3.6. Soil degradation

Main findings

The main problems for soils in the EU are irreversible losses due to increasing soil sealing and soil erosion, and continuing deterioration due to local contamination and diffuse contamination (acidification and heavy metals). The incremental loss and deterioration of Europe's soil resource will continue, and will probably increase as a result of climate change, land-use changes and other human activities.

Soil degradation is mainly caused by urbanisation and infrastructure development (in western and northern Europe) and erosion (in the Mediterranean region). There is a significant risk of water erosion mainly in southern and central Europe and the Caucasus region; at present, this risk is high to very high in one-third of Europe.

In the EU, policies are in place to prevent an increase in local soil contamination, which is high in areas with heavy industries and military bases. However, the problem of existing contamination remains and there is a danger of further contamination in the Accession Countries.

Diffuse contamination is particularly significant in areas with intensive agriculture. Southern Europe is increasingly affected due to increased industrial activity, urban expansion, tourism and agricultural intensification, while soils in northern Europe are prone to the effects of acid deposition.

Strategies for soil protection, and systems for monitoring of soil, are not adequately developed at European or national level, as compared with air and water for which monitoring, assessment and policy frameworks are already in place. A policy framework is needed which recognises the environmental importance of soil, takes account of problems arising from the competition among its concurrent uses (ecological and socio-economical), and is aimed at maintaining its multiple functions.

1. Why are Europe's soils degrading?

1.1. The issue

Soil must be considered as a finite, non-renewable resource since its regeneration through chemical and biological weathering of underlying rock requires a long time. In humid climates, for example, it takes 500 years on average for the formation of only 2.5 cm of soil (The Tutzing Project, 1998).

Notwithstanding the limitations of available information (see detailed discussion in Chapter 4.2), it is clear that the damage to soils caused by human activities is increasing, and manifested for instance in rates of erosion 10-50 times higher than the rates of naturally induced erosion. Pressure on soils results from agricultural intensification (including consolidation of small fields into larger units) (see Chapters 3.13 and 3.14), and population growth coupled with increasing urbanisation (see Chapters 2.3 and 3.12).

Soil is affected in terms of "loss" or "deterioration" of its functions (Box 3.6.1). A variety of economic sectors all play a part in contributing to soil degradation. As a consequence, approaches to solving soil problems must be based on multi-layered and integrated measures (Figure 3.6.1).

Some of the problems and their consequences are irreversible, such as soil losses, mainly due to erosion and soil sealing. Others can be improved with adequate measures, such as clean-up and remediation plans set up to eliminate local contamination.

1.2. Assessing the impacts of economic activities – on soil

The capability of soil to provide a support to life and ecosystems can be expressed through its ecological and socio-economic functions (Box 3.6.1).

Competition in terms of space exists between the ecological and the socio-economic functions, as well as among concurrent uses of soil within each group of functions.

For example, the use of land for infrastructure construction – irreversible in relation to several generations time scale – makes soil unavailable to ecological functions. Meanwhile the "over-intensive use of soils by modern farming imposes too heavy a burden on the buffer, filter, transformation, and gene-protection functions, resulting in contamination of the food chain and/or groundwater, as well as the destruction of plant and animal species." (Blum, 1990).

The concept of multiple soil function and competition is crucial in understanding current soil-protection problems and their multiple impact on the environment (Figure 3.6.1). Accordingly, a conceptual assessment framework has been developed applying the DPSIR approach to soil issues (Figure 3.6.2). This of course requires development of indicators for soil degradation and loss of soil functions (see also chapter 4.2).

Soil quality and functions are of great importance for the environment. They are interrelated with other key environmental issues such as (see Figure 3.6.1):

- acidification: particularly affecting sensitive, poorly buffered soils (see Chapter 3.4);
- climate change (Box 3.6.2): leading to soil degradation, but it is also influenced by soils and vegetation (see Chapter 3.1);
- biodiversity: including gene reserve and protection, biomass production, protection of landscapes (see Chapter 3.11);
- water stress: soil has a filtering/buffering capacity, but there are threats from contamination, salinisation and eutrophication (see Chapter 3.5);
- dispersion of hazardous substances, due to run-off or leaching (see Chapters 3.3 and 3.5).

1.3. Driving forces and pressures affecting soil from main economic activities

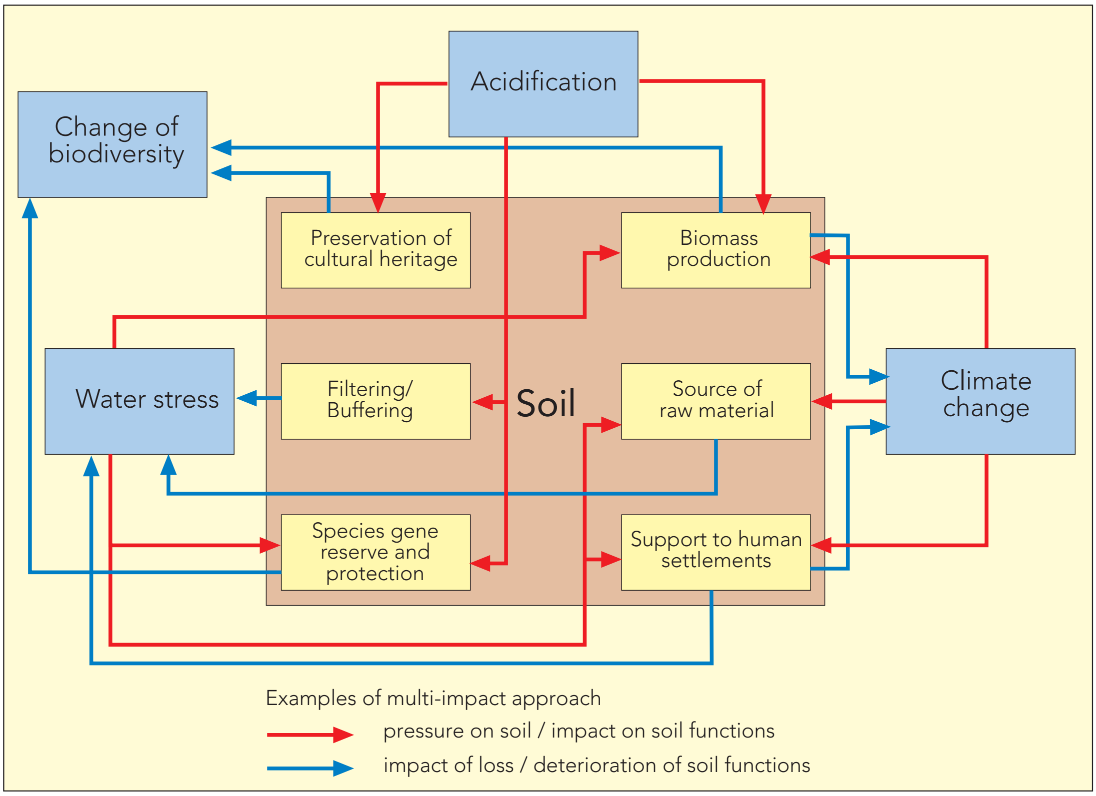
1.3.1. Land development, transport and tourism

Pressures on land use are particularly associated with urban sprawl (see Chapters 2.3, 3.12 and 3.13), increasing mobility (see chapter 2.2) and tourism (see Chapters 3.14 and 3.15).

A predicted 5% increase in the urban population between 1990 and 2010 will, according to present trends, require an

Figure 3.6.1 **Multi-function/Multi-impact approach (examples)**

Source: EEA



Box 3.6.1. Soil and soil functions

Many different definitions of soil exist, according to the particular context, purpose, and point of view from which soil issues are approached. This report, which considers soil with its multiple functions and impacts as having a fundamental role in Europe's Environment, requires a broad definition such as that adopted by the Council of Ministers of the Council of Europe in 1990:

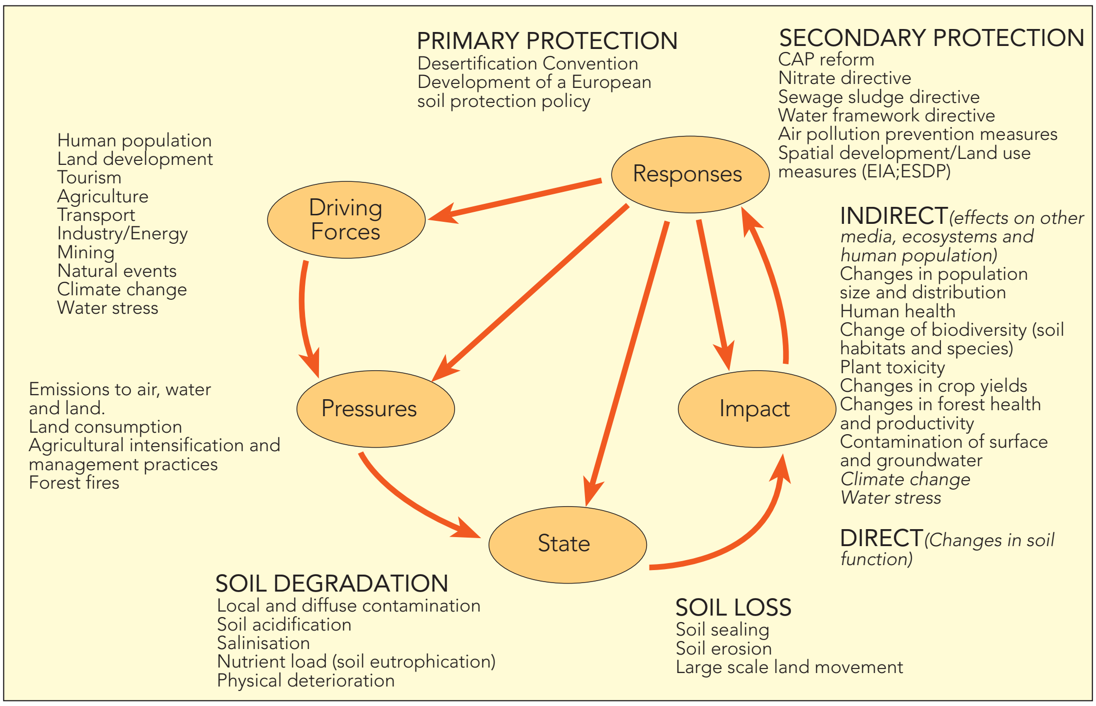
" Soil is an integral part of the Earth's ecosystems and is situated at the interface between the Earth's surface and the bedrock. It is subdivided into successive horizontal layers with specific physical, chemical and biological characteristics and has different functions. From the standpoint of history of soil use, and from an ecological and environmental point of view, the concept of soil also embraces porous sedimentary rocks and other permeable materials together with the water which these contain and the reserves of underground water." (Council of Europe, 1990).

