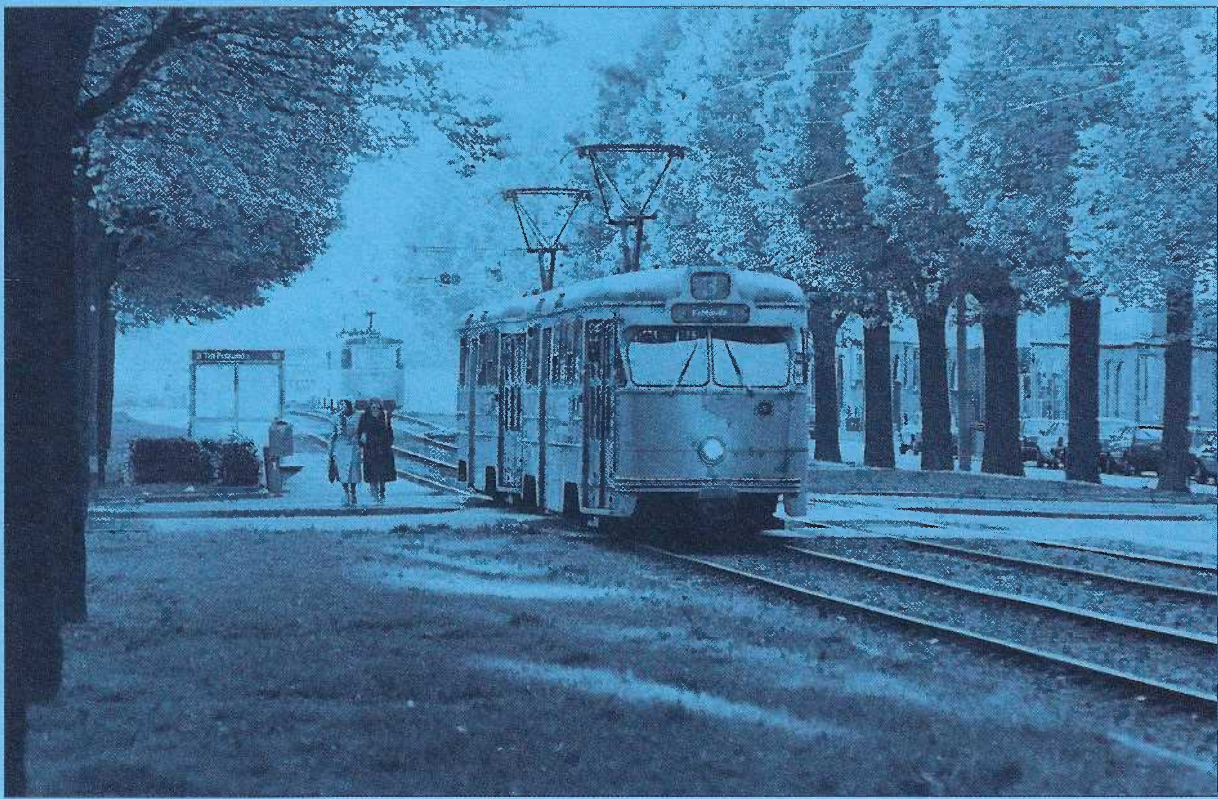
AIR POLLUTION AND CLIMATE SERIES

9

Environmental space

As applied to acidifying air pollutants



The concept of environmental space makes it possible to show what reducing emissions will mean in terms of the individual

The Swedish
NGO Secretariat
on Acid Rain

Environmental space

As applied to acidifying air pollutants

... in the case of four European countries

A study by
Birgit Nielsen
Melica Miljökonsulter

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AIR POLLUTION AND CLIMATE SERIES

Environmental space. As applied to acidifying air pollutants

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Preface

Ever since the mid-eighties, the European environmentalist organizations, referring to the critical loads, have been calling for a reduction of the emissions of acidifying air pollutants by at least 90 per cent. In that way the load on the environment would no longer exceed the natural tolerance. In other words, the deposition of pollutants would then have come under the critical loads.

In order to have demonstrated, with reference to the concept of environmental space, what reducing emissions to that extent will mean for the average European, in the way of changes in his daily round as well as in the community at large, the Swedish NGO Secretariat on Acid Rain engaged the services of Melica environmental consultants, the results of whose work are now presented in this report.

It is our hope that Melica's research, together with the accompanying commentary, will inspire to fresh thinking as to what might be accomplished through the democratic process as well as by environmentalist organizations and individuals.

Göteborg, June 1998

Mikael Johannesson
Chairman, The Swedish NGO Secretariat on Acid Rain

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Summary

Environmental space is a highly useful concept because it unites scientific demands with social aims. By mentally reducing emissions to the individual level, it makes the whole matter of pollution and its remedies more easily comprehensible. Using this concept also means taking several environmental problems into consideration simultaneously. It is for instance impossible to separate emissions of sulphur from energy use generally, or from emissions of carbon dioxide. And attacking associated problems simultaneously is most likely to be more cost-effective than dealing with each one separately.

In this study the environmental space in respect of emissions of sulphur dioxide, nitrogen oxides, and ammonia has been calculated for Europe as a whole, and the consequences examined in particular for Great Britain, Spain, Poland, and Sweden. The starting point has been the claim of the European environmentalist organizations that the emissions of sulphur and nitrogen oxides will have to be reduced by at least 90 per cent, and those of ammonia by 75 per cent (as from 1980), if they are to be brought down to the levels that nature can tolerate.

The environmental space for emissions of **sulphur dioxide** in Europe in 2010 is estimated to be 7.8 kilograms per head of population per annum. In Poland in 1990 they amounted on an average to 86 kilograms per head, in Great Britain 66, Spain 57, and Sweden 14 kilograms. Reductions of 86 to 91 per cent will be necessary in Poland, Great Britain and Spain. Sweden will need to reduce emissions by 44 per cent. Since the sources are mainly plants for the generation of power and heat, there is little the individual can do to influence emissions of sulphur dioxide – apart from engaging in "clean" electricity and so-called "negawatt," or buying into ecofunds.

For emissions of **nitrogen oxides**, the environmental space in Europe (calculated as NO_2) would be 3 kilograms per head per year in 2010. The actual figures for 1990 were 48 kilograms per individual for Britain, 47 for Sweden, 44 for Poland, and Spain 32 kilograms. There will have to be reductions of more than 90 per cent in all four countries. Here however are considerable opportunities for the individual to do his part in bringing about reductions – especially by changing his travel habits.

Another approach had to be taken for calculating the emissions and environmental space for **ammonia** – the main reasons being that the statistics proved inadequate and failed to take account of the great amounts of artificial fertilizers that are being used in agriculture. In this study the whole flow of nitrogen through the system has been quantified per hectare of farmland in each of the four countries that have been especially considered. It appeared that large amounts of nitrogen were simply not being utilized, being lost in ammonia evaporation and leakage of nitrate. The difference between the input of nitrogen to the land and that remaining in foodstuffs turned out to be greatest in Britain and least in Poland. In Britain no more than 20 per cent is utilized. For Spain it is also only 20 per cent, but for Sweden 30 per cent and Poland 55 per cent. The individual can do a lot to keep down the emissions he gives rise to by changing his diet – by reducing for instance his consumption of animal proteins, and buying as far as possible meat, cereals, and vegetables that have been produced without the use of artificial fertilizer.

A new concept

The concept of environmental space was put forward by Friends of the Earth Netherlands (*Vereniging Milieudefensie*) in 1992. It prescribes what may be considered acceptable limits to the use of resources and the pollution of the environment – set so as neither to infringe upon the possibilities of future generations to gain a livelihood nor damage biological diversity.

An important tenet is that the environmental space should be shared out equitably. Individuals everywhere have a right to an equal amount of space – although that will not mean that each one needs to use up all or any of the resources that would theoretically be at his disposal within that space. All should however have the possibility of satisfying reasonable needs. Differences in the right to consume may nevertheless arise on account of regional differences in resources.

There is also an educational aspect in calculating the available resources, and the necessary limits to emissions, in terms of the individual. It should make the whole matter easier for each one to take in and comprehend, and so pave the way for change. In this study the postulates expressed in *Towards Sustainable Europe – The Handbook* (1) have formed the basis for a transposition from critical loads to allowable emissions.

Critical loads and environmental space

There is a basic difference between these two concepts. Critical loads derive from strictly scientific facts concerning the amount of the depositions of pollutants, or other exposure to them, that various plant or animal species or types of nature can withstand without becoming damaged. Environmental space has to be based to some extent on assumptions relating to the precautionary principle – concerning the need, for instance, to reduce emissions of carbon dioxide or to halve the consumption of non-renewable resources such as iron and aluminium.

So far it has only been carbon dioxide, among air pollutants, that has been related to environmental space. In this report calculations are presented and the arguments reproduced as to how great that space can be for sulphur dioxide, nitrogen oxides, and ammonia.

Bases for calculation

NEED FOR REDUCTION. Proceeding from what is known of critical loads, a number of environmentalist organizations have agreed on the amounts by which emissions will have to be reduced if the limits for nature's tolerance are not to be exceeded. Critical loads are the maximum amounts of pollutant that an ecosystem or its most sensitive parts can manage without becoming changed or damaged. If the critical loads for acidification and eutrophication are not to be exceeded, the emissions of sulphur dioxide and nitrogen oxides will, according to the environmentalist organizations, have to be reduced by at least 90 per cent, and those of ammonia by at least 75 per cent (2).

The amounts of reduction are from the emission levels prevailing at the beginning of the eighties. No target date was set for their achievement, but in this report it has been put at 2010.

To determine what these reductions will mean for the individual, what remains after a 90-per-cent reduction of the total European emissions of sulphur dioxide and nitrogen oxides has been divided by the assumed population of Europe in 2010. Since the problem is more complicated, and the statistics unsure, a different approach had to be taken for ammonia – by noting the flows of nitrogen through the agricultural systems of the four countries in the study, a picture of nitrogen leakage could be obtained and so the necessary reduction calculated.

