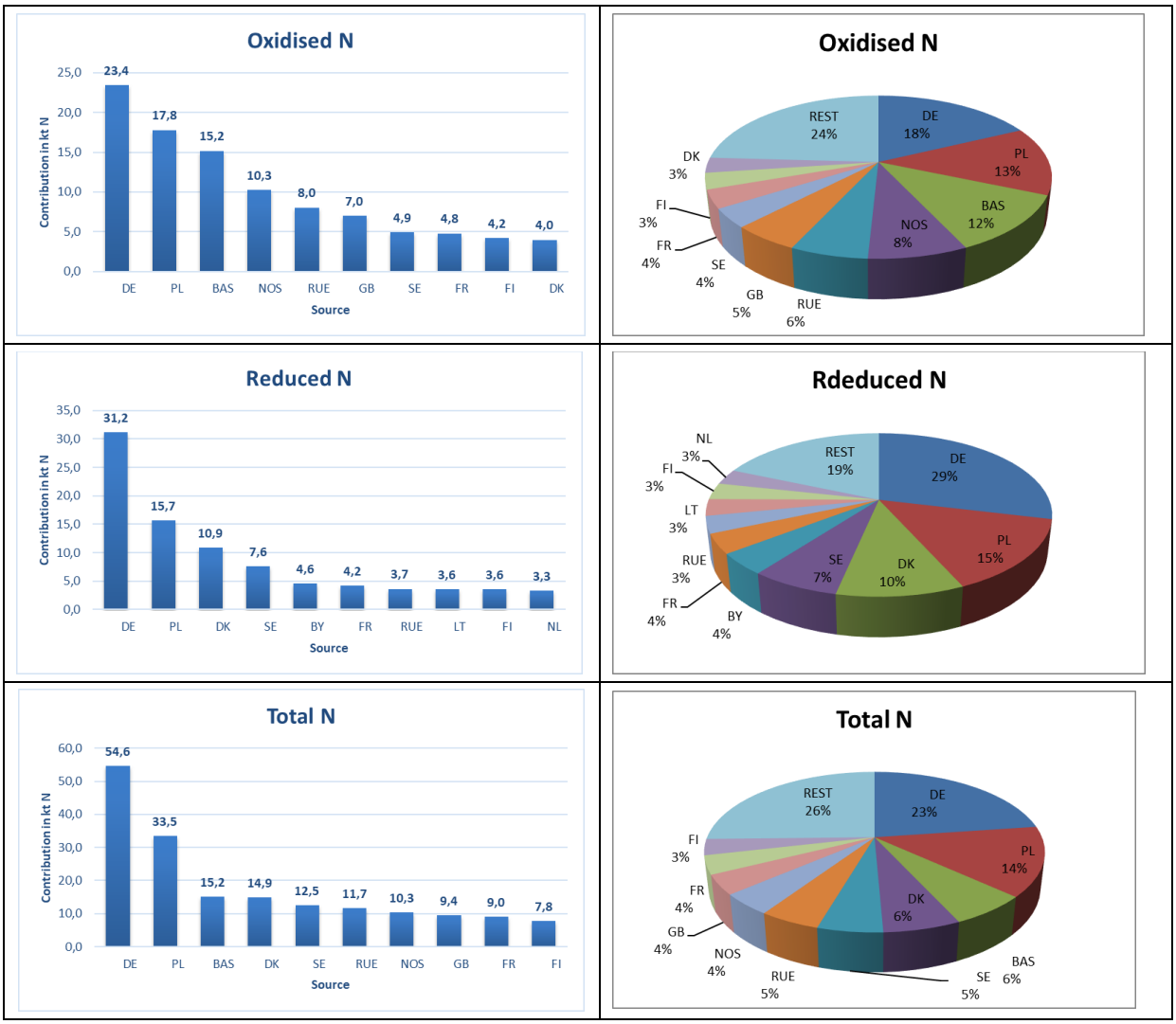


Fig. 2.1. Top ten sources contributing to atmospheric nitrogen deposition into the Baltic Sea basin in the year 2014 (Bartnicki et al., 2016). Acronyms for the sources: BAS – ship traffic on the Baltic Sea, BY – Belarus, DE – Germany, DK – Denmark, FI – Finland, FR – France, GB – United Kingdom, LT – Lithuania, NL – Netherlands, NOS – ship traffic on the North Sea, PL – Poland, RUE – Russia and SE – Sweden. Results based on calculated annual deposition in 2014 (not normalised).

Germany and Poland are the main sources, number one and number two, contributing to all kinds of nitrogen deposition shown in Fig 2.1. In the case of oxidised nitrogen, ship emissions from the Baltic Sea and from the North Sea are third and fourth contributors, respectively. Denmark is the contributor number three in the case of reduced nitrogen deposition. In

addition to local sources, some distant sources like, for example, ship traffic on the North Sea, United Kingdom and France are also among top ten contributors to nitrogen deposition. Estonia and Latvia are tyhe HELCOM Contracting Parties which are not present on the list of Top Ten contributors to atmospheric nitrogen deposition. However, since Estonia AND Latvia both belons to HELCOM Contracting Parties, they arealso included in the present study.

In the EMEP database nitrogen emissions from all sources are split into 11 SNAP sectors corresponding to different categories. For the model runs, distribution among sectors is available in each grid square of the numerical grid system. The 11 SNAP sectors are listed in Table 1.1.

Table 1.1. The list of 11 SNAP emission sectors as specified in the EMEP/MSC-W model.

Sector 1	Combustion in energy and transformation industry
Sector 2	Non-industrial combustion plants
Sector 3	Combustion in manufacturing industry
Sector 4	Production processes
Sector 5	Extraction and distribution of fossil fuels and geothermal energy
Sector 6	Solvent and other product use
Sector 7	Road transport
Sector 8	Other mobile sources and machinery (including ship traffic)
Sector 9	Waste treatment and disposal
Sector 10	Agriculture
Sector 11	Other sources and sinks

The contribution of the main sources of nitrogen emission to nitrogen deposition is relatively well known and does not change from one year to another, at least in the period 1995-2016 (Bartnicki et al. 2016). Here we concentrate on contributions from selected groups of emission sectors. All sectors listed in Table 1.1 can be assigned to one of the three groups which are most important: combustion (SNAP sectors 1, 2, 3), transportation (SNAP sectors 7, 8) and agriculture (SNAP sector 10). The main effort in this study is the analysis of contribution of each group from each main source (mainly countries) to nitrogen deposition into the Baltic Sea. To make this study complete we have also calculated depositions from a fourth group: rest, which includes all remaining SNAP sectors (SNAP sectors 4, 5, 6 , 9, 11). In this classification, ship emissions from the Baltic Sea and the North Sea belong to transportation (SNAP sector 8).

2.1 Emissions from all EMEP sources

All EMEP emissions sources contribute, in different levels, to atmospheric nitrogen deposition into the Baltic Sea basin. Therefore, in the first step we present and discuss annual nitrogen emissions from all EMEP sources. Distributions of annual nitrogen oxides and ammonia emissions from all EMEP sources in 2014 are shown in the Baltic Sea region in Fig. 2.2. On the maps presented in Fig. 2.2, nitrogen oxides emissions can be noticed both from the land and from the Baltic Sea basin, because of the presence of emissions from ship traffic on the Baltic Sea. Ammonia emissions are visible on land only. On both maps a clear gradient from south to north is visible, with nitrogen emissions being one-two orders of magnitude lower in the north. A similar, but not so strong gradient can also be noticed from west to east. The sum of annual nitrogen oxides emissions in 2014, from all EMEP sources is 18541 kt N. The sum of annual ammonia emissions in 2014 from all EMEP sources is 8664 kt N. Nitrogen

oxides emissions in the EMEP domain are therefore approximately two times higher than ammonia emissions.

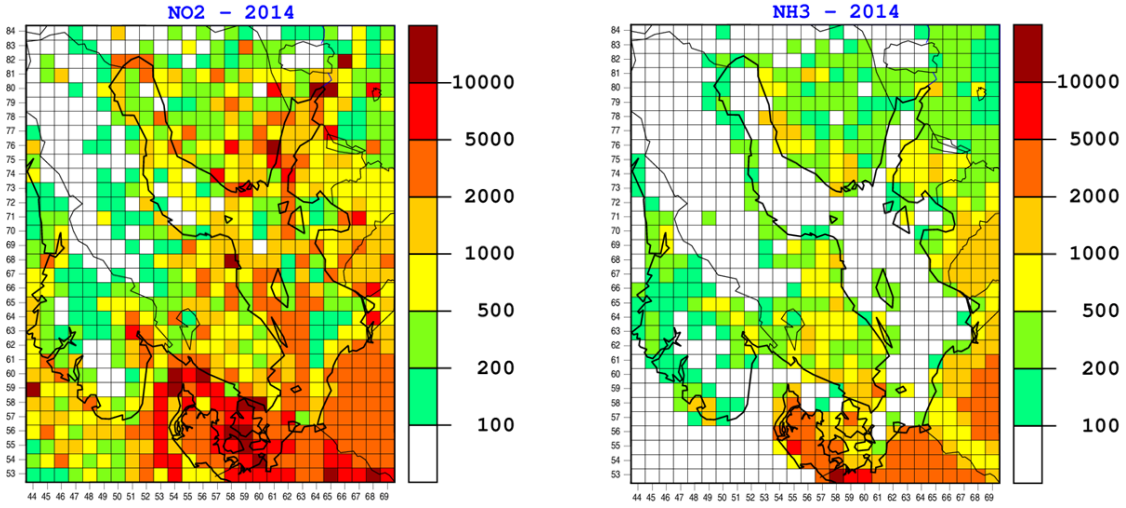


Fig. 2.2. Maps of annual 2014 nitrogen oxides and ammonia emissions from all EMEP sources in the Baltic Sea region. Units: tonnes N per grid and year.

Maps of total (NO_2+NH_3) annual emissions from each of the four groups of sectors selected for this study are shown in Fig. 2.3.

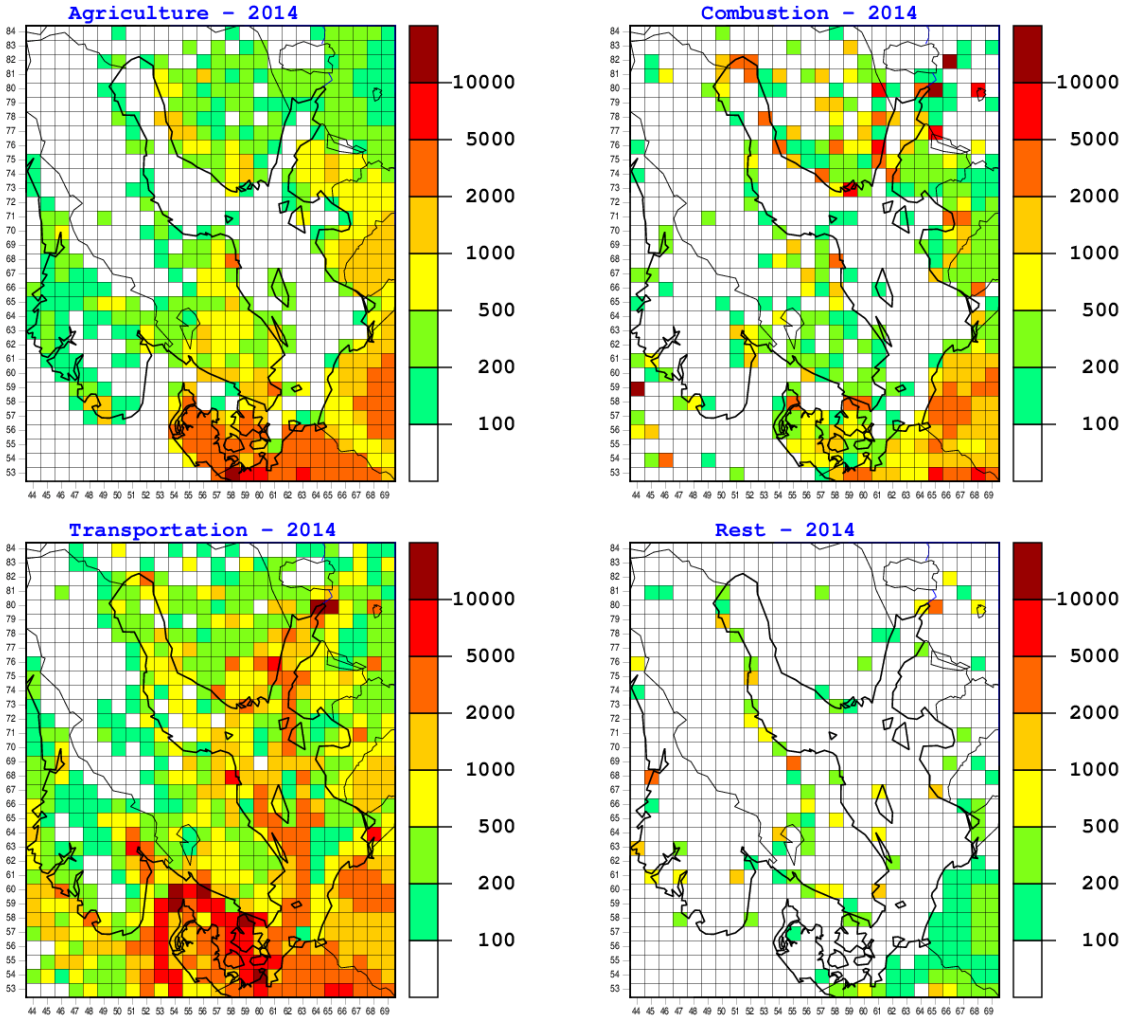


Fig. 2.3. Maps of all EMEP emission from individual groups of sectors. Units: tonnes N per grid and year.

Large and very large emissions from agriculture can be noticed in Denmark, Germany and Poland with relatively smooth distributions over the parts of those countries visible in Fig. 2.3. Emissions from combustion, on the other hand, include many scattered individual grids with high levels corresponding to large point sources in the region. Emissions from transportation are on a high level in Denmark, Germany and Poland, concerning land based emissions. However in this group, emissions from ship traffic on the Baltic Sea and the North Sea are clearly visible in Fig. 2.3 indicating the main routes of the ships. Nitrogen emissions from agriculture, combustion and transportation account for more than 90% of all nitrogen emissions in the Baltic Sea region and remaining emissions from the "REST" (SNAP sectors 4, 5, 6, 9, 11) are on a much lower level, but the distribution of those emissions is also shown in Fig. 2.3.

In the next sections, we will present and discuss nitrogen emissions from the major contributors to nitrogen deposition into the Baltic Sea basin as shown in Fig. 3.1. We will start with all HELCOM Contracting Parties in alphabetical order: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. Next emissions from the major external (to HELCOM) contributors are presented also in alphabetical order: Belarus, Netherlands, France and United Kingdom. Finally, we present nitrogen oxides emissions from ship traffic on the Baltic Sea and on the North Sea.

2.2 Emissions from Denmark

Denmark is the number three contributor to total and reduced nitrogen deposition into the Baltic Sea and number 11 contributor to oxidised nitrogen deposition in 2014. The maps of annual emissions of oxidised and reduced nitrogen from Denmark are shown in Fig. 2.4.

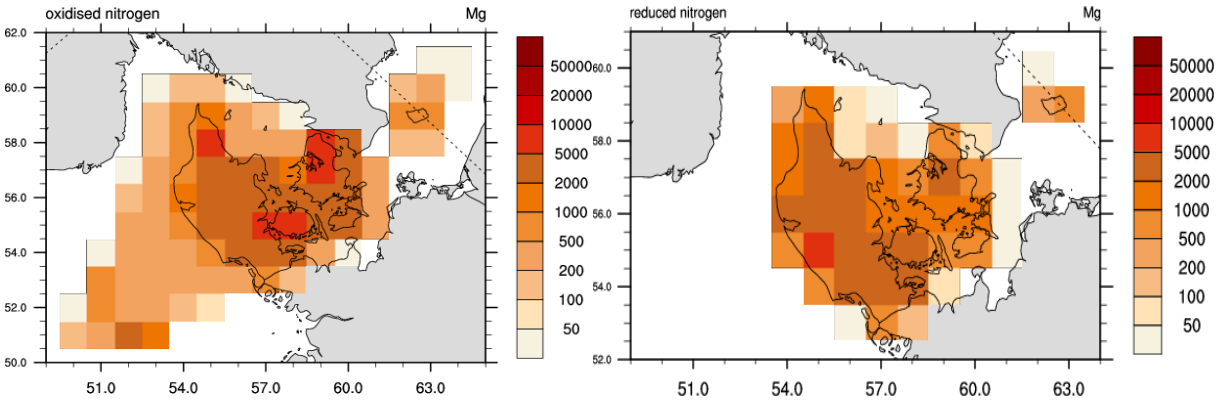


Fig. 2.4. Maps of annual 2014 nitrogen oxides and ammonia emissions from Denmark. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Denmark into four groups of sectors is shown in Fig. 2.5. Transportation (64%) is the major process responsible for nitrogen oxides emissions from Denmark, whereas agriculture (95%) dominates ammonia emissions. Agriculture (65%) is also a major process in emissions of total nitrogen from Denmark.

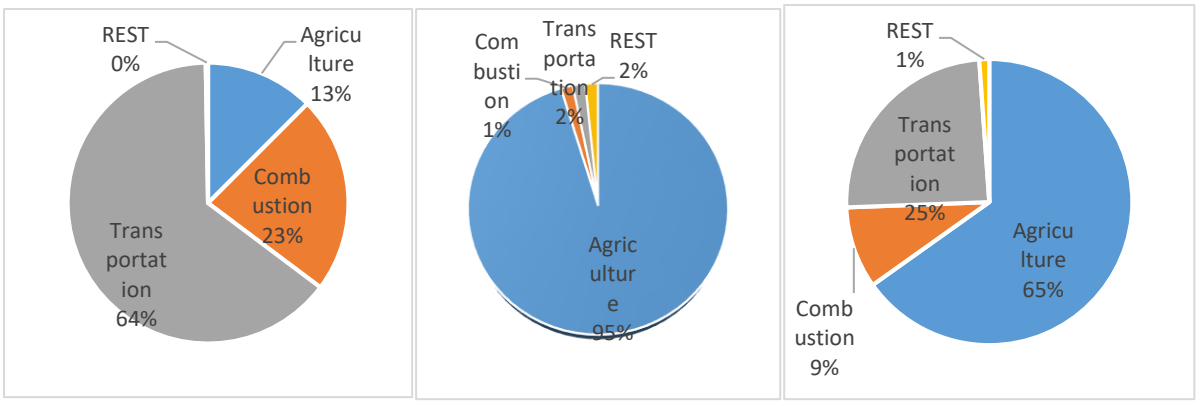


Fig. 2.5. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Denmark into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.3 Emissions from Estonia

Estonia is a very small contributor to total, oxidised and reduced nitrogen deposition into the Baltic Sea in 2014. The maps of annual emissions of oxidised and reduced nitrogen from Estonia in 2014 are shown in Fig. 2.6.

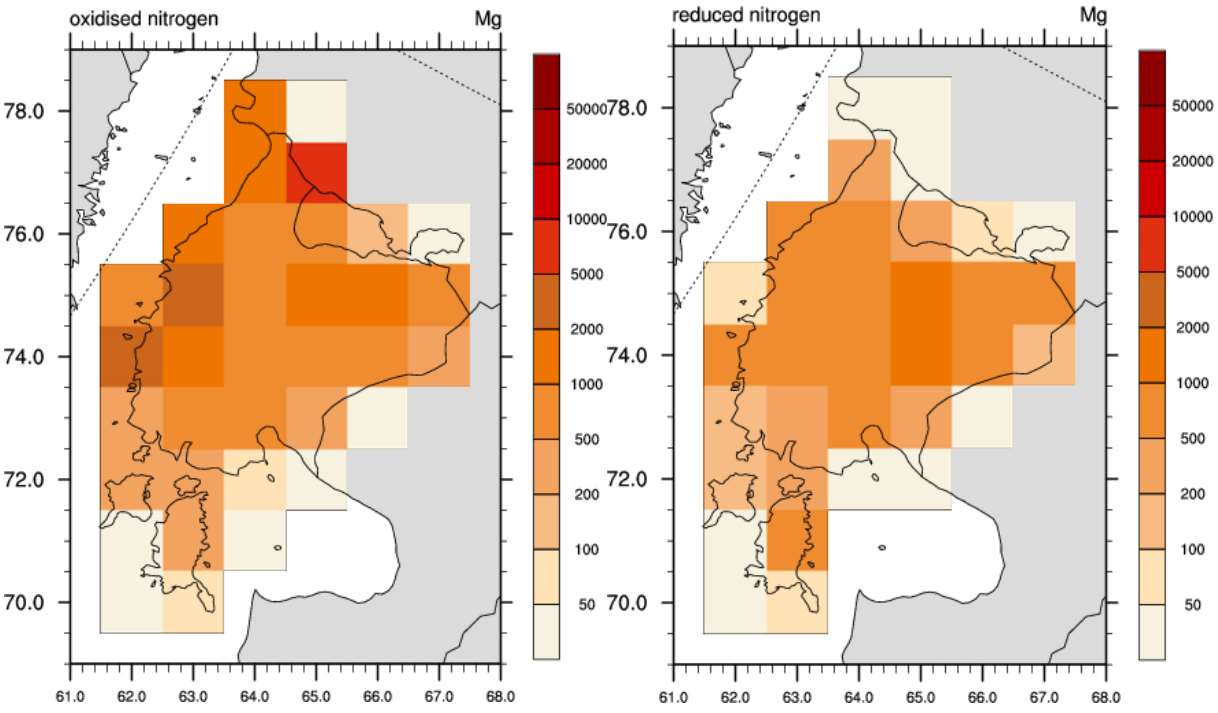


Fig. 2.6. Maps of annual 2014 nitrogen oxides and ammonia emissions from Estonia. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Estonia into four groups of sectors is shown in Fig. 2.7. Combustion (53%) is the major process responsible for nitrogen oxides emissions from Estonia, whereas agriculture (93%) dominates ammonia emissions. Agriculture (65%) is also a major process in emissions of total nitrogen from Estonia.

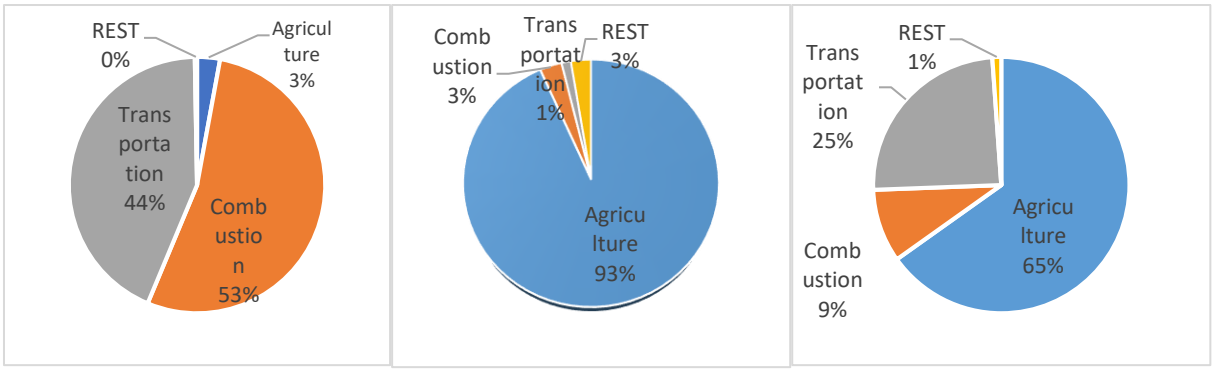


Fig. 2.7. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Estonia into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.4 Emissions from Finland

Finland is the number 9 and 10 contributor to total and oxidised nitrogen deposition into the Baltic Sea and number 7 contributor to reduced nitrogen deposition in 2014. The maps of annual emissions of oxidised and reduced nitrogen from Finland in 2014 are shown in Fig. 2.8.

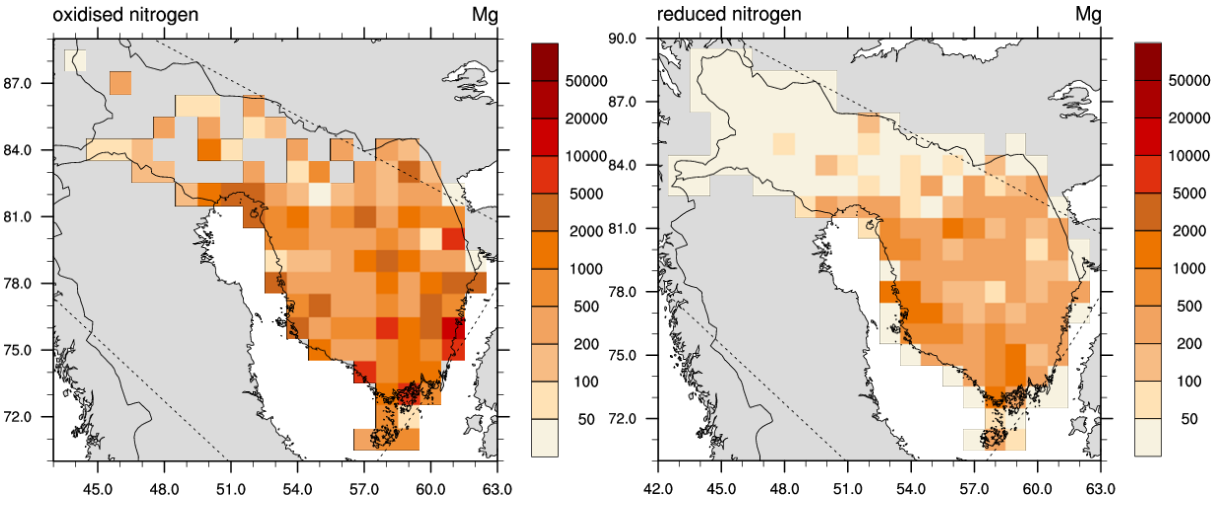


Fig. 2.8. Maps of annual 2014 nitrogen oxides and ammonia emissions from Finland. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Finland into four groups of sectors is shown in Fig. 2.9. In the case of Finland, contributions of combustion and transportation to nitrogen oxides emissions are almost equal, 50% and 49%, respectively. Emissions of ammonia are dominated by agriculture again with 91% contribution. Contributions of agriculture, combustion and transportation to total nitrogen are relatively uniform with 38%, 30% and 30%, respectively.

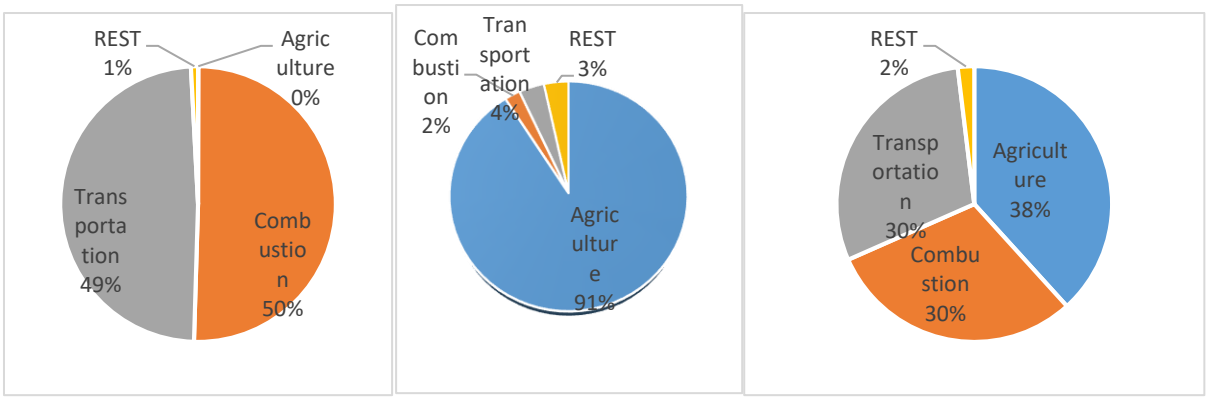


Fig. 2.9. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Finland into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.5 Emissions from Germany

Germany is the largest contributor to total, oxidised and reduced nitrogen deposition into the Baltic Sea in 2014. The maps of annual emissions of oxidised and reduced nitrogen from Germany in 2014 are shown in Fig. 2.10.

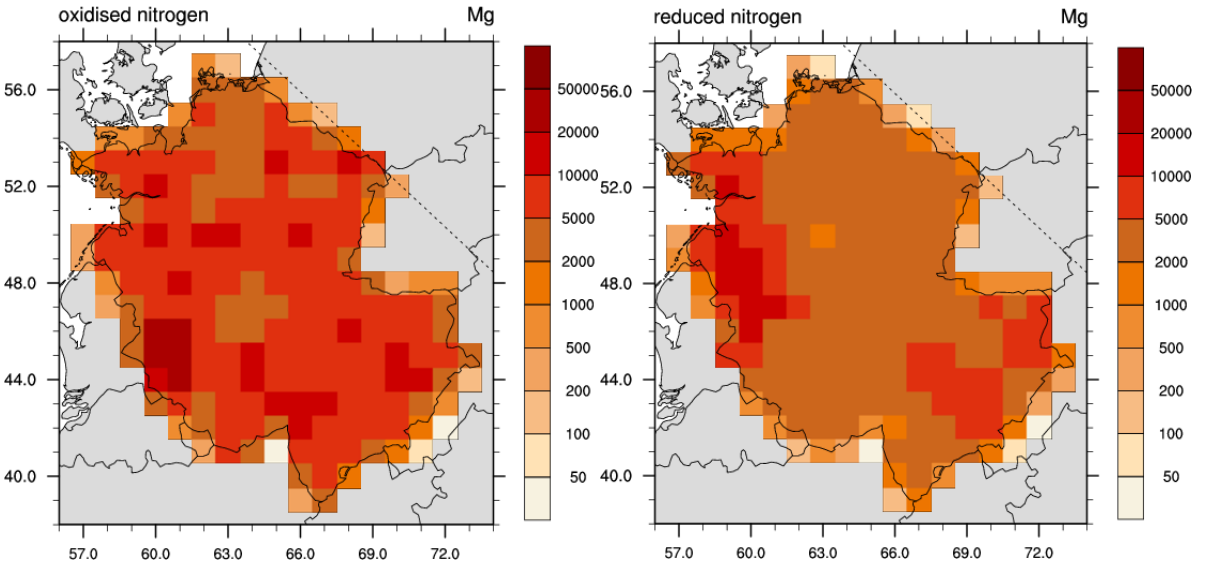


Fig. 2.10. Maps of annual 2014 nitrogen oxides and ammonia emissions from Germany. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Germany into four groups of sectors is shown in Fig. 2.11. Transportation (45%) is the main contributor of nitrogen oxides emissions, followed by combustion (38%). Also in the case of Germany, agriculture dominates ammonia emissions (95%) and is also a major process for emissions of total nitrogen from Germany with 63% contribution.