Ecological functions	Production of biomass	Soil produces food and fodder, providing nutrients, air, water. It provides a medium in which plants can penetrate with their roots.
	Filtering, buffering and transforming	This function enables soils to deal with harmful substances, mechanically filtering organic, inorganic and radioactive compounds; adsorbing, precipitating or even decomposing and transforming these substances - thus preventing them from reaching the groundwater or the food-chain.
	Gene reserve and protection of flora and fauna	Soil protects numerous organisms and micro-organisms which can live only in soil.
Socio-economic functions	Support to human settlements (housing and infrastructure, recreation) and waste disposal	Soil provides ground for the erection of houses, industries, roads, recreational facilities and waste disposal.
	Source of raw materials, including water	Soil provides resources of numerous raw materials, including water, clay, sand, gravel and minerals, as well as fuel (coal and oil).
	Protection and preservation of cultural heritage	Soil, as a geogenic and cultural heritage, forms an essential part of the landscape and is a source of paleontological and archeological evidence, relevant for the understanding of the evolution of earth and mankind.

Source: Blum, 1990, 1998

Soil degradation means loss or deterioration of its functions. For the purpose of this report, it includes both soil loss and soil deterioration. Soil losses due to sealing and erosion can be considered in large part as irreversible in relation to the time needed for soil to form or regenerate itself. Soil deterioration due to local and diffuse contamination can be reversed, if adequate measures are taken, such as clean-up and remediation plans.

The DPSIR Framework applied to soil Figure 3.6.2



Source: EEA

Box 3.6.2. An emerging issue: the relationships between soil and climate change

The Kyoto Protocol recognises the need to consider additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the categories of agricultural soils, land-use change and forestry. So far only activities related to forestry (afforestation, reforestation and deforestation) since 1990 have been regulated. Reliable and transparent methodologies, and guidelines on how to take into account additional sources/sinks still need to be developed (see Chapter 3.1; UNFCCC, 1998)

Soil can act as a carbon sink. This also has implications for the bio-availability and mobility of metals in soils, and has potentially harmful effects on both human, plant and animal health.
Soil can also act as a carbon source, as well as a source of other greenhouse gases. The direct application of agro-chemicals in the industrial agricultural sector, and other related management practices, can promote micro-organism activity in soils, and result in increased emissions of nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2) to the atmosphere, hence contributing to climate change (see Chapter 3.1).

In boreal soils, reduction in the extent and depth of permafrost due to global warming could lead to an additional flux of CO_2 into the atmosphere, and contribute to the release of CH_4 stored in the soil (IPCC, 1996).

Desertification and climate change

Desertification is "land degradation in arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities" (UNCCD, 1997). Some southern parts of the EU, including Spain, Greece, Portugal, Italy and France (Corsica) are affected (EEA,1998).

The modified patterns of precipitation, consequent to climate change, will probably induce greater risks of soil erosion, depending on the intensity of rain episodes (IPCC, 1998).

Desertification is likely to become irreversible if the environment becomes drier and the soil becomes further degraded through erosion and compaction (IPCC, 1996).

equal increase in the uptake of urban land (see Chapter 2.3).

Some EU, national and regional policies seem to encourage these sprawling trends: for instance, over the next decade, it is planned to extend the length of railways by approximately 12 000 km, of which 10 000 km is high-speed track and the road network by over 12 000 km (implementation of the TENs; see Chapter 2.2).

The major impacts of these developments on soil are its irreversible loss: through surface sealing, affecting the most productive agricultural and forest land; together with soil erosion, due to destruction of plant cover; local contamination due to waste accumulation; and salinisation caused by the abstraction and use of marine water in coastal areas.

Expansion of transport infrastructure and traffic emissions are also affecting soil in terms of diffuse contamination (heavy metals, soil acidification), while road spills and facilities connected to the transport sector (petrol stations and car-repair facilities) contribute to the generation of local soil contamination.

The consequences are observable in nearly all big cities and urban agglomerations in the EU, such as London, Paris and the Ruhr area (see Chapter 3.12, Box 3.12.6). Tourism affects mainly the Alps, Mediterranean coastal areas (which account for 30% of the total tourist arrivals in the EU), and sub-tropical islands (Canaries, Madeira).

1.3.2. Agriculture

There are marked regional imbalances in the EU between agricultural intensification – changes largely driven by the implementation of the CAP – and economic pressures on marginal farms. The latter causes land abandonment, which may accelerate soil degradation, and, in areas with a dry climate, may lead to desertification.

Intensive industrial agriculture gives rise to severe (and increasing) pressures on agricultural soils, which represent approximately 40% of the EU's total soil resource (see Chapter 2.2).

The major impacts on soil are (German Advisory Council of Global Change, 1994):

- increased susceptibility to wind and water erosion as a consequence of agricultural practices (long exposure of ploughed soil, loss of organic matter, cultivation on steep slopes, etc.);
- loss of grazing cover and erosion due to overgrazing;
- loss of fertility due to deep ploughing, elimination of crop residues, monoculture and elimination of mixed cultivation/animal farming;
- soil compaction by heavy machines, with increased run-off.

These problems, initially focused on zones with fertile soils in Europe, are now widespread at continental level, as industrial agriculture has spread to regions with less fertile and more vulnerable soils, such as the Mediterranean area.

1.3.3. Industry, energy and mining
These sectors are affecting soils both in terms of local contamination, mainly due to inadequate waste management and production processes, and diffuse contamination, due to emission and transport of pollutants via air, water and earth often in regions far from the original source (Box 3.6.3).

Local soil contamination most frequently occurs at waste-disposal sites, gas works, oil refineries, metal-processing industries, chemical industries and other production facilities.

The extraction of minerals, metals and construction materials can be another source of pollution, leading to: local contamination; destruction of arable land; changes in morphology and consequently erosion and hydrological disruption; and compaction, surface sealing and soil loss.

Box 3.6.3. The causes of local contamination

Contaminated sites are mostly due to industrial activities and waste disposal.

Waste disposal addresses most sectors, namely industry, households and consumers but also tourism.

The transport sector contributes to local soil contamination due to road spills and the huge number of repair and maintenance facilities.

Abandoned military bases pose a very serious problem in most of the Accession Countries, especially those of the former Soviet army forces. Local soil contamination at military bases is mostly due to air strips, vehicle repair and maintenance facilities, production of warfare agents, storage of chemicals and fuels, and shooting ranges.

The energy sector contributes to the problem with gas works and caloric power stations.

Industry	direct	chemicals industry, petrochemical/oil industry, steel industry and other
Energy	direct	gas works, petrochemical/oil industry
Transport	direct and indirect	accidents (road spills), maintenance of transport vehicles, inadequate interim storage of hazardous chemicals
Household/ Consumers	indirect	production of waste
Tourism	indirect	production of waste
Military	direct	military bases: production of war fare agents, shooting ranges, stocks, air strips, car-repair shops

2. What is the current state of Europe's soils?

Although soil degradation at European level is generally recognised as a serious and widespread problem, its quantification, geographical distribution and total area affected are only roughly known.

The most recent assessment of soil conditions in Europe is an evaluation of the current state of human-induced soil degradation, derived by ISRIC in 1993 from the world map on the status of human-induced soil degradation (GLASOD) (Maps of soil degradation in Europe, prepared by ISRIC, are published in EEA, 1998). There is a need for better, and more detailed information. Validation of the maps through the EIONET is ongoing.

2.1. Soil loss by urbanisation and infrastructures
The rates of real soil loss due to surface sealing through urbanisation and infrastructure construction in the EU are consistent. Since 1970, the increase of length of motorways has been significant in most of the countries. Occupation of land by infrastructure is high in Belgium, Germany and the Netherlands, and is increasing in Greece, Portugal and Spain (see Chapter 2.2, Table 2.2.1).

There is a lack of consistent data on the amount of soil loss through surface sealing at the EU level. Data on the total amount of built-up areas is only available for a limited number of countries, and is not comparable since countries use different methodologies. Within these limitations, existing data shows that since 1990 the growth of built-up areas has been consistent in Belgium, France and Germany, where it reached about 50 and 70 ha/day over the period 1990-1995 in Belgium and France respectively, and exceeded 120 ha/day over the period 1993-1997 in Germany (Table 3.6.1, Figure 3.6.4).

Built-up areas have grown at the expenses of agricultural land in France, Germany, the Netherlands, Poland and Iceland – where forest areas have also decreased in the period 1990-1995 (Figure 3.6.3).