Everywhere in this report the emissions of sulphur dioxide are counted as SO_2, those of nitrogen oxides as NO_2, and ammonia as pure nitrogen (N).

COUNTRIES SELECTED.For the purpose of the study they were Great Britain, Poland, Spain, and Sweden – on account of their having different patterns of energy supply, transportation, industry, and agriculture.

GEOGRAPHICAL DIFFERENCES. If only sensitivity to acidification were to be considered, the inhabitants of Spain could be permitted much greater emissions of, say, sulphur dioxide than people living in Poland, Britain, or Sweden – since the pollutants from Spanish sources fall mainly on places where the ecosystems are less sensitive. In the other three countries the most pollution gets deposited on very sensitive areas where the critical loads are already being exceeded up to ten times over (3) (4). There would thus be more environmental value-for-money in reducing sulphur emissions in Britain and Poland than in Spain.

But to worry only about acidification would mean ignoring other harmful effects of air pollution, such as damage to health and to buildings and materials generally. It would also mean turning a blind eye to the need to decrease the use of energy and the emissions of carbon dioxide. Those items cannot be left out in calculations of environmental space. There is also a risk of getting less overall effect if cost-effective measures are taken only for one pollutant at a time.

In the case of ammonia, it is more important to observe where the emissions take place, since the depositions occur to a greater extent in the vicinity of the sources (although some can be transported away over great distances). This means, in principle, that the more sensitive an area is, the lower the livestock density should be. Here there is no risk of going wrong, since a trend to lower livestock densities would be fully in line with a move towards sustainable farming, with the number of animals in balance with feed production.

POPULATION. The amount of environmental space will vary according to the size of the population. The more people sharing a certain "space," the smaller will be the space per individual. For the purposes of this report, Europe's population has been estimated for countries included in the EMEP database (3), which includes the Baltic States, Belarus, and Ukraine as well as the European part of Russia.

According to Eurostat's Demographic Statistics 1993 (1), Europe's population in 2010 should amount to 730.7 million. The table below shows the total European emissions of sulphur dioxide and nitrogen oxides in 1980, together with the environmental space – the total after a 90-per-cent reduction of emissions and then per individual. The emission figures have been taken from Eurostat (5).

	SO_2	**NOx**
European emissions 1980	57.3 mill. tons	21.7 mill. tons
Environmental space (after 90% reduction)	5.7 mill tons	2.2 mill. tons
Environmental space per individual 2010	**7.8 kg**	**3 kg**

Sulphur dioxide

If the critical loads for acidifying depositions are not to be exceeded, the emissions of sulphur dioxide will have to be reduced overall in Europe by 90 per cent, from 1980 levels (see p. 3). Between 1980 and 1995 there had been a reduction of about 50 per cent.

Burning of oil and coal

Sulphur is an element that occurs in small amounts in all living matter. Oil and coal are the compressed and altered remains of plant and animal life dating mainly from the Carboniferous Period, 345 to 280 million years ago. When coal and oil are burnt, the sulphur in them combines with the oxygen of the air to form sulphur dioxide. This gas can be borne along in the atmosphere for thousands of kilometres before descending to earth and causing acidification.

The quantities emitted will depend mainly on the amounts of coal and oil that are burned, as well as on their sulphur content. They will also be affected by the extent to which cleaning processes are employed, either before or after combustion, and their relative efficiency.

Figures for the energy input of each country in the study are shown in the table below. They represent gross input – that is, domestic energy production plus imports minus exports, and any stockpiling.

Energy input 1994. TWh per year.

	Coal	Oil	Natural gas	Nuclear power	Renew-ables	Electricity import	Total
Poland*	877	156	103	0	19	-	1155
Spain	221	618	73	38	38	1.9	989
Britain	562	997	700	19	19	17	2313
Sweden	32	184	7.4	140	140	0.23	502

Sources: (5), (9). *Source (5). Figure for 1990.

Fuels' differing sulphur content

The relative volume of the emissions from any fuel is determined by the sulphur content. Natural gas contains no sulphur. Among petroleum products petrol has the lowest sulphur content, while heavy fuel oils have the highest. The amounts vary according to the composition of crude oil and the degree to which sulphur is removed in the refining process. Of the fossil fuels coal usually has the highest sulphur content. It may also contain inorganic sulphur in the form of pyrite.

In the fifteen member countries of the European Union in 1990, 63 per cent of the emissions of sulphur dioxide came from the burning of coal, and 18 per cent from heavy fuel oils (6).

The sulphur content of petrol ranges from 0.0008 per cent in Sweden to 0.1 per cent in Spain. While it lies between 2 and 3.5 per cent in the heavy fuel oils used in Spain and the UK, in Sweden it is only 0.3 per cent. For marine diesel fuels on the other hand Britain shows the lowest figure – 0.14 per cent – whereas Sweden has 1.2 per cent. Although statistics for ships' bunkers are often lacking, the average for Sweden has been 1.8 per cent, as against a world average of just under 3 per cent. All the above figures come from background material to the EU's acidification strategy. There are no country-by-country statistics to show the sulphur content of coal, nor any for the average sulphur content of petroleum products in Poland.

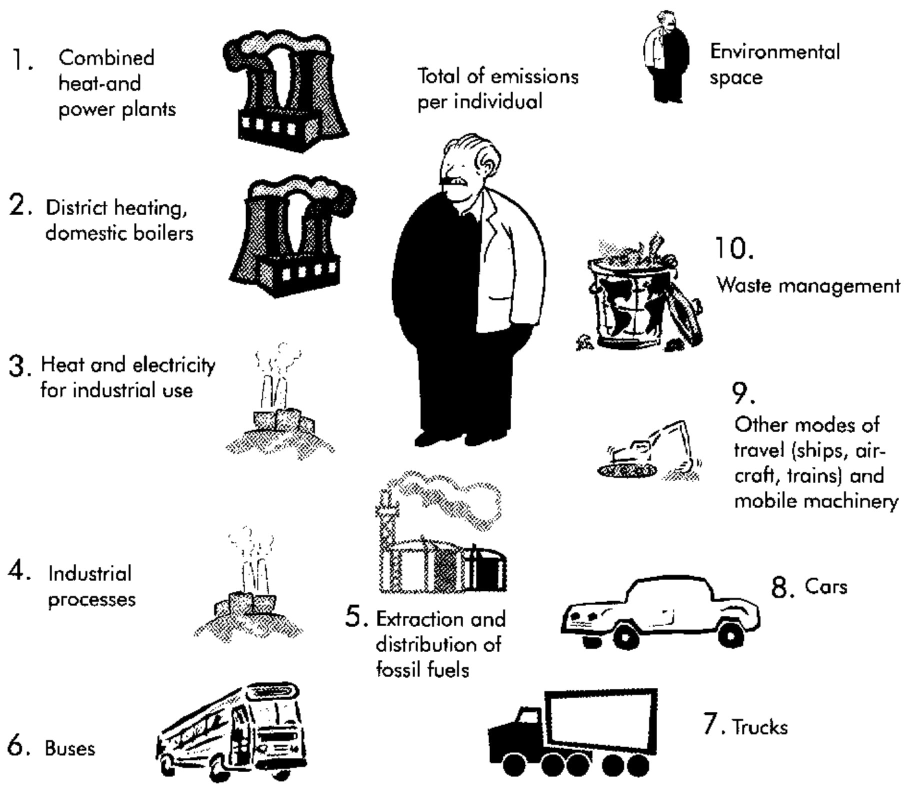
Desulphurization of the flue gases

Prior to 1990, Sweden was the only one of the four countries to have made any effort to remove sulphur from the flue gases of combustion plants, despite the fact that this method can be very effective for curbing emissions – as can also be judged from the account (7) concerning those plants in Europe that have achieved the best results in this respect, by emitting the least amount of sulphur dioxide per unit of energy input. In most cases their emissions were already under the levels proposed for new installations in EU legislation. Best of all was a combined heat-and-power plant at Västerås, in Sweden, with 3 milligrams of sulphur per megajoule of fuel (3 mg S/MJ).

The allowable environmental space

The following diagrams show the size of the present emissions per individual in each of the four countries in the study, and the extent to which they will have to be reduced if they are to arrive at the allowable environmental space per individual.

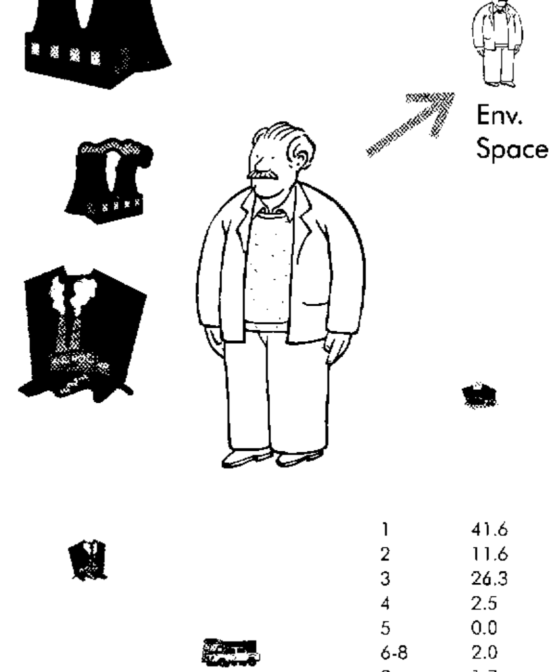
Explanation of the symbols



In the diagrams, each of the symbols is scaled in proportion to emissions per head of the country's population.