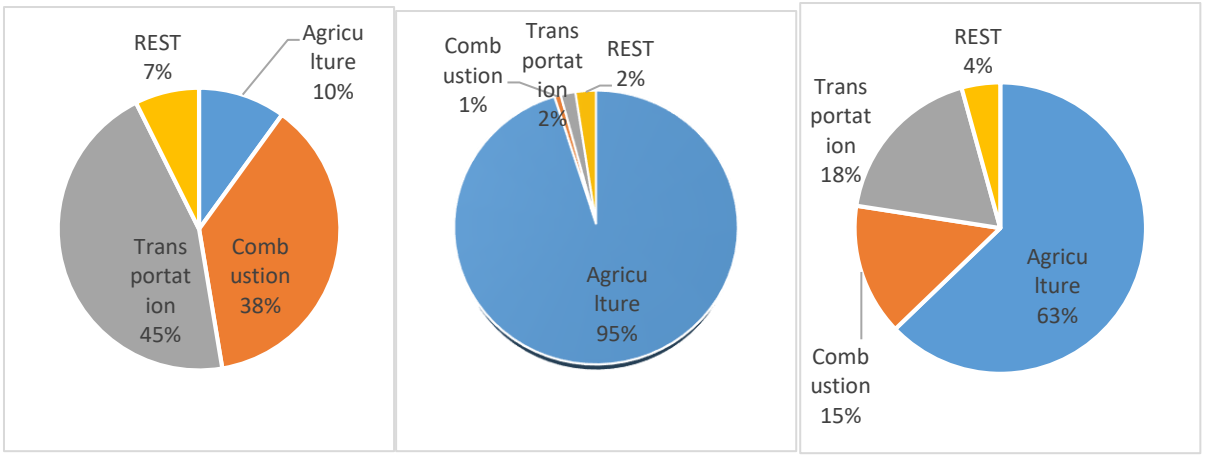


Fig. 2.11. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Germany into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.6 Emissions from Latvia

Latvia is a very small contributor to total, oxidised and reduced nitrogen deposition into the Baltic Sea in 2014. The maps of annual emissions of oxidised and reduced nitrogen from Latvia in 2014 are shown in Fig. 2.13.

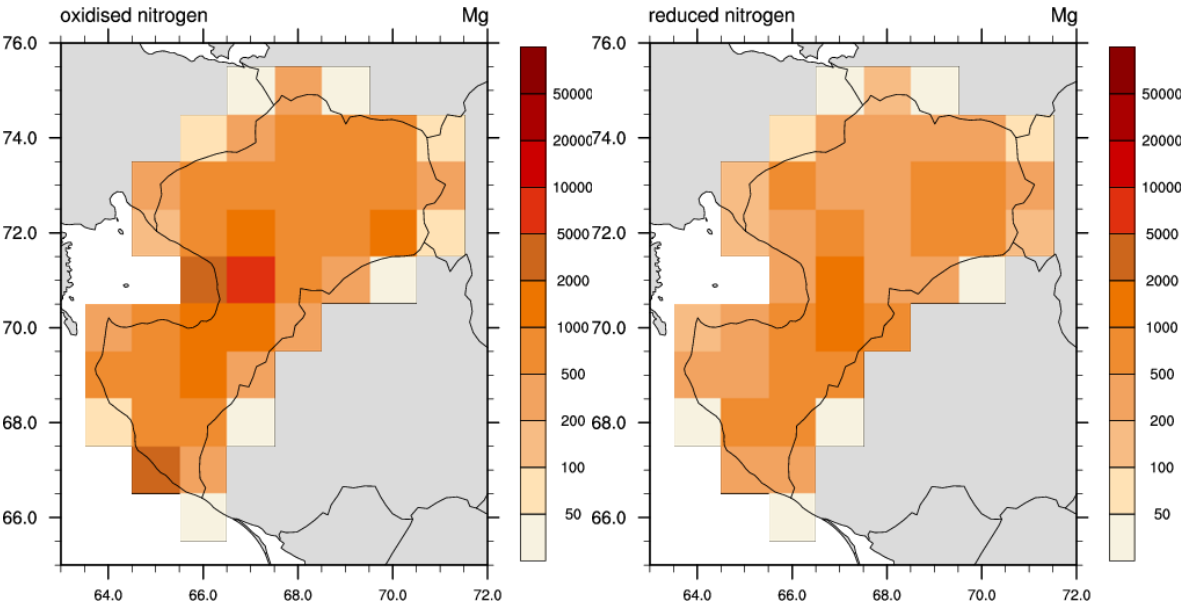


Fig. 2.13. Maps of annual 2014 nitrogen oxides and ammonia emissions from Latvia. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Latvia into four groups of sectors is shown in Fig. 2.14. Transportation (48%) is the main sector in nitrogen oxides emissions and agriculture (82%) is the main sector in ammonia emissions. Agriculture (51%) is also the number one sector in emissions of total nitrogen from Latvia.

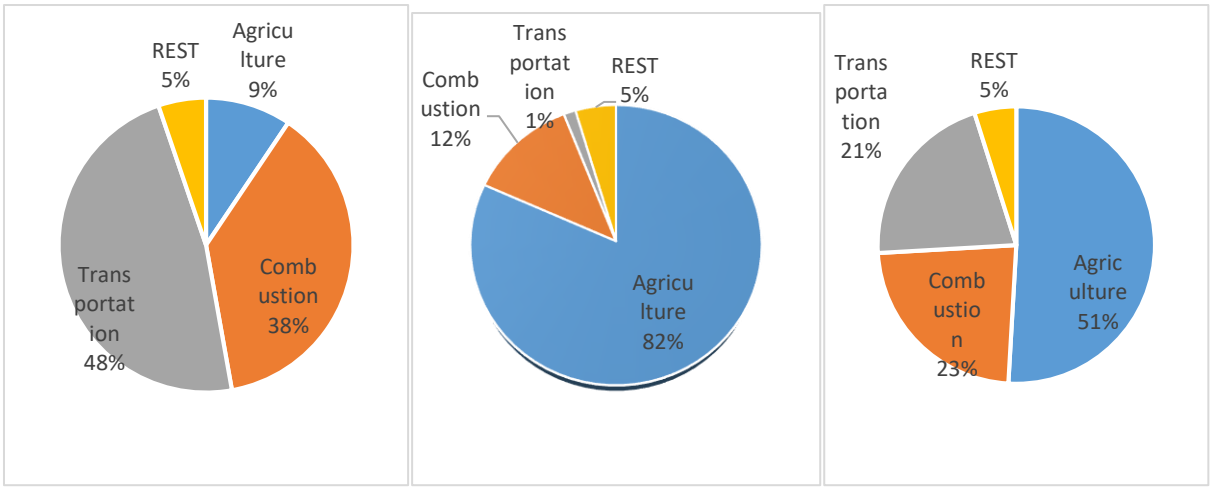


Fig. 2.14. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Latvia into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.7 Emissions from Lithuania

Lithuania is a very small contributor to total and oxidised nitrogen deposition into the Baltic Sea and number 9 contributor to reduced nitrogen deposition in 2014. The maps of annual emissions of oxidised and reduced nitrogen from Lithuania in 2014 are shown in Fig. 2.15.

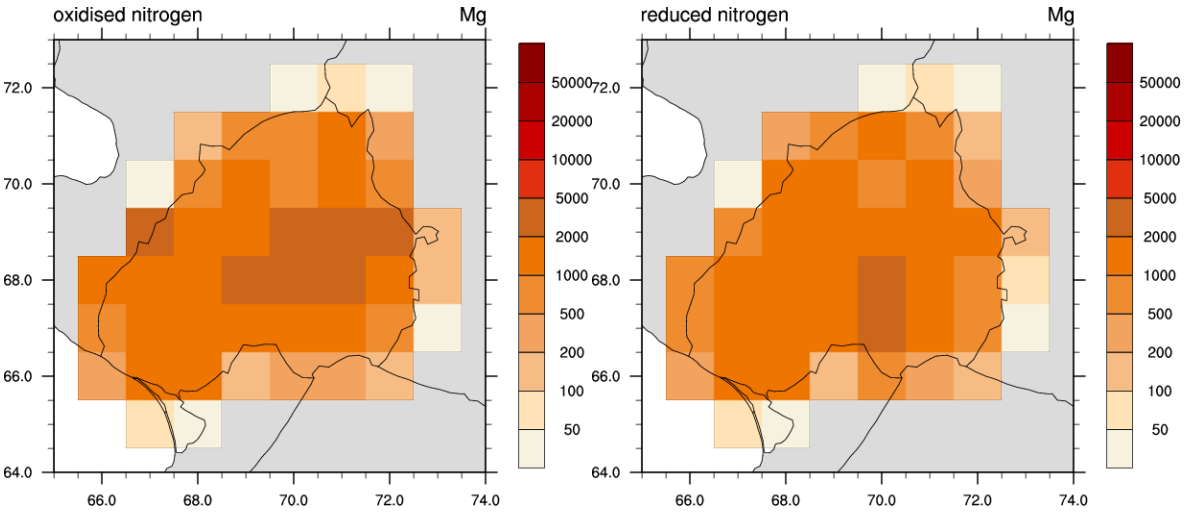


Fig. 2.15. Maps of annual 2014 nitrogen oxides and ammonia emissions from Lithuania. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Lithuania into four groups of sectors is shown in Fig. 2.16. Transportation (67%) dominates nitrogen oxides emissions and agriculture (89%) dominates ammonia emissions from Lithuania. Agriculture (64%) is also a major sector in emissions of total nitrogen.

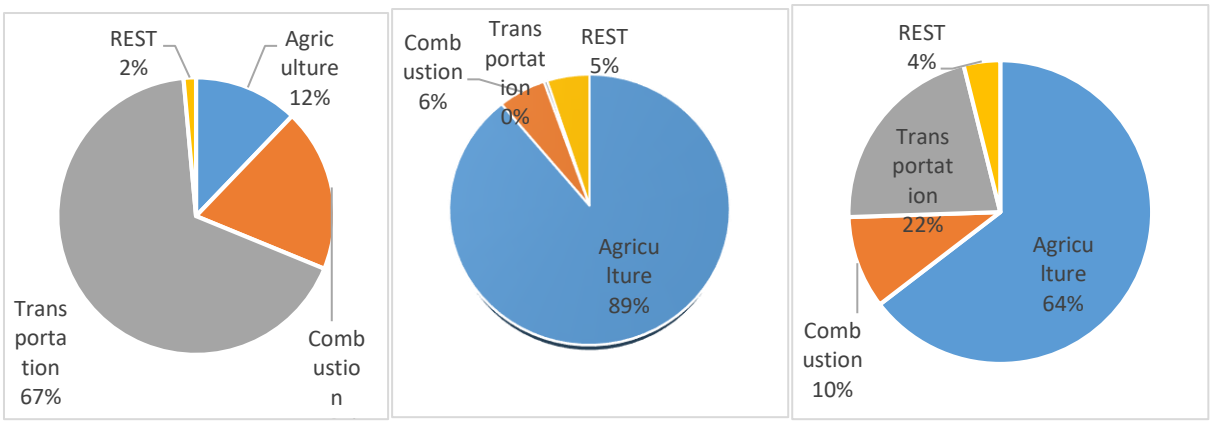


Fig. 2.16. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Lithuania into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.8 Emissions from Poland

Poland is the second largest contributor to total, oxidised and reduced nitrogen deposition into the Baltic Sea in 2014. The maps of annual emissions of oxidised and reduced nitrogen from Poland in 2014 are shown in Fig. 2.17.

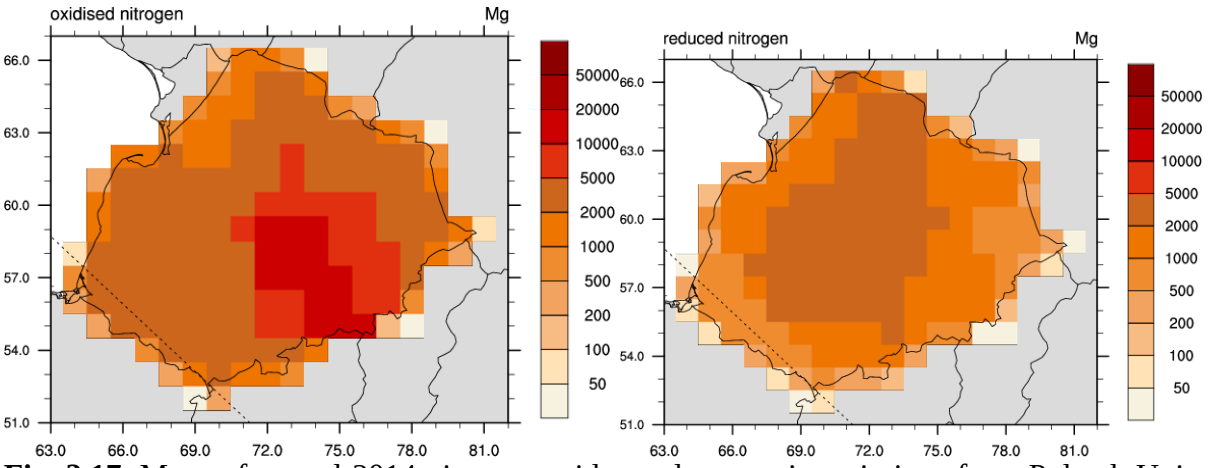


Fig. 2.17. Maps of annual 2014 nitrogen oxides and ammonia emissions from Poland. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Poland into four groups of sectors is shown in Fig. 2.18. Combustion (51%) is the major sector for nitrogen oxides emissions followed by Transportation (44%). Agriculture (99%) totally dominates ammonia emissions. Concerning total emissions of nitrogen, agriculture accounts for 50%, combustion for 26% and transportation for 22%.

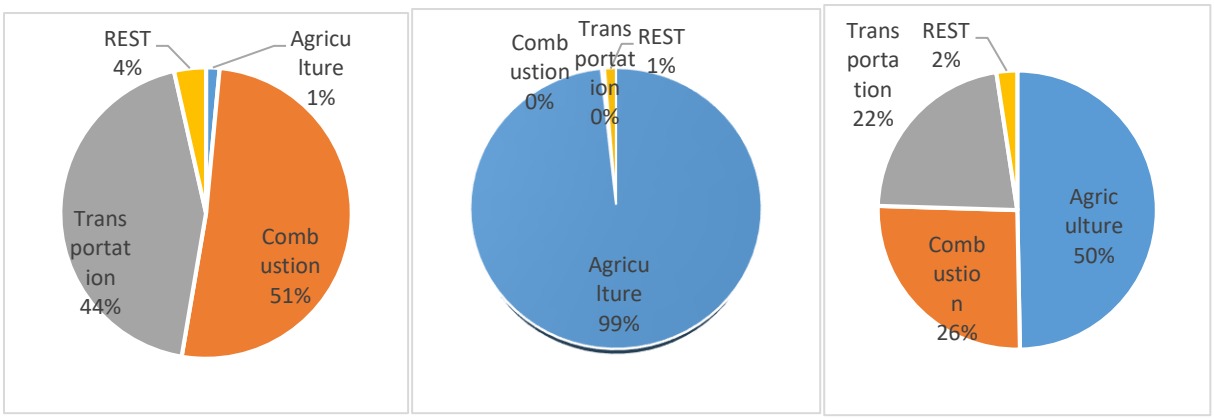


Fig. 2.18. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Poland into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.9 Emissions from Russia

Russia is the number six and eight contributor to total and reduced nitrogen deposition into the Baltic Sea and number 5 contributor to oxidised nitrogen deposition in 2014. The maps of annual emissions of oxidised and reduced nitrogen from Russia in 2014 are shown in Fig. 2.19.

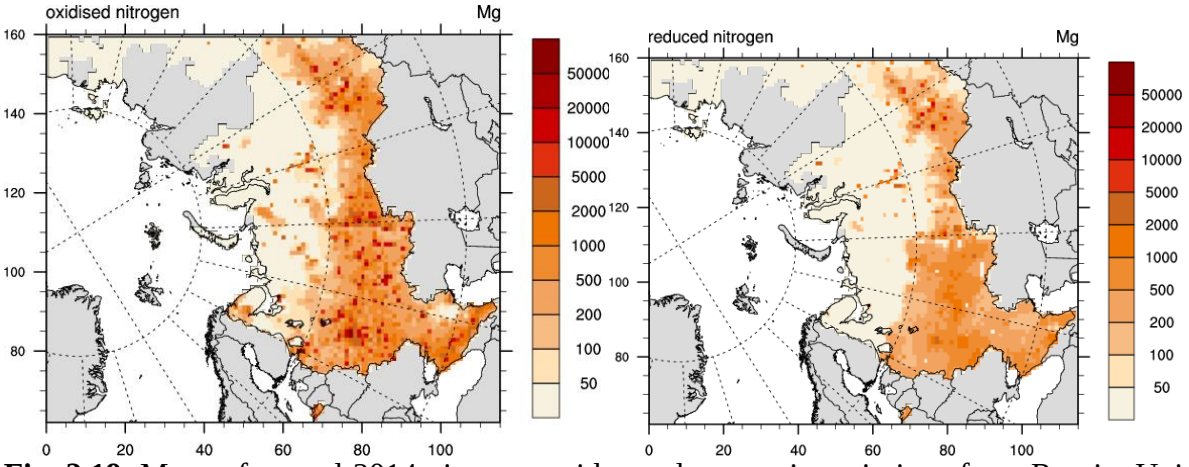


Fig. 2.19. Maps of annual 2014 nitrogen oxides and ammonia emissions from Russia. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Russia into four groups of sectors is shown in Fig. 2.20. Transportation (50%) is the main contributor to nitrogen oxides emissions followed by Combustion (45%). Contribution of agriculture to ammonia emissions is 91% and to total deposition of nitrogen it is 37%. Transportation (31%) and Combustion (27%) contribute to total nitrogen deposition on a similar level.

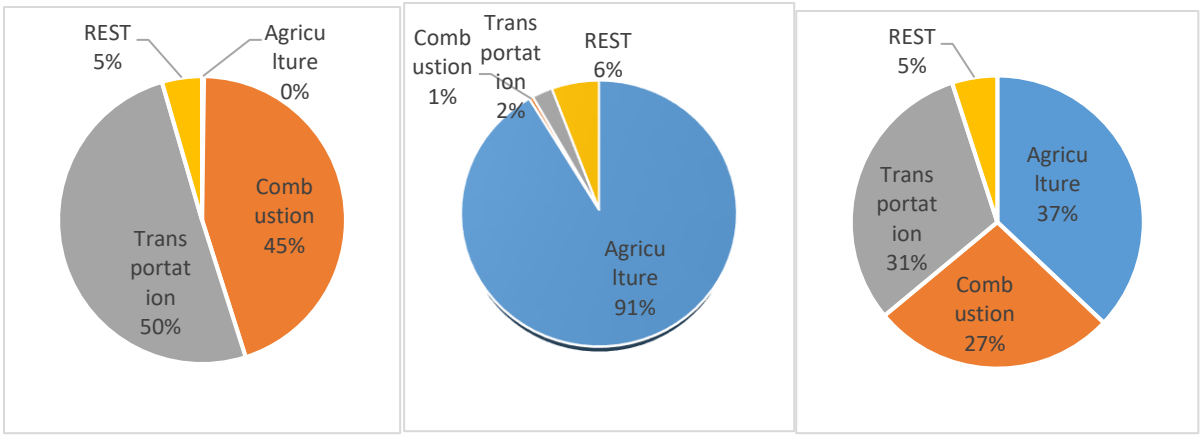


Fig. 2.20. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Russia into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.10 Emissions from Sweden

Sweden is the number five and four contributor to total and reduced nitrogen deposition into the Baltic Sea and number 7 contributor to oxidised nitrogen deposition in 2014. The maps of annual emissions of oxidised and reduced nitrogen from Sweden in 2014 are shown in Fig. 2.21.

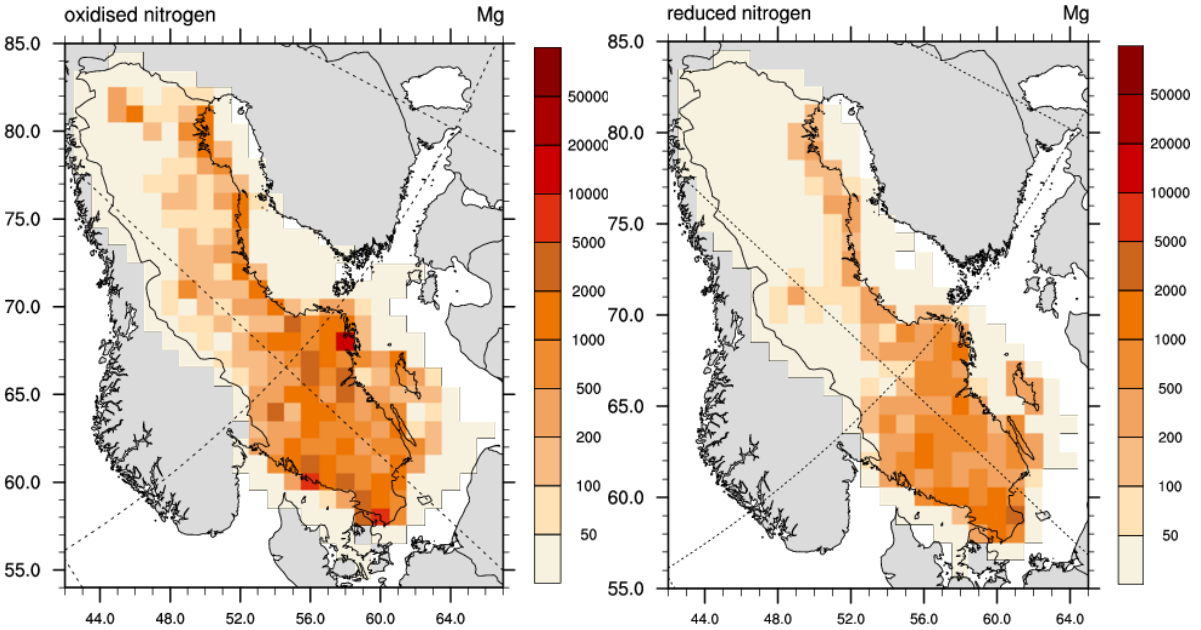


Fig. 2.21. Maps of annual 2014 nitrogen oxides and ammonia emissions from Sweden. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Sweden into four groups of sectors is shown in Fig. 2.22. Transportation (57%) is a prevailing contribution to nitrogen oxides emissions followed by combustion (23%). Agriculture (84%) is dominating ammonia emissions, but not to such extent as in other HELCOM countries. In the case of total nitrogen emissions is agriculture again with 48%, the largest emitter.

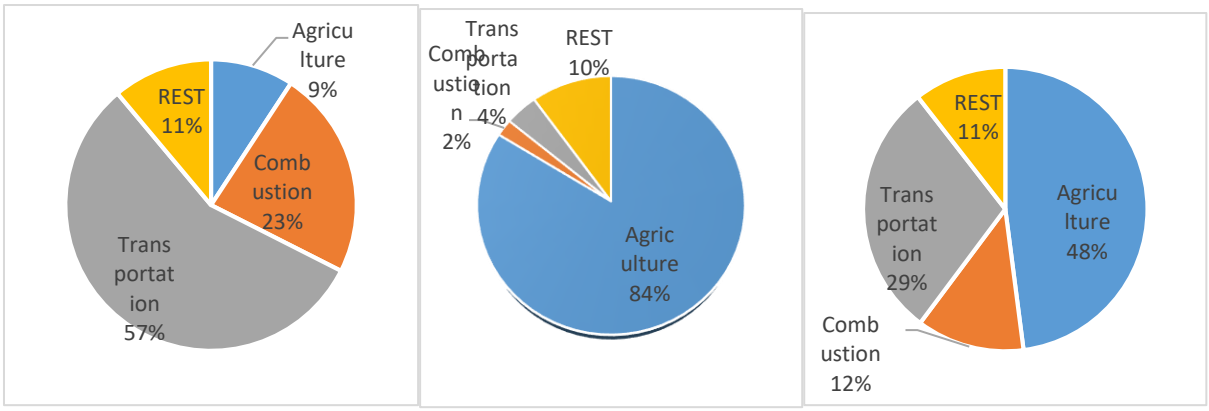


Fig. 2.22. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Sweden into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.11 Emissions from Belarus

Belarus is a very small contributor to total and oxidised nitrogen deposition into the Baltic Sea and number five contributor to reduced nitrogen deposition in 2014. The maps of annual emissions of oxidised and reduced nitrogen from Belarus in 2014 are shown in Fig. 2.23.

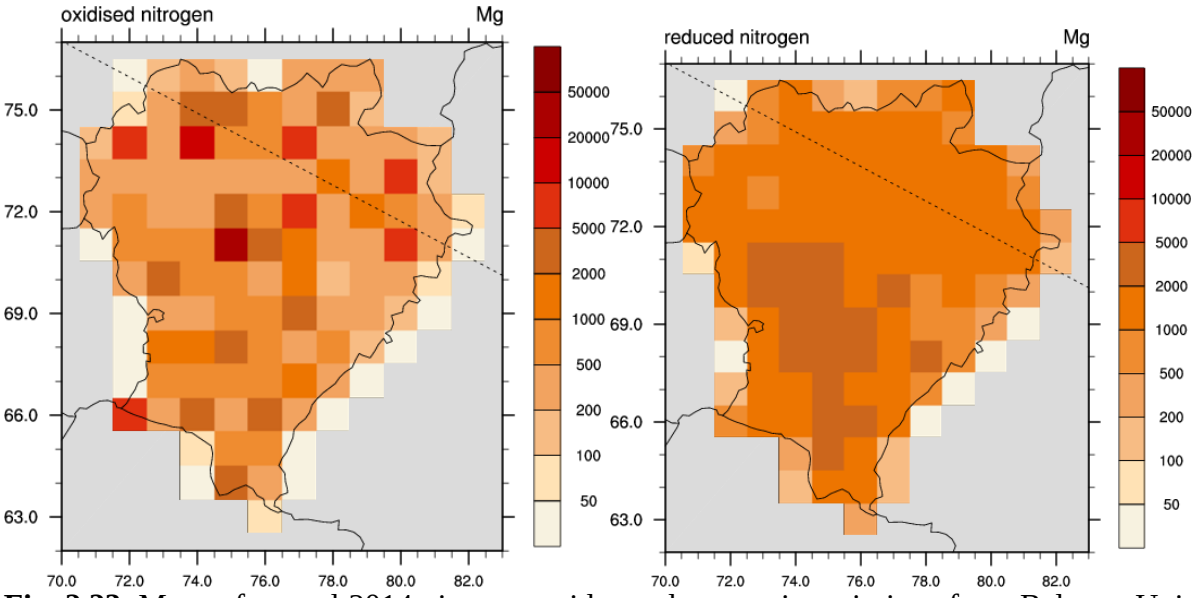


Fig. 2.23. Maps of annual 2014 nitrogen oxides and ammonia emissions from Belarus. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Belarus into four groups of sectors is shown in Fig. 2.24. In the case of nitrogen oxides emissions, transportation (45%) and combustion (43%) are on an equal level. Agriculture dominates both, ammonia emissions with 97% and total nitrogen emissions with 70%.

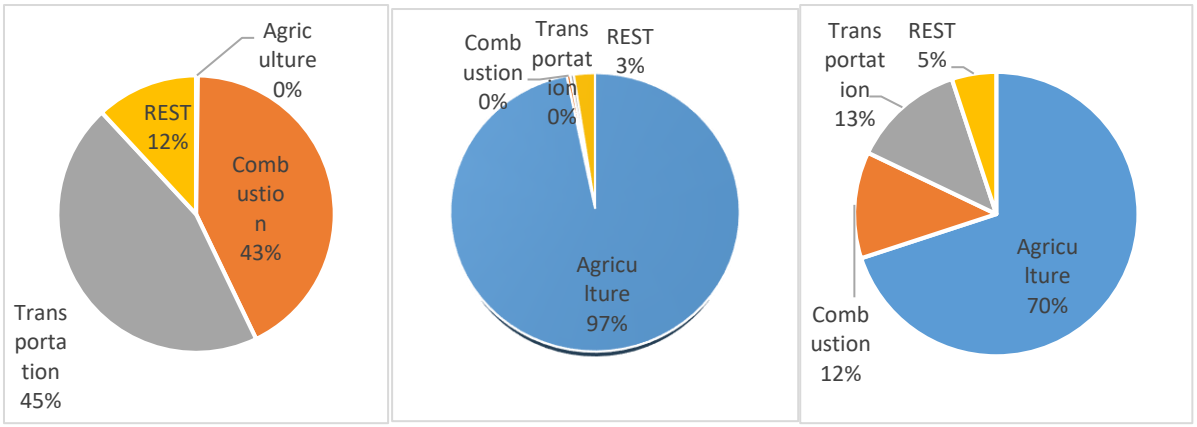


Fig. 2.24. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from Belarus into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.12 Emissions from France

France is the number nine and six contributor to total and reduced nitrogen deposition into the Baltic Sea and number 8 contributor to oxidised nitrogen deposition in 2014. The maps of annual emissions of oxidised and reduced nitrogen from France in 2014 are shown in Fig. 2.25.