Soil loss rates through land development and infrastructures may exceed those due to

Table 3.6.1. **Growth of built-up areas in selected countries in the period 1990-1995**

country	land area (km²) (1) (d)	built-up area (km²) (2) (e)	built-up (% of land area) (e)	built-up area increase (ha/day)	population (1000's) (4) (f)	built-up area increase (m²/person/year) (4)	increase of built-up area over the period as % of land area
Belgium/ Luxembourg (a)	32 820	5 960	18.2	49	10 039	18	2.7
Bulgaria	110 550	8 356	7.6	-6	8 614	-2	>-0.1
France	550 100	29 549	5.4	72	57 411	5	0.2
Germany (3) (b)	349 166	42 128	12.1	122	81 392	5	0.5
Iceland	100 250	1 353	1.3	6	262	79	0.1
Liechtenstein	160	12	7.4	<0.1	30	5	0.4
Netherlands	33 920	5 609	16.5	9	15 063	2	0.4
Poland	304 420	23 087	7.6	21	38 338	2	0.1
Slovak Republic	48 080	1 290	2.7	2	5 297	1	>0.1

(1) All countries except Germany, Land area: FAO at 16/06/98
(2) All countries except Germany, Built-up area: For EEA18 - Agricultural yearbook, 1995 and ENVSTAT/LUQ1 at 12/03/98. For others - General Questionnaire (NFP)
(3) For Germany: Flachennutzung in Deutschland 1997, Statistisches Bundesamt
(4) Population: World Population Prospects: the 1996 Revision (United Nations, New York)
(a) Figure for "built-up area" refers only to Belgium
(b) Data for Germany refers to the period 1993-1997
(c) data for the Netherlands refers to the period 1989-1993
(d) land area is referred to year 1995
(e) built-up area is referred to most recent figure
(f) population is an average over the selected period

Sources: EEA data elaboration

Figure 3.6.3 **Changes in built-up areas vs. other land uses in selected countries in the period 1990-1995 as a % of total land area**

Source: EEA data elaboration (see Table 3.6.1 for data sources)

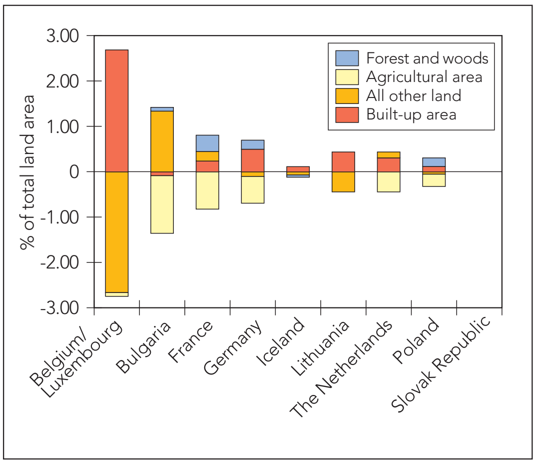
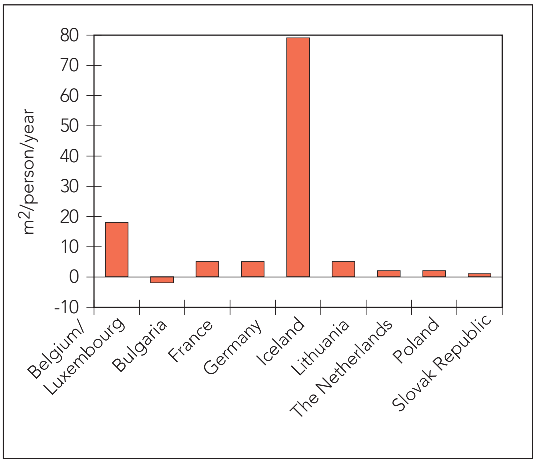


Figure 3.6.4 **Increase of built-up areas in selected countries during in the period 1990-1995 in m²/person/year**

Source: EEA data elaboration (see Table 3.6.1 for data sources)



soil erosion in many EU countries, with the likely exception of some countries in Southern Europe (see Table 3.6.3).

2.2. Soil erosion

Soil erosion in Europe is mainly due to water and to a lesser extent to wind. The major causes are unsustainable agricultural practices and overgrazing. Soil erosion reduces the ecological functions of soil: mainly biomass production, crop yields due to removal of nutrients for plant growth, and soil filtering capacity due to disturbance of the hydrological cycle (from precipitation to runoff).

The loss of plant nutrients and organic matter *via* eroded sediment reduces the fertility and productivity of the soil. This leads to a vicious cycle whereby farmers apply more fertilisers to compensate for the loss of fertility. Soil, once eroded, tends to be more susceptible to further erosion, and thus the cycle intensifies. The loss of applied nutrients in this way, represents an enormous cost to the agricultural community.

It has been calculated that in Austria, potential loss of organic matter in agricultural soil due to erosion could be more than 150 000 tonnes per year, while potential loss of nutrients, such as nitrogen and phosphorous, could be more than 15 000 and 8 000 tonnes per year respectively (Stalzer, 1995).

2.2.1 How much soil is being eroded?

Soil erosion causes irreversible soil loss over time-scales of tens or hundreds of years and is an increasing phenomenon in Europe (Blum, 1990). In parts of the Mediterranean region, erosion has reached a stage of irreversibility and in some places soil erosion has practically stopped through lack of soil. With a very slow rate of soil formation, any soil loss of more than 1 t/ha/year can be considered irreversible within a time span of 50-100 years. Losses of 30-40 t/ha in individual storms that may happen once every one or two years are measured regularly in the EU, with losses of more than 100 t/ha in extreme events (Van Lynden, 1995).

The amount of soil loss from erosion in the EU is not known. The area affected by water erosion and yearly amounts of soil loss for selected countries in the period 1990-1995 are shown in Tables 3.6.2 and 3.6.3. Figure 3.6.5 shows distribution of loss per land-use class in the same period.

Soil losses are high in Spain, where loss of soil in agricultural land reached a peak of an average 28 t/ha/year, in the period 1990-1995, while the total area affected was 18% of the total land in 1995. Substantial losses have been calculated for Austria, where an average of more than 9 t/ha/year in agricultural land losses affected an area of approximately 8% of the total land.

2.2.2 Where in Europe?

Although it has always been considered as a severe and increasing problem in southern Europe, soil erosion, especially due to water, is becoming increasingly relevant in northern Europe. The area with the greatest severity of soil loss for both wind and water erosion is the Balkan Peninsula and the countries surrounding the Black Sea. Some central European Countries such as the Czech Republic and the Slovak Republic, also suffer from extremely serious soil erosion problems (EEA, 1998).

The EU Mediterranean countries have severe soil erosion problems, which can reach the ultimate stage and lead to desertification. At present rates of erosion, considerable areas in the Mediterranean and the Alps, currently not at risk, may reach a state of ultimate physical degradation, beyond a point of no return within 50-75 years. Some smaller areas have already reached this stage (Van Lynden, 1995).

2.2.3 Outlooks: the effects of climate change in agricultural areas - changes in water erosion risk

Water erosion risk is, under current climate and land cover, high to very high in one-

Area affected by water erosion in selected countries in the period 1990-1995 — Table 3.6.2.

Country	Total area affected (ha)	Agricultural land	Forest land	Dry open land with vegetation	Dry open land
Germany	2 400 000	2 400 000			
Spain	9 161 000	6 477 000	255 000	2 024 000	405 000
Austria	625 000	625 000			
Iceland	6 800 000	1 500 000			5 300 000

Source: OECD-Eurostat joint 1996 questionnaire; for Austria: Östat & UBA,1998; EEA

Soil loss due to water erosion in selected countries in the period 1990-1995 — Table 3.6.3.

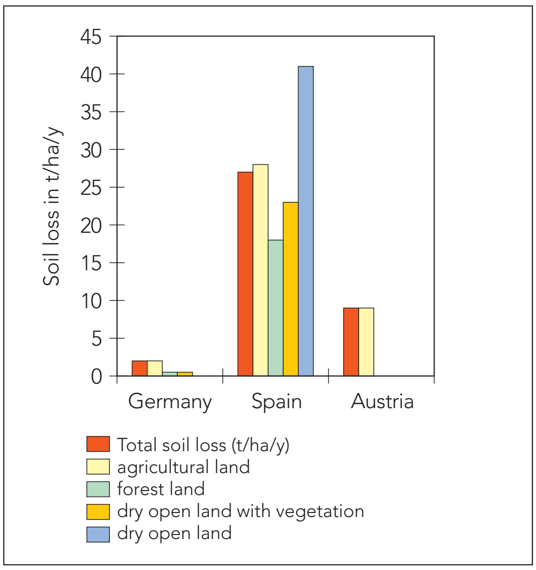
Country	Total soil loss (t/ha/y)	Soil loss in agricultural land	Soil loss in forest land	Soil loss in dry open land with veg.	Soil loss in dry open land
Germany	2	2	0.4	0.4	
Spain	27	28	18	23	41
Austria	9 (a)	9 (a)			
Iceland	n.a.	n.a.	n.a.	n.a.	n.a.

n.a.: the unit (t/ha/yr) is not applicable to Icelandic conditions

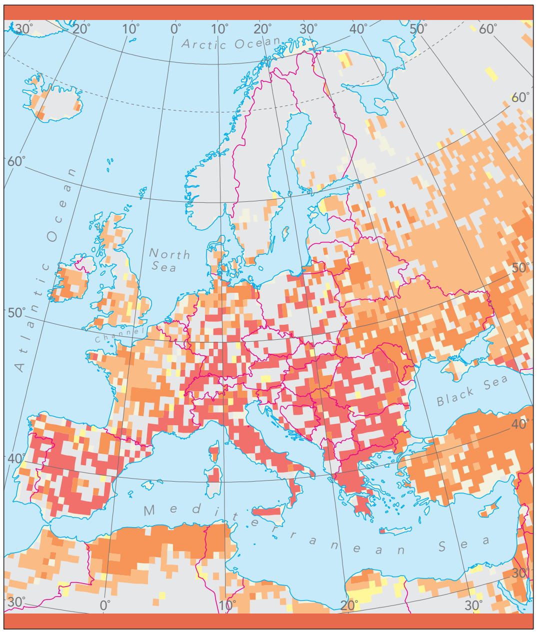
(a) The value for Austria refers to an average loss for agricultural land covered by corn, potatoes, sugar beet and spring grain