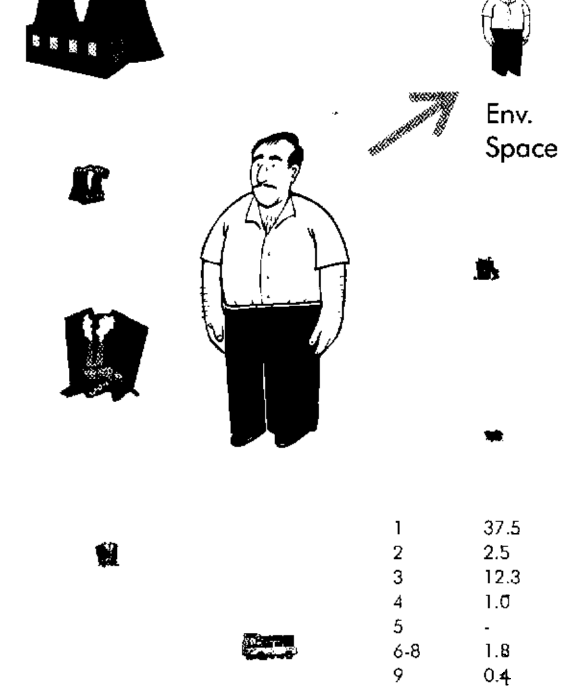
Sulphur-dioxide emissions: kilograms per head per annum.

Poland



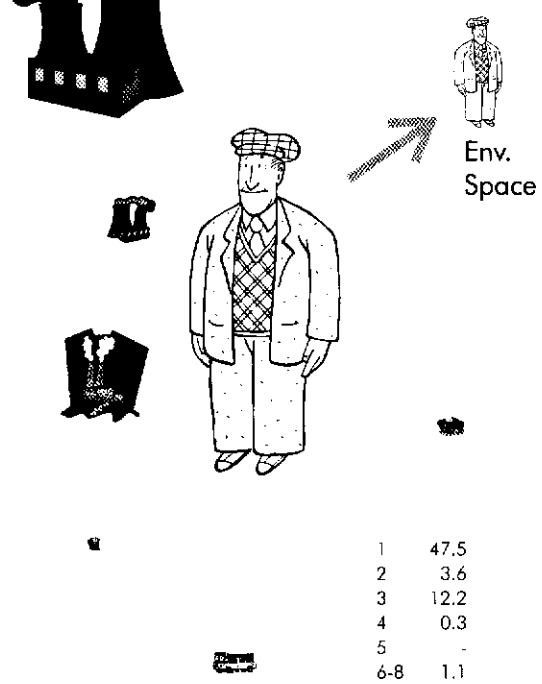
1	41.6
2	11.6
3	26.3
4	2.5
5	0.0
6-8	2.0
9	1.7
10	0.0
Total	85.7

Spain



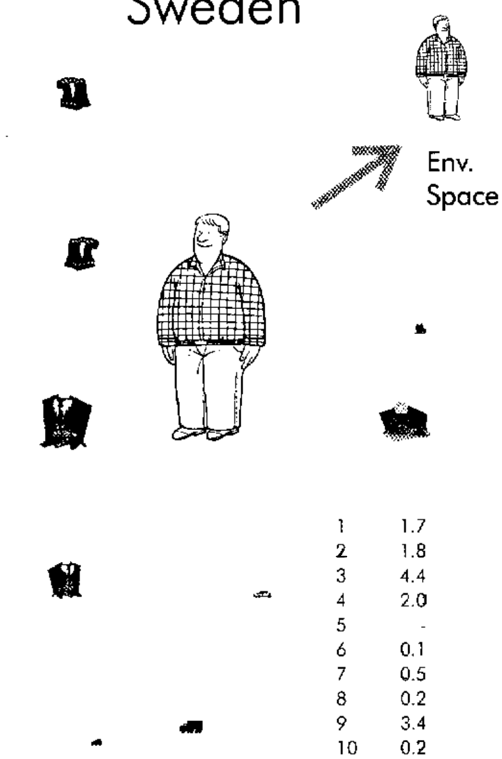
1	37.5
2	2.5
3	12.3
4	1.0
5	-
6-8	1.8
9	0.4
10	1.1
Total	56.6

Great Britain



1	47.5
2	3.6
3	12.2
4	0.3
5	-
6-8	1.1
9	1.1
10	0.0
Total	65.8

Sweden



1	1.7
2	1.8
3	4.4
4	2.0
5	-
6	0.1
7	0.5
8	0.2
9	3.4
10	0.2
Total	14.3

Notes to the diagrams

As might be expected, most of the emissions come from the generation of heat and power. The regularity is broken only by Sweden, where emissions per individual are already approaching the desirable.

POLAND. This is the country with the highest emissions of sulphur dioxide per head of population among the four studied – 86 kilograms in 1990 – although the actual energy input was less than either in Sweden or the United Kingdom. This is mainly because the Polish power plants have been less efficient and there has been more use of coal with a higher sulphur content. The country's energy system is based almost entirely on coal. To get within the figure for environmental space per individual, Poland will have to reduce its emissions, as from 1990, by 91 per cent.

In 1990, Poland was however in a period of transition between a planned and a market economy. By 1994 its emissions of sulphur dioxide had dropped from 3.2 million tons to 2.6 million. This last figure corresponds to 68 kilograms per individual. From a study of the Polish power industry (8) it appears that the reduction had taken place to a great extent within the generating sector – which is remarkable, since power production had only fallen off by 6.5 per cent between 1988 and 1994. According to Salay (8), there were three reasons: in the same period, the coal that was bought had a lower sulphur content and a higher energy value than the previous supplies; then the efficiency of the plants was improved, and a number were retrofitted for flue-gas desulphurization. In their energy policy the Poles have adopted a stick-and-carrot method, although the switch to a market economy had in any case given the generators an incentive to improve efficiency.

GREAT BRITAIN had the next highest emissions of sulphur dioxide per inhabitant in 1990. The reason was not only a great use of coal and oil, but also the fact that flue-gas desulphurization has been little employed. An 88-per-cent reduction of emissions per individual will be needed.

Because of an increase in the use of natural gas, and less burning of coal, British emissions of sulphur dioxide have however markedly decreased since 1990, despite the overall consumption of energy having remained relatively constant (9).

SPAIN. Emissions will have to be reduced by 86 per cent, compared with 1990. Energy consumption is lower in Spain than in northern European countries, but about on a level with that general in southern Europe. The use of natural gas is increasing and is likely to have doubled by 2000 (11). Energy input per head of population had been steadily increasing all through the eighties and into the nineties.

SWEDEN. Of all four countries, Sweden was using the greatest amount of energy per inhabitant in 1990, yet had the lowest emissions of sulphur dioxide: 14 kilograms. Since 1980, emissions had come down by 80 per cent. To attain a 90-per-cent reduction, all that will be needed now is a reduction of 44 per cent from the 1990 figure.

The great reduction in Sweden is mainly due to less use of oil, a lowering of its sulphur content, and increasingly stricter requirements both for combustion plants and manufacturing processes. Oil has been replaced primarily by nuclear power, biofuels, and a more efficient use of energy. Of late, overall energy consumption has tended to remain constant.

What is needed vs actual proposals

In the following table the emission reductions that will be needed to meet environmental-space requirements are shown against actual and likely measures.

Year	Emissions of SO_2 kg/head/yr 1980	1990	1995	Env. Space kg/head 2010	Needed reduction from 1990	Expected reduction from measures already adopted 1990-2010*
Poland	110	86	68	7.8	91%	56%
Spain	86	57	53	7.8	86%	54%
Britain	86	66	40	7.8	88%	74%
Sweden	60	14	11	7.8	44%	29%

* According to the reference scenario (REF) in the IIASA Second Interim Report (Amann et al. 1997).

In March 1997 the EU Commission presented a strategy for combating acidification (6), where it had calculated the extent to which emissions would be reduced between 1990 and 2010 as a result of measures already adopted (the REF scenario), and also how great the reductions would have to be in order to meet an interim environmental aim, the so-called 50-per-cent gap closure. According to the reference scenario there would be a 66-per-cent reduction of sulphur dioxide emissions, but to achieve a 50-per-cent gap closure it would have to be 84 per cent (in both cases for Europe as a whole).

A 50-per-cent gap closure means that between 1990 and 2010 the acidified area within each grid square on the EMEP maps would have to be halved. In other words, the area of the ecosystem in each 150x150-kilometre square where the critical loads are being exceeded should be cut by at least 50 per cent.

Bound-up with carbon dioxide

Although it is possible to bring about a reduction of 80-90 per cent in the emissions of sulphur dioxide by purely technical means, it is often cheaper to reduce them through a more efficient use and distribution of energy, by saving energy, and using renewable sources to a greater extent, rather than by employing the most expensive methods for cleaning the flue gases. The use of fossil fuels will in any case also have to be cut down in order to reduce the emissions of carbon dioxide and so lessen the risk of climate change.

The equitable environmental space for emissions of carbon dioxide has been put at 1.7 tons of carbon dioxide per head per year (10). That would imply that the use of primary energy from fossil fuels should not exceed 7 MWh per individual a year (provided the proportions of the different kinds do not change; natural gas, for instance, yields considerably more energy per unit of emitted carbon dioxide than coal). The following table shows the energy inputs of the various countries and the proportions of fossil fuel. The year 1994 was chosen in this case because the later figures were more easily obtainable.

Energy input and emissions per head in 1994.

	Energy input MWh/head	Renewables incl. waste MWh/head	Fossil fuels MWh/head	Nuclear power MWh/head	Emissions of SO_2 1990 kg/head
Env. space	18	11[4]	7	0	
Poland	30[2]	0.5 [3]	30[3]	0	86[1]
Spain	29	0.9	24	4	57
Britain	45	0.3	40	4.5	66
Sweden	68	16	26	27	14

Sources: (5), (9). [1] Emissions in 1994 68 kg/head (10). [2] Eurostat (5). [3] Deduced from (5), as the difference between the per capita consumption of fossil fuels and the total energy input per head. [4] In (10), waste is not included.