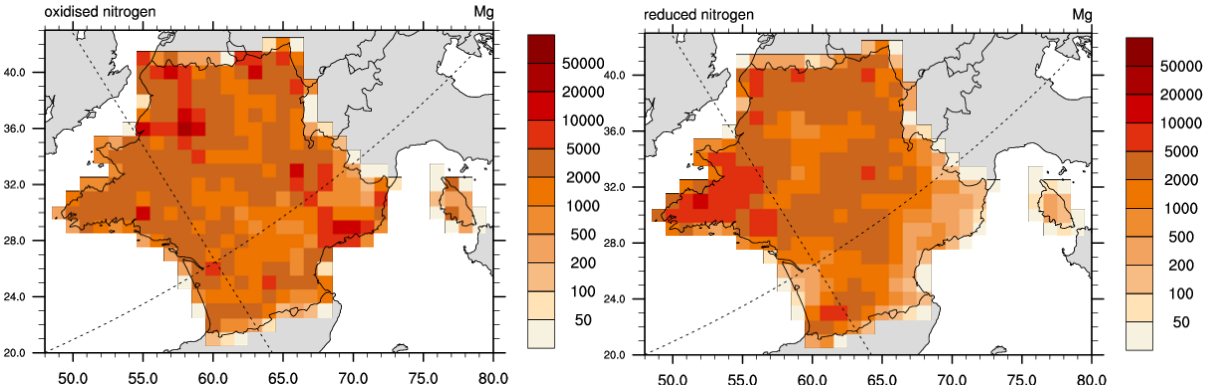


Fig. 2.25. Maps of annual 2014 nitrogen oxides and ammonia emissions from France. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from France into four groups of sectors is shown in Fig. 2.26. Contribution of transportation (73%) is very high to nitrogen oxides emissions, whereas agriculture dominates both, ammonia emissions (97%) and emissions of total nitrogen (67%).

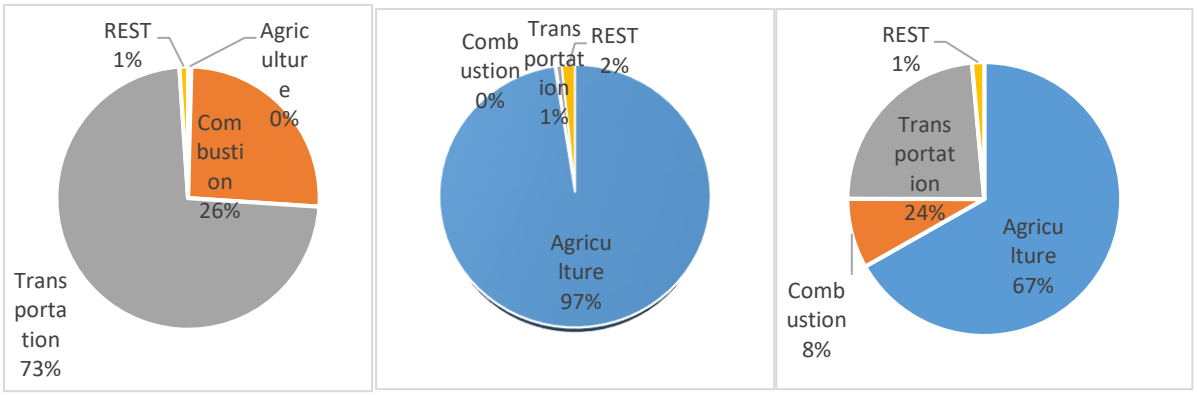


Fig. 2.26. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from France into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.13 Emissions from The Netherlands

The Netherlands is the number ten contributor to oxidised and reduced nitrogen deposition into the Baltic Sea and a very small contributor to total nitrogen deposition in 2014. The maps of annual emissions of oxidised and reduced nitrogen from the Netherlands in 2014 are shown in Fig. 2.27.

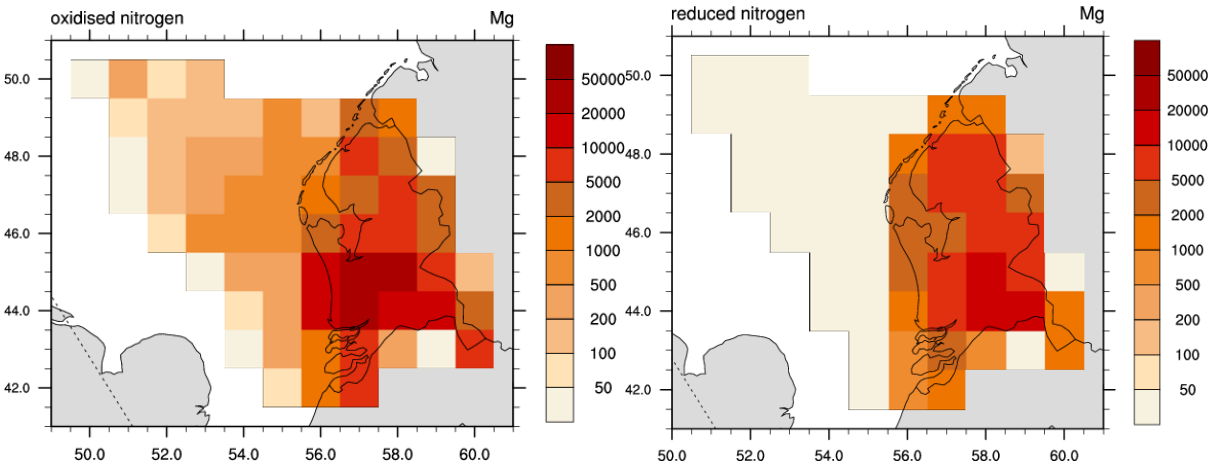


Fig. 2.27. Maps of annual 2014 nitrogen oxides and ammonia emissions from the Netherlands. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from the Netherlands into four groups of sectors is shown in Fig. 2.28. Contribution of transportation (63%) to nitrogen oxides emissions is also high for the Netherlands. Agriculture contributes to ammonia emissions with 86% and agriculture is the number one contributor to emissions of total nitrogen (53%).

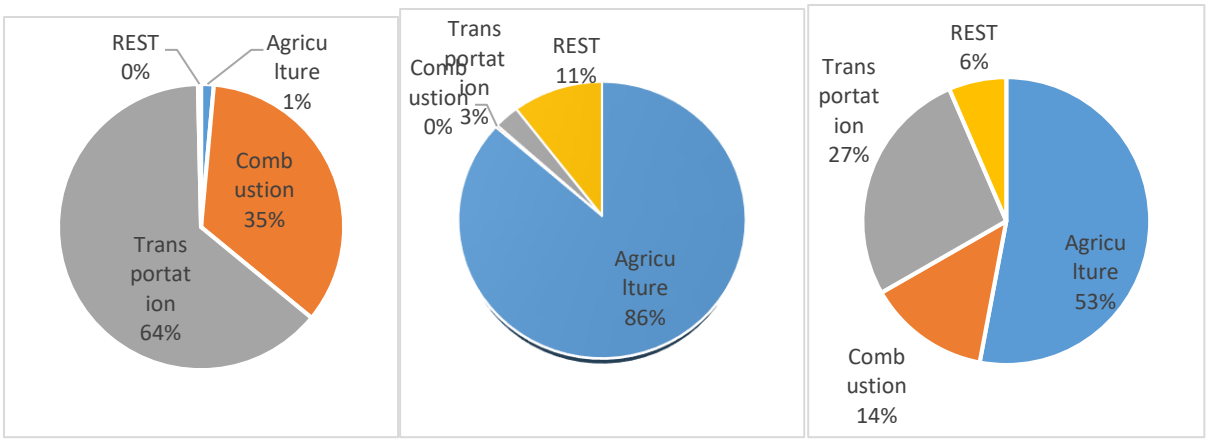


Fig. 2.28. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from the Netherlands into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.14 Emissions from the United Kingdom

The United Kingdom is a very small contributor to reduced nitrogen deposition into the Baltic Sea and number 6 and 8 contributor to oxidised and total nitrogen deposition in 2014. The maps of annual emissions of oxidised and reduced nitrogen from the United Kingdom in 2014 are shown in Fig. 2.29.

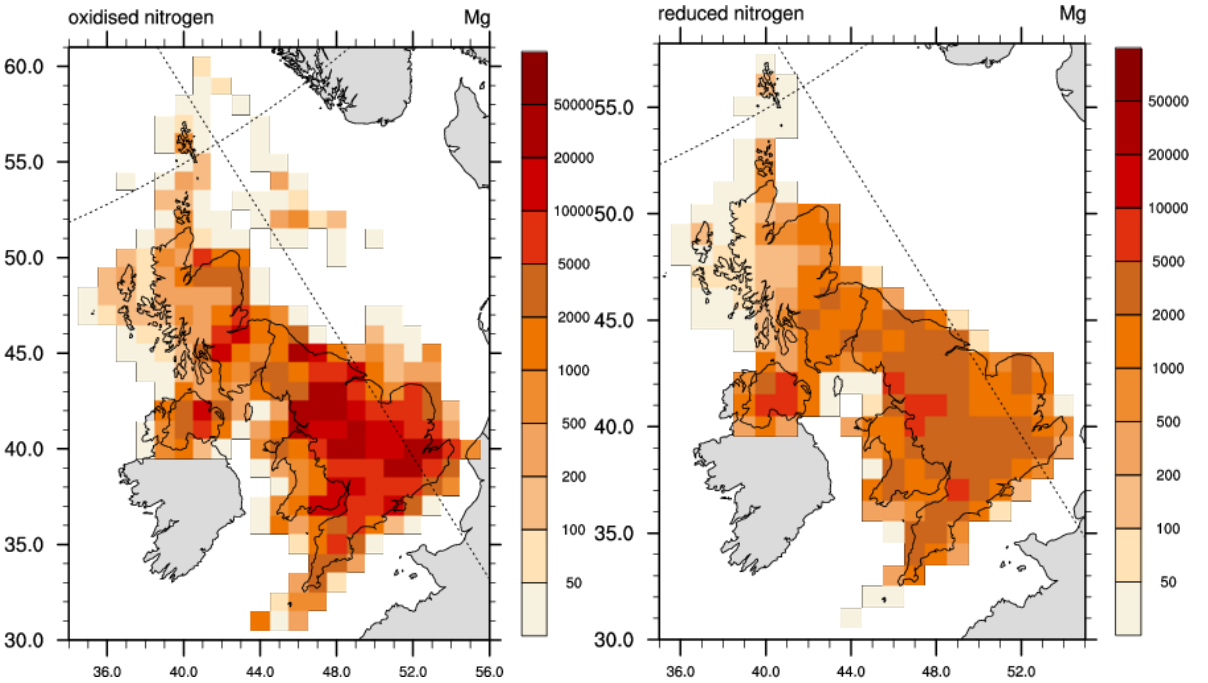


Fig. 2.29. Maps of annual 2014 nitrogen oxides and ammonia emissions from the United Kingdom. Units: tonnes per grid and year.

Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from the United Kingdom into four groups of sectors is shown in Fig. 2.30. Contributions of combustion (50%) and transportation (49%) are equal and they practically cover all nitrogen oxides emissions. As for the other countries, agriculture is the largest contributor to ammonia emissions. For emissions of total nitrogen, contributions of agriculture (37%) combustion

(29%) and transportation (28%) are on similar levels.

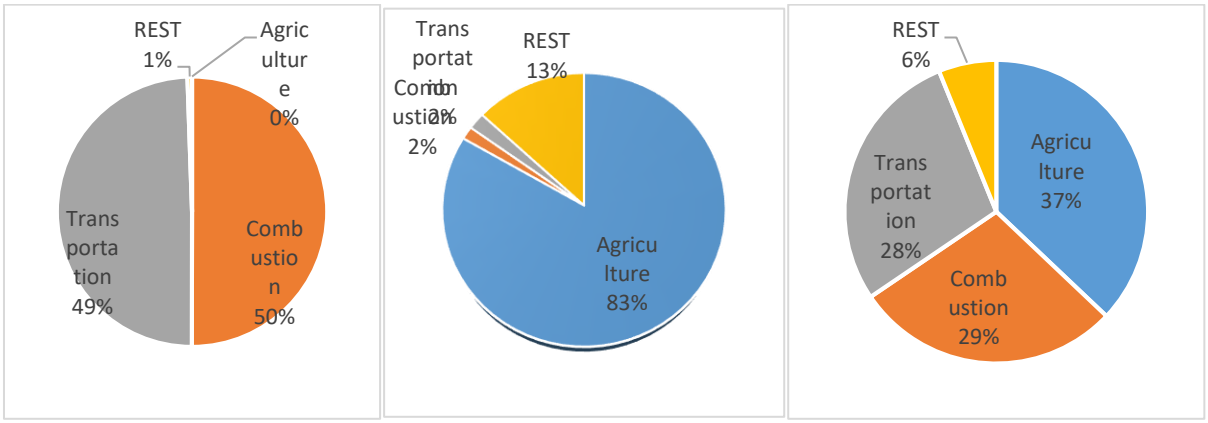


Fig. 2.30. Distribution of annual 2014 nitrogen oxides, ammonia and total nitrogen emissions from United Kingdom into four groups of sectors: agriculture, combustion, transportation and remaining sectors - REST.

2.15 Emissions from ship traffic on the Baltic Sea

The only source of nitrogen emissions from the Baltic Sea basin is ship traffic which contributes significantly to nitrogen deposition and especially oxidised nitrogen deposition. Nitrogen oxides emissions from international ship traffic belong to category transportation and only to one SNAP sector 8. Emissions from ship traffic on the Baltic Sea are among the most important contributors (contributor No. 3) to oxidised nitrogen deposition and total nitrogen deposition (contributor No. 4) into the Baltic Sea basin.

Annual nitrogen oxides emission from ship traffic on the Baltic Sea and the North Sea in 2014 is 82 kt N. This number corresponds to 0.44% of annual 2014 nitrogen oxides emission from all EMEP sources. This number may not look very large compared to other sources, e.g. Russia or Germany, but a part of the ship emissions contributing to nitrogen deposition into the Baltic Sea is much higher compared to the two mentioned countries. A map with nitrogen oxides emissions from ship traffic on the Baltic Sea is shown in Fig. 2.31.

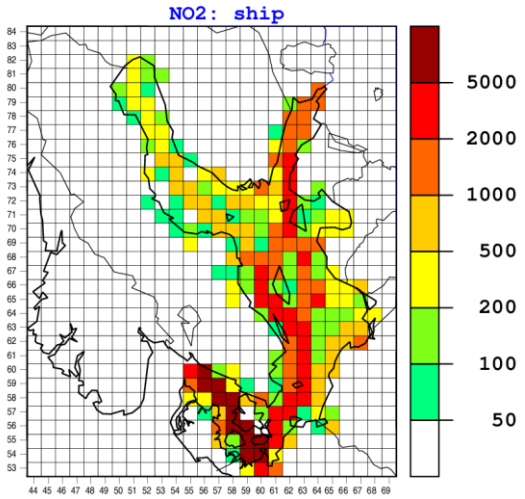


Fig. 2.31. Map of nitrogen oxides emissions from ship traffic on the Baltic Sea in 2014. Units: tonnes per grid and year.

2.16 Emissions from ship traffic on the North Sea

Ship traffic on the North Sea is a major distant contributor to oxidised and total nitrogen deposition into the Baltic Sea. Annual nitrogen oxides emission from ship traffic on the North Sea in 2014 is 196 kt N and corresponds to 1.06% of annual 2014 nitrogen oxides emission from all EMEP sources. A map with nitrogen oxidised emissions from ship traffic on the North Sea is shown in Fig. 2.32.

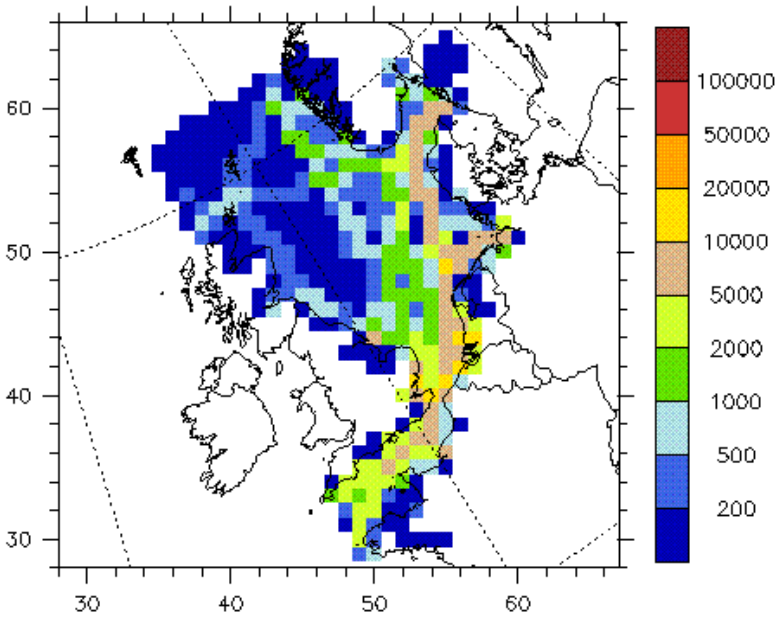


Fig. 2.32. Map of nitrogen oxides emissions from ship traffic on the North Sea in 2014. Units: tonnes per grid and year.

3. Contributions from countries and sectors

In this Chapter we present and discuss the combined contributions to deposition on the Baltic Sea and its sub-basins from each country and selected group of sectors within each country. In addition, we present contributions from ship traffic on the Baltic Sea and on the North Sea. Finally, the contributions from all EMEP sources and selected groups of sectors within EMEP is included here. Here we are source oriented and the main question is: where the nitrogen emitted from the considered source and group of sector is deposited? It should be mentioned that due to non-linear effects the calculated sum of contributions from individual groups of sectors can be slightly different from calculated deposition from all sources. However, these differences are small not exceeding 3%.

3.1 Contributions from Denmark

Maps of nitrogen deposition from four selected groups of emissions sectors in Denmark are shown in Fig. 3.1.

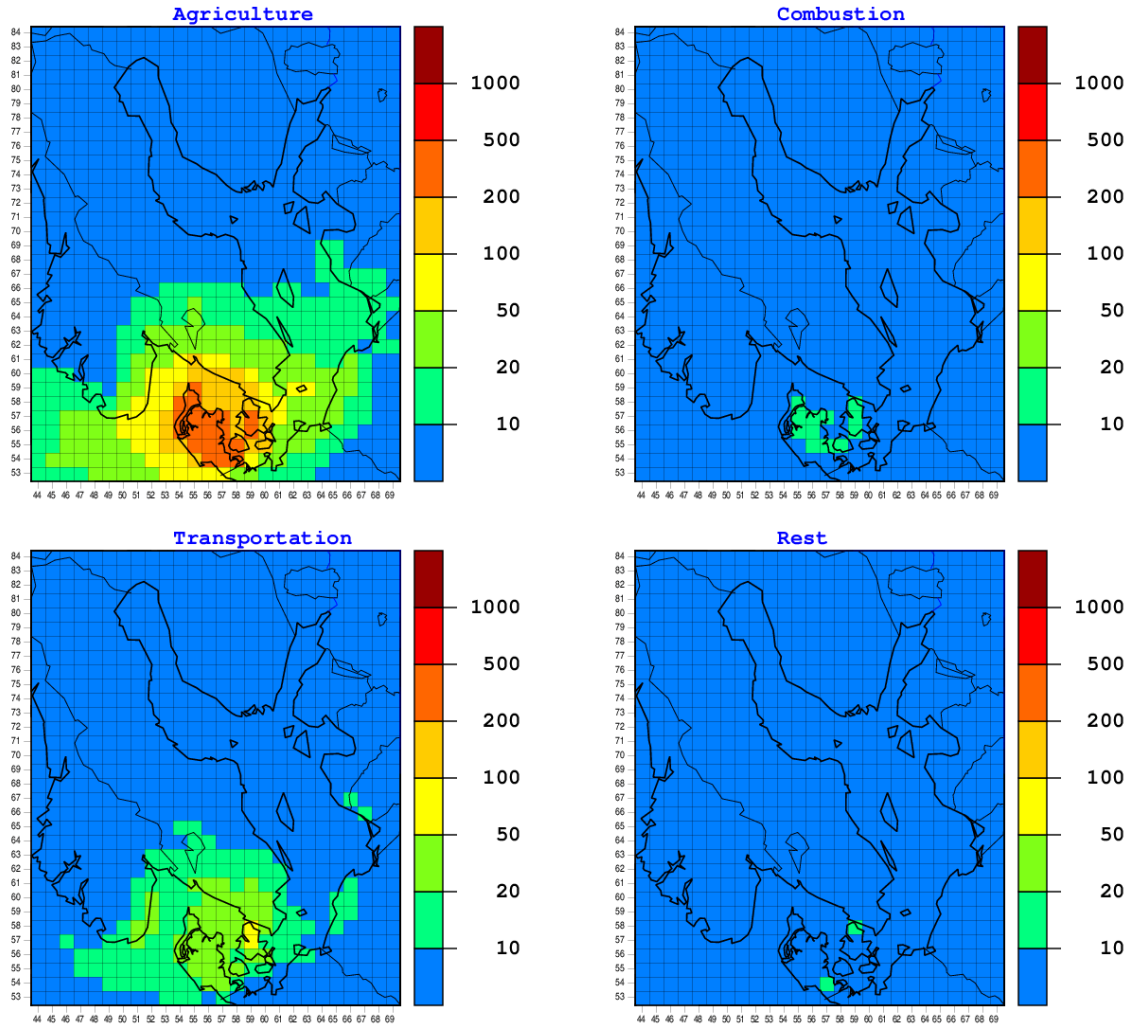


Fig. 3.1. Maps of nitrogen deposition from four selected groups of emissions sectors in Denmark. Units: tonnes N per grid.

The contributions from Denmark to oxidised, reduced and total nitrogen to individual Baltic Sea sub-basins in 2014 are given in Table 3.1.

Table 3.1. Contributions from Denmark to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.009	0.322	0.012	0.049	0.017	0.017	0.087	0.012	0.074	0.599
Combustion	0.017	0.422	0.029	0.073	0.029	0.028	0.123	0.012	0.056	0.789
Transportation	0.046	1.395	0.071	0.198	0.081	0.085	0.518	0.068	0.278	2.740
REST	0.000	0.004	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.007
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.055	3.240	0.072	0.250	0.091	0.112	3.748	0.239	2.612	10.419
Combustion	0.001	0.074	0.002	0.005	0.002	0.002	0.063	0.010	0.053	0.212
Transportation	0.001	0.066	0.001	0.005	0.002	0.002	0.066	0.014	0.048	0.205
REST	0.001	0.065	0.001	0.005	0.002	0.002	0.065	0.011	0.038	0.190
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.064	3.562	0.084	0.299	0.108	0.129	3.835	0.251	2.686	11.018
Combustion	0.018	0.496	0.031	0.078	0.031	0.030	0.186	0.022	0.109	1.001
Transportation	0.047	1.461	0.072	0.203	0.083	0.087	0.584	0.082	0.326	2.945
REST	0.001	0.069	0.001	0.006	0.002	0.002	0.066	0.011	0.039	0.197

The relative contributions from Denmark to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.2.

Agriculture dominates contributions from Denmark. The largest contributions can be noticed to nitrogen deposition in Kattegat, Baltic Proper and Western Baltic sub-basins. There is also a significant contribution from transportation first of all to Baltic Proper, then to Kattegat and to Western Baltic sub-basins. Contribution from combustion is much lower in all sub-basins.

Fig. 3.2. The relative contributions from Denmark to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from Denmark.

3.2 Contributions from Estonia

Maps of nitrogen deposition from four selected groups of emissions sectors in Estonia are shown in Fig. 3.3.

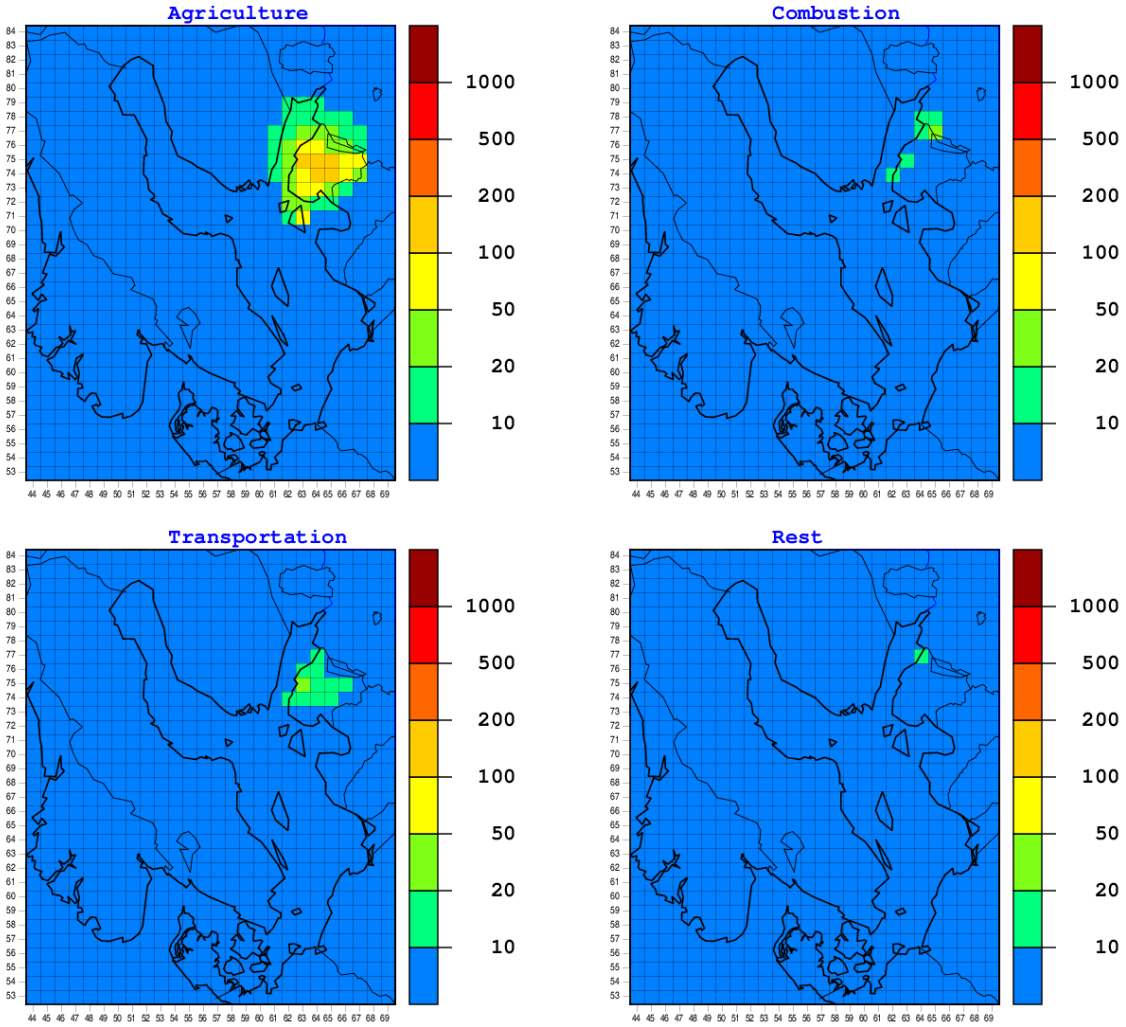


Fig. 3.3. Maps of nitrogen deposition from four selected groups of emissions sectors in Estonia. Units: tonnes N per grid.

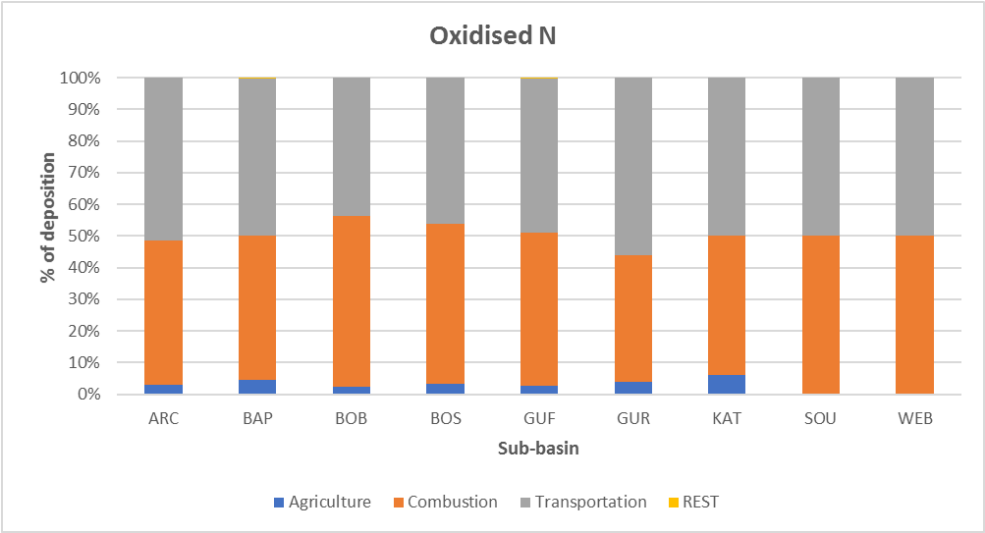
The contributions from Estonia to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.2.

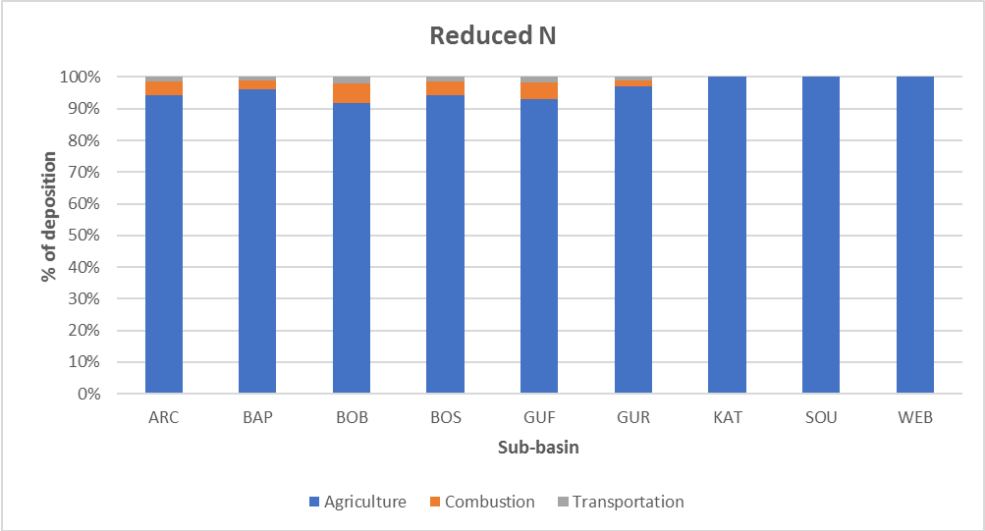
Table 3.2. Contributions from Estonia to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.002	0.015	0.002	0.006	0.010	0.004	0.001	0.000	0.000	0.040
Combustion	0.031	0.155	0.043	0.094	0.181	0.040	0.007	0.001	0.003	0.555
Transportation	0.035	0.169	0.035	0.086	0.183	0.056	0.008	0.001	0.003	0.576
REST	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.002
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.065	0.406	0.045	0.134	0.668	0.255	0.013	0.002	0.006	1.594
Combustion	0.003	0.012	0.003	0.006	0.038	0.005	0.000	0.000	0.000	0.067
Transportation	0.001	0.005	0.001	0.002	0.013	0.003	0.000	0.000	0.000	0.025
REST	0.002	0.007	0.002	0.004	0.048	0.002	0.000	0.000	0.000	0.065
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.067	0.421	0.047	0.140	0.678	0.259	0.014	0.002	0.006	1.634
Combustion	0.034	0.167	0.046	0.100	0.219	0.045	0.007	0.001	0.003	0.622
Transportation	0.036	0.174	0.036	0.088	0.196	0.059	0.008	0.001	0.003	0.601
REST	0.002	0.008	0.002	0.004	0.049	0.002	0.000	0.000	0.000	0.067

The relative contributions from Estonia to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.4.