Source: OECD-Eurostat joint 1996 questionnaire; for Austria: Östat & UBA, 1998; EEA

Soil loss due to erosion in selected countries in the period 1990-1995 — Figure 3.6.5

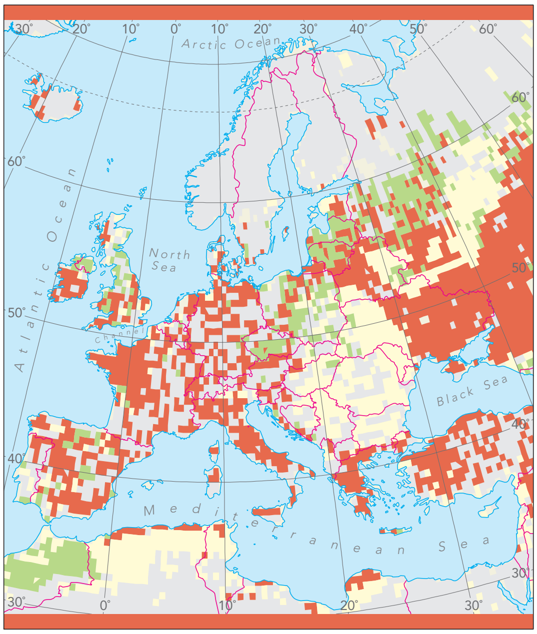


Source: OECD-Eurostat joint 1996 questionnaire; for Austria: Östat & UBA, 1998; EEA



Map 3.6.1

Source: European Commission, 1999; EEA



Map 3.6.2

Source: European Commission, 1999; EEA

third of the European land area. Areas with such high risk are dominantly located in southern and central Europe and the Caucasus area. In the remaining parts of Europe the risk is low to moderate.

Under the baseline scenario, the water erosion risk is expected to increase by 2050 in about 80% of the EU agricultural areas, as an effect of climate change. It remains the same in 10% of the areas and decreases in the remaining 10%. The areas with highest increase in erosion risk are mainly located in the western part of central Europe, in the Mediterranean area, and in the north and south of the Black Sea. Areas with 10% or more decrease in risk can be found across the EU (parts of UK and Spain), but are mainly located in the areas south or south-east of the Gulf of Bothnia (Maps 3.6.1 and 3.6.2).

2.3. Local contamination

Local contamination is a characteristic of regions where intensive industrial activities, inadequate waste disposal, mining, military activities or accidents pose a special stress to soil. If the natural soil functions of buffering, filtering and transforming are overexploited, a variety of negative environmental impacts arise, the most problematic of which are water pollution, direct contact by humans with polluted soil, uptake of contaminants by plants and explosion of landfill gases.

2.3.1. How many contaminated sites are there in Europe?

There is no European-wide monitoring of contaminated sites. Monitoring exits only on a country-by-country basis. Countries are at different levels of progress and apply different methodologies and definitions.

Several countries have initiated national inventories. However, data on the number of contaminated sites based on national inventories is not currently comparable, since it is based on different national approaches. Therefore, national totals do not represent the scale of the problem, but give only an indication of the efforts made by each country.

Information available for 20 European countries reveals that the estimated total of sites which are definitely or potentially contaminated exceeds 1.5 million and that these are mostly located in 13 EU Member States (Table 3.6.4).

2.3.2 Where in Europe?

Land contamination usually affects areas with a high density of urban agglomeration and with a long tradition of heavy industry, or in the vicinity of former military installations. However, a single site may pose a major threat to a large population group or to a vast area, as for the mine of Aznacóllar (Andalusia, Spain), where an accident occurred in April 1998 and provoked the contamination of an area of about 4 500 ha, threatening the national park of Doñana (Box 3.6.4).

The largest and most affected areas are located in north-west Europe, from Nord-Pas de Calais in France to the Rhein-Ruhr region in Germany, across Belgium and the Netherlands. Other areas include the Saar region in

Germany; northern Italy, north of the river Po, from Milan to Padua; the region located at the corner of Poland, the Czech Republic and the Slovak Republic, with Krakow and Katowice at its centre; and the areas around all major urban agglomerations in Europe.

In order to identify 'hot-spots' for local contamination, an integrated inventory of pollution sources to air, water and land is needed.

2.3.3 What is being done? Investigation and remediation of contaminated land in Europe.
Identification of sites posing a potential risk to human health and ecosystems (identification of potential contamination through the screening process), verification that a contamination exists, and assessment of the risks involved are the first steps in the management of contaminated land before any remediation activity can take place.

Progress in the identification of contaminated sites in some European countries is summarised in Figure 3.6.6. In Denmark, for instance, screening has been completed for 93% of suspected sites and risk assessment for 26% of the definitely contaminated sites; in Austria, the percentages are 9% and 35% respectively. It is not possible at present to make a more comprehensive assessment of progress in the management of contaminated land in the EU, because the available information is far from complete.

Many countries have developed special funding tools for the clean-up of contaminated sites, such as tax systems, new land-use incentives or the prevention of new contamination. Public expenditure on clean-up and remediation of contaminated sites for selected countries is illustrated in Table 3.6.5.

In the EU, policies now in place reflecting the precautionary principle will help to avoid contamination in the future. Thus expenditure on the clean-up of contaminated sites will stabilise or even decline, except in countries which have only recently begun to address the problem. Monitoring activities will increase; many countries have only recently started to set up a monitoring system.

At EU level the programmes of the European Regional Development Fund provide some support for the clean-up of local soil contamination (Table 3.6.6).

Many Accession Countries have enacted legislation for contaminated sites, started inventories and set up specific funding tools. Hungary and the Czech Republic can be regarded as the most advanced in this respect. The Slovak Republic and Slovenia are working on a new regime including financing models. Lithuania, Latvia, Hungary and the Czech Republic have started to set up inventories, while all Accession Countries have made assessments of the costs of remedial measures for former military bases. Co-operation with the EU is increasing.

2.4. Diffuse contamination
Soils are often used for the disposal of industrial and urban waste products. Contaminants from flowing water over soil or eroded soil itself can pollute surface waters such as rivers, streams and reservoirs. Leaching of contaminants through channels in the soil via preferential flow is a large source of chemicals in groundwater (see Chapter 3.3).

Soil characteristics play a major role in the movement of chemicals within the soil. Movement of chemicals that adsorb to mineral or organic soil particles is governed mainly through erosion mechanisms, whereas transport of soluble chemicals tends to be via water flow either through the soil or as surface runoff. Many chemicals exhibit both partial adsorption and solubilisation, making predictions of their fate, behaviour and environmental impacts difficult (see Chapter 3.3).

The soil function most affected by diffuse contamination is its buffering, filtering and transforming capacity. When the buffering capacity of soil with respect to a certain substance is exceeded, the substance is released to the environment. This delayed release of pollutants is very dangerous and renders the soil a "chemical time-bomb".

The most relevant problems posed by diffuse contamination and treated here are soil acidification, soil contamination by heavy metals and chemicals, and surplus nutrients.

2.4.1 Soil acidification
Soil acidification occurs as a result of emissions from vehicles, power stations, other industrial processes and natural biogeochemical cycles, re-depositing onto the soil surface mainly via rainfall and dry deposition (see Chapter 3.4).

Exceedances of critical loads of acidification and eutrophication are at present mostly dominated by nitrogen deposition. The

Table 3.6.4. **Available data on the number of potentially and definitely contaminated sites, for selected categories and countries**

ab = abandoned;
op = operating:
n.i. = no information

screening process = identification of sites with a potential for contamination

risk assessment process = verification of the contamination and assessment of the risks involved

Potentially contaminated site: a location where as a result of human activity an unacceptable hazard to human health and ecosystems might exist

Contaminated site: a potentially contaminated site where an unacceptable hazard to human health and ecosystems does exist, on the basis of the results of risk assessment

Source: EEA-ETC/S, 1998

	Industrial sites		Waste sites		Military sites	Potentially contaminated sites		Contaminated sites	
	ab	op	ab	op		identified (screening completed)	estimated total	identified (risk assessment completed)	estimated total
Albania	•	•	•	•		n.i.	n.i.	78	n.i.
Austria	•	•	•	•	•	28 000	~80 000	135	~1 500
Belgium (Flemish region)	•	•	•	•	•	5 528	~9 000	7 870	n.i.
Denmark	•	•	•		•	37 000	~40 000	3 673	~14 000
Estonia	•	•	•	•	•	~755	n.i.	n.i.	n.i.
Finland	•	•	•	•	•	10396	25 000	1 200	n.i.
France	•	•	•	•	•	n.i.	700 000-800 000	896	n.i.
Germany	•	•	•		•	202 880	~240 000	n.i.	n.i.
Hungary	•	•	•	•	•	n.i.	n.i.	600	10 000
Ireland						n.i.	2 000	n.i.	n.i.
Iceland			•			n.i.	300-400	2	n.i.
Italy	•	•	•	•		8 873	n.i.	1 251	n.i.
Lithuania	•	•	•	•	•	~1 700	n.i.		n.i.
Luxembourg			•	•		616	n.i.	175	n.i.
Netherlands	•	•	•	•	•	n.i.	110 000 - 120 000	n.i.	n.i.
Norway	•	•	•	•	•	2 121	n.i.	n.i.	n.i.
Spain	•	•	•	•		4 902	n.i.	370	n.i.
Sweden	•	•	•	•	•	7 000	n.i.	12 000	22 000
Switzerland	•	•	•	•	•	35 000	50 000	~3 500	n.i.
United Kingdom						n.i.	~100 000	n.i.	~10 000

Box 3.6.4. The accident of Doñana

In April 1998, a tailing-dam dike in an open-cast pyrite mine at Aznalcóllar (Seville, Spain) breached, allowing water and solid materials from the tailings pond to be discharged into the nearby Agrio river, an affluent of Guadiamar. About 4.5 million cubic meters of slurry composed of acidic water, fine divided metals (mainly pyrite) and other materials inundated the riverbanks of the Agrio and Guadiamar rivers threatening Doñana, Europe's largest national park. A strip of ca. 300 m wide and 40 km long, at both sides of the rivers, was covered by a layer of toxic black sludge. About 4 500 ha of agricultural land became polluted.