The energy structure of all four countries will quite clearly have to be changed, if equitable environmental space is to be attained. As may be deduced from the next table, attainment of the environmental-space level for carbon dioxide would result in a distinct reduction of the emissions of sulphur dioxide. This assumes however [illegible] ive proportions of the fossil fuels tha [illegible] reat deal whether they are coal or natural gas. Here the figures have been calculated from the statistics for 1990.

	Fossil energy use in 1990 MWh/head	Needed reduction %	SO_2 emissions 2050 kg/head	Necessary further reduction as from 1990
Poland	29.5 →7	76	21 →7.8	15%
Spain	24 →7	71	16 →7.8	15%
Britain	40 →7	82	12 →7.8	6%
Sweden	26 →7	73	4 →7.8	0%

A conclusion that can be drawn is that the decreases in the use of fossil fuels in line with the environmental-space principle will also make for large reductions in the emissions of sulphur dioxide. But that is not to say that it would be as well to wait for that to take place. The target year for the reductions of carbon dioxide lies as far off as 2050, and the problem of acidification will have to be solved long before that. Technical and structural measures will have to be carried out in parallel, so as to solve several problems simultaneously and in the most cost-effective way.

What the individual can do

There is not much he can do about sulphur dioxide. Home owners with private heating can turn to low-sulphur fuels, but most people have no choice as regards fuel, and can do nothing about cleaning the coal or oil that is used for heat and power production. All they can do is to cut down on their individual consumption of energy and so contribute to changing their country's energy structure. A general economizing with heating and lighting is of course fine and necessary, but most people will want to see tangible results of their actions and, further, be able to influence the type of energy that is used. Here are some of the possibilities.

The "negawatt" concept is one. Already applied in California (at Sacramento) to enable a nuclear power plant to be closed down, it can be used to avoid further investing in generating capacity. Instead, the money can be turned to promoting a more efficient use of energy. The energy thus saved – negawatt – makes it unnecessary to build new capacity.

Several suppliers in Sweden are now offering their consumers environmentally tagged electricity – that is from non or low-polluting sources. The more people buy such power, the more electricity from renewable sources can be developed. Another possibility for the individual to influence his energy supply, which has been started by Göteborg Energi, is to invest in an ecological fund, financed by adding one öre per kilowatt-hour to the consumer's electricity bill. The fund money is applied to the development of the kind of environmentally favourable electricity the consumer chooses to support.

Through a combination of lower energy use, switching to renewable fuels, and the application of the best available technology, the emissions both of sulphur and carbon dioxide can indeed be brought down to levels that nature can tolerate.

Nitrogen oxides

If the critical loads for acidifying depositions are not to be exceeded, the emissions of nitrogen oxides will have to be reduced overall in Europe by 90 per cent, from 1980 levels (see p. 3). Between 1980 and 1995 they had gone down by 10 per cent.

Formed in all kinds of combustion

During combustion the nitrogen gas and oxygen of the air react to form nitrogen oxides, collectively referred to as NOx. Nitrogen in the fuel itself will also affect the amount of NOx that is formed. Nitrogen oxides can, like sulphur dioxide, be carried along by the winds over thousands of kilometres. Among the effects are acidification, eutrophication, and the formation of ground-level ozone.

The size of the emissions will depend on the completeness of combustion, as well as its temperature and the extent to which the exhaust gases are cleaned.

Sources of emissions

The greatest single source of nitrogen-oxide emissions in Europe is road traffic, accounting for 44 per cent. Next are combustion plants for the generation of heat and power (25 per cent), followed by the burning of fuel in industrial processes (14 per cent), and emissions from mobile machinery and other non-transportation sources (13 per cent). (5)

After a rapid increase that started in the fifties, emissions levelled off towards the end of the eighties, and have since tended to diminish. The initial rise was mainly due to a great increase in road traffic, while the subsequent decrease can be ascribed in part to the introduction of cleaning techniques, but also to the industrial decline in many countries.

Cleaner emissions

Cars equipped for catalytic cleaning of the exhaust gases started to come onto the market in most European countries early in the nineties, and discussions of ways of dealing with heavy vehicles began at the same time. After 1980, requirements for control of the emissions of nitrogen oxides from large combustion plants, both new and existing, have gradually been introduced and subsequently tightened up.

Reducing the emissions of nitrogen oxides calls either for adaptation of the process of combustion or treatment of the flue gases, or both. It should by no means be impossible to bring down emissions from heat and power generating to the level of environmental targets by 2010, although it would require some structural changes. Meeting the environmental-space requirements for the use of fossil energy in 2050 may however lead to difficulty in hitting the targets for nitrogen oxides (by causing increased burning of biofuels).

It will be more difficult to deal with the problems of the transportation sector by 2010. Catalytic converters alone will not do it – a main reason being the slowness with which catalyzer-equipped cars come onto the market. Also exhaust-gas cleaning is still not as effective for diesel vehicles as it is for petrol-driven cars. The volume of traffic, too, is expected to increase. Consequently big – and quick – changes will be needed both in the transportation structure itself and the daily travel habits of the individual.

Environmental space vs current measures

In the table below the results of measures that have already been adopted are set against the targets for acceptable environmental space in 2010. According to calculations made for the EU acidification strategy (6), the emissions of nitrogen oxides will, in consequence of well-advanced plans, as well as measures already adopted, drop by 48 per cent between 1990 and 2010. But to achieve a 50-per-cent gap closure (the interim target for acidification), a reduction of 55 per cent would be needed.

Year	Emissions Of No_2 Kg/head/yr 1980	1990	1995	Env. Space Kg/head 2010	Needed Reduction From 1990	Expected Reduction From Measures Already Adopted 1990-2010*
Poland	40	45	29	3	93%	36%
Spain	25	32	31	3	91%	28%
Britain	42	48	39	3	94%	55%
Sweden	50	47	41	3	94%	50%

* According to the reference scenario (REF) in the IIASA Second Interim Report (Amann et al. 1997).

Emissions and environmental space

The figures for nitrogen oxides have been taken from Eurostat 1995 (5), where however those for road traffic are said to be based on inadequate statistical material. The emission data for nitrogen oxides are therefore less reliable than those for sulphur dioxide. They do not, according to Eurostat, always cover the emissions from all mobile sources.

The proportion coming from passenger cars is naturally of especial interest when considering emissions per individual. In the table the figures for Great Britain and Spain have been taken from CORINAIR (11), and those for Sweden and Poland from national sources (12, 13).

Nitrogen-oxide emissions from road traffic in 1990.

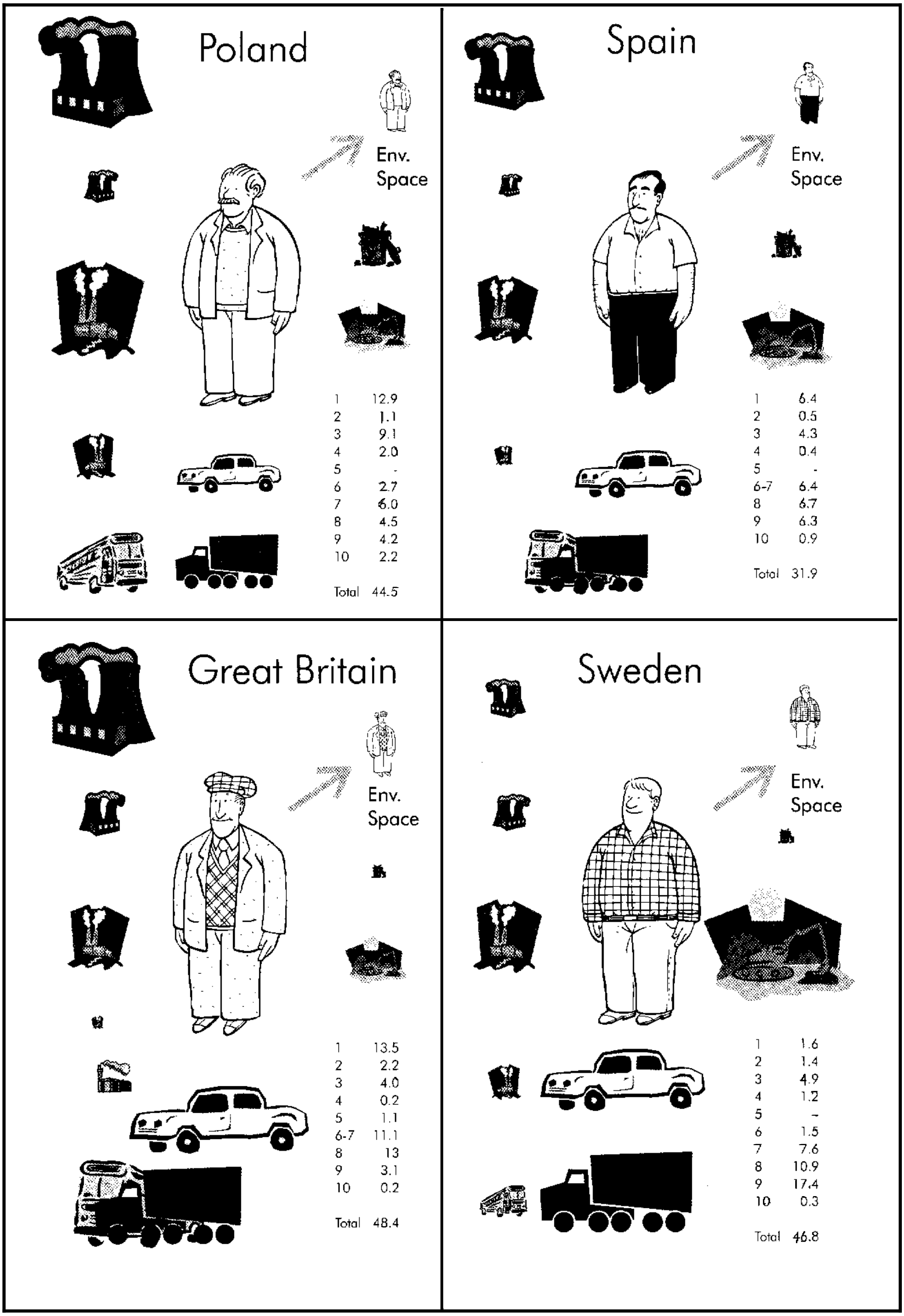
	Emissions kg NOx/head	Passenger cars' share of road-traffic emissions	Emissions from cars kg/head
Poland[1]	13	34%	4.5
Great Britain[2]	24	54%	13
Spain[2]	13	51%	7
Sweden[3]	20	54%	11

[1] Ref. (13) [2] Ref. (11) [3] Ref. (12)

Here follow diagrams to illustrate, for the four countries in the study, the present relative size of their emissions of nitrogen oxides, per head of population per year, with the reductions that will be necessary to bring them into line with the allowable environmental space. As before, the figures refer to the symbols.