As in the case of Denmark, agriculture dominates contributions from Estonia as well. The largest contributions can be noticed to Gulf of Finland, Baltic Proper and Gulf of Riga sub-basins. Contribution from combustion and transportation is on a similar level in all sub-basins, but lower.





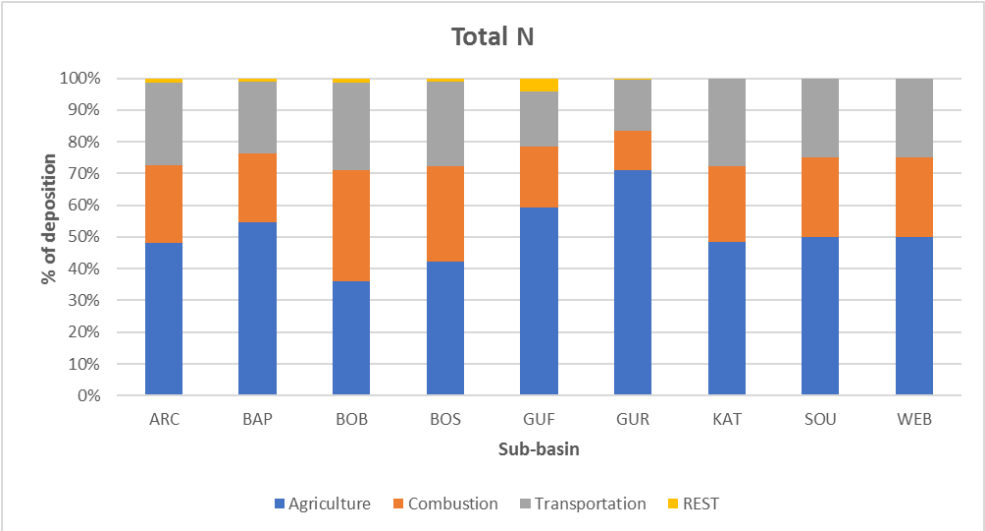


Fig. 3.4. The relative contributions from Estonia to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from Estonia.

3.3 Contributions from Finland

Maps of nitrogen deposition from four selected groups of emissions sectors in Finland are shown in Fig. 3.5.

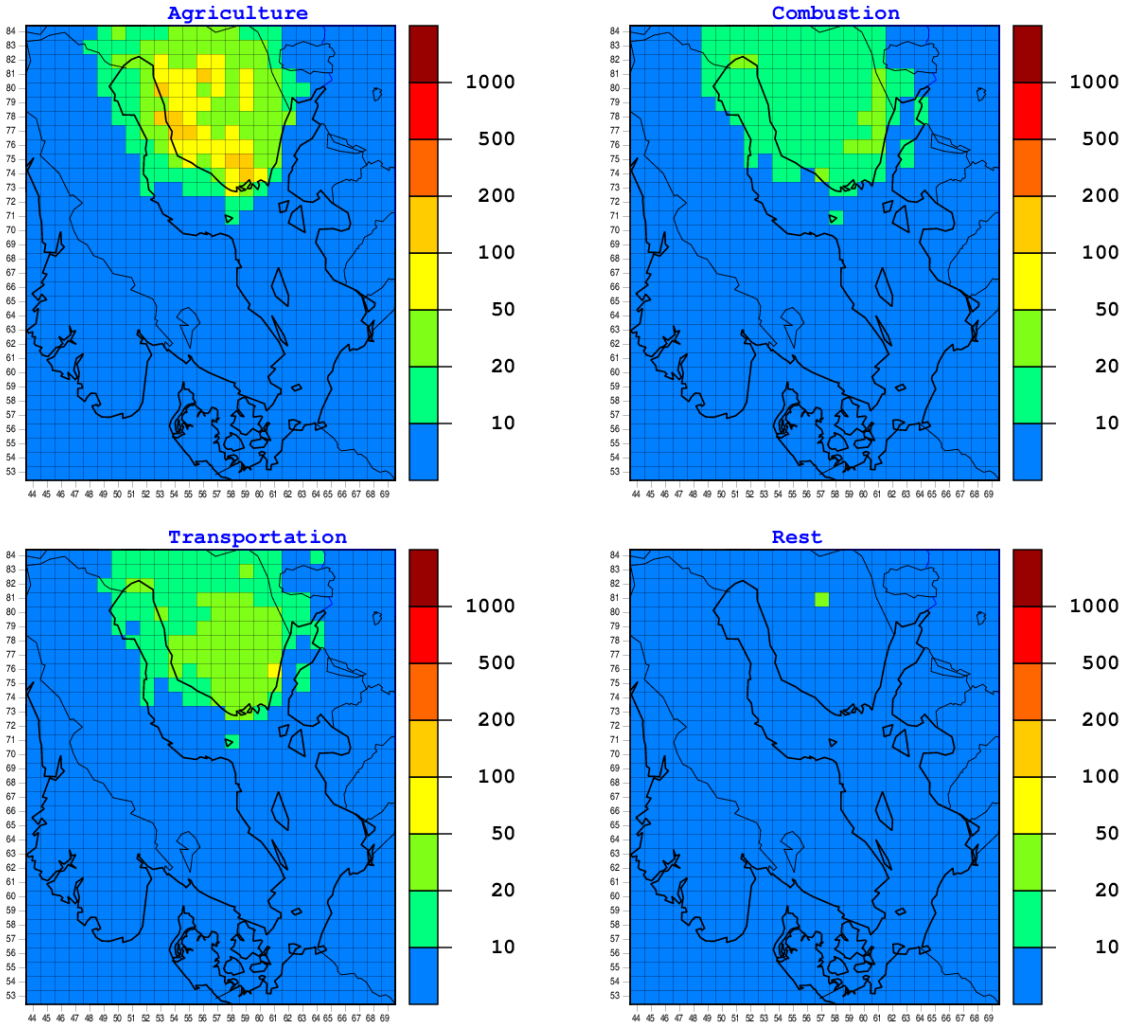


Fig. 3.5. Maps of nitrogen deposition from four selected groups of emissions sectors in Finland. Units: tonnes N per grid.

The contributions from Finland to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.3.

Table 3.3. Contributions from Finland to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001
Combustion	0.099	0.411	0.402	0.490	0.278	0.075	0.015	0.002	0.007	1.779
Transportation	0.136	0.437	0.428	0.533	0.327	0.082	0.015	0.002	0.007	1.967
REST	0.004	0.010	0.005	0.011	0.006	0.002	0.000	0.000	0.000	0.038
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.281	0.377	1.208	0.886	0.315	0.060	0.013	0.002	0.006	3.148
Combustion	0.034	0.025	0.043	0.057	0.017	0.002	0.000	0.000	0.000	0.178
Transportation	0.014	0.018	0.031	0.030	0.037	0.003	0.001	0.000	0.000	0.134
REST	0.026	0.022	0.020	0.043	0.027	0.004	0.000	0.000	0.000	0.142
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.281	0.377	1.208	0.887	0.315	0.060	0.013	0.002	0.006	3.149
Combustion	0.133	0.436	0.445	0.547	0.295	0.077	0.015	0.002	0.007	1.957
Transportation	0.150	0.455	0.459	0.563	0.364	0.085	0.016	0.002	0.007	2.101
REST	0.030	0.032	0.025	0.054	0.033	0.006	0.000	0.000	0.000	0.180

The relative contributions from Finland to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.6.

In the case of Finland, agriculture dominates in the two sub-basins: Bay of Bothnia and Bothnian Sea. Transportation is the largest contributor in remaining sub-basins, but combustion is on the same level.

Fig. 3.6. The relative contributions from Finland to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from Finland.

3.4 Contributions from Germany

Maps of nitrogen deposition from four selected groups of emissions sectors in Germany are shown in Fig. 3.7.

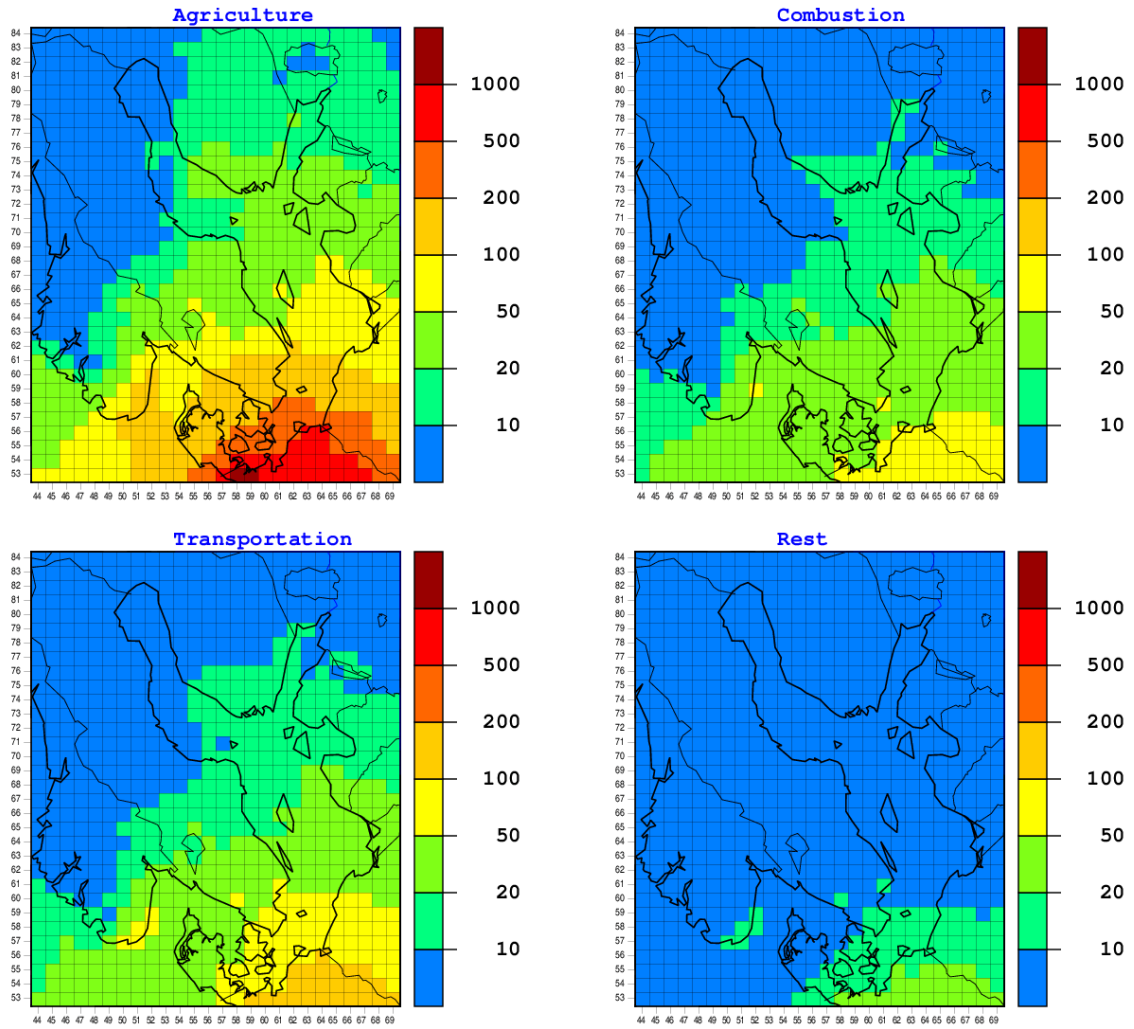


Fig. 3.7. Maps of nitrogen deposition from four selected groups of emissions sectors in Germany. Units: tonnes N per grid.

The contributions from Germany to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.4.

Table 3.4. Contributions from Germany to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.051	1.806	0.036	0.173	0.093	0.071	0.246	0.030	0.276	2.782
Combustion	0.168	5.304	0.166	0.518	0.301	0.253	0.745	0.092	0.800	8.347
Transportation	0.188	6.505	0.171	0.561	0.331	0.283	0.891	0.114	1.032	10.076
REST	0.030	0.941	0.027	0.089	0.052	0.043	0.128	0.016	0.141	1.467
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.277	16.704	0.221	0.879	0.492	0.448	2.998	0.409	7.11	29.538
Combustion	0.003	0.138	0.002	0.009	0.005	0.005	0.023	0.003	0.043	0.231
Transportation	0.006	0.335	0.004	0.015	0.01	0.009	0.05	0.007	0.111	0.547
REST	0.007	0.358	0.005	0.021	0.012	0.011	0.061	0.009	0.119	0.603
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.328	18.510	0.257	1.052	0.585	0.519	3.244	0.439	7.386	32.320
Combustion	0.171	5.442	0.168	0.527	0.306	0.258	0.768	0.095	0.843	8.578
Transportation	0.194	6.840	0.175	0.576	0.341	0.292	0.941	0.121	1.143	10.623
REST	0.037	1.299	0.032	0.110	0.064	0.054	0.189	0.025	0.260	2.070

The relative contributions from Germany to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.8.

Compared to other countries, relative contribution of agriculture from Germany is even larger. Agriculture dominates in all sub-basins and especially in the Baltic Proper sub-basin. The contributions from combustion and transportation are very similar.

Fig. 3.8. The relative contributions from Germany to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from Germany.

3.5 Contributions from Latvia

Maps of nitrogen deposition from four selected groups of emissions sectors in Latvia are shown in Fig. 3.9.

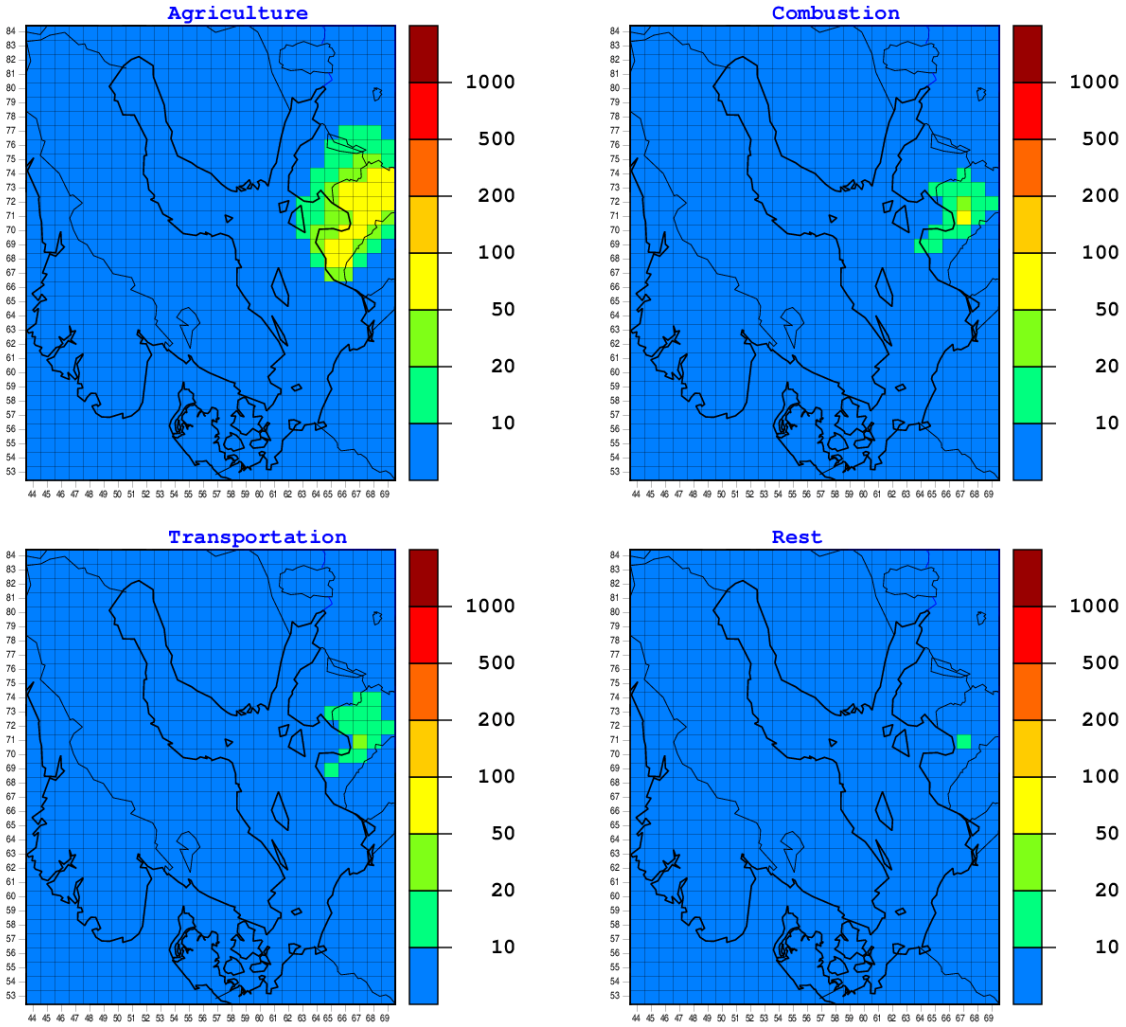


Fig. 3.9. Maps of nitrogen deposition from four selected groups of emissions sectors in Latvia. Units: tonnes N per grid.

The contributions from Latvia to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.5.

Table 3.5. Contributions from Latvia to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.005	0.075	0.005	0.014	0.017	0.024	0.003	0.000	0.001	0.144
Combustion	0.021	0.232	0.032	0.067	0.064	0.074	0.011	0.001	0.003	0.505
Transportation	0.025	0.305	0.029	0.069	0.077	0.111	0.011	0.002	0.006	0.635
REST	0.004	0.078	0.003	0.011	0.007	0.011	0.002	0.000	0.001	0.117
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.040	0.724	0.036	0.099	0.144	0.420	0.020	0.003	0.010	1.496
Combustion	0.008	0.125	0.009	0.022	0.028	0.080	0.004	0.000	0.001	0.277
Transportation	0.001	0.013	0.001	0.002	0.003	0.008	0.000	0.000	0.000	0.028
REST	0.003	0.046	0.003	0.007	0.011	0.026	0.001	0.000	0.001	0.098
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.045	0.799	0.041	0.113	0.161	0.444	0.023	0.003	0.011	1.640
Combustion	0.029	0.357	0.041	0.089	0.092	0.154	0.015	0.001	0.004	0.782
Transportation	0.026	0.318	0.030	0.071	0.080	0.119	0.011	0.002	0.006	0.663
REST	0.007	0.124	0.006	0.018	0.018	0.037	0.003	0.000	0.002	0.215

The relative contributions from Latvia to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.10.

Agriculture dominates again in all sub-basins in the case of Latvia. Combustion is the second largest contributor and contributions from transportation are only slightly lower. Main contributions from Latvia can be noticed in the Baltic Proper and Gulf of Riga sub-basins.

Fig. 3.10. The relative contributions from Latvia to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from Latvia.

3.6 Contributions from Lithuania

Maps of nitrogen deposition from four selected groups of emissions sectors in Lithuania are shown in Fig. 3.11.

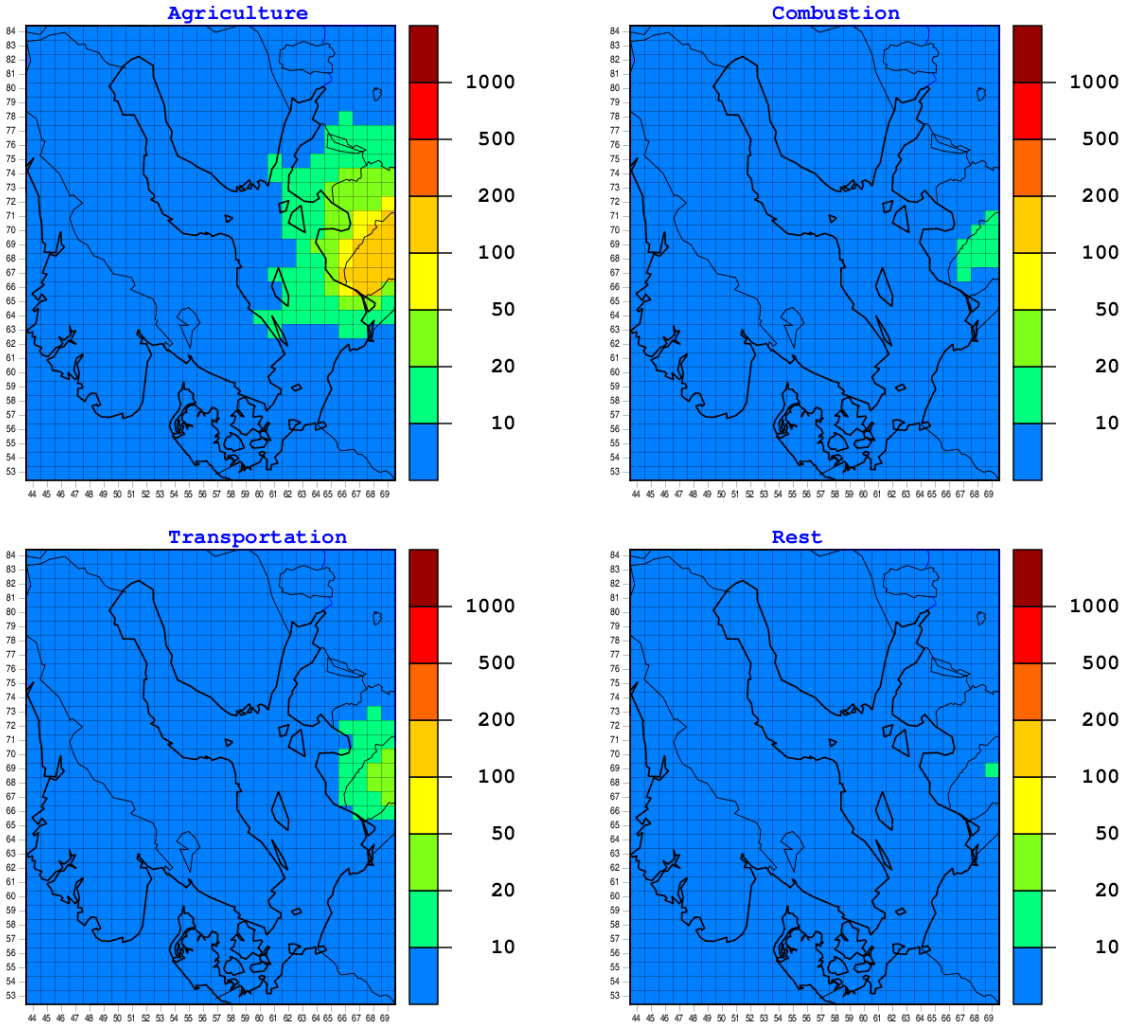


Fig. 3.11. Maps of nitrogen deposition from four selected groups of emissions sectors in Lithuania. Units: tonnes N per grid.

The contributions from Lithuania to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.6.

Table 3.6. Contributions from Lithuania to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.007	0.150	0.006	0.020	0.020	0.024	0.008	0.001	0.004	0.240
Combustion	0.013	0.183	0.016	0.038	0.034	0.036	0.013	0.001	0.004	0.338
Transportation	0.039	0.655	0.045	0.106	0.106	0.127	0.038	0.004	0.014	1.134
REST	0.001	0.011	0.001	0.002	0.002	0.003	0.001	0.000	0.000	0.021
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.076	2.042	0.064	0.178	0.228	0.377	0.079	0.010	0.034	3.088
Combustion	0.007	0.150	0.007	0.017	0.018	0.028	0.008	0.001	0.002	0.238
Transportation	0.000	0.009	0.000	0.001	0.001	0.002	0.000	0.000	0.000	0.013
REST	0.005	0.121	0.005	0.012	0.016	0.023	0.005	0.000	0.002	0.189
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.083	2.192	0.070	0.198	0.248	0.401	0.087	0.011	0.038	3.328
Combustion	0.020	0.333	0.023	0.055	0.052	0.064	0.021	0.002	0.006	0.576
Transportation	0.039	0.664	0.045	0.107	0.107	0.129	0.038	0.004	0.014	1.147
REST	0.006	0.132	0.006	0.014	0.018	0.026	0.006	0.000	0.002	0.210

The relative contributions from Lithuania to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.12.

Agriculture dominates the contribution from Lithuania to all sub-basins followed by transportation and combustion. Gulf of Finland and Baltic Proper are the two sub-basins with most significant contribution from Lithuania.

Fig. 3.12. The relative contributions from Lithuania to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from Lithuania.

3.7 Contributions from Poland

Maps of nitrogen deposition from four selected groups of emissions sectors in Poland are shown in Fig. 3.13.

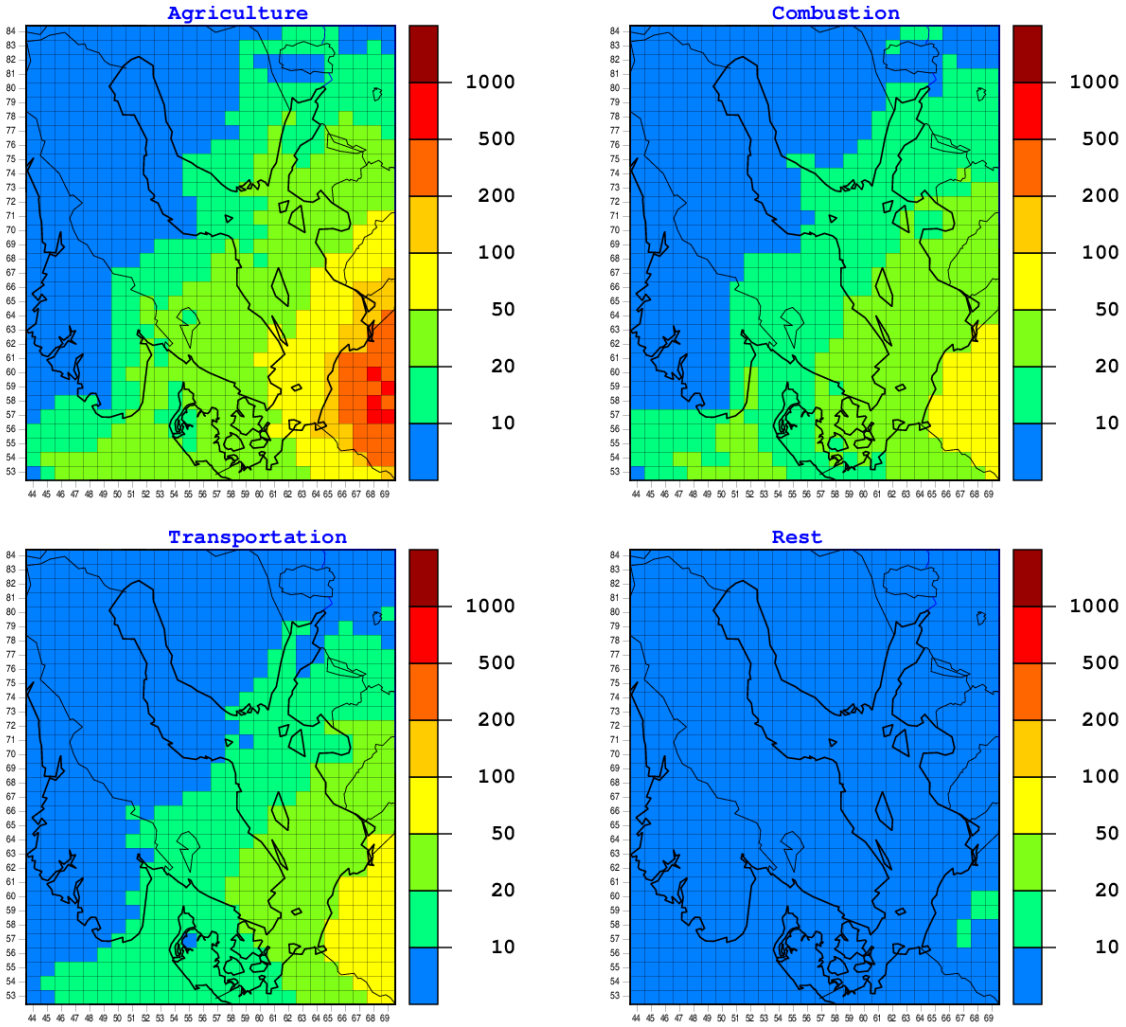


Fig. 3.13. Maps of nitrogen deposition from four selected groups of emissions sectors in Poland. Units: tonnes N per grid.

The contributions from Poland to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.7.

Table 3.7. Contributions from Poland to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.005	0.210	0.003	0.014	0.013	0.013	0.014	0.002	0.013	0.287
Combustion	0.188	5.503	0.190	0.608	0.404	0.364	0.475	0.059	0.401	8.192
Transportation	0.149	5.105	0.142	0.461	0.328	0.325	0.359	0.050	0.317	7.236
REST	0.012	0.390	0.011	0.037	0.026	0.026	0.029	0.004	0.025	0.560
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.230	11.861	0.178	0.635	0.561	0.616	0.661	0.093	0.639	15.474
Combustion	0.001	0.023	0.000	0.002	0.001	0.001	0.002	0.000	0.002	0.032
Transportation	0.001	0.032	0.001	0.002	0.001	0.001	0.002	0.000	0.002	0.042
REST	0.003	0.159	0.003	0.009	0.007	0.007	0.010	0.001	0.010	0.209
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.235	12.071	0.181	0.649	0.574	0.629	0.675	0.095	0.652	15.761
Combustion	0.189	5.526	0.190	0.610	0.405	0.365	0.477	0.059	0.403	8.224
Transportation	0.150	5.137	0.143	0.463	0.329	0.326	0.361	0.050	0.319	7.278
REST	0.015	0.549	0.014	0.046	0.033	0.033	0.039	0.005	0.035	0.769

The relative contributions from Poland to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.14.