Studies carried out immediately after the spilling showed that the sludge were composed mainly of pyrite (68-78%) in very fine particle size. Chemical analysis of the sludge showed a great content in heavy metals and other toxic elements (Cabrera *et al.*, 1998).

A year later 68% of soils are still contaminated with high and very high concentrations of heavy metals. With reference to the arable layer up to a depth of 10 cm, 68% of soils are contaminated with arsenic, 47% with zinc, 25% with lead, 15% with copper, 11% with tallium and 4% with cadmium. The most contaminated areas are located close to the mine and in the surroundings of the park.

Although remediation started soon after the accident and current measures allow the immobilization of a large part of the contaminants, the re-use of affected land is still a major problem.

Source: CSIC, 1999

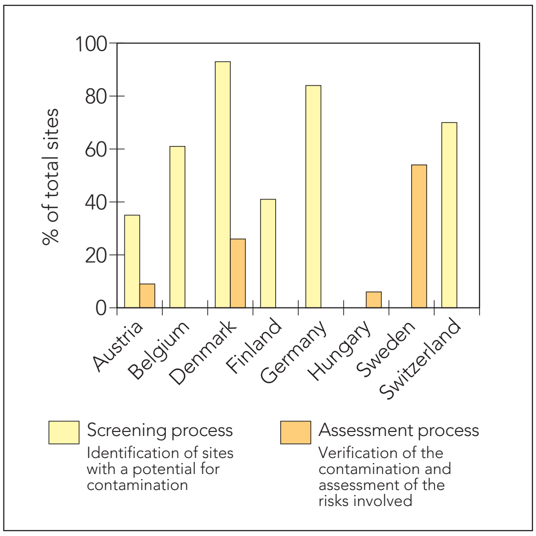
situation is not homogeneous over Europe, and some 'hot-spots' have been identified.

A survey to assess the effects of acid deposition on European forest soils began in 1989 as a joint initiative of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forest in the UNECE region (ICP Forests) and the EU Scheme on the Protection of Forests against Atmospheric Pollution. Although a common methodology for sampling and analysis was adopted in most countries, differences in national methods used exist. Moreover, information is available only for a subset of sites. Further analysis is needed to substantiate large-scale impacts of acid depositions on forest soils.

Information from 23 European countries (including the EU Member States) reported acid topsoil conditions in 42% of the 4 532 sites covered, and indicated a relationship between acid deposition and soil acidity. Extremely acid conditions (defined as a mineral surface layer pH below 3.0) were reported in 1.9% of sites, mainly located in regions receiving a very high atmospheric deposition load, and often where the soils have an extremely low buffering capacity against acidification (EC, UNECE and MFC, 1997).

Map 3.6.3 and Figure 3.6.7 show the sensitivity to acidification of the European forest soil, measured by the soil buffering capacity against added acids. The highest proportion of acid-sensitive sites are found in the Netherlands, Finland and Belgium. In Luxembourg, the Slovak Republic, Hungary, Slovenia, Portugal, Switzerland and Austria the majority of the observed forest soils are resistant to acidification.

Progress in identification of contaminated sites in selected countries as % of estimated total — Figure 3.6.6.



Source: EEA-ETC/S, 1998

Public expenditure on clean-up activities and contaminated-site management in some European countries in 1996 — Table 3.6.5.

Country	Specification	M euros/year
Austria	1996 public remediation fund + overheads	~ 25
Belgium (Flemish region)	1996 public remediation budget	~ 36
Denmark (1)	1997 public expenditure for investigations and remediations	~ 48
Finland	1996 public expenditures for investigations and remediations	~12
Hungary	1996 includes only remediation activities along with the national remediation programme	~ 6
Sweden	1996 first public budget along with a five-year action plan, the plan has already been revised and the budget been reduced	~ 23
Netherlands	1996 total public expenditure	~ 280

(1) refers to the year 1997

Source: EEA-ETC/S

Overview of clean-up funding tools — Table 3.6.6.

Country	Instruments	Specification
Austria, France	tax	Waste tax to fund remediation activities.
Belgium (Flemish region)	license system	The end of exploitation of an industrial facility requires a simple site investigation to be conducted.
Czech Republic	privatisation / property transfer	Property transfer and privatisation is only possible under the provision that the private investor conducts an environmental audit at the site and the audit is approved by the authorities.
Netherlands, Sweden, Denmark, Finland	fee on petrol price	Voluntary agreements of the petrochemical/oil industry to fund the remediation of abandoned petrol stations; financed by a fee included in the petrol price.
United Kingdom	land development	Public funds support the recycling and reuse of derelict land, including the remediation of contaminated sites.
EU	land development	The European Regional Development Fund supports regions of industrial decline in land recycling activities. These activities cover to some extent the clean-up of contaminated sites.

Source: EEA-ETC/S

There have already been further substantial reductions in emissions of sulphur dioxide; nitrogen oxides and VOCs emissions will be reduced by 2010 by implementation of policies in the pipeline (see Chapter 3.4). Nevertheless, there is still concern over acid deposition in 'hot-spots' and areas with sensitive ecosystems, and if acid deposition does not decrease, the area of European forest under threat may increase by 50% to 110 million ha (representing 45% of the total forest area) (EEA, 1995).

2.4.2 Heavy metals

Soils naturally contain trace elements, which function as micro-nutrients essential to plant and animal growth, while high concentrations can be a threat to the food chain. The elements of most concern are mercury (Hg), lead (Pb), cadmium (Cd) and arsenic (As), which are especially toxic to humans and animals, and copper (Cu), nickel (Ni) and cobalt (Co) which are of more concern because of phyto-toxicity. The toxicology of these contaminants depends on soil type,

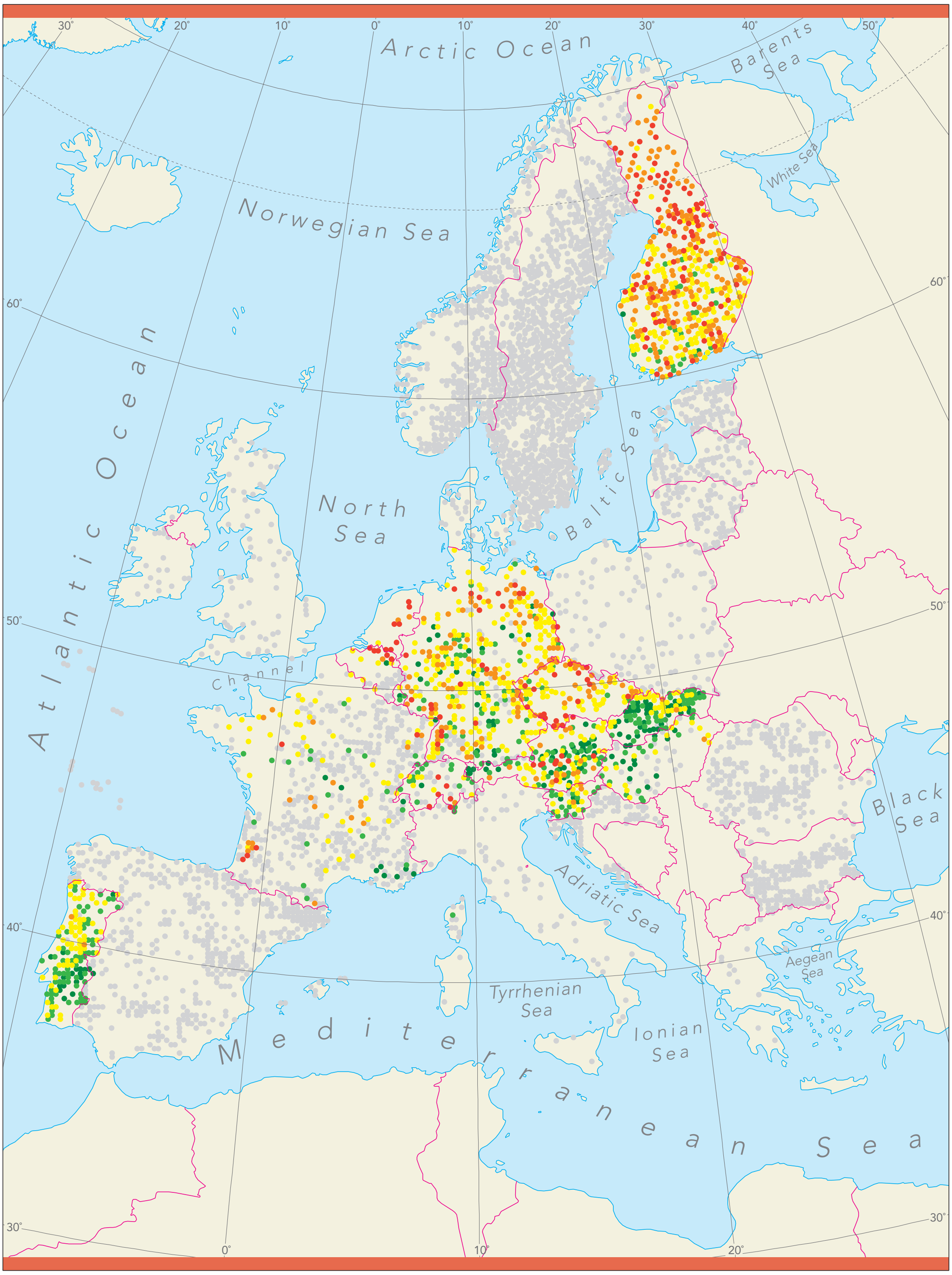
Sensitivity to acidification of European forest soils

0 500 km

- very high
- high
- medium
- low
- very low
- no data

Map 3.6.3

Source EC-UN/ECE-MFC, 1997



vegetation and climate, as well as, their concentration.