1. Combined heat-and-power plants.
2. District heating, domestic boilers.
3. Heat and electricity for industrial use.
4. Industrial processes.
5. Extraction and distribution of fossil fuels.
6. Buses.
7. Trucks.
8. Cars.
9. Other modes of travel (ships, aircraft, trains) and mobile machinery.
10. Waste management.

Nitrogen-oxide emissions: kilograms per head per annum.



Notes to the diagrams

Emissions of nitrogen oxides per head do not differ so much from country to country as they do for sulphur dioxide. In all cases they will have to be reduced by more than 90 per cent from 1990 levels to get within the limit for environmental space.

POLAND. Emissions amounted to 45 kilograms per individual in 1990, calling for a reduction of 93 per cent. More than half come from the burning of fuel in industry and the generation of heat and power. Emissions from road traffic are notably less than in any of the other countries – cars having accounted for no more than 10 per cent of the nitrogen-oxide total.

SPAIN. This was the country with the lowest emissions per head: 32 kilograms. It nevertheless needs to reduce them by 91 per cent. The relatively low figure is probably not so much due to better control of the emissions as to the fact that the need for space heating is less than in countries further north. The emissions from road traffic per individual are also less than in Great Britain and Sweden.

GREAT BRITAIN has the highest figure of all: 48 kilograms per head per annum in 1990. Needed reduction: 94 per cent. The emissions from space heating and power generation, as well as road traffic, are especially great.

SWEDEN. With an emissions figure almost as large as the British – 47 kilograms per head in 1990 – Sweden will also have to cut back by 94 per cent. The predominant sources are cars and trucks, along with shipping and mobile machinery. That the emissions from the last should appear to be so much greater for Sweden is probably due, at least in part, to more accurate reporting.

Transport volume increasing

The tendency of road traffic to preponderate in the emission figures is evident from the calculations for environmental space (see diagrams). Traffic is moreover tending to increase, especially in countries where car ownership is still relatively low. But it is probably precisely in individual travel that people will have the greatest possibilities of influencing emissions of nitrogen oxides, which is why we are treating it more in detail here.

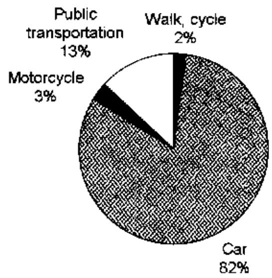
The great volume of emissions is largely due to changing patterns of transportation as well as large increases. People are now travelling much greater distances. At the beginning of the century an adult in Sweden would travel less than a kilometre a day (14), and the same would probably apply in the other countries as well. But in 1990 a Pole was travelling on an average 20 kilometres daily, and a Swede twice that distance. The increase in transport work was most marked in the 1960s and 1970s. In Sweden it has quinduplicated for personal transportation since 1950, and quadrupled for freight.

The movement of persons by road has increased most. Both in Sweden and Britain the predominant means of individual transportation is by car. Car travel accounted for 76 per cent of personal transportation kilometres in Sweden in 1990, the corresponding figure for Britain in 1995 was 82 per cent. In Poland, where people travel much less altogether, the figure was only about half as great, or 38 per cent. Similar statistics for Spain were not available.

Whither now?

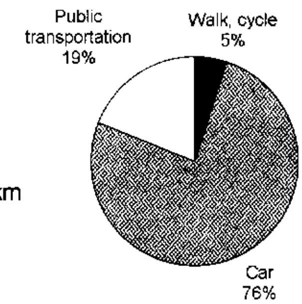
Investigations have shown the way cars are most used. Both in Sweden and Britain about 30 per cent of the travel was for taking people to work, and other uses were also similar in each case, with leisure trips and visits to friends and relations accounting for about a third, and shopping and miscellaneous uses for somewhat less.

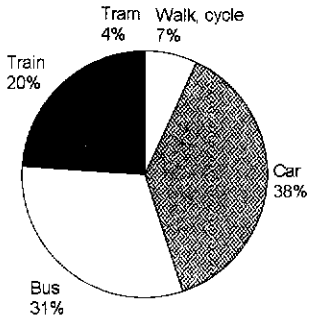
Modes of travel in three countries



Great Britain 1995 (Ref. 15)
Total of passenger-kilometres: 602 billion
Individual's average daily travel distance: 29 km

Sweden 1990 (Ref. 14)
Total of passenger-kilometres: 114 billion
Individual's average daily travel distance: 36 km





Poland 1989 (Ref. 13)
Total of passenger-kilometres: 280 billion
Individual's average daily travel distance: 20 km

The environmental-space allowance for personal travel

To get within the bounds of environmental space as regards carbon dioxide (see p. 9), both Swedes and Britons will have to cut down their individual consumption of fossil fuels for travel by about three-quarters, from today's levels. Poles will have to reduce the amounts they use in car and bus trips by a quarter. Here again there is no information for Spain, but as car ownership is about as high in Spain as in Britain and Sweden, it may be assumed that in this case the use of fossil fuels for travel will at least have to be halved. (5)

The effect this will have on emissions of nitrogen oxides is hard to discern. If the reductions should purely be a result of fewer vehicle-kilometres, they would be proportionate to those for carbon dioxide. But if they were only due to the arrival on the roads of more fuel-efficient cars and buses, nitrogen-oxide emissions would hardly be affected at all.

Doing one's part

Reducing transport needs, both for people and freight, will require planning. Even today, though, it would be quite possible for people to keep within their environmental space for travel. Anyone choosing to walk, cycle, or use public transportation in his daily round, and save fuel by taking the train, or using a catalyzer car for leisure movements, would be likely to get within the limits as regards both nitrogen-oxide emissions and energy consumption. Buying things produced in the vicinity, such as food, also helps to reduce a certain amount of transportation.

Cutting down the volume of road traffic would not only help to reduce the emissions of nitrogen oxides, but also give rise to a number of side effects in the way of reduced emissions of carbon dioxide and volatile hydrocarbons (and thus less forming of ground-level ozone), less noise and lower intrusions into the urban and rural environment.

Ammonia

To get depositions within the bounds of the critical loads in Europe, the emissions of ammonia will have to come down by 75 per cent (see p. 3). The European emissions are estimated to come mainly (80-95 per cent) from farming – and of the farm emissions about 80 per cent occur in the handling of manure. The rest are evaporations from artificial fertilizer. (16)

Evaporations tend to be the only consideration when thinking of reductions. But to deal with the issue properly, one needs a picture of the whole flow of nitrogen through the agricultural system. Then it will also be possible to relate the emissions of ammonia to environmental space and individual behaviour.

The flow of nitrogen in agriculture

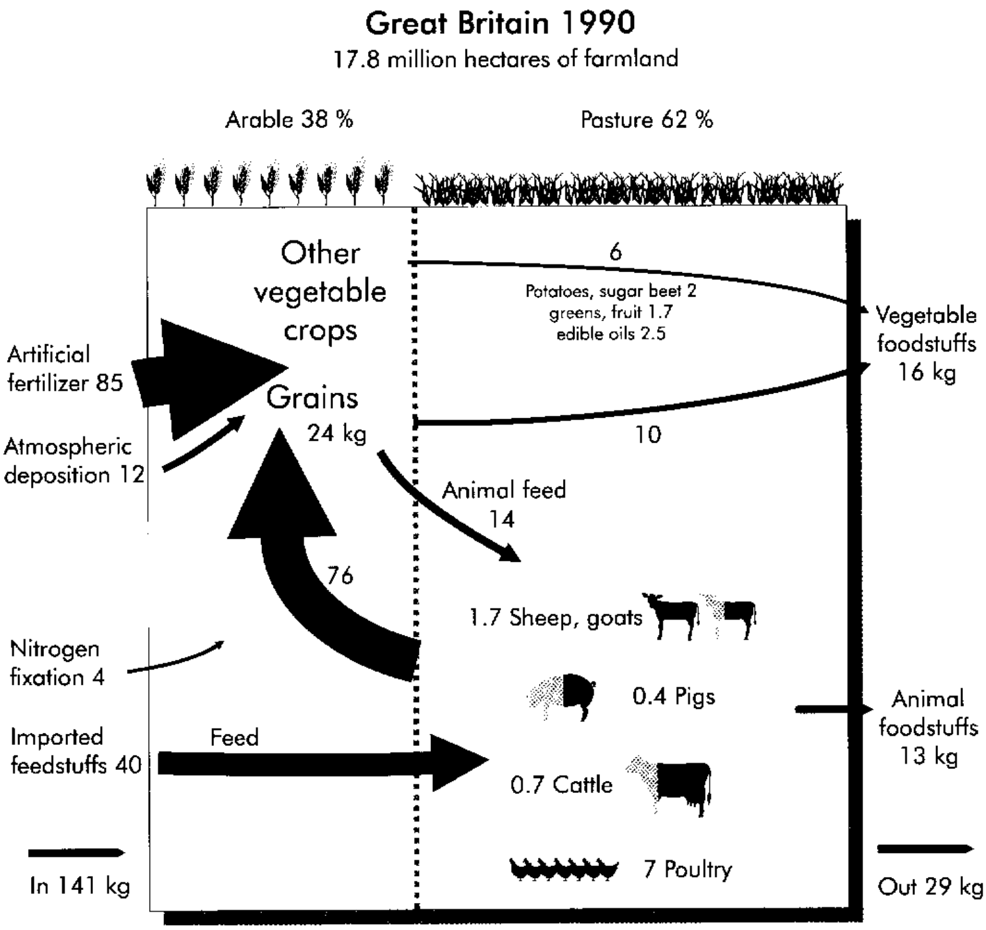
Up to the end of the forties, farming was based on a circulation of nutrients within the system – from crops via farm animals back to the land. The advent of artificial fertilizer broke this cycle, making it possible to farm without animals and grow, say, only grains. The nutrients that were removed in harvesting could be replaced with the nitrogen, phosphorous, and potassium in bought fertilizer. Stock raising and milk production could also be carried on without the necessary arable land to support it. The need for animal feed could be met from crops grown with the aid of artificial fertilizer.