Agriculture is the main contributor to all sub-basins except one (Bay of Bothnia), in the case of Poland. Next is combustion followed closely by transportation. Poland mainly contributes to Baltic Proper sub-basin.

Fig. 3.14. The relative contributions from Poland to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from Poland.

3.8 Contributions from Russia

Maps of nitrogen deposition from four selected groups of emissions sectors in Russia are shown in Fig. 3.15.

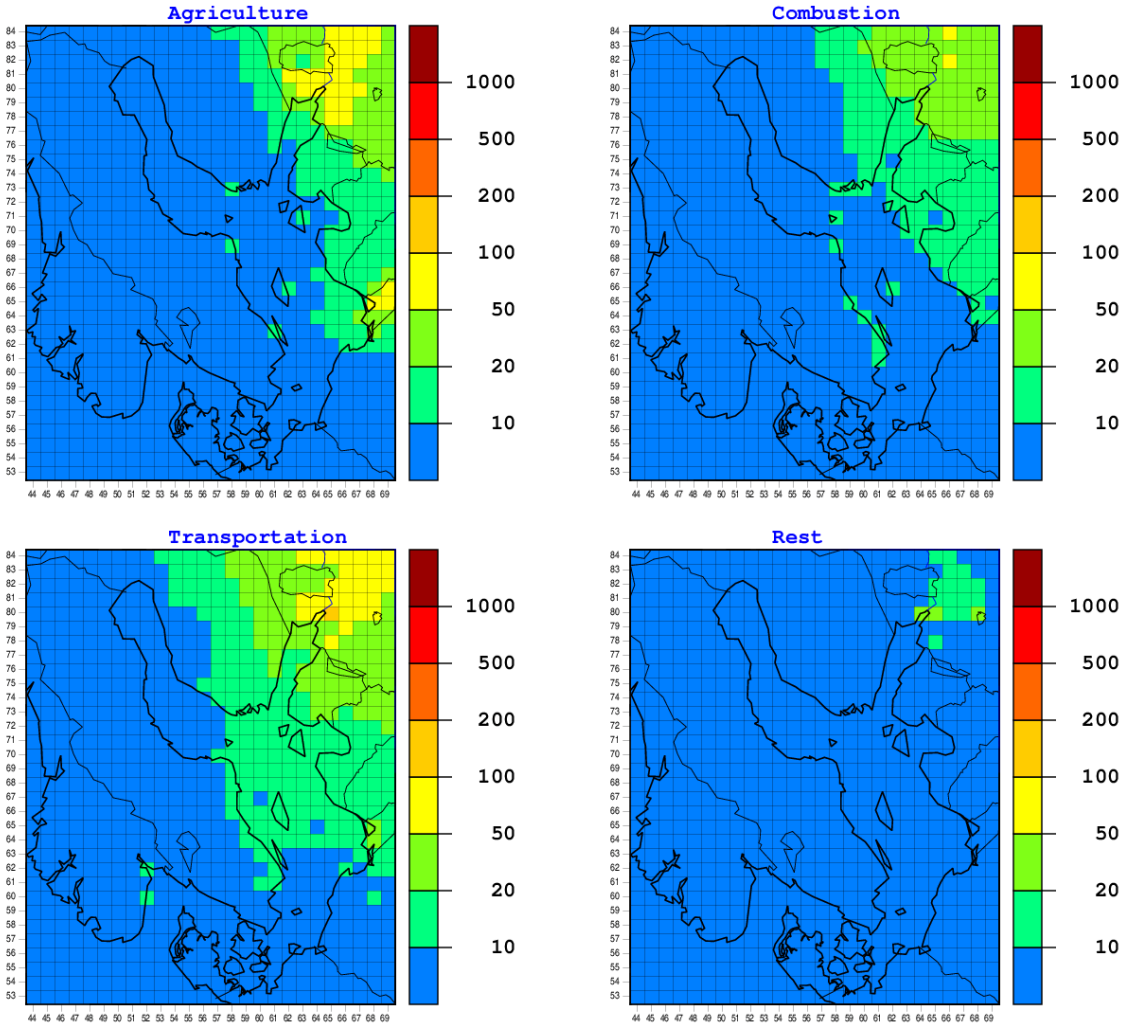


Fig. 3.15. Maps of nitrogen deposition from four selected groups of emissions sectors in Russia. Units: tonnes N per grid.

The contributions from Russia to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.8.

Table 3.8. Contributions from Russia to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0,001	0,009	0,001	0,003	0,002	0,001	0,001	0,000	0,000	0,018
Combustion	0,124	1,624	0,143	0,400	0,409	0,216	0,111	0,012	0,055	3,094
Transportation	0,157	1,983	0,202	0,509	0,694	0,262	0,130	0,014	0,068	4,019
REST	0,012	0,167	0,015	0,039	0,043	0,021	0,011	0,001	0,006	0,315
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0,105	1,848	0,120	0,357	0,490	0,183	0,105	0,012	0,064	3,284
Combustion	0,001	0,014	0,001	0,003	0,007	0,001	0,001	0,000	0,000	0,028
Transportation	0,004	0,062	0,004	0,012	0,039	0,006	0,003	0,000	0,002	0,132
REST	0,008	0,117	0,010	0,026	0,066	0,013	0,007	0,001	0,004	0,252
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0,106	1,857	0,121	0,360	0,492	0,184	0,106	0,012	0,064	3,302
Combustion	0,125	1,638	0,144	0,403	0,416	0,217	0,112	0,012	0,055	3,122
Transportation	0,161	2,045	0,206	0,521	0,733	0,268	0,133	0,014	0,070	4,151
REST	0,020	0,284	0,025	0,065	0,109	0,034	0,018	0,002	0,010	0,567

The relative contributions from Russia to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.16.

Transportation dominates contribution from Russia to all sub-basins. Contributions from combustion and agriculture are on a similar level. Major contribution from Russia is visible in Baltic Proper sub-basin.

Fig. 3.16. The relative contributions from Russia to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from Russia.

3.9 Contributions from Sweden

Maps of nitrogen deposition from four selected groups of emissions sectors in Sweden are shown in Fig. 3.17.

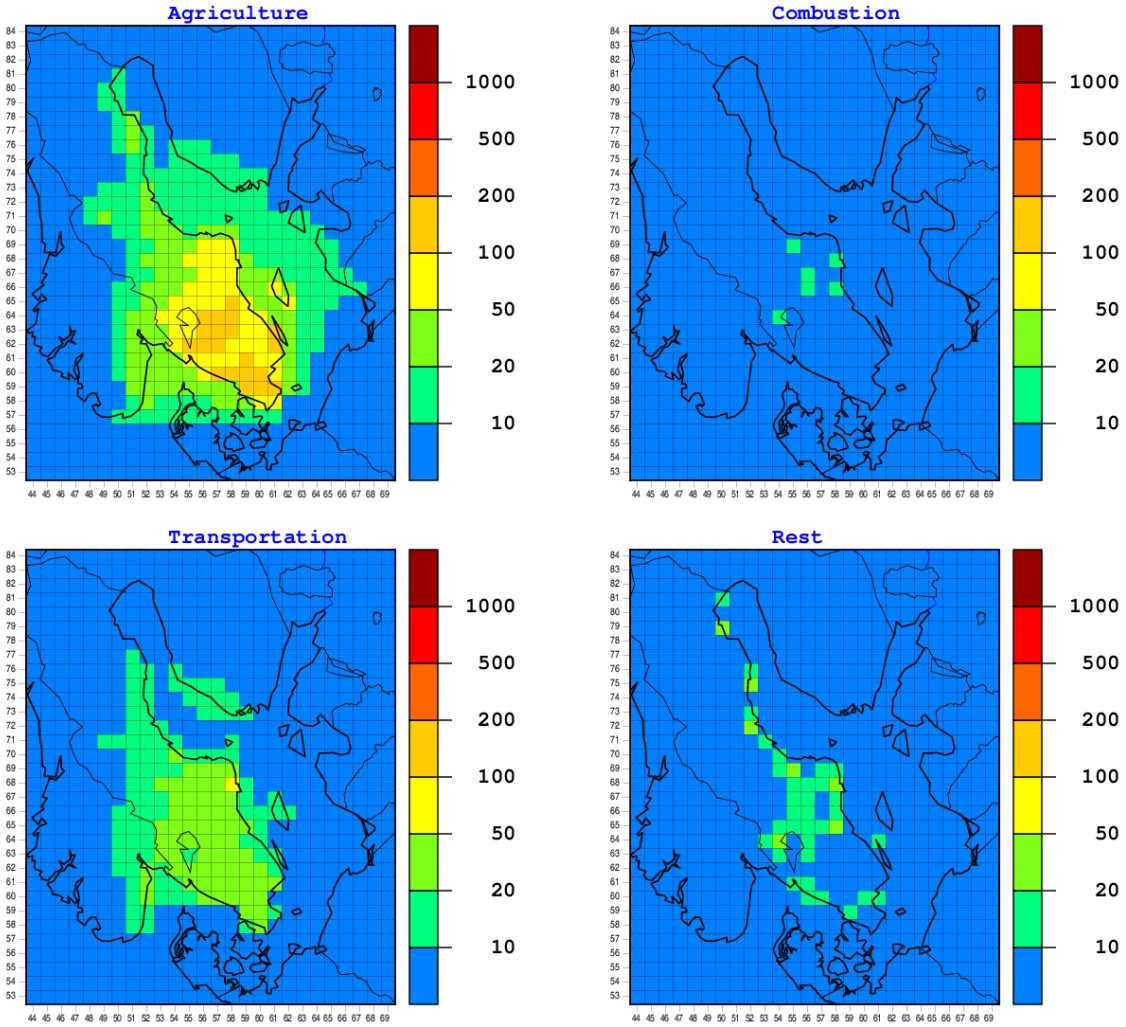


Fig. 3.17. Maps of nitrogen deposition from four selected groups of emissions sectors in Sweden. Units: tonnes N per grid.

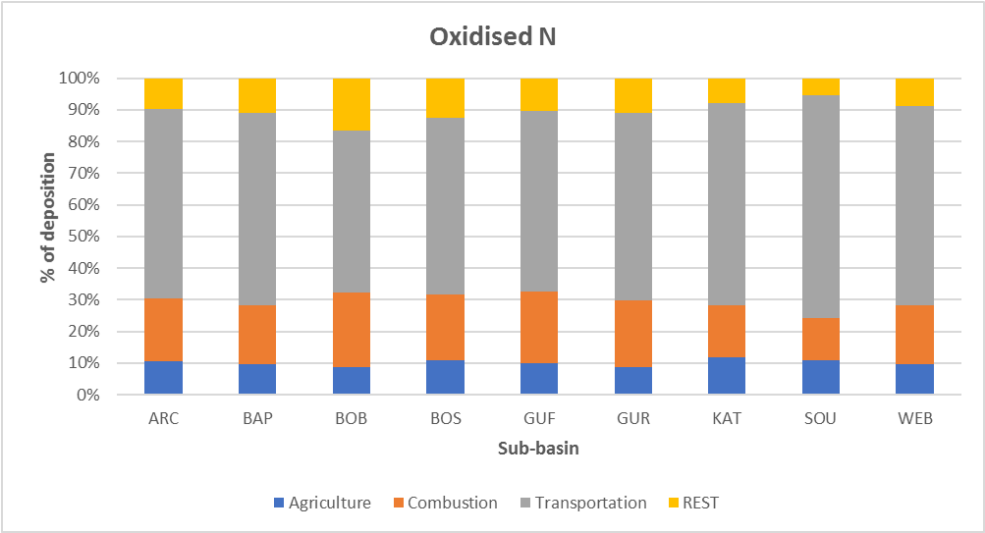
The contributions from Sweden to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.9.

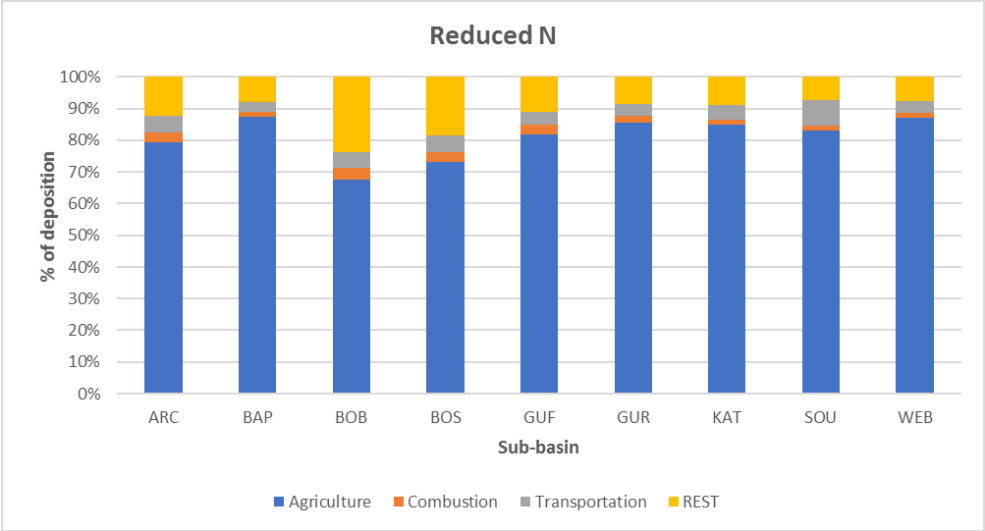
Table 3.9. Contributions from Sweden to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0,021	0,199	0,042	0,127	0,022	0,015	0,036	0,004	0,009	0,475
Combustion	0,039	0,391	0,113	0,241	0,051	0,037	0,050	0,005	0,017	0,944
Transportation	0,118	1,269	0,247	0,649	0,128	0,103	0,194	0,026	0,058	2,792
REST	0,019	0,227	0,080	0,148	0,023	0,019	0,024	0,002	0,008	0,550
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0,162	3,698	0,286	0,880	0,141	0,147	0,737	0,103	0,114	6,268
Combustion	0,006	0,067	0,016	0,039	0,005	0,004	0,014	0,002	0,002	0,155
Transportation	0,011	0,127	0,021	0,063	0,007	0,006	0,040	0,010	0,005	0,290
REST	0,025	0,335	0,100	0,221	0,019	0,015	0,077	0,009	0,010	0,811
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0,183	3,897	0,328	1,007	0,163	0,162	0,773	0,107	0,123	6,743
Combustion	0,045	0,458	0,129	0,280	0,056	0,041	0,064	0,007	0,019	1,099
Transportation	0,129	1,396	0,268	0,712	0,135	0,109	0,234	0,036	0,063	3,082
REST	0,044	0,562	0,180	0,369	0,042	0,034	0,101	0,011	0,018	1,361

The relative contributions from Sweden to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.18.

Agriculture is the largest contributor to all sub-basins in the case of Sweden. Transportation is the second contributor and combustion the third. Baltic Proper sub-basins is the main receptor of contribution from Sweden.





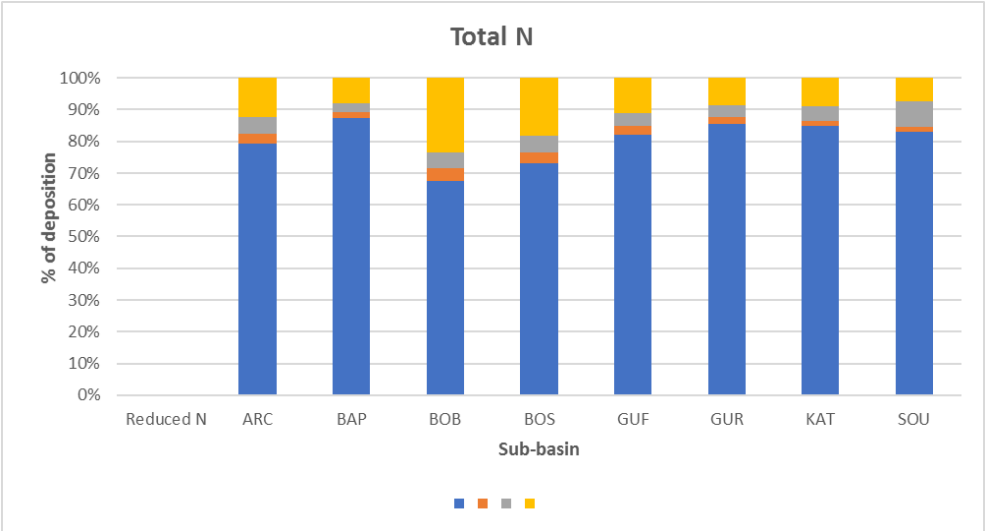


Fig. 3.18. The relative contributions from Sweden to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from Sweden.

3.10 Contributions from Belarus

Maps of nitrogen deposition from four selected groups of emissions sectors in Belarus are shown in Fig. 3.19.

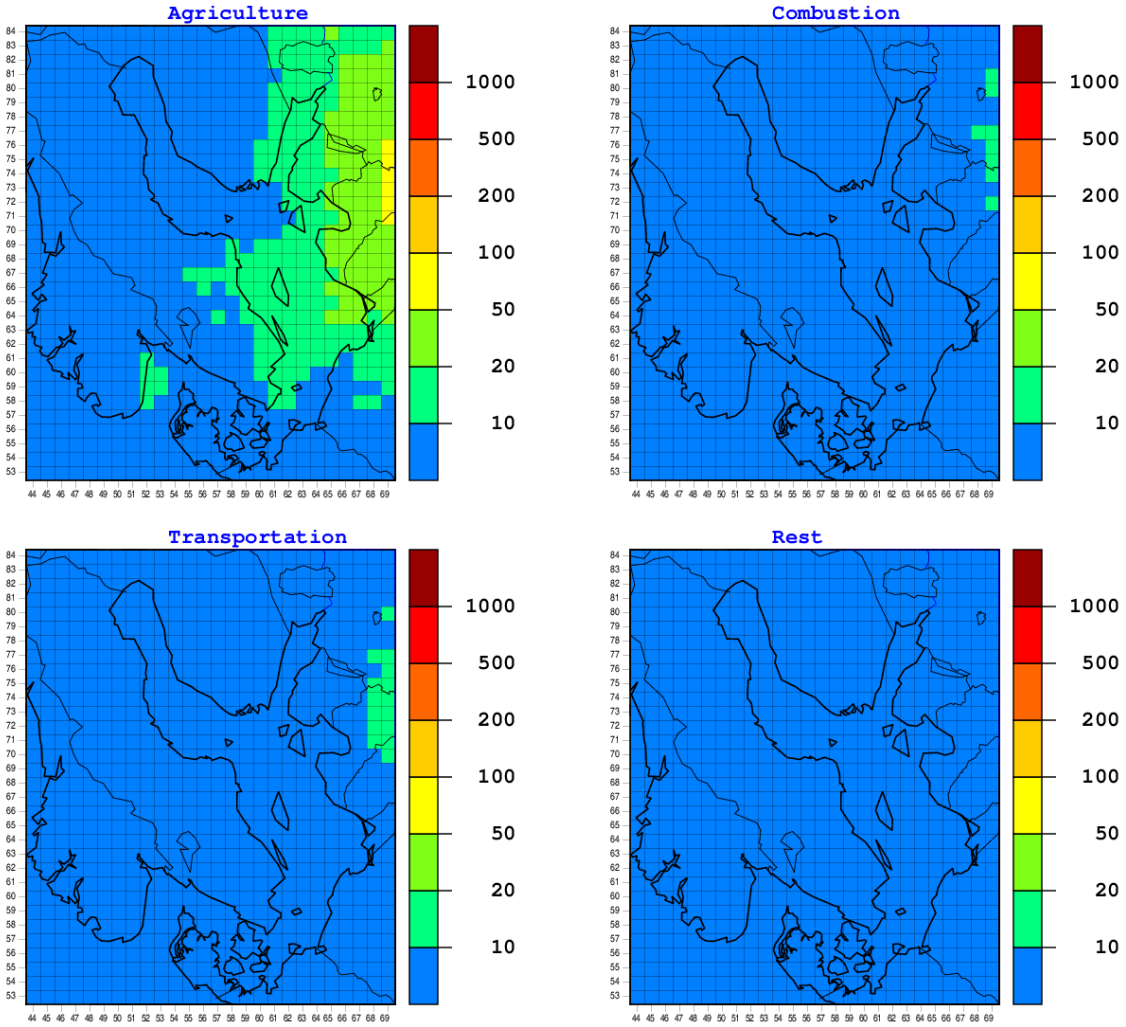


Fig. 3.19. Maps of nitrogen deposition from four selected groups of emissions sectors in Belarus. Units: tonnes N per grid.

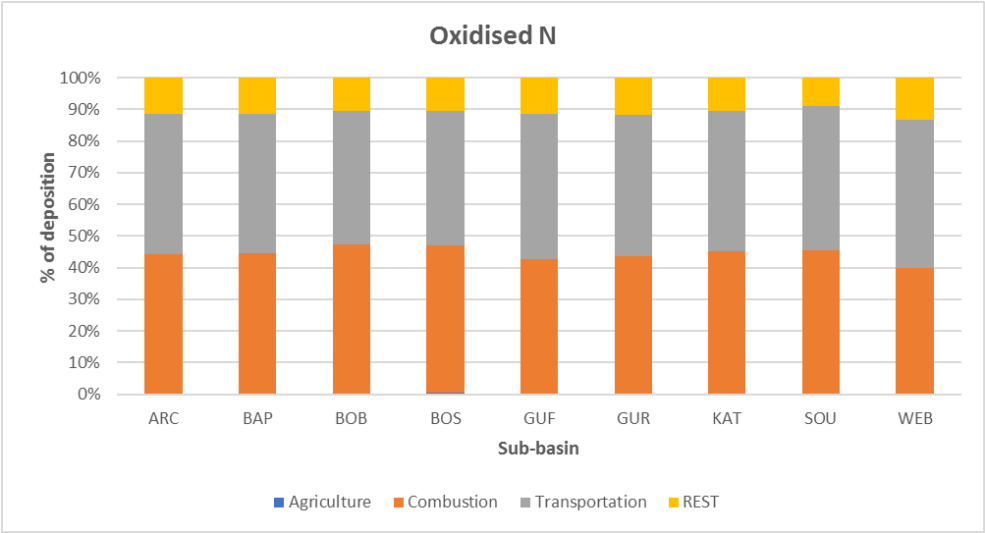
The contributions from Belarus to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.10.

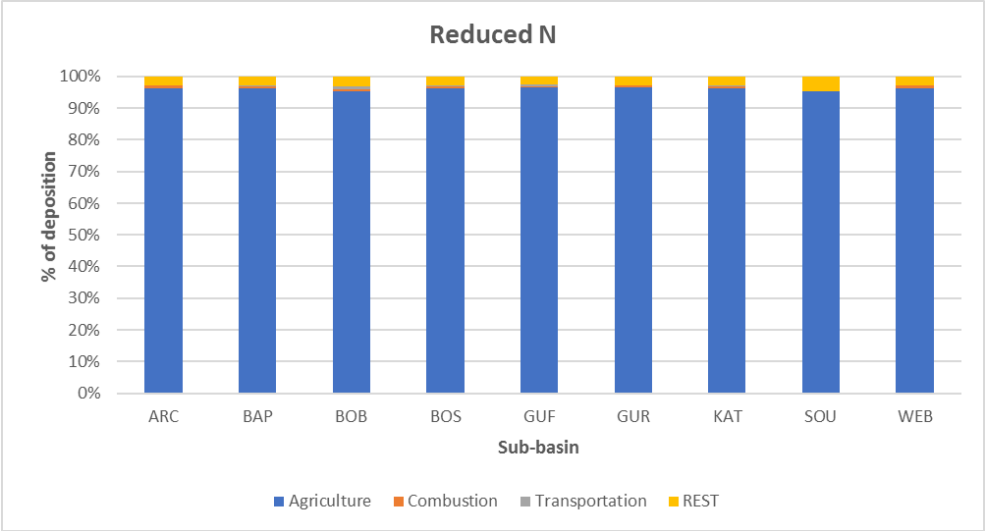
Table 3.10. Contributions from Belarus to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.005
Combustion	0.031	0.591	0.045	0.101	0.096	0.070	0.043	0.005	0.018	1.000
Transportation	0.031	0.590	0.040	0.092	0.103	0.072	0.042	0.005	0.021	0.996
REST	0.008	0.152	0.010	0.023	0.026	0.019	0.010	0.001	0.006	0.255
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.107	2.753	0.122	0.361	0.405	0.325	0.178	0.021	0.103	4.375
Combustion	0.001	0.017	0.001	0.002	0.002	0.002	0.001	0.000	0.001	0.027
Transportation	0.000	0.013	0.001	0.002	0.002	0.001	0.001	0.000	0.000	0.020
REST	0.003	0.081	0.004	0.010	0.011	0.009	0.005	0.001	0.003	0.127
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.107	2.757	0.122	0.362	0.405	0.325	0.178	0.021	0.103	4.380
Combustion	0.032	0.608	0.046	0.103	0.098	0.072	0.044	0.005	0.019	1.027
Transportation	0.031	0.603	0.041	0.094	0.105	0.073	0.043	0.005	0.021	1.016
REST	0.011	0.233	0.014	0.033	0.037	0.028	0.015	0.002	0.009	0.382

The relative contributions from Belarus to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.20.

Agriculture is the main contributor from Belarus to all sub-basins. Then combustion and transportation contributions are very similar but on a much lower level than agriculture. The Belarusian contribution is mainly located in the Baltic Proper sub-basin.





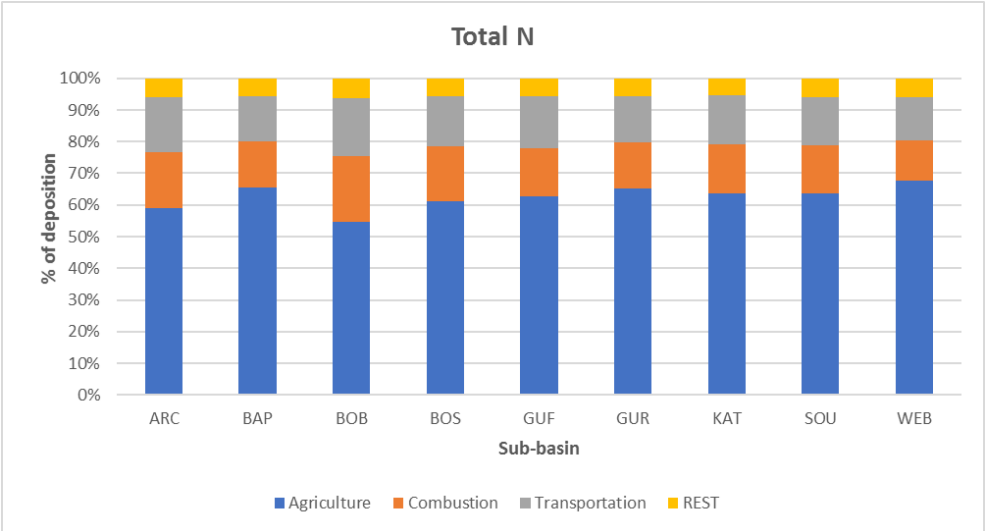


Fig. 3.20. The relative contributions from Belarus to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from Belarus.

3.11 Contributions from France

Maps of nitrogen deposition from four selected groups of emissions sectors in France are shown in Fig. 3.21.

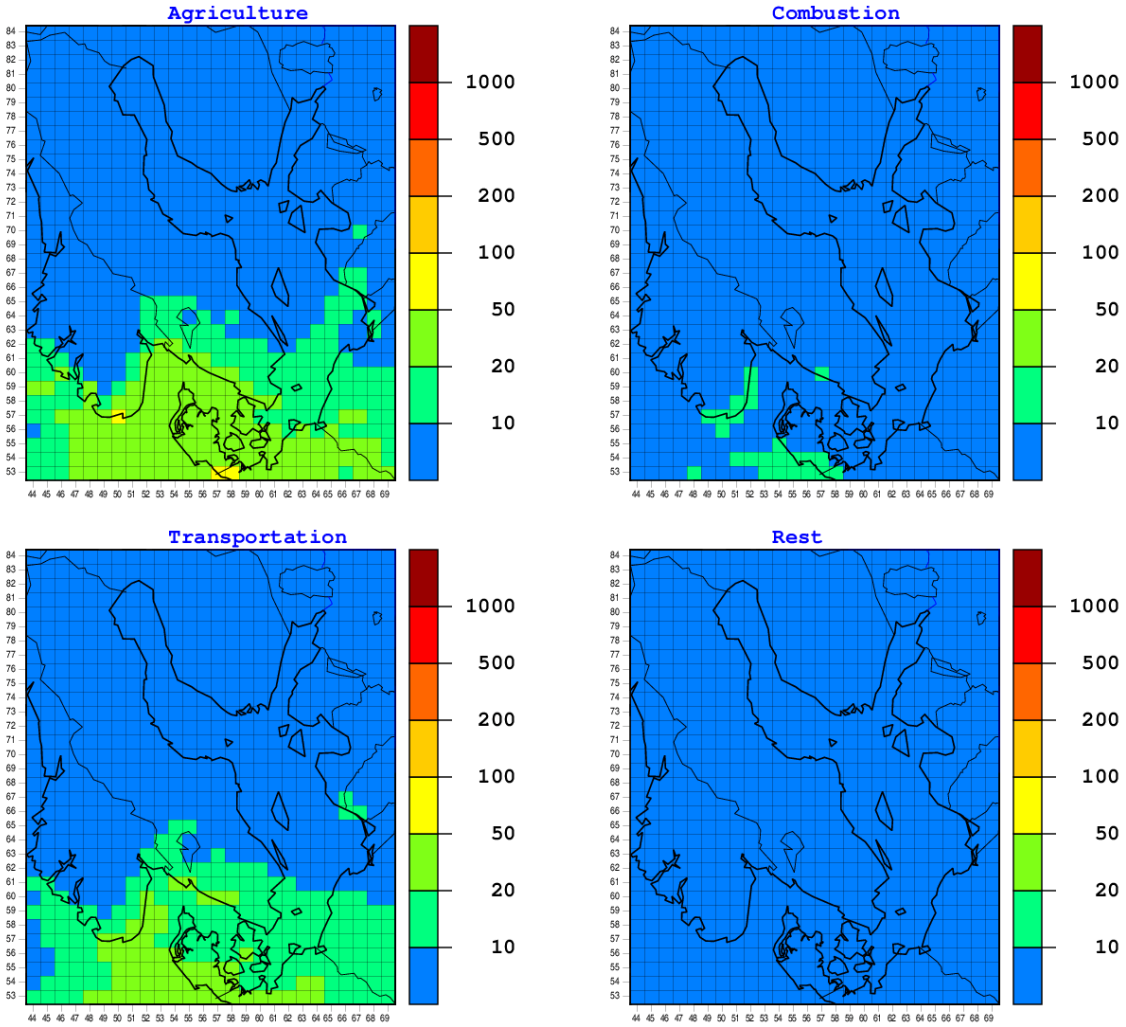


Fig. 3.21. Maps of nitrogen deposition from four selected groups of emissions sectors in France. Units: tonnes N per grid.