Concentrations of heavy metals in soil cover a very wide range. In many cases, the higher values indicate contamination from man's activities, although large values can occur because of natural geological or soil-forming conditions.

In forest soils, results from the above-mentioned forest soil survey show that concentrations of heavy metals such as lead and zinc in humus layers and topsoils follow regional gradients, reflecting atmospheric deposition patterns. The majority of sites with high lead or zinc concentrations in the soil organic layer are found in the region with the highest deposition load. However, critical concentration of lead, zinc and cadmium are exceeded in less than 1% of sites for which values have been reported. Exceedances of critical organic layer concentration of chromium and copper have reported more frequently, in 9% and 19% of the sites respectively.

Map 3.6.4 and Figure 3.6.8 show lead availability in European forest soils. The risk of toxic amounts of plant-available lead is associated with highly industrialised areas in Germany, England and Wales. All sites classified in the highest availability class are located in the region of Europe receiving a high or moderately high deposition load (EC,UN/ECE and MFC, 1997).

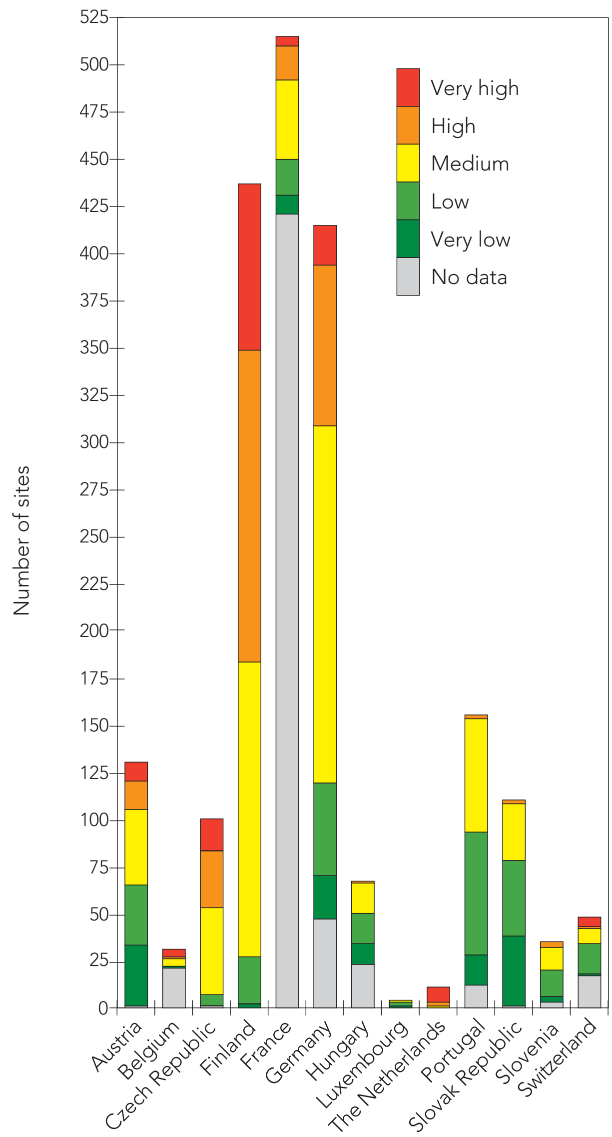
Heavy-metal exposure has been reduced throughout Europe, and a further decline is expected in the Accession Countries, although increases in cadmium and mercury in waste are projected in the EEA countries (see Chapter 3.3).

Positive effects from these reductions on European soils are expected, although methodological differences between countries preclude accurate quantitative assessment. Moreover, there are still major gaps in quantifying heavy-metal emission factors from industrial processes and in knowledge about the toxic effects of heavy metal on ecosystems or the bearing capacity of different soils.

2.4.3 Nutrient load

The over-application to soil of fertilisers with a high phosphorus and nitrogen content or livestock manure, together with acid depositions with a high content in these two elements, can have important effects on the environment. Here, capability of soil to provide nutrients to plant growth is affected, and its buffering and filtering capacity plays an important role. Both nitrogen and phosphorous are essential elements for plant growth, but can become damaging when present in quantities excessive to plant requirements. The accumulation may lead to the soil becoming saturated and the excess may be leached from the soil, eroded or simply washed off into the groundwater, waterways and coastal systems, causing eutrophication (see Chapter 3.5).

Sensitivity to acidification of forest soils in selected countries Figure 3.6.7



Source: EC-UN/ECE-MFC, 1997; EEA data elaboration, ISSS

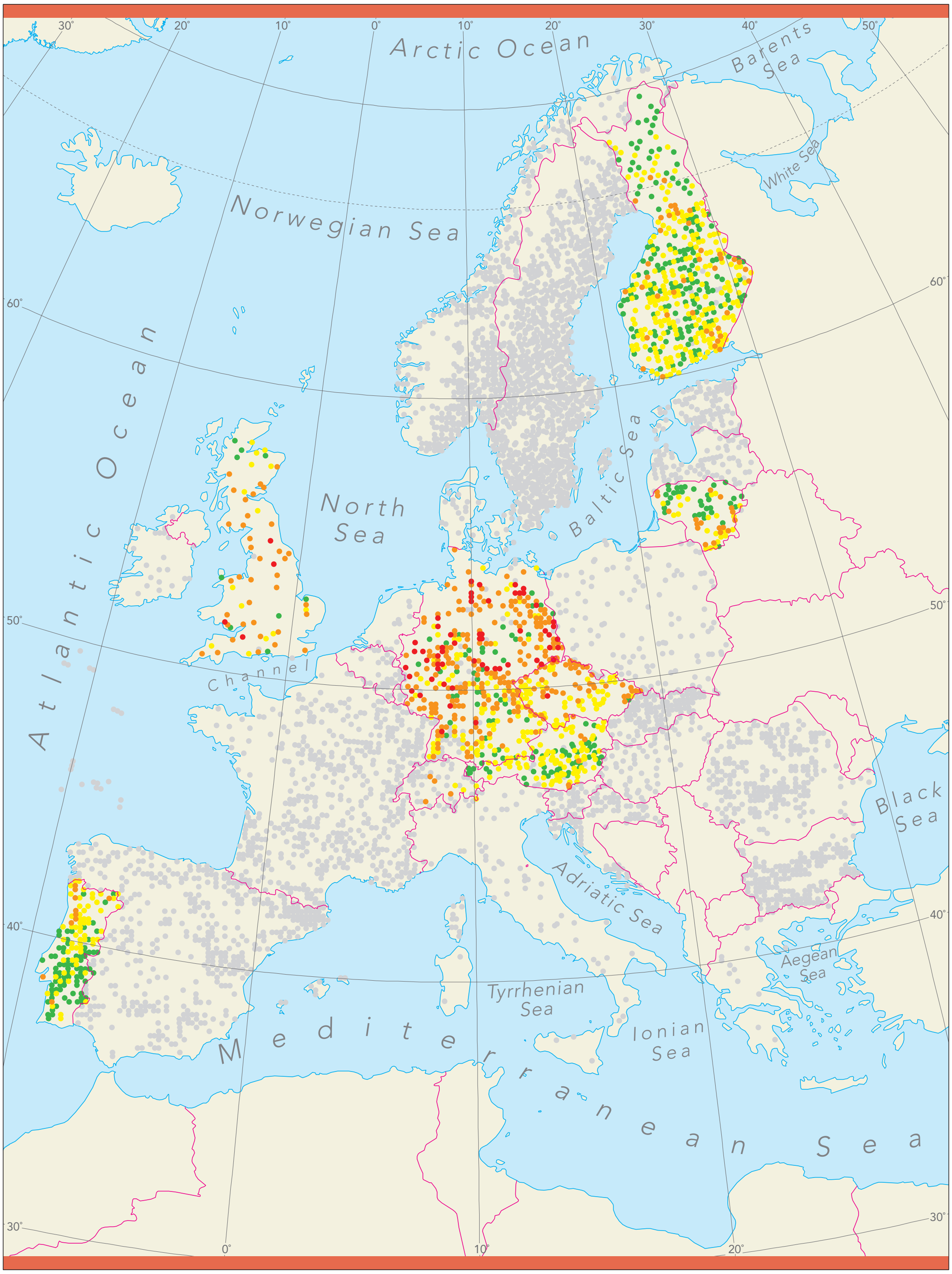
A high nitrogen content in soil may also be an important cause for the loss of vitality of European forests. In forest soils, a higher nitrogen content in the organic layer has been observed in areas receiving a high atmospheric deposition load compared with remote areas of Europe. About 17% of the sites present high nitrogen levels in the organic layer. A low nitrogen availability has been found in Scandinavian countries and in the UK, while in the rest of Europe very low availability is expected to occur rarely. A concentration of sites with high or very high nitrogen availability has been observed in Germany, the Slovak Republic and northern Spain (EC, UN/ECE and MFC, 1997).