But even as late as the 1950s little fertilizer was being used. In Sweden it was then only about 5 kilograms per hectare arable land per year as nitrogen, compared with about 80 kilograms today.

Farm specialization has often been carried so far, especially in Sweden and Great Britain, that grain growers have no animals at all, while livestock farmers either grow no feed themselves, or too little of it. For the latter animal manure becomes a disposal problem instead of a resource. The grain growers on the other hand have to cover their lack of natural nutrients by using artificial fertilizer. A large part of all grain goes to feeding animals – so that in effect the nitrogen that evaporates from animal manure in the form of ammonia often originates from artificial fertilizer. The availability of artificial fertilizer has meant that animal manure is no longer being treated as a valuable source of nutrients.

In all the four countries studied, the input of nutrient in agriculture was much greater than the amount subsequently remaining in foodstuffs and animal fodder. The unutilized nitrogen either evaporates in the form of ammonia or becomes leached out as nitrate, thus contributing to acidification and eutrophication. Plant-available nitrogen can also be moved out through denitrification, a bacterial process that takes place under anaerobic conditions, in which nitrate is reduced to nitrogen gas (N_2) and to some extent to nitrous oxide (N_2O).

A certain countertrend to monofarming, with the use of artificial fertilizer, is however making itself felt. In ecological farming the nitrogen flow is more like it was before the arrival of artificial fertilizer. The nitrogen input is chiefly through animal manure, livestock density is low and in balance with the ability of the property to grow feedstuffs.

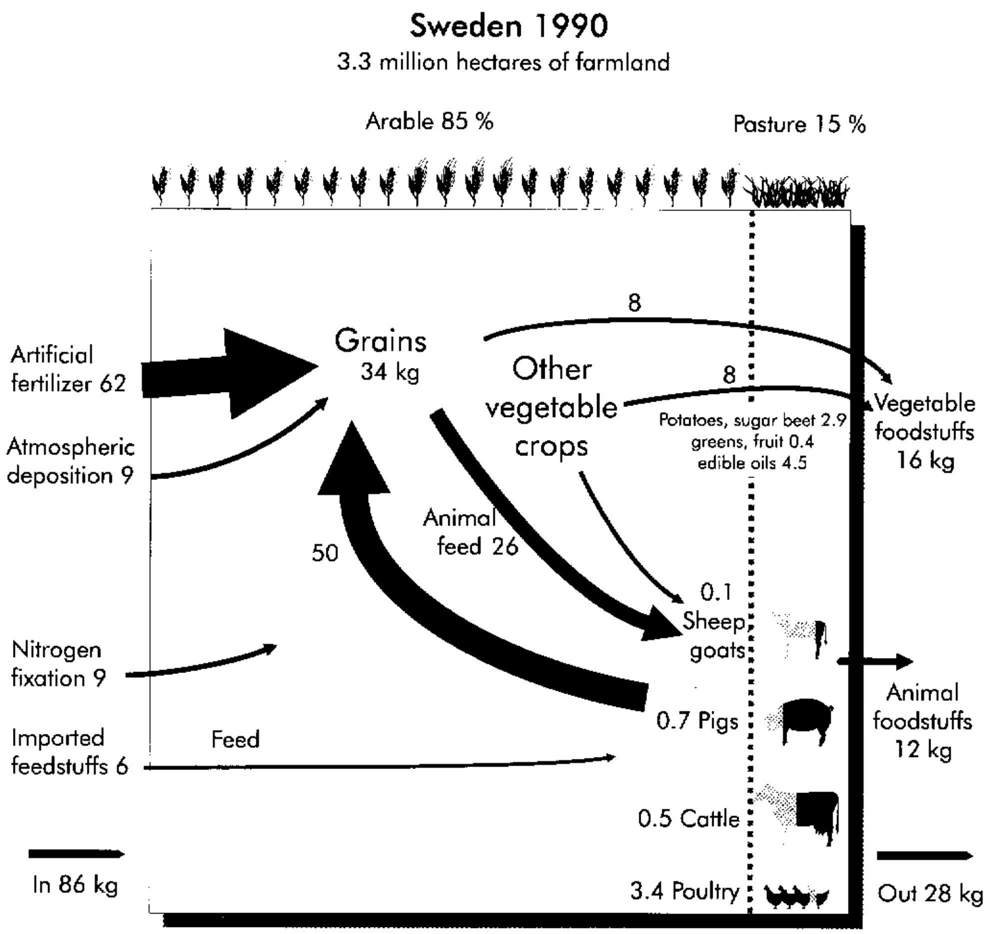


Of the four countries studied, Great Britain has the largest nitrogen input to farmland. The yield content in agricultural products amounts to one-fifth of the input. It is worth noting that while Britain has the largest input of artificial fertilizer per hectare, it also has the smallest proportion of arable land (38 per cent). The nitrogen input via imported foodstuffs is also greatest in Britain.

Evaporation of ammonia

The extent of evaporation will be governed in the main by
- The number and kind of animals and their feed.
- The management of the manure, from handling in the shed to storage and spreading on the fields.
- The input of artificial fertilizer, either directly onto the fields or indirectly via the feed.
- The amounts in either case will depend on how far the business has been specialized. The greater the accent on grain growing or stock raising, the less use the farmer will be making of animal manure.
- The degree of specialization will in turn depend on the pattern of demand for food products; in other words, what and how much people are eating.

In the diagrams the nitrogen flows per hectare of farmland have been quantified for each country. The way in which the calculations and estimates have been made is explained in Appendix 2. It may be worth noting that the figures for Sweden in this report have turned out to correspond well with those for other flow studies – see e.g. (17) – in spite of some differences in the methods employed. Here the nitrogen content is the actual content in vegetable and animal produce, whereas in Steineck (17) it is the remainder from input and losses.



In Sweden the yield content in farm products come to one-third of the nitrogen input per hectare of farmland. While the input of artificial fertilizer per hectare is high, that of nitrogen via imported feed is low.

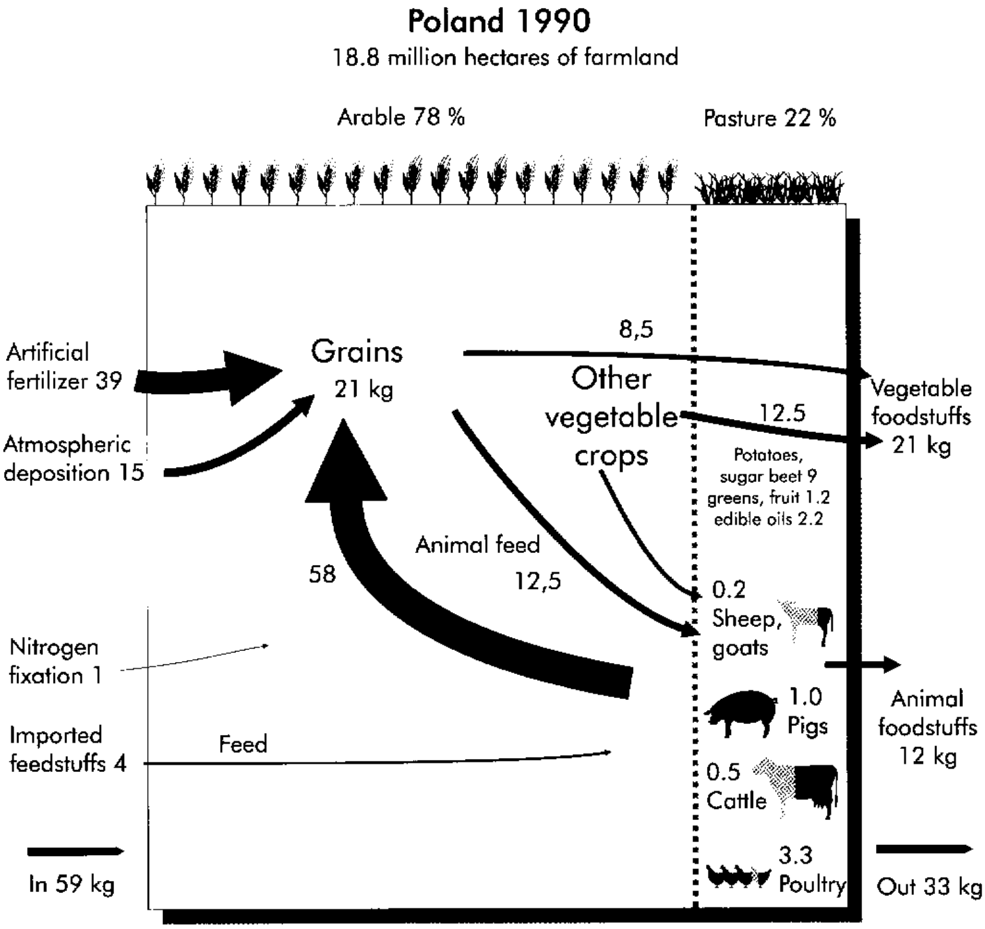
Notes to the diagrams

As can be seen from the studies of the flow (Figs. 1-4), a great amount of the nitrogen goes unused in farming. There is no means of estimating how much of the nitrogen runs off as ammonia. In that study (17) of the nitrogen flow in Swedish agriculture, the outflow of ammonia and the leaching of nitrate are estimated to be about equal, or 20 kilograms per hectare of arable land per annum. Speaking generally, the conclusion must be that the more nitrogen is put into the land via artificial fertilizer, the less will be the utilization of the nitrogen emanating from stock raising.