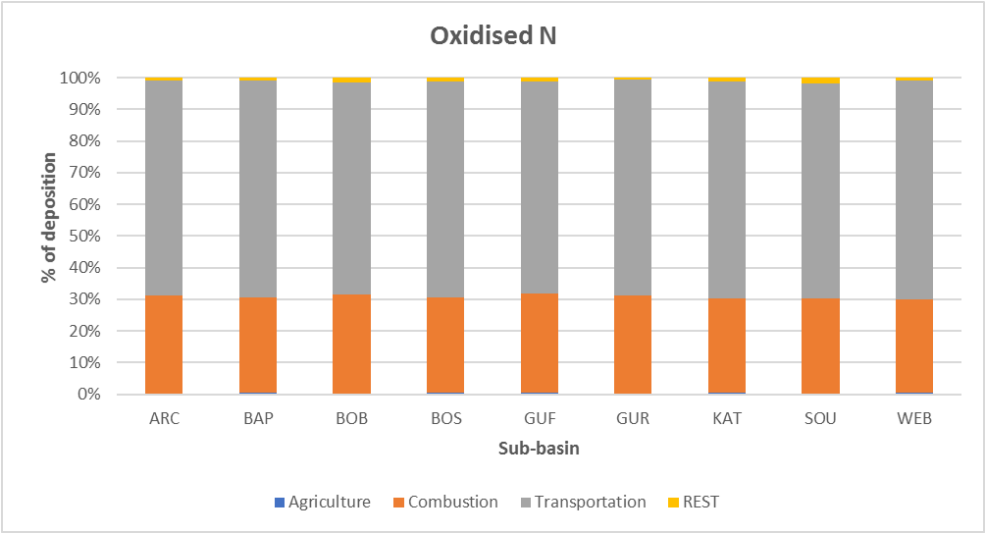
The contributions from France to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.11.

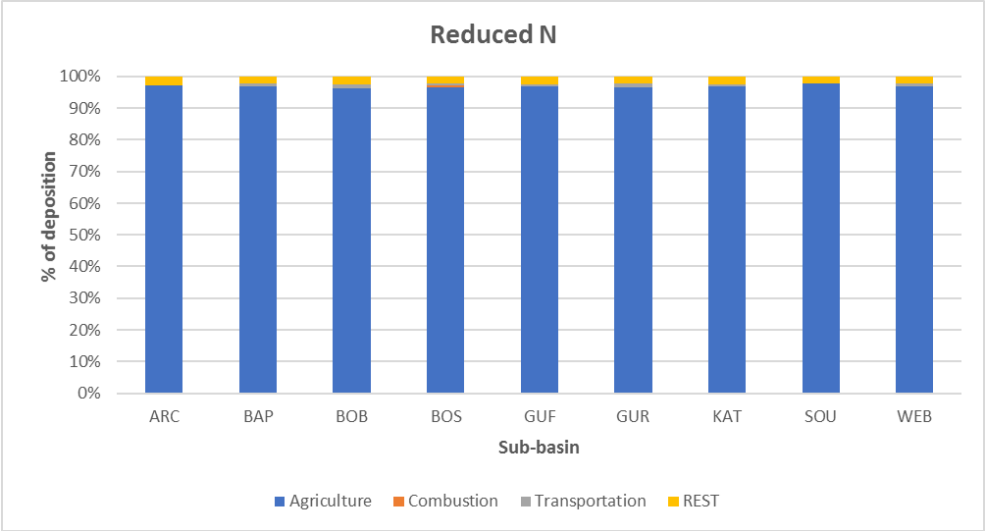
Table 3.11. Contributions from France to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.000	0.010	0.000	0.002	0.001	0.000	0.003	0.000	0.002	0.018
Combustion	0.032	0.766	0.044	0.125	0.058	0.043	0.179	0.017	0.149	1.413
Transportation	0.070	1.740	0.093	0.285	0.125	0.094	0.413	0.038	0.347	3.205
REST	0.001	0.026	0.002	0.005	0.002	0.001	0.007	0.001	0.005	0.050
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.067	1.893	0.080	0.263	0.121	0.086	0.573	0.047	0.537	3.667
Combustion	0.000	0.005	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.008
Transportation	0.000	0.014	0.001	0.002	0.001	0.001	0.004	0.000	0.004	0.027
REST	0.002	0.045	0.002	0.006	0.003	0.002	0.014	0.001	0.013	0.088
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.067	1.903	0.080	0.265	0.122	0.086	0.576	0.047	0.539	3.685
Combustion	0.032	0.771	0.044	0.126	0.058	0.043	0.180	0.017	0.150	1.421
Transportation	0.070	1.754	0.094	0.287	0.126	0.095	0.417	0.038	0.351	3.232
REST	0.003	0.071	0.004	0.011	0.005	0.003	0.021	0.002	0.018	0.138

The relative contributions from France to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.22.

The French emission sources influence mainly western and southern part of the Baltic Sea. Contributions from agriculture and transportation are on a similar level, whereas contributions from combustion are lower and contributions from remaining sources can be neglected.





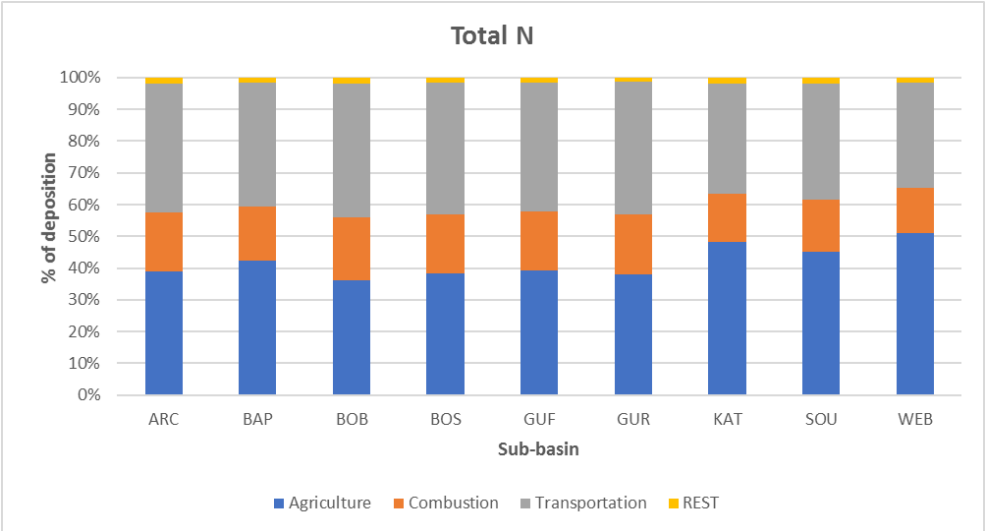


Fig. 3.22. The relative contributions from France to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from France.

3.12 Contributions from the Netherlands

Maps of nitrogen deposition from four selected groups of emissions sectors in the Netherlands are shown in Fig. 3.23.

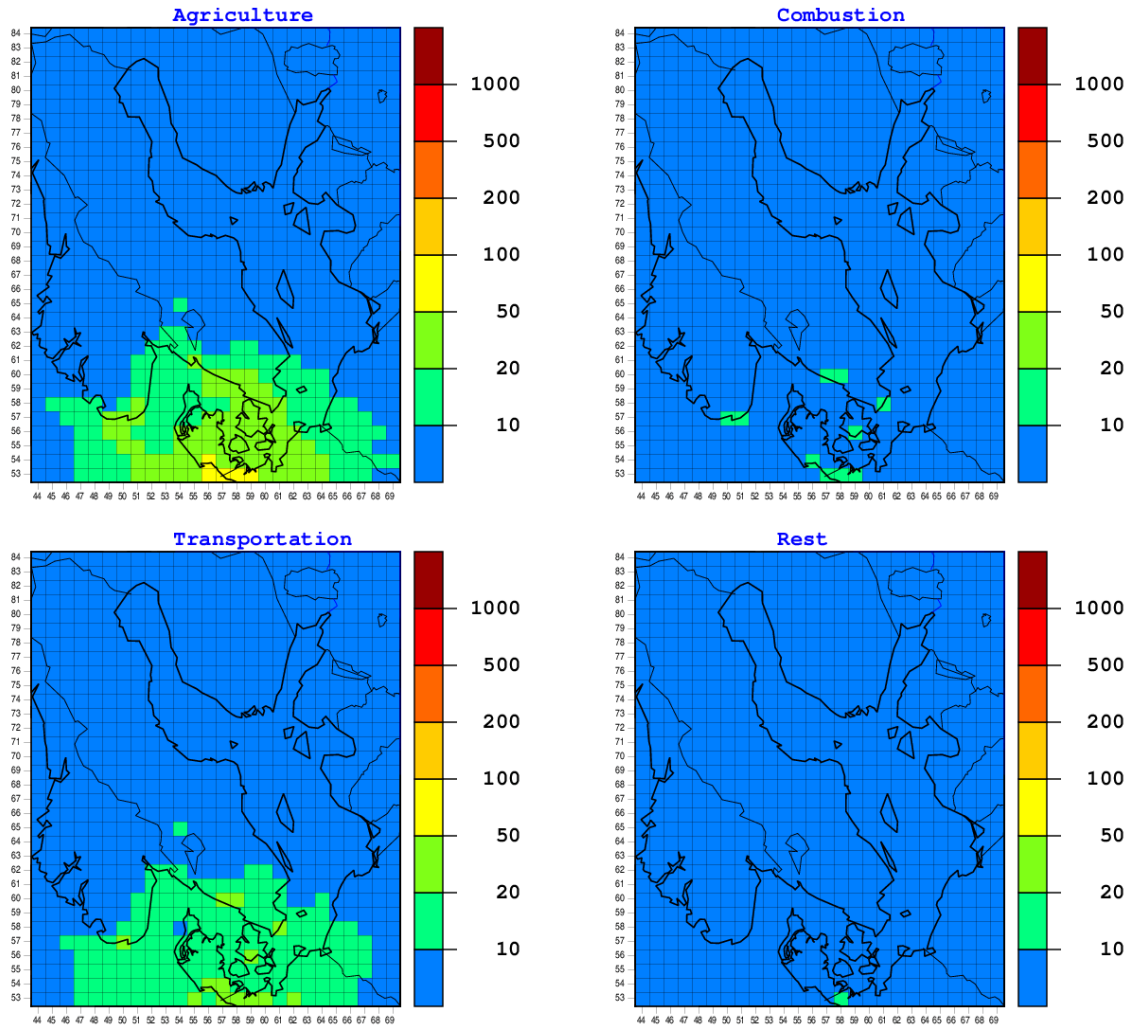


Fig. 3.23. Maps of nitrogen deposition from four selected groups of emissions sectors in the Netherlands. Units: tonnes N per grid.

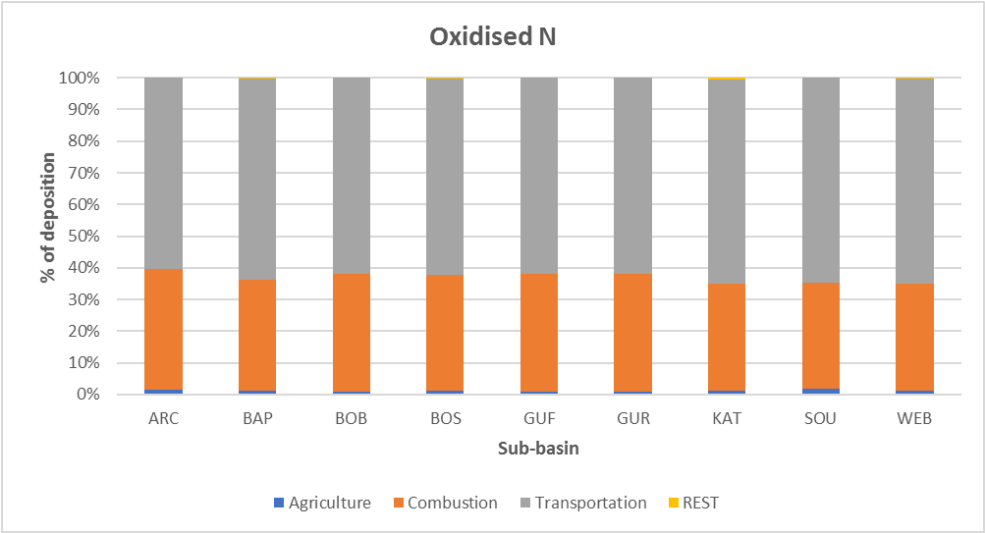
The contributions from the Netherlands to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.12.

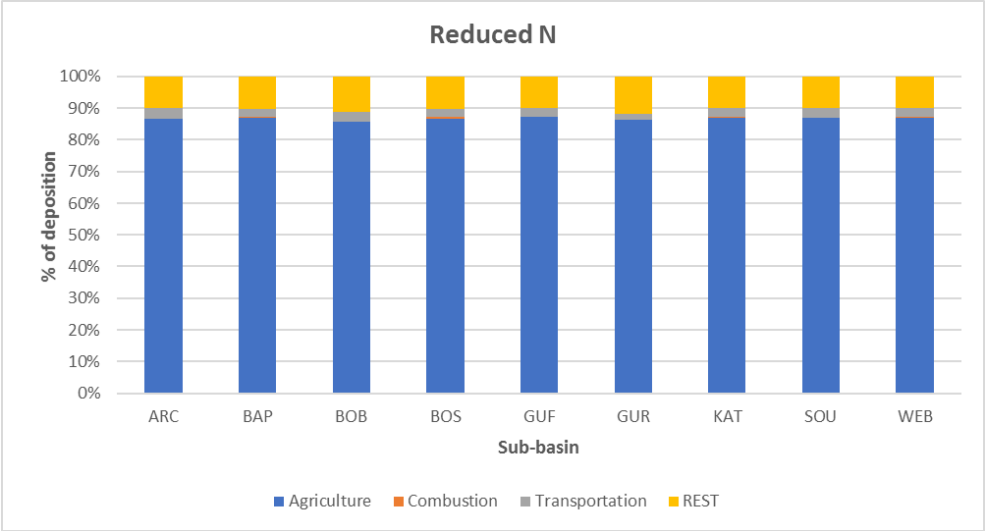
Table 3.12. Contributions from the Netherlands to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.001	0.022	0.001	0.004	0.001	0.001	0.005	0.001	0.006	0.042
Combustion	0.026	0.727	0.044	0.120	0.048	0.036	0.161	0.018	0.153	1.333
Transportation	0.041	1.304	0.073	0.202	0.080	0.060	0.305	0.035	0.295	2.395
REST	0.000	0.007	0.000	0.001	0.000	0.000	0.002	0.000	0.001	0.011
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.026	1.332	0.054	0.169	0.061	0.044	0.504	0.053	0.621	2.864
Combustion	0.000	0.005	0.000	0.001	0.000	0.000	0.002	0.000	0.002	0.010
Transportation	0.001	0.041	0.002	0.005	0.002	0.001	0.016	0.002	0.018	0.088
REST	0.003	0.156	0.007	0.020	0.007	0.006	0.057	0.006	0.072	0.334
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.027	1.354	0.055	0.173	0.062	0.045	0.509	0.054	0.627	2.906
Combustion	0.026	0.732	0.044	0.121	0.048	0.036	0.163	0.018	0.155	1.343
Transportation	0.042	1.345	0.075	0.207	0.082	0.061	0.321	0.037	0.313	2.483
REST	0.003	0.163	0.007	0.021	0.007	0.006	0.059	0.006	0.073	0.345

The relative contributions from the Netherlands to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.24.

As in the case of France, also Dutch emission sources influence mainly western and southern part of the Baltic Sea. Contributions from agriculture and transportation are on a similar level, with contribution from agriculture higher closer to the source and contributions from transportation prevailing in sub-basins further from the source. Contributions from combustion are lower and contributions from remaining sources can be practically neglected.





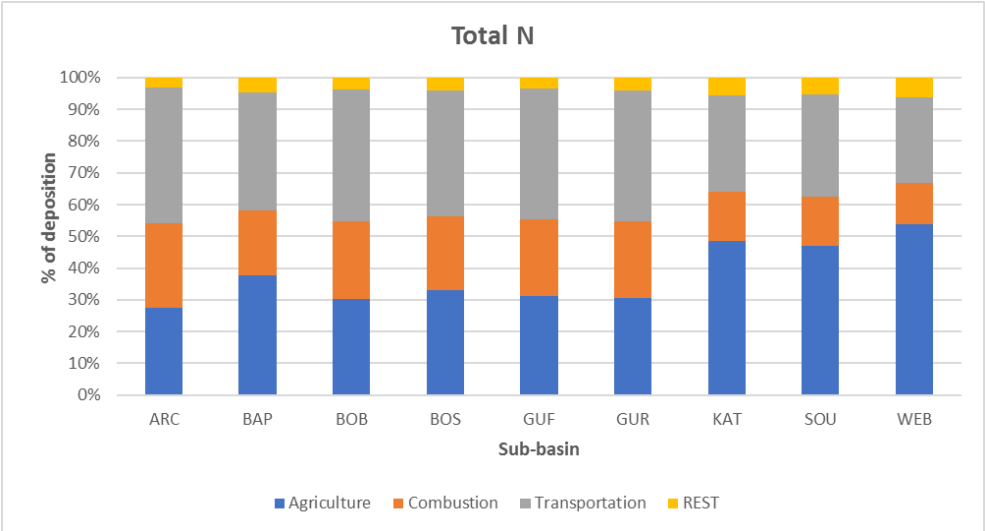


Fig. 3.24. The relative contributions from the Netherlands to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from the Netherlands.

3.13 Contributions from the United Kingdom

Maps of nitrogen deposition from four selected groups of emissions sectors in the United Kingdom are shown in Fig. 3.25.

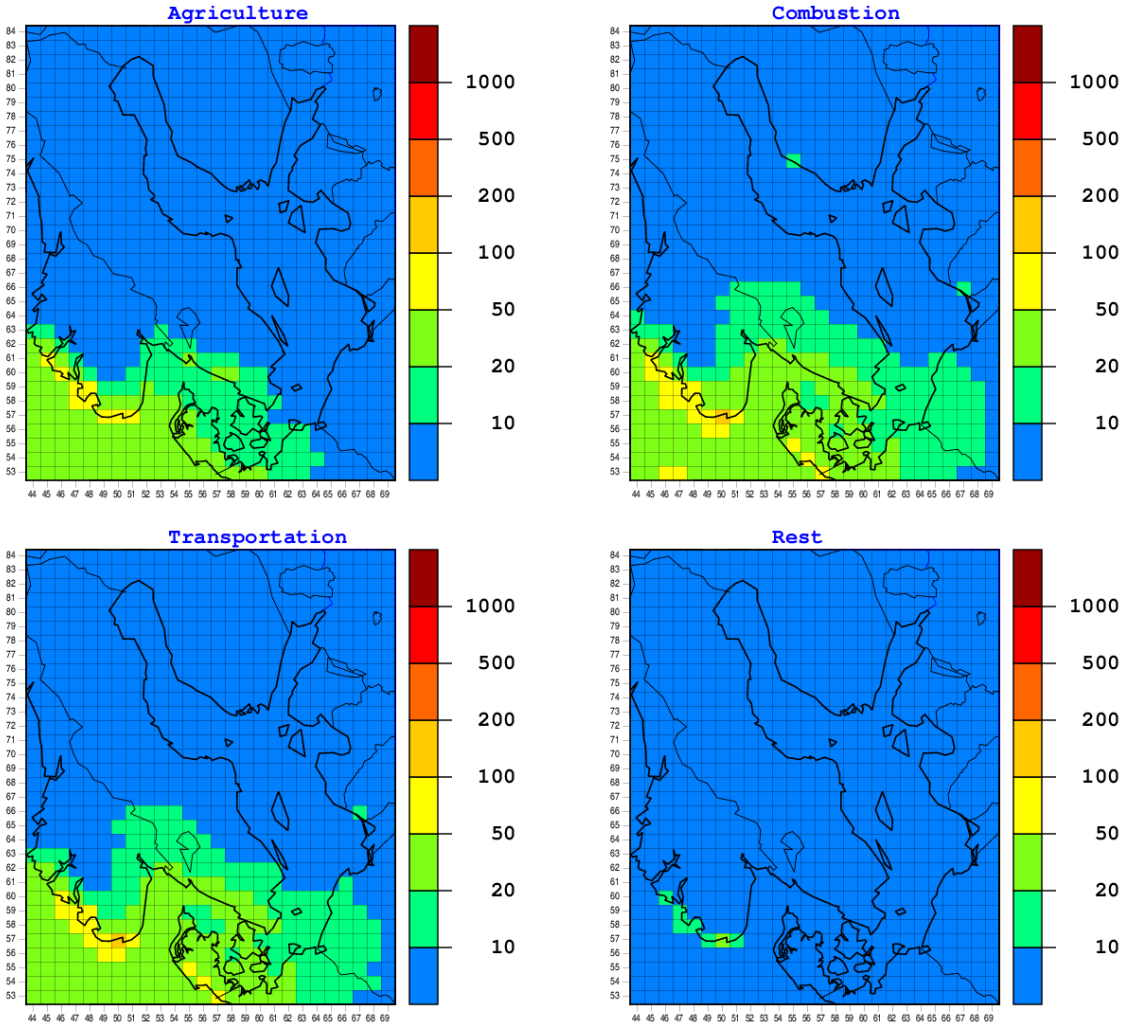


Fig. 3.25. Maps of nitrogen deposition from four selected groups of emissions sectors in the United Kingdom. Units: tonnes N per grid.

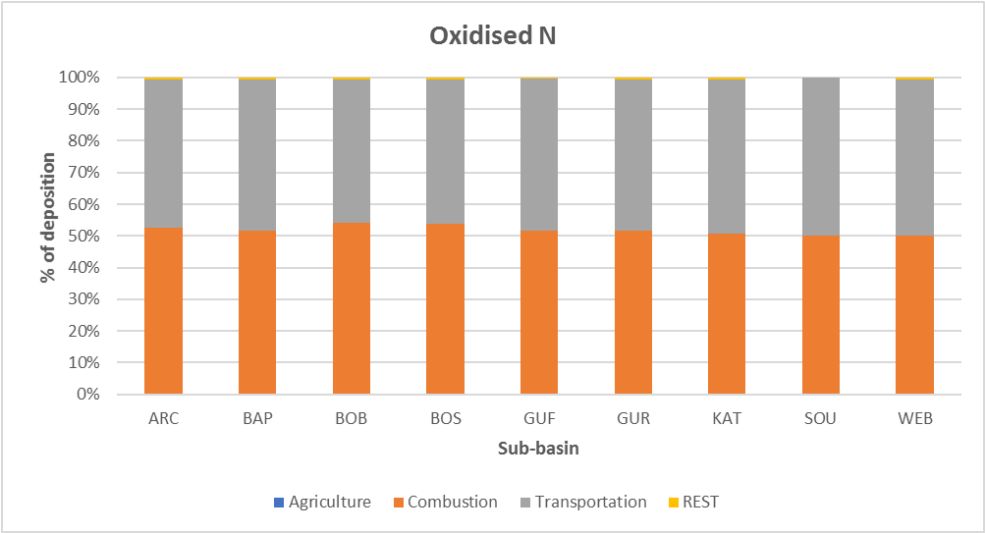
The contributions from the United Kingdom to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.13.

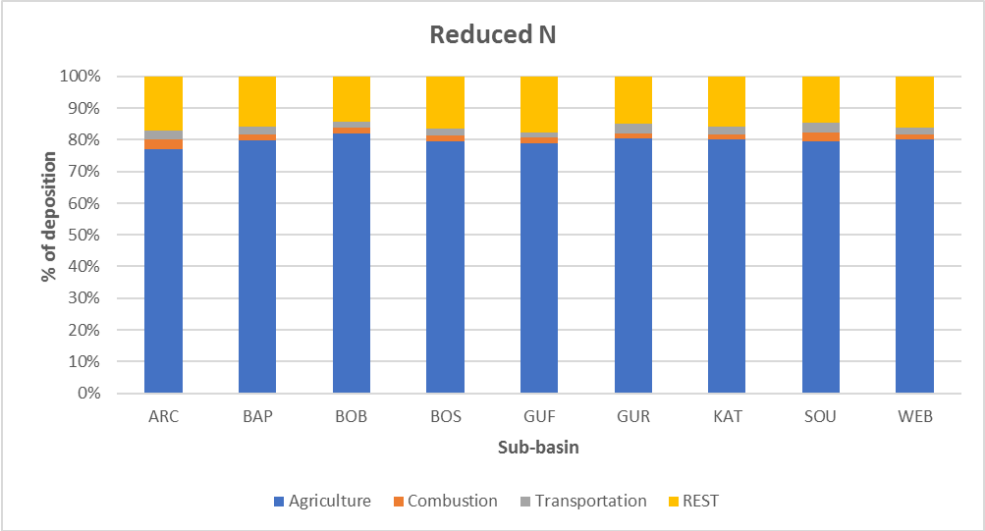
Table 3.13. Contributions from the United Kingdom to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Combustion	0.074	1.759	0.203	0.367	0.126	0.101	0.565	0.046	0.402	3.643
Transportation	0.066	1.637	0.171	0.313	0.117	0.094	0.543	0.046	0.395	3.382
REST	0.001	0.018	0.002	0.004	0.001	0.001	0.006	0.000	0.004	0.037
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.027	0.829	0.086	0.136	0.045	0.049	0.359	0.027	0.269	1.827
Combustion	0.001	0.018	0.002	0.003	0.001	0.001	0.007	0.001	0.005	0.039
Transportation	0.001	0.026	0.002	0.004	0.001	0.002	0.011	0.001	0.008	0.056
REST	0.006	0.165	0.015	0.028	0.010	0.009	0.071	0.005	0.054	0.363
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.027	0.829	0.086	0.136	0.045	0.049	0.359	0.027	0.269	1.827
Combustion	0.075	1.777	0.205	0.370	0.127	0.102	0.572	0.047	0.407	3.682
Transportation	0.067	1.663	0.173	0.317	0.118	0.096	0.554	0.047	0.403	3.438
REST	0.007	0.183	0.017	0.032	0.011	0.010	0.077	0.005	0.058	0.400

The relative contributions from the United Kingdom to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.26.

As in the case of France and the Netherlands, deposition from the emission sources in the United Kingdom are mainly visible in western and southern part of the Baltic Sea. However, compared to other countries the structure of contribution from the United Kingdom is different. Namely, combustion is the major contributor to all sub-basins, followed by transportation on a slightly lower level. Agriculture is significantly lower than combustion and transportation in all sub-basins.





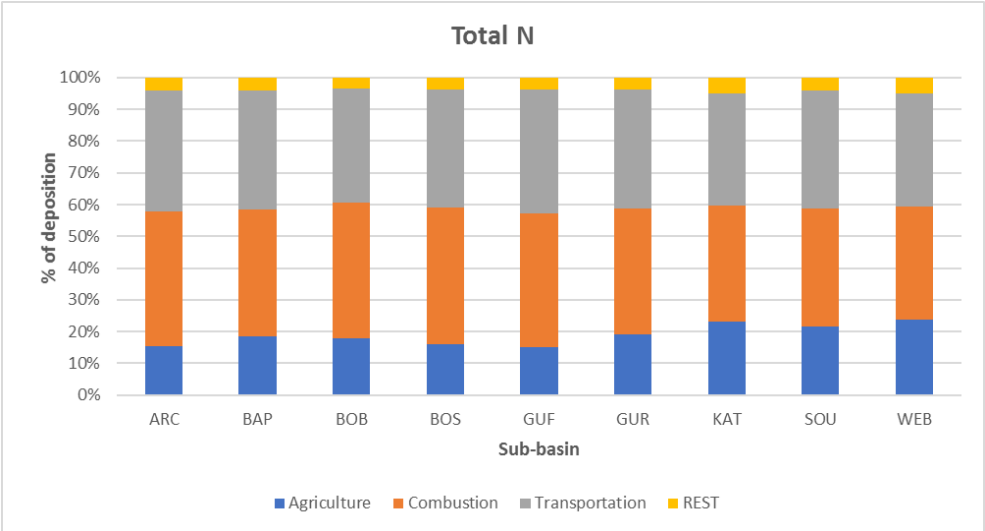


Fig. 3.26. The relative contributions from the United Kingdom to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from the United Kingdom.

3.14 Contributions from the Baltic Sea

Contribution from ship traffic to nitrogen deposition to the Baltic Sea comes from one emission sector only – transportation. Therefore, the deposition of reduced nitrogen from ship traffic can be neglected. The contributions from the Baltic Sea ship traffic to oxidised and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.14.

Table 3.14. Contributions from the Baltic Sea to oxidized and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Transportation	0.526	8.454	0.581	1.607	1.01	0.698	1.222	0.15	0.93	15.178
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Transportation	0.526	8.454	0.581	1.607	1.010	0.698	1.222	0.150	0.930	15.178

Main contribution from ship traffic on the Baltic Sea is to the largest sub-basin, Baltic Proper, followed by Bothnian Sea and Kattegat.

3.15 Contributions from the North Sea

The contributions from the North Sea to oxidized and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are given in Table 3.15.