Although fertiliser consumption was constant or slightly decreased during the last decade, nutrient loads (nitrogen and phosphate) from diffuse agricultural sources remain high, with special reference to parts of north-western Europe where there is intensive livestock production (Map 3.6.5). However, phosphorus

Lead availability in the European forest soils

0 500 km

- risk for toxicity
- high
- medium
- low
- no data



Map 3.6.4

Source: EC-UN/ECE-MFC, 1997

surpluses are also relatively high in the southern Europe, due to low removal rates by harvested crops. In Accession Countries, fertiliser consumption has declined markedly, but in future agriculture production, and hence fertiliser use, may be expected to increase from its current low level (see Chapter 3.13).

3. In search of responses

3.1. What has been done to address soil degradation and local contamination

3.1.1 At the European level

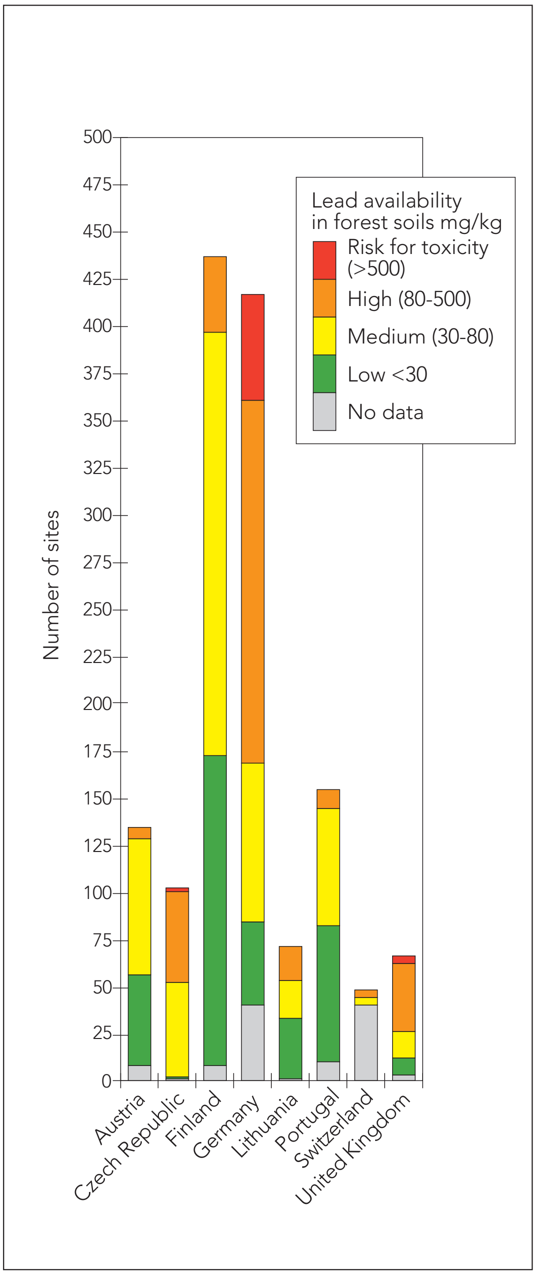
Sustainable management of soil as a natural resource, together with air and water, is among the challenges and priorities mentioned in the Fifth Environmental Action Programme (5EAP). However, unlike for the two other media, soil protection is not usually the subject of specific objectives and targets; rather, it is addressed indirectly through measures directed at the protection of air and water or developed within sector policies (secondary protection). Moreover, measures developed for specific sectors without considering the possible effects on soil may lead to its further damage. The main objectives and targets with an effect on soil protection, set out in the 5EAP, are summarised in Table 3.6.7.

Below the broad framework of the 5EAP, there is also no legislation at an EU level which directly addresses soil protection (primary protection). However, there is EU legislation indirectly (but not explicitly) concerned with soil protection, including Directives on Nitrate (91/676/EEC) and Sewage Sludge (86/278/EEC and 91/271/EEC, now under revision). Table 3.6.8 lists the main policy measures which to some extent address soil protection. These measures mostly address general soil degradation and contamination due to agricultural activities and local soil contamination due to industrial activities or waste disposal.

With respect to local soil contamination due to industrial activities or waste disposal, EU policy addresses the issue of pollution prevention, of which the Environmental Programme for Europe (1995) and the EU directive on Integrated Pollution Control (1996) are the most relevant. A EU landfill directive is in preparation.

Present EU legislation has required that Member States utilise pollution-abatement

Lead availability in the forest soils of selected countries Figure 3.6.8



Source: EC-UN/ECE-MFC, 1997; EEA data elaboration, ISSS

technologies in industry to minimise pollution and many of these technologies are installed in operating mines. However, a major cause for concern are mines that have been abandoned, often closed for many years and are still leaking pollutants to soil and water courses. In the UK, for example, abandoned coal and metal mines discharge more mining wastes to rivers than mines currently in operation.

3.1.2. At the national level

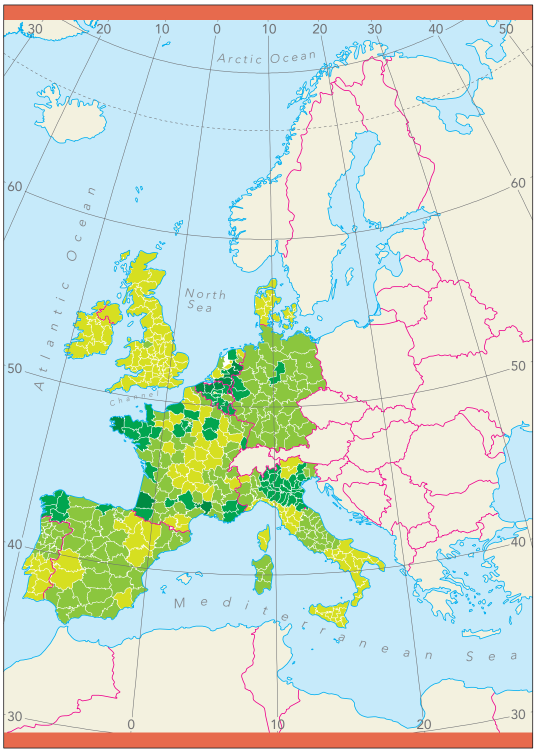
Many Member States have produced legislation, policies or guidelines to improve soils or prevent them from further degradation (Table 3.6.9). However, the policy measures

Phosphorus surplus by administrative region

0 1000 km

Phosphorus balance

- < 25
- 25 - 50
- 50 -100
- >100



Map 3.6.5

Source: Eurostat

are primarily aimed at combating pollution in other compartments and affect soils indirectly.

With special regard to local soil contamination, it can be said that most EU and Accession Countries have recognised the need to set up regulatory frameworks on how to manage existing local soil contamination and how to prevent future contamination. National policies of most countries address liability questions and the prevention of new pollution. With respect to existing contamination, most western European countries and some eastern European countries also address the keeping of regional inventories, financing aspects, and site investigation procedures. A variety of countries have made an attempt to calculate total national clean-up costs. Though results of such calculations are not comparable, they are important indicators for the attention paid to this particular matter. Cost estimates deriving from Accession Countries usually address the environmental damage of former Soviet military bases. In the case of the Czech Republic and Hungary, national costs estimated go beyond this issue.

The development of a policy framework which recognises the role of soil, takes account of the problems arising from the competition among its concurrent uses (ecological and socio-economical), and aimed at the maintenance of its multiple functions, could have multiple benefits and could achieve a consistent improvement of Europe's environment as a whole. Such a policy framework is currently absent at the EU level and in most EU Member States and Accession Countries.

3.2. Monitoring and assessment frameworks for soil – what exists and what is needed

There is no European-wide monitoring network for soil, although some progress has made in some areas, such as the monitoring of forest soils within the framework of UNECE-ICP Forest and the EU Scheme for Protection of Forests already mentioned.

Statutory soil monitoring is carried out in a number of Member States, but rarely for the purposes of soil protection per se. Monitoring is more often performed in support of, for example, the provision of better plant nutrient advice for the agricultural sector. Further difficulties within the concept of soil monitoring arise from the great diversity which exists in the design of soil monitoring schemes, the frequency of sampling, the range of parameters determined, and the methods of analysis used. There are also increasing problems of data ownership and transfer (see Chapter 4.2). As a result of this diversity, there is lack of harmonisation of the data derived from soil monitoring, and there is no pan-European quality control of the existing soil-monitoring networks.

As shown by the multi-function/multi-impact approach, soil monitoring and assessment need to be addressed in an integrated way. There is a need to work towards the establishment of certain standards for all relevant types of soil degradation, based on a uniform general methodology. An appropriate degree of co-ordination at the EU level would be necessary to obtain some level of uniformity between countries in the development of criteria and methodology for the production of relevant data on soil conditions.

To this end, a complete framework for monitoring, assessment and reporting on soil issues in Europe must be developed, similar to those already in place for air and water. This must include the harmonisation/streamlining of data collection/data flow activities (setting up a European Soil Monitoring Network and related databases), the development of policy-relevant indicators, and the establishment of a coherent reporting mechanism on soil.