The flow studies show Great Britain to have the greatest evaporation of ammonia per hectare of farmland of all the four countries. The reason is that the nitrogen yield in farm produce is low and the surplus of nitrogen per hectare is high. Because of its relatively high nitrogen yield in farm produce, and having the lowest nitrogen surplus per hectare, Poland can probably boast the lowest evaporation of ammonia per hectare.

The size of the emissions

Estimates of the various countries' emissions of ammonia from farming, taken from the Eurostat statistics, are shown in the following table. They waver

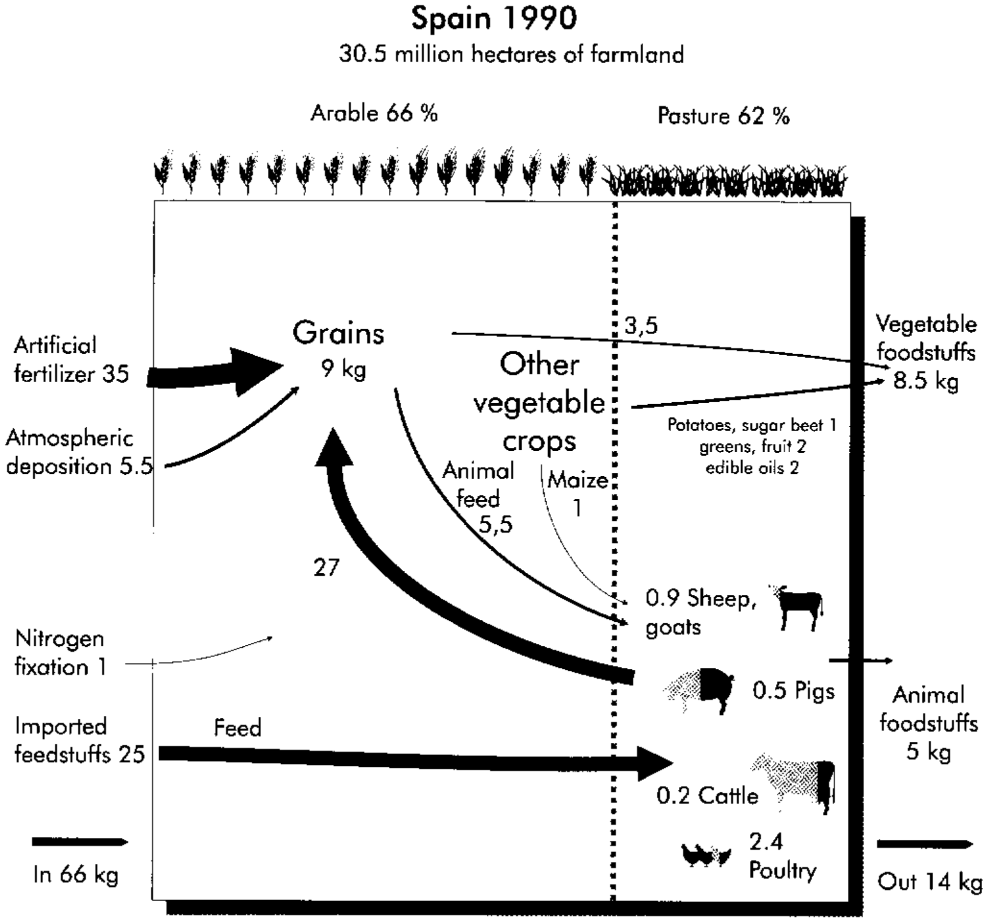


Poland shows the highest nitrogen yield of all the four countries, with 55 per cent of the input remaining in its agricultural products – the main reason being a lower input of nitrogen in the form of artificial fertilizer, and lower imports of animal feed.

nitrogen yield in farm produce is low and the surplus of nitrogen per hectare is high. Because of its relatively high nitrogen yield in farm produce, and having the lowest nitrogen surplus per hectare, Poland can probably boast the lowest evaporation of ammonia per hectare.

The size of the emissions

Estimates of the various countries' emissions of ammonia from farming, taken from the Eurostat statistics, are shown in the following table. They waver however to some extent, and make comparison difficult. There is stated to be uncertainty as to how much the national figures include all farm emission sources. It is also said that the estimates are probably incomplete. The Emission Inventory Guidebook (16) gives two methods for estimating emissions: one simple, the other more detailed. The simpler one merely calculates ammonia emissions by using an arbitrary figure for each animal category – with the only result that the more livestock a country possesses, the greater will be the emissions of ammonia. The more detailed method makes use of a variety of specific information from each country, such as feedstuffs, manure handling and methods of spreading, but still does not reveal how detailed the information has been in each case. An exception is Sweden, where the data, such as it is, is fully detailed.



In Spain the yield is one-fifth of the nitrogen input. The input via fertilizer is about the same as in Poland, despite a much lower grain production. Vegetable and fruit crops predominate, and vegetables and fruit have much lower contents of nitrogen than grains. Imports of feedstuffs are on the other hand high, but their nitrogen content is only a rough estimate.

Since, therefore, there is no possibility of comparison between countries, it is also difficult to draw conclusions. It might easily be assumed that the greatest emissions of ammonia per hectare of farmland occur in Great Britain and Poland. Readings from the diagrams of nitrogen flow indicate however that this conclusion is misleading: to get a proper idea of the extent of ammonia evaporation and decide how to deal with the problem, one must consider the total flow of nitrogen. It will then be easier to figure out the responsibility of the individual and see how each one of us can accommodate to the desirable environmental space.

Possibilities for individual action

Since the statistics are incomplete, and determining cause and effect is a complicated matter, no exact figures can be given to show the proportion of the ammonia emissions each European is causing today. It is quite clear on the other hand from the flow diagrams that the decisive factor is the way our foodstuffs are produced. If they come from farms where there is a balance between the input and outgo of nitrogen, the risk of ammonia evaporation will be lower – and probably much lower – than it would be from a farm where the nitrogen flow is unbalanced.

No artificial fertilizer is used on an ecological farm, and livestock density is lower than in one run on conventional lines. In Sweden, for example, the number of animals per hectare on an ecological farm is usually only half of the maximum allowable by law. Often, too, such a farm will be self-sufficient in feed. And instead of being a problem of waste disposal, the manure is a valuable resource for the production of grains and feed. Since any nitrogen leakage will constitute a loss that will affect the size of the harvest and so farm economy, there is a strong incentive to employ practices that will conserve nitrogen, such as spring ploughing, growing cover crops, and using the best techniques for spreading the farmyard manure.

Turning to the individual's possibilities, it would be of interest to study the way eating habits can affect nitrogen flows in agriculture. One way of measuring this is through meat – the amount consumed and the method of production. The table shows, alongside the figures for meat consumption, the extent to which nitrogen is utilized in the four countries' agriculture.

	Meat consumption kg per head per annum	**Nitrogen yield in farm products**	**Nitrogen surplus kg per hectare**
Poland	74	55%	26
Spain	90	20%	52
Great Britain	70	20%	112
Sweden	50	30%	58

People in the West consume more than twice as much in the way of animal proteins as the body needs. Swedes eat altogether 40 per cent more proteins than is necessary, and 70 per cent are of animal origin.

There are thus two main ways in which the individual can start right away taking action to reduce ammonia emissions to the amount allotted to him under the environmental space concept:

- Reduce his consumption of animal proteins.
- Choose meat, vegetable and cereal products from ecological farms.

A Swede cutting down his consumption of animal proteins to half of the present average, and buying to a large extent ecologically produced foodstuffs, would probably not be causing greater emissions of ammonia than his allotted share – or what nature can withstand.

It is also possible to reverse the argument. The more unbalanced the farming is in a country, the less will be the amount of conventionally produced animal products that can be allowed in the individual's figure for environmental space. A Pole should therefore be able to eat more meat than a Briton. But people in all the four countries eat more animal products than they need.

More advantages than a reduction of ammonia emissions will accrue from less use of artificial fertilizer and a switch to ecological farming. Among them will be less use of energy in agriculture, the conservation of phosphorus (a finite resource), and a curb on the spreading of cadmium (found in phosphate mineral).

Appendix 1

Underlying statistics for emissions of sulphur and nitrogen oxides

Emissions of sulphur and nitrogen oxides in 1990. Sources: 9, 16.

	Poland Population 38.2 million.				**Spain** Population: 39.0 million.			
	SO_2-tot	SO_2/pers	NO_x-tot	NO_x/pers	SO_2-tot	SO_2/pers	NO_x-tot	NO_x/pers
	1000 ton	kg	1000 ton	kg	1000 ton	kg	1000 ton	kg
Public power	1 588,9	41,6	492,6	12,9	1 463,1	37,5	248,9	6,4
Combustion, commercial etc.	443,9	11,6	43,4	1,1	97,9	2,5	21,3	0,5
Industrial combustion	1 005,6	26,3	348,3	9,1	478,5	12,3	169,4	4,3
Production processes	93,7	2,5	75,3	2,0	38,0	1,0	14,5	0,4
Extraction and distr. of fossil fuels								
Waste treatment & disposal	0,8	0,0	83,4	2,2	41,8	1,1	34,2	0,9
Road transport total	75,4	2,0	500,0	13,1	69,4	1,8	511,0	13,1
- Passenger cars		0,0	170,0	4,5		0,0	260,6	6,7
- Light-duty vehicles		0,0		0,0		0,0	59,0	1,5
- Heavy-duty vehicles		0,0	228,0	6,0		0,0	191,2	4,9Incl. bus
- Buses		0,0	102,0	2,7		0,0		
Other mobile sources and machinery	64,8	1,7	159,0	4,2	17,0	0,4	246,4	6,3
Sum	**3 273**	**86**	**1 702**	**45**	**2 206**	**57**	**1 246**	**32**

Emissions of sulphur and nitrogen oxides in 1990. Sources: 9, 15.