Table 3.15. Contributions from the North Sea to oxidised, reduced and total nitrogen deposition in 2014 to individual Baltic Sea sub-basins. Units: kt N per year.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Transportation	0.203	5.092	0.400	0.952	0.332	0.294	1.709	0.137	1.164	20.363
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Transportation	0.203	5.092	0.400	0.952	0.332	0.294	1.709	0.137	1.164	20.363

Main contribution from the ship traffic on the North Sea is again. as in case of the Baltic Sea ships. to largest sub-basin Baltic Proper, but this time followed by two western sub-basins. Kattegat and Western Baltic.

3.16 Contributions from all EMEP sources

In this section we present the contributions from all EMEP sources together to oxidised. reduced and total nitrogen deposition to the Baltic Sea and its sub-basins.

Maps of nitrogen deposition from four selected groups of emissions sectors in all EMEP sources together are shown in Fig. 3.27.

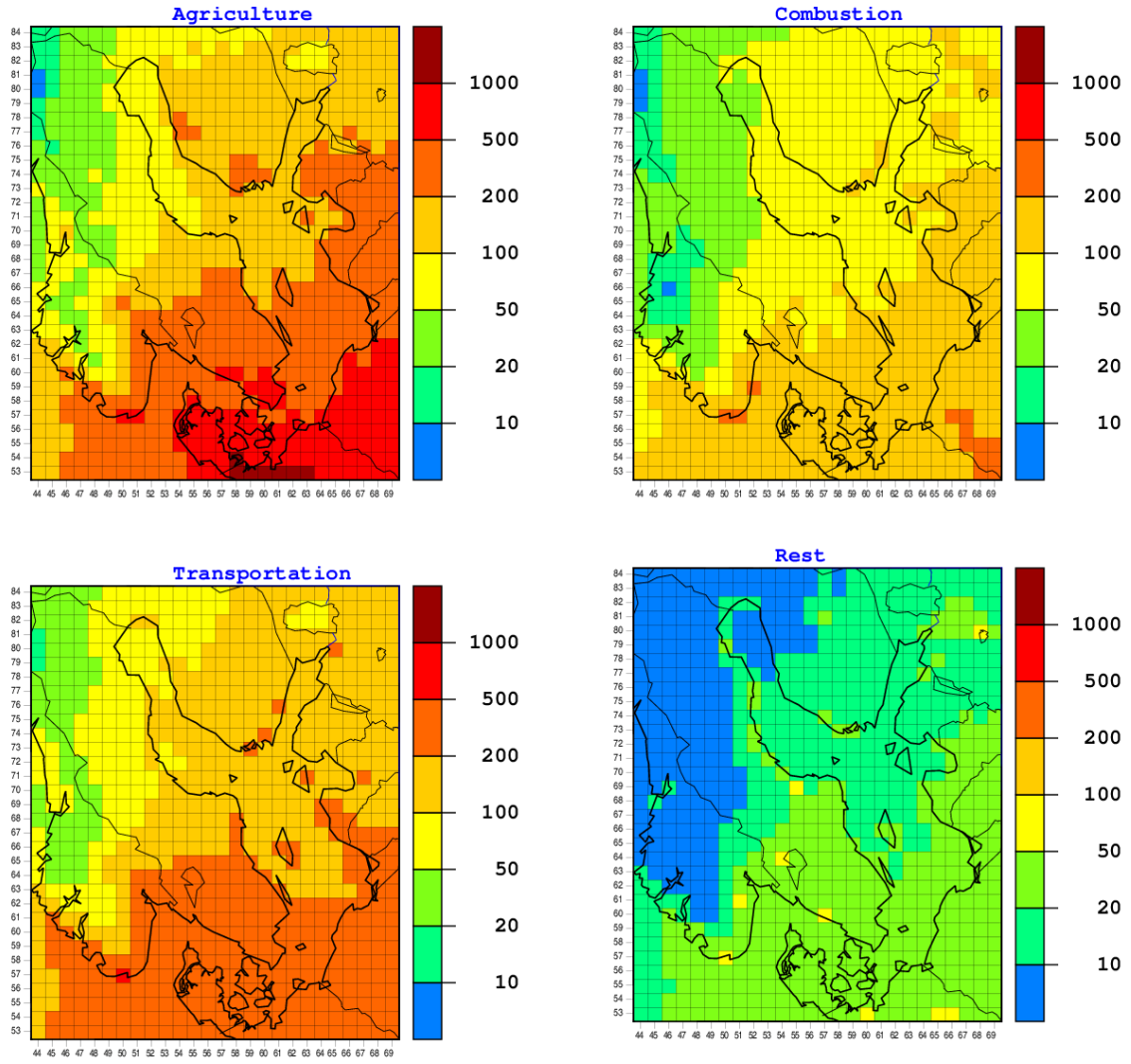


Fig. 3.27. Maps of nitrogen deposition from four selected groups of emissions sectors in all EMEP sources together. Units: tonnes N per grid.

The contributions from all EMEP sources to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins are given in Table 3.16.

Table 3.16. Contributions from all EMEP sources to oxidised, reduced and total nitrogen to individual Baltic Sea sub-basins.

Oxidised N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	0.116	3.167	0.118	0.451	0.225	0.193	0.455	0.056	0.437	5.218
Combustion	1.050	22.848	1.687	3.867	2.488	1.699	3.055	0.333	2.564	39.591
Transportation	2.016	41.425	3.011	7.371	4.404	3.046	7.007	0.745	5.342	74.367
REST	0.111	2.500	0.189	0.449	0.234	0.179	0.292	0.034	0.256	4.244
Reduced N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	1.793	55.345	2.853	6.096	4.368	3.594	10.955	1.115	13.021	99.140
Combustion	0.073	0.878	0.095	0.195	0.142	0.147	0.150	0.020	0.135	1.835
Transportation	0.045	0.898	0.075	0.162	0.129	0.054	0.212	0.037	0.216	1.828
REST	0.106	1.985	0.188	0.451	0.267	0.155	0.410	0.049	0.359	3.970
Total N	**ARC**	**BAP**	**BOB**	**BOS**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
Agriculture	1.909	58.512	2.971	6.547	4.593	3.787	11.410	1.171	13.458	104.36
Combustion	1.123	23.726	1.782	4.062	2.630	1.846	3.205	0.353	2.699	41.426
Transportation	2.061	42.323	3.086	7.533	4.533	3.100	7.219	0.782	5.558	76.195
REST	0.217	4.485	0.377	0.900	0.501	0.334	0.702	0.083	0.615	8.214

The relative contributions from all EMEP sources to oxidised, reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014 are shown in Fig. 3.16.

Inspection of the maps in Fig. 3.27 indicate that agriculture is the major contributor to nitrogen deposition followed by transportation and combustion. It is confirmed by Table 3.16 with agriculture being the main contributor in six out of nine sub-basins. Only in three north-east sub-basins (ARC. BOB and BOS) contribution from transportation to total nitrogen deposition is higher. In western sub-basins KAT and WEB. contribution from agriculture to total nitrogen deposition is one order of magnitude higher than contribution from remaining sectors.

Fig. 3.28. The relative contributions from all EMEP sources to oxidised. reduced and total nitrogen deposition to individual Baltic Sea sub-basins in 2014. Units: % of total deposition from all EMEP sources.

4. Contributions to sub-basins of the Baltic Sea

In this chapter we also. like in the previous chapter. present and discuss the combined contributions to the Baltic Sea and its sub-basins from each country and selected group of sectors within each country. However. this time we are receptor oriented and the main question is: from which country and sector nitrogen is deposited to considered sub-basin of the Baltic Sea? We take into account contributions from ship traffic on the Baltic Sea and on the North Sea. Finally the contributions from all EMEP sources and selected groups of sectors within EMEP is included here.

4.1 Archipelago Sea

The ranking of the sources (combined country and group of sectors) to Archipelago Sea sub-basin are given in Table 4.1.

Table 4.1. List of all combined sources contributing to nitrogen deposition in the Archipelago Sea sub-basin in descending order. Units: kt N per year.

Country/Sea	Sector	Deposition
BAS	Transportation	0.526
Germany	Agriculture	0.328
Finland	Agriculture	0.281
Poland	Agriculture	0.235
NOS	Transportation	0.203
Germany	Transportation	0.194
Poland	Combustion	0.189
Sweden	Agriculture	0.183
Germany	Combustion	0.171
Russia	Transportation	0.161
Finland	Transportation	0.150
Poland	Transportation	0.150
Finland	Combustion	0.133
Sweden	Transportation	0.129
Russia	Combustion	0.125
Belarus	Agriculture	0.107
Russia	Agriculture	0.106
Lithuania	Agriculture	0.083
UK	Combustion	0.075
France	Transportation	0.070
Estonia	Agriculture	0.067
France	Agriculture	0.067
UK	Transportation	0.067
Denmark	Agriculture	0.064
Denmark	Transportation	0.047
Latvia	Agriculture	0.045

Sweden	Combustion	0.045
Sweden	REST	0.044
Netherlands	Transportation	0.042
Lithuania	Transportation	0.039
Germany	REST	0.037
Estonia	Transportation	0.036
Estonia	Combustion	0.034
Belarus	Combustion	0.032
France	Combustion	0.032
Belarus	Transportation	0.031
Finland	REST	0.030
Latvia	Combustion	0.029
Netherlands	Agriculture	0.027
UK	Agriculture	0.027
Latvia	Transportation	0.026
Netherlands	Combustion	0.026
Lithuania	Combustion	0.020
Russia	REST	0.020
Denmark	Combustion	0.018
Poland	REST	0.015
Belarus	REST	0.011
Latvia	REST	0.007
UK	REST	0.007
Lithuania	REST	0.006
France	REST	0.003
Netherlands	REST	0.003
Estonia	REST	0.002
Denmark	REST	0.001
BAS	Agriculture	0.000
BAS	Combustion	0.000
BAS	REST	0.000
NOS	Agriculture	0.000
NOS	Combustion	0.000
NOS	REST	0.000

Transportation and agriculture are dominating contributions to the Archipelago Sea sub-basin. Emissions from the Baltic Sea ship traffic is the number one contributor, followed by tree agriculture sources: in Germany Finland and Poland. There are only two combustion sources among top ten contributors: in Poland and Germany.

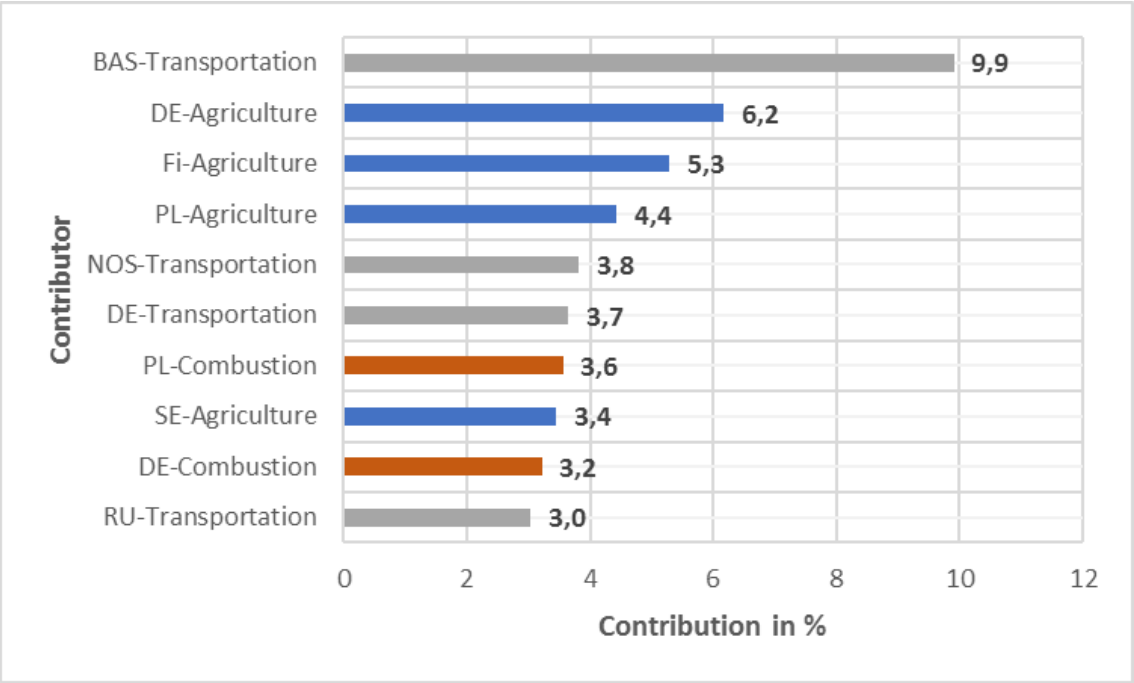


Fig. 4.1. Top ten contributors to annual total 2014 nitrogen deposition to the Archipelago Sea sub-basin. Units: % of total (from all EMEP sources) nitrogen deposition to the Archipelago Sea sub-basin.

4.2 Baltic Proper

Table 4.2. List of all combined sources contributing to nitrogen deposition in the Baltic Proper sub-basin in descending order. Units: kt N per year.

Country/Sea	Sector	Deposition
Germany	Agriculture	18.510
Poland	Agriculture	12.071
BAS	Transportation	8.454
Germany	Transportation	6.840
Poland	Combustion	5.526
Germany	Combustion	5.442
Poland	Transportation	5.137
NOS	Transportation	5.092
Sweden	Agriculture	3.897
Denmark	Agriculture	3.562
Belarus	Agriculture	2.757
Lithuania	Agriculture	2.192
Russia	Transportation	2.045
France	Agriculture	1.903
Russia	Agriculture	1.857
UK	Combustion	1.777
France	Transportation	1.754
UK	Transportation	1.663
Russia	Combustion	1.638
Denmark	Transportation	1.461

Sweden	Transportation	1.396
Netherlands	Agriculture	1.354
Netherlands	Transportation	1.345
Germany	REST	1.299
UK	Agriculture	0.829
Latvia	Agriculture	0.799
France	Combustion	0.771
Netherlands	Combustion	0.732
Lithuania	Transportation	0.664
Belarus	Combustion	0.608
Belarus	Transportation	0.603
Sweden	REST	0.562
Poland	REST	0.549
Denmark	Combustion	0.496
Sweden	Combustion	0.458
Finland	Transportation	0.455
Finland	Combustion	0.436
Estonia	Agriculture	0.421
Finland	Agriculture	0.377
Latvia	Combustion	0.357
Lithuania	Combustion	0.333
Latvia	Transportation	0.318
Russia	REST	0.284
Belarus	REST	0.233
UK	REST	0.183
Estonia	Transportation	0.174
Estonia	Combustion	0.167
Netherlands	REST	0.163
Lithuania	REST	0.132
Latvia	REST	0.124
France	REST	0.071
Denmark	REST	0.069
Finland	REST	0.032
Estonia	REST	0.008
BAS	Agriculture	0.000
BAS	Combustion	0.000
BAS	REST	0.000
NOS	Agriculture	0.000
NOS	Combustion	0.000
NOS	REST	0.000

Agriculture sources in Germany and Poland are number one and two contributors, respectively, to nitrogen deposition in the Baltic Proper sub-basin. Those two sources together contribute more than 25% to total nitrogen deposition. Two transportation sources, from Baltic Sea ship traffic and Germany are next on the list. Again there are only two combustion sources. from Poland and Germany. among top ten contributors.

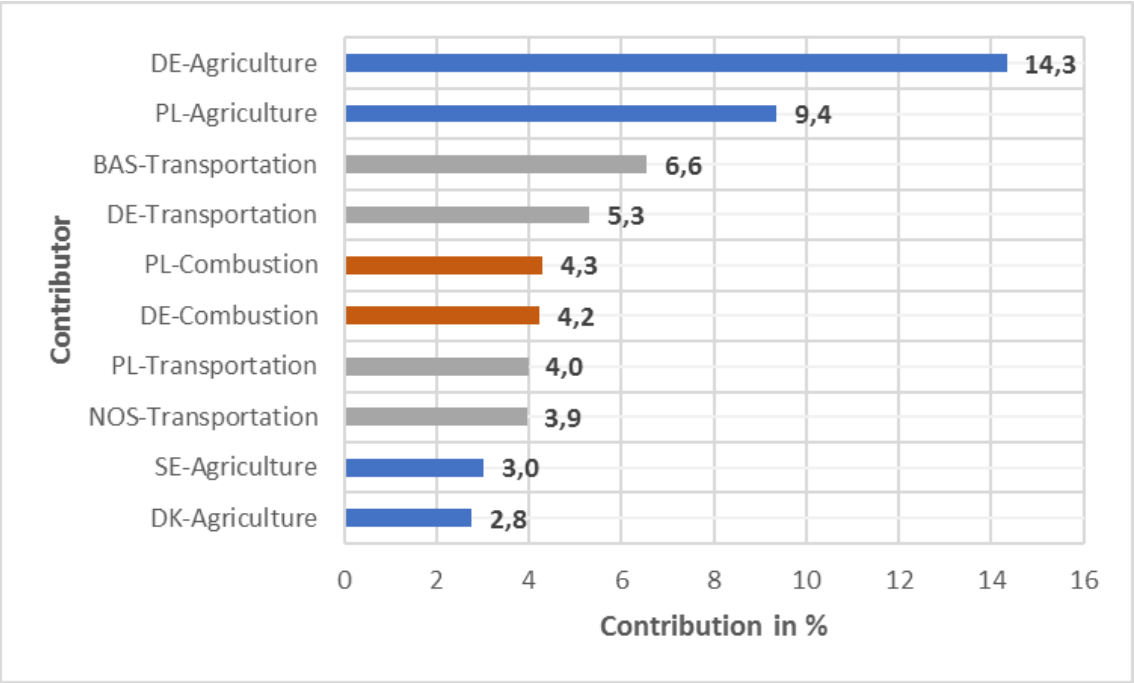


Fig. 4.2. Top ten contributors to annual total 2014 nitrogen deposition to the Baltic Proper sub-basin. Units: % of total (from all EMEP sources) nitrogen deposition to the Baltic Proper sub-basin.

4.3 Bothnian Bay

Table 4.3. List of all combined sources contributing to nitrogen deposition in the Bothnian Bay sub-basin in descending order. Units: kt N per year.

Country/Sea	Sector	Deposition
Finland	Agriculture	1.208
BAS	Transportation	0.581
Finland	Transportation	0.459
Finland	Combustion	0.445
NOS	Transportation	0.400
Sweden	Agriculture	0.328
Sweden	Transportation	0.268
Germany	Agriculture	0.257
Russia	Transportation	0.206
UK	Combustion	0.205
Poland	Combustion	0.190
Poland	Agriculture	0.181
Sweden	REST	0.180
Germany	Transportation	0.175
UK	Transportation	0.173
Germany	Combustion	0.168
Russia	Combustion	0.144
Poland	Transportation	0.143
Sweden	Combustion	0.129

Belarus	Agriculture	0.122
Russia	Agriculture	0.121
France	Transportation	0.094
UK	Agriculture	0.086
Denmark	Agriculture	0.084
France	Agriculture	0.080
Netherlands	Transportation	0.075
Denmark	Transportation	0.072
Lithuania	Agriculture	0.070
Netherlands	Agriculture	0.055
Estonia	Agriculture	0.047
Estonia	Combustion	0.046
Belarus	Combustion	0.046
Lithuania	Transportation	0.045
France	Combustion	0.044
Netherlands	Combustion	0.044
Latvia	Combustion	0.041
Belarus	Transportation	0.041
Latvia	Agriculture	0.041
Estonia	Transportation	0.036
Germany	REST	0.032
Denmark	Combustion	0.031
Latvia	Transportation	0.030
Finland	REST	0.025
Russia	REST	0.025
Lithuania	Combustion	0.023
UK	REST	0.017
Belarus	REST	0.014
Poland	REST	0.014
Netherlands	REST	0.007
Latvia	REST	0.006
Lithuania	REST	0.006
France	REST	0.004
Estonia	REST	0.002
Denmark	REST	0.001
BAS	Agriculture	0.000
BAS	Combustion	0.000
BAS	REST	0.000
NOS	Agriculture	0.000
NOS	Combustion	0.000
NOS	REST	0.000

Agriculture in Finland is the main contributor to nitrogen deposition to the Bothnian Bay sub-basin with close to 15% contribution. Next on the list are two transportation sources from Baltic ship traffic and Finland followed by the combustion in Finland ant transportation on the North Sea. Besides North Sea transportation, there is one more distant source on the top ten list – combustion in the United Kingdom.

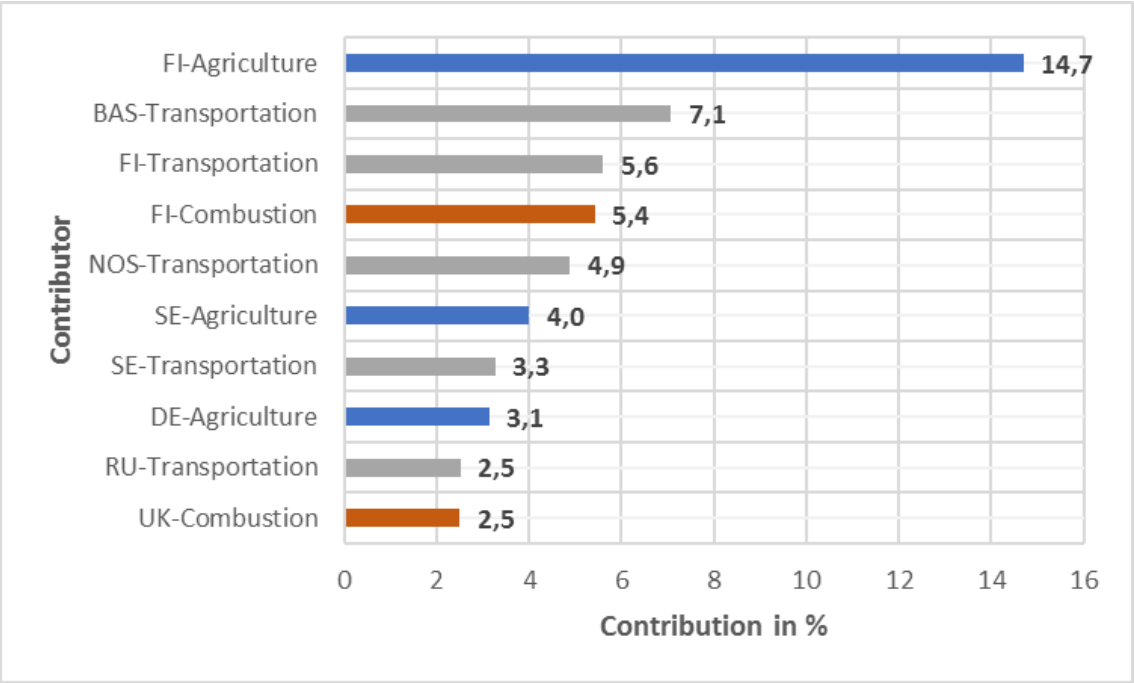


Fig. 4.3. Top ten contributors to annual total 2014 nitrogen deposition to the Bothnian Bay sub-basin. Units: % of total (from all EMEP sources) nitrogen deposition to the Bothnian Bay sub-basin.

4.4 Bothnian Sea

Table 4.4. List of all combined sources contributing to nitrogen deposition in the Bothnian Sea sub-basin in descending order. Units: kt N per year.

Country/Sea	Sector	Deposition
BAS	Transportation	1.607
Germany	Agriculture	1.052
Sweden	Agriculture	1.007
NOS	Transportation	0.952
Finland	Agriculture	0.887
Sweden	Transportation	0.712
Poland	Agriculture	0.649
Poland	Combustion	0.610
Germany	Transportation	0.576
Finland	Transportation	0.563
Finland	Combustion	0.547
Germany	Combustion	0.527
Russia	Transportation	0.521
Poland	Transportation	0.463
Russia	Combustion	0.403
UK	Combustion	0.370
Sweden	REST	0.369
Belarus	Agriculture	0.362
Russia	Agriculture	0.360

UK	Transportation	0.317
Denmark	Agriculture	0.299
France	Transportation	0.287
Sweden	Combustion	0.280
France	Agriculture	0.265
Netherlands	Transportation	0.207
Denmark	Transportation	0.203
Lithuania	Agriculture	0.198
Netherlands	Agriculture	0.173
Estonia	Agriculture	0.140
UK	Agriculture	0.136
France	Combustion	0.126
Netherlands	Combustion	0.121
Latvia	Agriculture	0.113
Germany	REST	0.110
Lithuania	Transportation	0.107
Belarus	Combustion	0.103
Estonia	Combustion	0.100
Belarus	Transportation	0.094
Latvia	Combustion	0.089
Estonia	Transportation	0.088
Denmark	Combustion	0.078
Latvia	Transportation	0.071
Russia	REST	0.065
Lithuania	Combustion	0.055
Finland	REST	0.054
Poland	REST	0.046
Belarus	REST	0.033
UK	REST	0.032
Netherlands	REST	0.021
Latvia	REST	0.018
Lithuania	REST	0.014
France	REST	0.011
Denmark	REST	0.006
Estonia	REST	0.004
BAS	Agriculture	0.000
BAS	Combustion	0.000
BAS	REST	0.000
NOS	Agriculture	0.000
NOS	Combustion	0.000
NOS	REST	0.000

Transportation and agriculture are dominating contribution to the Bothnian Sea sub-basin. Transportation on the Baltic Sea is the number one contributor, but agriculture in Germany and Sweden are contributors number two and three. Among top ten contributors to nitrogen deposition to the Bothnian Sea sub-basin there are five transportation sources, four agriculture sources and only one combustion source from Poland.

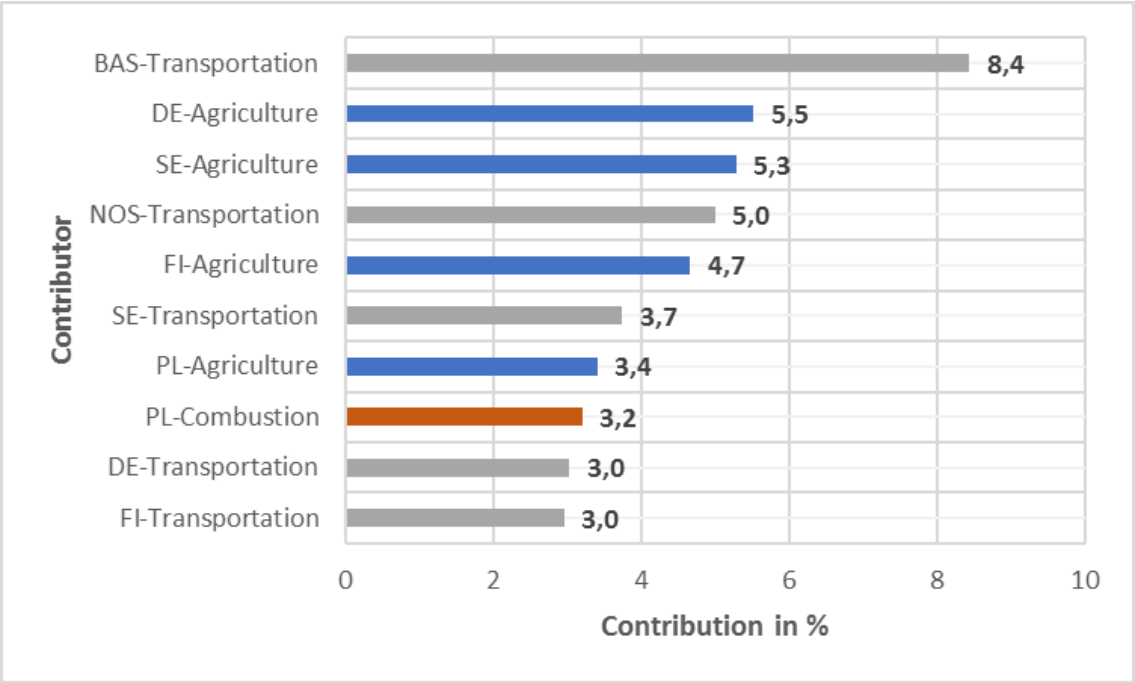


Fig. 4.4. Top ten contributors to annual total 2014 nitrogen deposition to the Bothnian Sea sub-basin. Units: % of total (from all EMEP sources) nitrogen deposition to the Bothnian Sea sub-basin.

4.5 Gulf of Finland

Table 4.5. List of all combined sources contributing to nitrogen deposition in the Gulf of Finland sub-basin in descending order. Units: kt N per year.

Country/Sea	Sector	Deposition
BAS	Transportation	1.010
Russia	Transportation	0.733
Estonia	Agriculture	0.678
Germany	Agriculture	0.585
Poland	Agriculture	0.574
Russia	Agriculture	0.492
Russia	Combustion	0.416
Poland	Combustion	0.405
Belarus	Agriculture	0.405
Finland	Transportation	0.364
Germany	Transportation	0.341
NOS	Transportation	0.332
Poland	Transportation	0.329
Finland	Agriculture	0.315
Germany	Combustion	0.306
Finland	Combustion	0.295
Lithuania	Agriculture	0.248
Estonia	Combustion	0.219

Estonia	Transportation	0.196
Sweden	Agriculture	0.163
Latvia	Agriculture	0.161
Sweden	Transportation	0.135
UK	Combustion	0.127
France	Transportation	0.126
France	Agriculture	0.122
UK	Transportation	0.118
Russia	REST	0.109
Denmark	Agriculture	0.108
Lithuania	Transportation	0.107
Belarus	Transportation	0.105
Belarus	Combustion	0.098
Latvia	Combustion	0.092
Denmark	Transportation	0.083
Netherlands	Transportation	0.082
Latvia	Transportation	0.080
Germany	REST	0.064
Netherlands	Agriculture	0.062
France	Combustion	0.058
Sweden	Combustion	0.056
Lithuania	Combustion	0.052
Estonia	REST	0.049
Netherlands	Combustion	0.048
UK	Agriculture	0.045
Sweden	REST	0.042
Belarus	REST	0.037
Finland	REST	0.033
Poland	REST	0.033
Denmark	Combustion	0.031
Lithuania	REST	0.018
Latvia	REST	0.018
UK	REST	0.011
Netherlands	REST	0.007
France	REST	0.005
Denmark	REST	0.002
BAS	Agriculture	0.000
BAS	Combustion	0.000
BAS	REST	0.000
NOS	Agriculture	0.000
NOS	Combustion	0.000
NOS	REST	0.000

Transportation on the Baltic Sea and in Russia are number one and two contributors to nitrogen deposition to the Gulf of Finland sub-basin. followed by four agriculture sources: from Estonia, Germany, Poland and Russia. Altogether, among top ten, there are five agriculture, three transportation and two combustion sources.

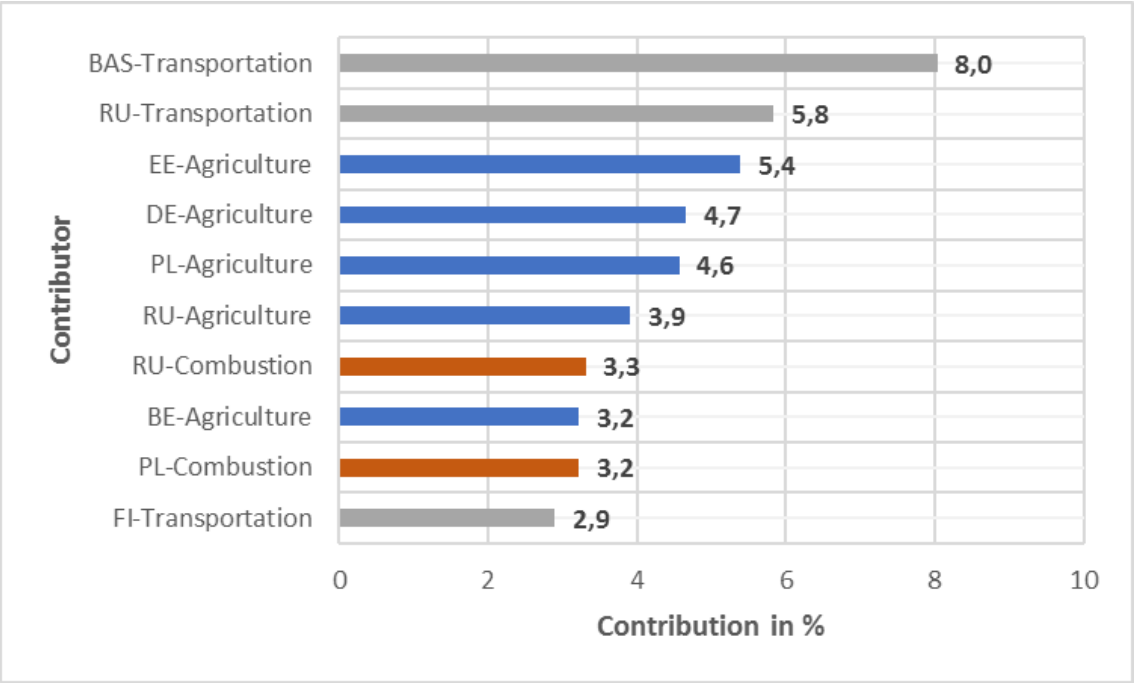


Fig. 4.5. Top ten contributors to annual total 2014 nitrogen deposition to the Gulf of Finland sub-basin. Units: % of total (from all EMEP sources) nitrogen deposition to the Gulf of Finland sub-basin.

4.6 Gulf of Riga

Table 4.6. List of all combined sources contributing to nitrogen deposition in the Gulf of Riga sub-basin in descending order. Units: kt N per year.

Country/Sea	Sector	Deposition
BAS	Transportation	0.698
Poland	Agriculture	0.629
Germany	Agriculture	0.519
Latvia	Agriculture	0.444
Lithuania	Agriculture	0.401
Poland	Combustion	0.365
Poland	Transportation	0.326
Belarus	Agriculture	0.325
NOS	Transportation	0.294
Germany	Transportation	0.292
Russia	Transportation	0.268
Estonia	Agriculture	0.259
Germany	Combustion	0.258
Russia	Combustion	0.217
Russia	Agriculture	0.184
Sweden	Agriculture	0.162
Latvia	Combustion	0.154
Denmark	Agriculture	0.129
Lithuania	Transportation	0.129

Latvia	Transportation	0.119
Sweden	Transportation	0.109
UK	Combustion	0.102
UK	Transportation	0.096
France	Transportation	0.095
Denmark	Transportation	0.087
France	Agriculture	0.086
Finland	Transportation	0.085
Finland	Combustion	0.077
Belarus	Transportation	0.073
Belarus	Combustion	0.072
Lithuania	Combustion	0.064
Netherlands	Transportation	0.061
Finland	Agriculture	0.060
Estonia	Transportation	0.059
Germany	REST	0.054
UK	Agriculture	0.049
Estonia	Combustion	0.045
Netherlands	Agriculture	0.045
France	Combustion	0.043
Sweden	Combustion	0.041
Latvia	REST	0.037
Netherlands	Combustion	0.036
Russia	REST	0.034
Sweden	REST	0.034
Poland	REST	0.033
Denmark	Combustion	0.030
Belarus	REST	0.028
Lithuania	REST	0.026
UK	REST	0.010
Finland	REST	0.006
Netherlands	REST	0.006
France	REST	0.003
Denmark	REST	0.002
Estonia	REST	0.002
BAS	Agriculture	0.000
BAS	Combustion	0.000
BAS	REST	0.000
NOS	Agriculture	0.000
NOS	Combustion	0.000
NOS	REST	0.000

Like in previous case. ship traffic on the Baltic Sea is the main contributor to nitrogen deposition to the Gulf of Riga sub-basin. Next on the list are four agriculture sources: from Poland. Germany, Latvia and Lithuania. The only combustion source on the top ten list is from Poland.

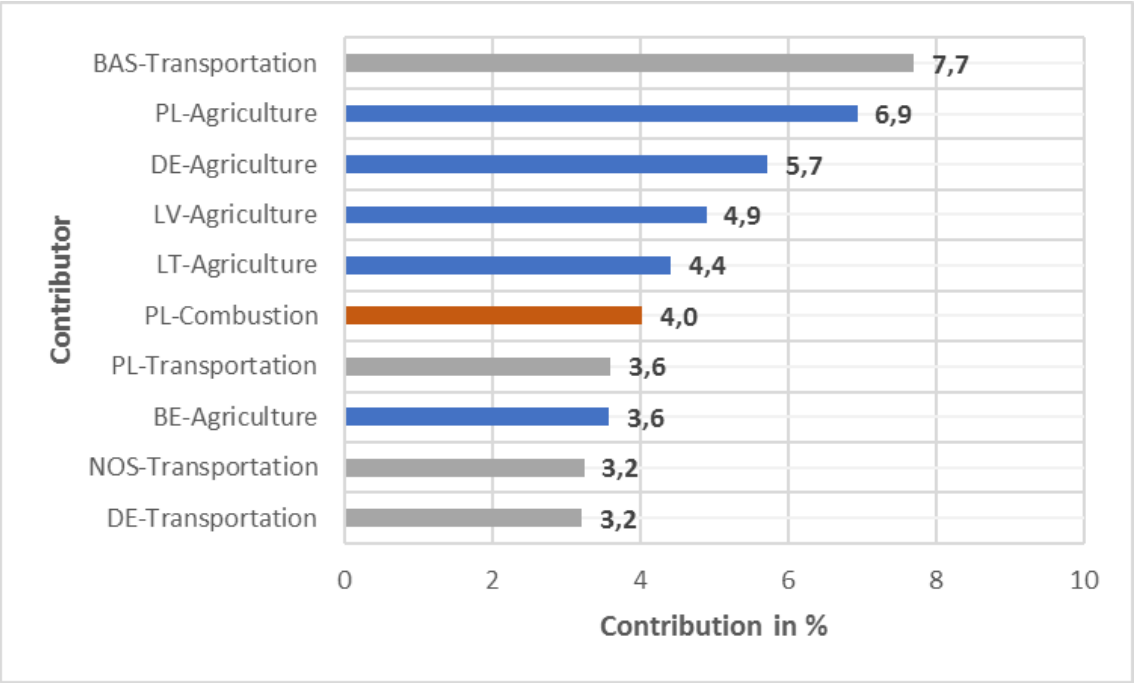


Fig. 4.6. Top ten contributors to annual total 2014 nitrogen deposition to the Gulf of Riga sub-basin. Units: % of total (from all EMEP sources) nitrogen deposition to the Gulf of Riga sub-basin.

4.7 Kattegat

Table 4.7. List of all combined sources contributing to nitrogen deposition in the Kattegat sub-basin in descending order. Units: kt N per year.

Country/Sea	Sector	Deposition
Denmark	Agriculture	3.835
Germany	Agriculture	3.244
NOS	Transportation	1.709
BAS	Transportation	1.222
Germany	Transportation	0.941
Sweden	Agriculture	0.773
Germany	Combustion	0.768
Poland	Agriculture	0.675
Denmark	Transportation	0.584
France	Agriculture	0.576
UK	Combustion	0.572
UK	Transportation	0.554
Netherlands	Agriculture	0.509
Poland	Combustion	0.477
France	Transportation	0.417
Poland	Transportation	0.361
UK	Agriculture	0.359
Netherlands	Transportation	0.321
Sweden	Transportation	0.234

Germany	REST	0.189
Denmark	Combustion	0.186
France	Combustion	0.180
Belarus	Agriculture	0.178
Netherlands	Combustion	0.163
Russia	Transportation	0.133
Russia	Combustion	0.112
Russia	Agriculture	0.106
Sweden	REST	0.101
Lithuania	Agriculture	0.087
UK	REST	0.077
Denmark	REST	0.066
Sweden	Combustion	0.064
Netherlands	REST	0.059
Belarus	Combustion	0.044
Belarus	Transportation	0.043
Poland	REST	0.039
Lithuania	Transportation	0.038
Latvia	Agriculture	0.023
France	REST	0.021
Lithuania	Combustion	0.021
Russia	REST	0.018
Finland	Transportation	0.016
Finland	Combustion	0.015
Latvia	Combustion	0.015
Belarus	REST	0.015
Estonia	Agriculture	0.014
Finland	Agriculture	0.013
Latvia	Transportation	0.011
Estonia	Transportation	0.008
Estonia	Combustion	0.007
Lithuania	REST	0.006
Latvia	REST	0.003
Estonia	REST	0.000
Finland	REST	0.000
BAS	Agriculture	0.000
BAS	Combustion	0.000
BAS	REST	0.000
NOS	Agriculture	0.000
NOS	Combustion	0.000
NOS	REST	0.000

In the case of the Kattegat sub-basin. two strong agriculture sources. Denmark and Germany are at the top of the contributors list with 17% and 14.4% contribution, respectively. Next three places are occupied by three transportation sources: from the North Sea, the Baltic Sea and Germany. There is only one combustion sources (Germany) visible on the top ten list of the Kattegat sub-basin.

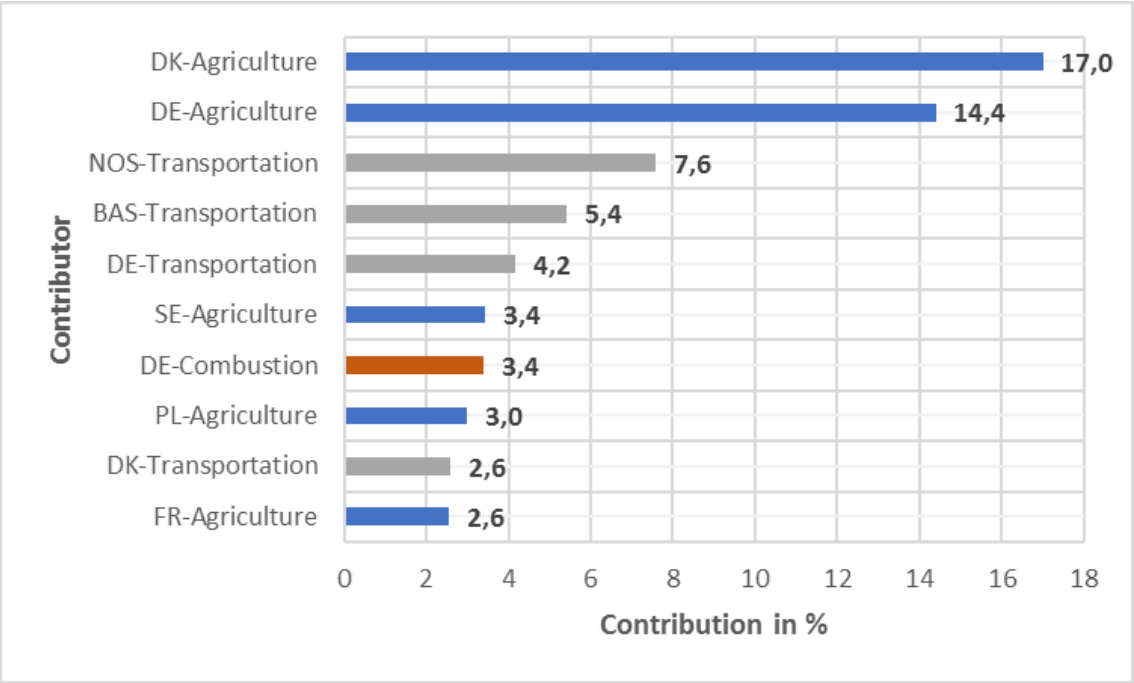


Fig. 4.7. Top ten contributors to annual total 2014 nitrogen deposition to the Kattegat sub-basin. Units: % of total (from all EMEP sources) nitrogen deposition to the Kattegat sub-basin.

4.8 The Sound

Table 4.8. List of all combined sources contributing to nitrogen deposition in the Sound sub-basin in descending order. Units: kt N per year.

Country/Sea	Sector	Deposition
Germany	Agriculture	0.439
Denmark	Agriculture	0.251
BAS	Transportation	0.150
NOS	Transportation	0.137
Germany	Transportation	0.121
Sweden	Agriculture	0.107
Germany	Combustion	0.095
Poland	Agriculture	0.095
Denmark	Transportation	0.082
Poland	Combustion	0.059
Netherlands	Agriculture	0.054
Poland	Transportation	0.050
France	Agriculture	0.047
UK	Combustion	0.047
UK	Transportation	0.047
France	Transportation	0.038
Netherlands	Transportation	0.037
Sweden	Transportation	0.036
UK	Agriculture	0.027

Germany	REST	0.025
Denmark	Combustion	0.022
Belarus	Agriculture	0.021
Netherlands	Combustion	0.018
France	Combustion	0.017
Russia	Transportation	0.014
Russia	Agriculture	0.012
Russia	Combustion	0.012
Denmark	REST	0.011
Lithuania	Agriculture	0.011
Sweden	REST	0.011
Sweden	Combustion	0.007
Netherlands	REST	0.006
Poland	REST	0.005
Belarus	Combustion	0.005
Belarus	Transportation	0.005
UK	REST	0.005
Lithuania	Transportation	0.004
Latvia	Agriculture	0.003
Estonia	Agriculture	0.002
Finland	Agriculture	0.002
Finland	Combustion	0.002
Finland	Transportation	0.002
Latvia	Transportation	0.002
Lithuania	Combustion	0.002
Russia	REST	0.002
Belarus	REST	0.002
France	REST	0.002
Estonia	Combustion	0.001
Estonia	Transportation	0.001
Latvia	Combustion	0.001
Estonia	REST	0.000
Finland	REST	0.000
Latvia	REST	0.000
Lithuania	REST	0.000
BAS	Agriculture	0.000
BAS	Combustion	0.000
BAS	REST	0.000
NOS	Agriculture	0.000
NOS	Combustion	0.000
NOS	REST	0.000

Agriculture from Germany (18.4%) and Denmark (10.5%) are the major sources of nitrogen deposition to the Sound sub-basin. Then three transportation sources are next on the list (the North Sea. the Baltic Sea. Germany). and they contribute 18.1% together. almost the same as the largest contribution from German agriculture.

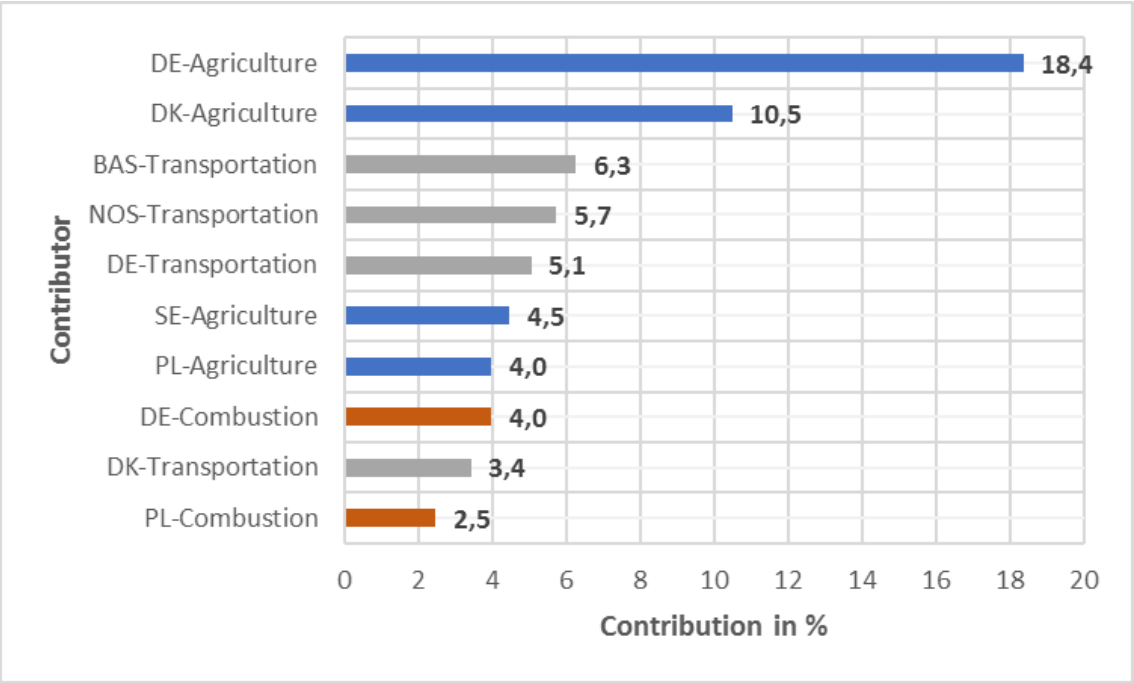


Fig. 4.8. Top ten contributors to annual total 2014 nitrogen deposition to the Sound sub-basin. Units: % of total (from all EMEP sources) nitrogen deposition to the Sound sub-basin.

4.9 Western Baltic

Table 4.9. List of all combined sources contributing to nitrogen deposition in the Western Baltic sub-basin in descending order. Units: kt N per year.

Country/Sea	Sector	Deposition
Germany	Agriculture	7.386
Denmark	Agriculture	2.686
NOS	Transportation	1.164
Germany	Transportation	1.143
BAS	Transportation	0.930
Germany	Combustion	0.843
Poland	Agriculture	0.652
Netherlands	Agriculture	0.627
France	Agriculture	0.539
UK	Combustion	0.407
Poland	Combustion	0.403
UK	Transportation	0.403
France	Transportation	0.351
Denmark	Transportation	0.326
Poland	Transportation	0.319
Netherlands	Transportation	0.313
UK	Agriculture	0.269
Germany	REST	0.260
Netherlands	Combustion	0.155

France	Combustion	0.150
Sweden	Agriculture	0.123
Denmark	Combustion	0.109
Belarus	Agriculture	0.103
Netherlands	REST	0.073
Russia	Transportation	0.070
Russia	Agriculture	0.064
Sweden	Transportation	0.063
UK	REST	0.058
Russia	Combustion	0.055
Denmark	REST	0.039
Lithuania	Agriculture	0.038
Poland	REST	0.035
Belarus	Transportation	0.021
Sweden	Combustion	0.019
Belarus	Combustion	0.019
Sweden	REST	0.018
France	REST	0.018
Lithuania	Transportation	0.014
Latvia	Agriculture	0.011
Russia	REST	0.010
Belarus	REST	0.009
Finland	Combustion	0.007
Finland	Transportation	0.007
Estonia	Agriculture	0.006
Finland	Agriculture	0.006
Latvia	Transportation	0.006
Lithuania	Combustion	0.006
Latvia	Combustion	0.004
Estonia	Combustion	0.003
Estonia	Transportation	0.003
Latvia	REST	0.002
Lithuania	REST	0.002
Estonia	REST	0.000
Finland	REST	0.000
BAS	Agriculture	0.000
BAS	Combustion	0.000
BAS	REST	0.000
NOS	Agriculture	0.000
NOS	Combustion	0.000

Agriculture from Germany (33.1%) is the major source of nitrogen deposition to the Western Baltic sub-basin. Together with source number two. agriculture from Denmark – 12%. they account for 45% of nitrogen deposition to the Western Baltic sub-basin. Three transportation sources are next on the list (the North Sea, Germany, the Baltic Sea), but they contribute less than 15% together.

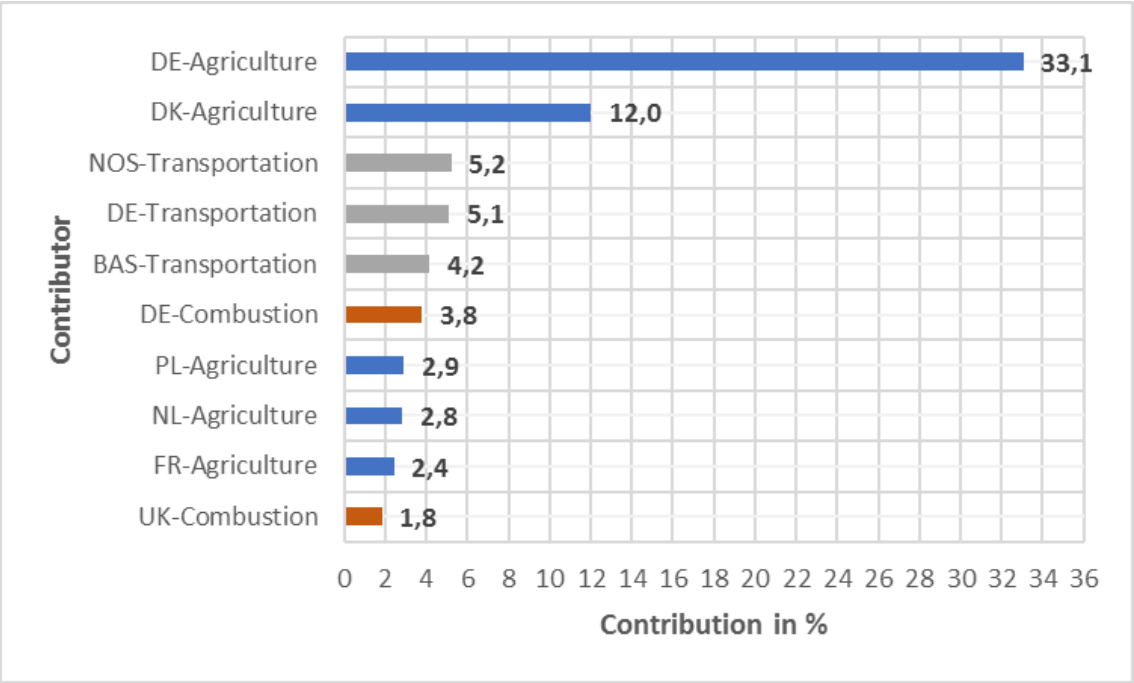


Fig. 4.9. Top ten contributors to annual total 2014 nitrogen deposition to the Western Baltic sub-basin. Units: % of total (from all EMEP sources) nitrogen deposition to the Western Baltic sub-basin.

4.10 The entire Baltic Sea basin

Table 4.10. List of all combined sources contributing to nitrogen deposition in the entire Baltic Sea basin in descending order. Units: kt N per year.

Country/Sea	Sector	Deposition
Germany	Agriculture	32.320
Poland	Agriculture	15.761
BAS	Transportation	15.178
Denmark	Agriculture	11.018
Germany	Transportation	10.623
NOS	Transportation	10.283
Germany	Combustion	8.578
Poland	Combustion	8.224
Poland	Transportation	7.278
Sweden	Agriculture	6.743
Belarus	Agriculture	4.380
Russia	Transportation	4.151
France	Agriculture	3.685
UK	Combustion	3.682
UK	Transportation	3.438
Lithuania	Agriculture	3.328
Russia	Agriculture	3.302
France	Transportation	3.232
Finland	Agriculture	3.149
Russia	Combustion	3.122

Sweden	Transportation	3.082
Denmark	Transportation	2.945
Netherlands	Agriculture	2.906
Netherlands	Transportation	2.483
Finland	Transportation	2.101
Germany	REST	2.070
Finland	Combustion	1.957
UK	Agriculture	1.827
Latvia	Agriculture	1.640
Estonia	Agriculture	1.634
France	Combustion	1.421
Sweden	REST	1.361
Netherlands	Combustion	1.343
Lithuania	Transportation	1.147
Sweden	Combustion	1.099
Belarus	Combustion	1.027
Belarus	Transportation	1.016
Denmark	Combustion	1.001
Latvia	Combustion	0.782
Poland	REST	0.769
Latvia	Transportation	0.663
Estonia	Combustion	0.622
Estonia	Transportation	0.601
Lithuania	Combustion	0.576
Russia	REST	0.567
UK	REST	0.400
Belarus	REST	0.382
Netherlands	REST	0.345
Latvia	REST	0.215
Lithuania	REST	0.210
Denmark	REST	0.197
Finland	REST	0.180
France	REST	0.138
Estonia	REST	0.067
BAS	Agriculture	0.000
BAS	Combustion	0.000
BAS	REST	0.000
NOS	Agriculture	0.000
NOS	Combustion	0.000

Agriculture in Germany is a dominating source with 14% contribution to nitrogen deposition to the entire Baltic Sea basin. The number two source is also agriculture. from Poland this time. but with much lower contribution (6.8%). Number three contribution (6.6%) is transportation from the Baltic Sea ship traffic. Altogether, there are four agriculture sources (Germany, Poland, Denmark and Sweden), four transportation sources (the Baltic Sea. Germany, the North Sea and Poland) and only two combustion sources (Germany and Poland) among top ten contributors to the entire Baltic Sea basin.

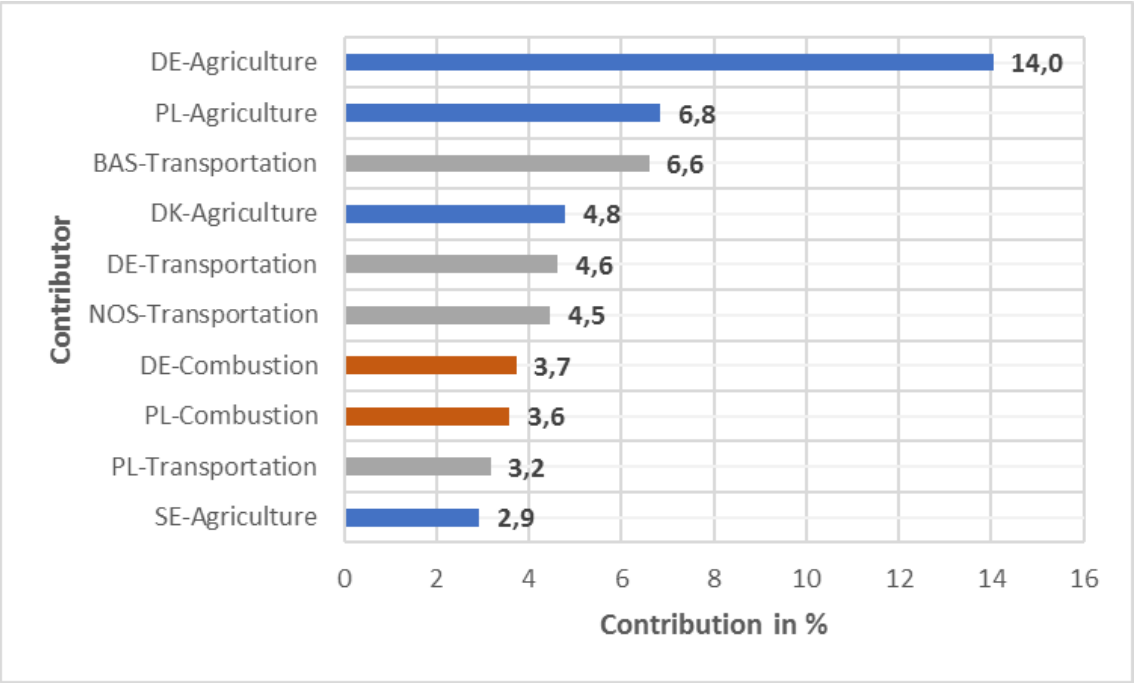


Fig. 4.10. Top ten contributors to annual total 2014 nitrogen deposition to the entire Baltic Sea basin. Units: % of total (from all EMEP sources) nitrogen deposition to the Baltic Sea basin.

5. Conclusions

The main conclusions from this investigation are listed below:

- Emissions are the driving forces for all the depositions calculated in this report. Meteorological conditions and chemical processes are also important. but not as much as emissions. Concerning nitrogen oxides emissions, a major part of them is generated from transportation followed by combustion and then a very small part from agriculture. This is the situation for six out of nine HELCOM Contracting Parties and three out of four external countries. In the remaining countries, combustion is the major source of nitrogen oxides emissions, followed by transportation and very small contribution from agriculture.

- In the case of ammonia emissions. agriculture dominates in all countries generating up to 98% of ammonia emissions.

- Agriculture is also a major component of the total nitrogen emissions. followed in most of the countries by transportation and combustion. However in three countries (Latvia. Poland and the United Kingdom) combustion contributes more than transportation to total nitrogen emissions.

- Emissions from ship traffic on the Baltic Sea come from transportation only, but are very important, because this is the only emission source located in the Baltic Sea basin.

- Emissions from ship traffic on the North Sea are also important because they contribute to nitrogen deposition in the western part of the Baltic Sea.

- The structure of nitrogen emissions in the HELCOM Contracting Parties and external sources is reflected in the distribution of nitrogen deposition in the Baltic Sea basin and sub-basins. For most of the countries the major contribution to the deposition comes from agriculture, followed by transportation and combustion.

- Concerning combined contribution from countries and emission sectors to individual sub-basins. the major contributors are: Baltic Sea transportation and agriculture in Germany, Baltic Sea transportation appear among top three contributors to eight out of nine sub-basins and is the number one contributor in four sub-basins. The same applies to agriculture in Germany. This is the number one contributor to four sub-basins and is among top three contributors to eight sub-basins.

- Concerning combined contribution from countries and emission sectors to the entire Baltic Sea basin the major contributors are: 1. Agriculture in Germany. 2. Agriculture in Poland and 3. Baltic Sea transportation.

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