	Great Britain Population: 57.4 million.				**Sweden** Population: 8.6 million.			
	SO_2-tot	SO_2/pers	NO_x-tot	NO_x/pers	SO_2-tot	SO_2/pers	NO_x-tot	NO_x/pers
	1000 ton	kg	1000 ton	kg	1000 ton	kg	1000 ton	kg
Public power	2 729,1	47,5	775,9	13,5	14,9	1,7	13,9	1,6
Combustion, commercial etc.	208,0	3,6	123,9	2,2	15,7	1,8	12,1	1,4
Industrial combustion	702,5	12,2	228,7	4,0	37,7	4,4	42,3	4,9
Production processes	18,5	0,3	8,9	0,2	16,9	2,0	10,2	1,2
Extraction and distr. of fossil fuels			64,7	1,1				
Waste treatment & disposal		0,0	12,4	0,2	1,8	0,2	2,2	0,3
Road transport total	63,1	1,1	1 382,8	24,1	8,0	0,9	172,0	20,0
- Passenger cars		0,0	747,0	13,0	2,0	0,2	94,0	10,9
- Light-duty vehicles		0,0	85,3	1,5	0,0	0,0	11,0	1,3
- Heavy-duty vehicles		0,0	550,0	9,6	4,0	0,5	54,0	6,3
- Buses		0,0		0,0	1,0	0,1	13,0	1,5
Other mobile sources and machinery	65,5	1,1	175,9	3,1	29,0	3,4	150,0	17,4
Sum	**3 787**	**66**	**2 773**	**48**	**124**	**14**	**403**	**47**

Appendix 2

Underlying statistics and methods of calculation for ammonia

Artificial fertilizer: Figures from (5).

Deposition: Figures from (18).

Nitrogen fixation: Figure for Sweden from (19), where the figure for extra nitrogen from fixation was obtained by assuming that 25 per cent of the pasturage was annual pasture with a nitrogen fixation of 100 kg/ha. For old pasture and areas with peas grown for feed the nitrogen due to fixation was assumed to be 50 kg/ha. That makes an average of 11 kg/ha for ploughland, or 9 kg/ha for farmland as a whole.

In Poland nitrogen from fixation is assumed to be 1 kg/ha for farmland generally as a result of truck-garden cultivation of legumes, but there are no legumes in the pastureland (Steineck private). No information is available for Great Britain, but the figure is assumed to be similar to that for the Swedish arable area. But as arable only accounts for 38 per cent of the farmland in Britain, as against 85 per cent in Sweden, the figure for Britain has been put at 4 kg/ha of farmland. While a certain amount may accrue from the growing of green peas, that has been ignored. Information is also lacking for Spain, but there is assumed to be no pasture cultivation there with the addition of legumes. Nitrogen fixation from truck cultivation of legumes is assumed to be 1 kg per hectare.

Denitrification: No attempt has been made to estimate this for any particular country. Source (17) puts the outflow in Sweden at 35 kg/ha per annum from farmland generally.

Animal feed: The figure for Swedish imports is taken from (19), where the nitrogen content is calculated from the difference between the livestock's total feed requirement and the plant nutrient in domestically produced feed. Besides oats and barley among cereals, half of the autumn wheat crop is estimated to go to feed.

There has been assumed to be a rough relation between the nitrogen content and the monetary value of feed imports. The nitrogen content of imports to the other three countries has thus been estimated according to their value in comparison with that of Swedish imports and their nitrogen content (19). Value of imports from (20). The value of Polish imports was 60 per cent of the Swedish, while that for the Spanish was 4.3 times greater and for the British 6.4 times greater than the Swedish.

Cereals and vegetable crops: The figures for grain crops, as well as potatoes, sugar beets, and maize are taken from Eurostat (5), and their nitrogen content calculated from (17). Crop figures for vegetables, fruit, rape, olives, and sunflower seed are from (20). The nitrogen content has been calculated by taking the content of protein and water and comparing it with that of potatoes where the water and protein as well as the nitrogen content are well known (21).

The protein content of most vegetables is not found to greatly differ if one takes account of their differing water content – although the nitrogen-fixing plants are of course a class apart, with almost four times as great a protein content as the others. In maize it is also higher. Consequently vegetables and olives, which have almost the same water and protein contents as potatoes, are estimated to have a nitrogen content of 0.35 per cent. Since maize has almost the same water content but double the protein content of potatoes, the nitrogen content has been put at 0.7 per cent. Counted in the same manner, fruits are reckoned to have a nitrogen content of 0.175 per cent (since they have on an average the same water content as potatoes, but only half the protein content). About 25 per cent of the Swedish cereal crop is used for human food, as against some 40 per cent in the rest of Europe (23). Except in Spain, where most of the maize is thought to be used for feeding animals, all other vegetable crops will be for human consumption. No estimate has been made of the proportion of potatoes and sugar beet that goes to animal feed in any of the countries.

Livestock. Figures for the number of animals per hectare of farmland have come from Eurostat (5), which however says nothing about age, size or gender. In Sweden's case the nitrogen content of animal products has been calculated from the consumption of meat, 90 per cent coming from domestic products (22). This averages 50 kilograms per head per annum (Steineck private). The nitrogen content of meat products for human consumption is estimated to be 2.5 per cent (21). Of interest in this case is the amount of nitrogen delivered from agriculture (that is, in animal carcasses). It is, roughly, twice the amount that eventually turns up in the meat sold in the shops. The rest has disappeared in butcher's waste.

Nitrogen in meat, calculation for Sweden: 0.9 x 50 kg meat x 8.6 mill. inhabitants = 387 mill. kg/3.3 mill ha = 117 kg meat/ha. 117 kg x 2.5% N = 2.932 kg N/ha consumed.

Meat production = 2 x 2.932 = 5.9 kg N/ha. Meat: 5.9 kg N. Milk: 5.46 kg N. Eggs: 0.66 kg N. Sum: 12 kg N in animal products per hectare of farmland.

The figures for milk and egg production on Swedish farms have been taken from (24), and the nitrogen content of these products derived from (18). The figures for the other countries are from (20), and the nitrogen content also calculated from (18).

It has been assumed, in order to estimate the nitrogen content of animal products in Britain, Poland, and Spain, that slaughtering is done in much the same way as in Sweden, and that the age and gender percentages will be the same as in Sweden. In this way a conversion factor has been obtained for each type of animal, making it possible to "translate" the number of animals to the Swedish animal unit and so calculate the nitrogen content of the meat products.

1 Swedish animal unit = 5.9 kg N per ha/0.518 animal units per ha = 11.6 kg N.

Barnyard manure: Figures from Eurostat (5), where the totals and the nitrogen contents have been obtained by using an arbitrary figure. The figures all represent total amounts of nitrogen, both as input of nutrient to the fields and leakage to air and water.

Land areas: Figures for the total areas of farmland, as well as the subdivision into arable and pasture land, are from Eurostat (5).

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About the Secretariat

The essential aim of the Swedish NGO Secretariat on Acid Rain is to promote awareness of the problems associated with air pollution, and thus, in part as a result of public pressure, to bring about the necessary reductions in the emissions of air pollutants. The eventual aim is to have those emissions brought down to levels – the so-called critical loads – that the environment can tolerate without suffering damage.

In furtherance of these aims, the secretariat operates by

☐ Keeping under observation political trends and scientific developments.

☐ Acting as an information centre, primarily for European environmentalist organizations, but also for the media, authorities, and researchers.

☐ Publishing a magazine, *Acid News*, which is issued four to five times a year and is distributed free of charge to some 4000 selected recipients.

☐ Producing and distributing other information material.

☐ Supporting environmentalist bodies elsewhere by various means, financial and other, in their work towards common ends.

☐ Acting as coordinator of the international activities, including lobbying, of European environmentalist organizations, as for instance in connection with the meetings of the bodies responsible for international conventions, such as the Convention on Long Range Transboundary Air Pollution.

☐ Acting as observer at the proceedings involving international agreements for reducing the emissions of greenhouse gases.

The work of the secretariat is largely directed on the one hand towards eastern Europe, especially Poland, the Baltic States, Russia, and the Czech Republic, and on the other towards members of the European Union, in particular Great Britain. By emitting large amounts of sulphur and nitrogen oxides, these countries add significantly to the depositions of acid over Sweden.

As regards the eastern European countries, activity mostly takes the form of supporting and cooperating with the local environmentalist movements. Since 1988, for instance, financial support has been given to the maintenance of information centres on energy, transport, and air pollution, all run by local environmentalist organizations.

To date, four European conferences on strategy for environmental NGOs have been arranged by the secretariat, where common objectives and cooperative projects were developed. An important outcome has also been the agreement on calls for a reduction of emissions, based on scientific data concerning critical loads.

The secretariat was formed in 1982 with a board now comprising one representative from each of the following organizations:

Friends of the Earth Sweden
Swedish Anglers' National Association
Swedish Society for Nature Conservation
Swedish Youth Association for Environmental Studies and Conservation
World Wide Fund for Nature Sweden

AIR POLLUTION AND CLIMATE SERIES

The emissions of acidifying air pollutants will have to be greatly reduced in Europe, if depositions are to be brought down to levels that nature can tolerate. And the present study gives an indication of the ways this will affect us in our daily lives. Taking the concept of environmental space as a yardstick, it examines the changes that will have to be made and each individual's possibilities of influencing them so as to help bring down the emissions of sulphur dioxide, nitrogen oxides, and ammonia.

THE SWEDISH NGO SECRETARIAT ON ACID RAIN