		Policy objectives and targets related to soil in the 5th EAP	Table 3.6.7.
Target sectors	**Objectives**	**Targets/Measures**	**Instruments**
Industry		Integrated pollution control. Reduced waste/better waste management.	Emission and waste inventories. Civil liability.
Energy		Reduction in pollution.	Specific targets for CO_2, NO_x, SO_2.
Transport		Land-use planning. Infrastructure investments.	Environmental impact assessment. Structural funds.
Agriculture	Maintenance of the basic natural processes for a sustainable agriculture, by conservation of water, soil and genetic resources.	Maintenance/reduction of nitrate levels in groundwater. Stabilisation/increase of organic material levels in the soil.	Strict application of the nitrate directive. Setting of regional emission standards for new livestock units (NH3) and silos. Reduction for phosphate use.
	Decrease in the input of chemicals; Equilibrium between input of nutrients and the adsorption capacity of soils and plants.	Significant reduction of pesticide use per unit of land under production.	Control of sales and use of pesticides. Promotion of organic farming.
	Rural environment management permitting the maintenance of biodiversity and natural habitats and minimising natural risks (e.g. erosion, avalanches) and fires.	Management plans for all rural areas in danger.	Programmes for agriculture and environment zones.
	Optimisation of forest areas to fulfil all their functions.	Increase of forest plantation, including on agricultural land. Improved protection (health and forest fires).	New afforestation and regeneration of existing forests. Further action against forest fires.
Tourism		Better management of mass tourism. National and regional integrated management plans for coastal and mountain areas.	Improved control on land use. Strict rules for new constructions. Structural funds.
Environmental issues	Objectives	Targets	Actions/Instruments
Climate change	CO_2- CH_4-N_2O: no exceedance of natural absorbing capacity.	Stabilisation or reduction of emissions.	
Acidification	NO_x, SO_x, ammonia, general VOCs, dioxins, heavy metals: No exceedance of critical loads and levels.	Various. Emission reduction or stabilisation.	
Biodiversity	Maintenance of biodiversity through sustainable development.	Maintenance and restoration of natural habitats.	Habitats directive; CAP reform; forest protection; international conventions.
Water quality and quantity	Sustainable use of fresh water resources.	Integration of resource conservation and sustainable use criteria into other policies, including, in particular, agriculture and land use planning. Reduction of groundwater and fresh water pollution.	
	Groundwater: maintain the quality of uncontaminated water, prevent further contamination, and restore contaminated groundwater to a quality required for drinking water production.	Groundwater: prevent pollution from point sources and reduce pollution from diffuse sources.	Implementation of urban waste water and nitrate directives to reduce the input of nutrients to the soil, water and sediments. Proposals for progressive replacement of harmful pesticides and progressive use limitations.

.../...

Environmental issues	Objectives	Targets	Actions/ Instruments
Coastal zones	Sustainable development of coastal zones and their resources.	Development of better criteria for a better balance of land use and conservation and use of natural resources.	
Waste	Municipal and hazardous waste: prevention and safe disposal of any waste that cannot be recycled or reused.	Considerable reduction of dioxins emissions. Waste management plans in Member States.	Landfill directive operational. Incineration of hazardous waste operational.
Risk management	Chemicals control; risk reduction and management		

Source: European Commission; EEA

Table 3.6.8. **European policy measures addressing soil protection**

Policy document	Sector addressed	Issue addressed
Council of Europe European Soils' Charter (1972)	General	soil protection and deterioration
FAO World Charter of Soils (1981)	General	request to support sustainable farming
CAP Reform (Council Regulation, 1992)	Agriculture	lower environmental impacts within agriculture
Fifth Environmental Action Programme (5EAP, 1992)	Agriculture, Transport, Tourism, Energy	soil degradation, erosion and acidification, in relation to the contributions from various economic sectors
Environmental Programme for Europe (EPE, 1995)	Agriculture, Industry	pollution prevention; sets out long-term environmental policies
EU directive on Integrated Pollution Prevention and Control (IPPC, 1996)	Industry	pollution prevention; encouragement of cleaner production
EU Landfill Directive (draft)	Industry, Households	landfill management
Protection of Ground Water from Hazardous Substance Discharges (1980)	Agriculture, Industry	groundwater protection
Directive on Hazardous Waste (91/689/EEC)	Industry, Households	waste management
Waste Framework Directive (75/442/EEC;91/156/EEC)	Industry, Households	waste management
Directive on disposal of waste oils (75/439/EEC;87/101/EEC)	Industry	waste management
Packaging directive (94/62/EEC)	Industry, Households	waste management
Nitrate Directive (91/676/EEC)	Agriculture	fertiliser reduction
Sewage Sludge Directive (86/278/EEC; 91/271/EEC)	Agriculture	limitation of heavy metal concentrations in soils and sludge
Directive on Environmental Impact Assessment (85/337/EEC)	Transport, Industry, Land development	land consumption and contamination

Source: EEA-ETC/S

References

Blum, W.E.H. 1990. *The challenge of soil protection in Europe*. Environmental Conservation 17. In: World Resources Institute,1991. *Accounts Overdue. Natural Resource Depreciation in Costa Rica*. Oxford University Press. Oxford, New York.

Blum, W.E.H. 1998. *Soil degradation caused by industrialization and urbanization.* In: Blume H.-P., H. Eger, E. Fleischhauer, A. Hebel, C. Reij, K.G. Steiner (Eds.): *Towards Sustainable Land Use*, Vol. I, 755-766, Advances in Geoecology 31, Catena Verlag, Reiskirchen.

Cabrera, F. *et al*. 1998. *Contaminación por metales pesados de suelos caraterísticos de la cuenca del Guadiamar afectados por el vertido tóxico*. Jornadas científicas para analizar los resultados obtenidos durante el seguimiento del efecto del vertido tóxico en el entorno de Doñana. El Rocío, Almonte, Huelva, Spain.

Council of Europe, 1990. European Conservation Strategy. Recommendation for the 6th European Ministerial Conference on the Environment. Council of Europe, Strasbourg.

CSIC, Grupo de expertos del Consejo Superior de Investigaciones Científicas y organismos colaboradores sobre la emergencia ecologica del rio Guadiamar. 10° Informe, 9 March 1999. Published on the Internet at http://www.csic.es/hispano/coto/infor10/info10.htm

EEA, 1995. *Europe's Environment: The Dobris Assessment*. European Environment Agency. Office des Publications, Luxembourg, 676 pp.

EEA, 1998 . *Europe's Environment: The Second Assessment*. European Environment Agency. Elsevier, UK, 293 pp.

EEA-ETC/S 1998. *Contaminated Sites in the EU and EFTA countries*, Prokop. G., Edelgaard I., Schamann M. (forthcoming).

EPE, 1995. *Environment for Europe* - Some key documents. UNECE, Geneva

European Commission, 1992. *CORINE Soil Erosion Risk and Important Land Resources in the Southern Regions of the European Community*. EUR 13233, Commission of the European Communities, Luxembourg, 97 pp.

European Commission, United Nation/Economic Commission for Europe and the Ministry of the Flemish Community, 1997 (EC,UN/ECE and MFC, 1997). *Forest Soil condition in Europe*. Results of a Large-Scale Soil Survey.

European Commission, 1999 (forthcoming). "*Economic Assessment of Priorities for a European Environmental Policy Plan* (working title)". Report prepared by RIVM, EFTEC, NTUA and IIASA for Directorate General XI (Environrment, Nuclear Safety and Civil Protection).

Eurostat, 1995. *Europe's Environment: Statistical Compendium for the Dobris Assessment*. Office des Publications. Luxembourg, 455 pp.

Eurostat, 1998. *Towards Environmental Pressure Indices for the EU*. Draft of September, 07, 1998, 182 pp.

IPCC, 1996. *Second Assessment Climate Change 1995*, a Report of the Intergovernmental Panel on Climate Change (including summary for policy makers). WMO, UNEP, 1995.

IPCC, 1998. *The Regional Impacts of Climate Change, An Assessment of Vulnerability*, R.T. Watson, M.C. Zinyowera, R.H. Moss. Cambridge, Cambridge University Press.

German Advisory Council on Global Change. 1994. *World in Transition: The Threat to Soils*. 1994 Annual Report. Economica, Bonn.

Stalzer, W. (1995): Rahmenbedingungen für eine gewässerverträgliche Landbewirtschaftung. Schriftenreihe des Bundesamtes für Wasserwirtschaft, Bd. 1, S. 1-24.

The Tutzing Project "Time Ecology", 1998. *Preserving Soils for Life*. Ökom - Verlag

ÖSTAT & UBA, 1998: Umweltdaten 1997, p.39ff, Österreichisches Statistisches Zentralamt, Vienna.

UNCCD Interim Secretariat, 1997. *United Nation Convention to Combat Desertification in those countries experiencing serious drought and/ or desertification, particularly in Africa*. Text with Annexes. Geneva, Switzerland.

UNFCCC 1998. Kyoto protocol to the United Nations Framework Convention on Climate Change. FCCC/ CP/1997/L.7/Add.1, December 1997.

Van Lynden, G.W.J., 1994. *The European Soil Resource: Current Status of Soil Degradation causes, impacts and need for action*. Council of Europe. Strasbourg, 71 pp.

Country overview indicating the existence of policy measures for contaminated land — Table 3.6.9.

Country	Legislation		Inventory		Special CS funding	Official cost estimates
	Indirect	Direct	PCS	CS		
Austria	•	•	•	•	•	•
Belgium(1)	•	•	•	•	•	•
Denmark	•	•		•	•	•
Finland	•	•	•	•	•	•
France	•	•	•	•	•	
Germany	•	•	•	•	•	•
Greece	•					
Iceland	•					
Ireland	•					
Italy (2)	•	•	•			•
Luxembourg	•					
Netherlands	•	•	•	•	•	•
Norway	•	•	•	•	•	•
Portugal	•					
Spain	•		•	•	•	•
Sweden (3)	•	•	•	•	•	•
Switzerland	•	•	•	•	•	•
UK	•	•			•	•
Bulgaria	•					
Czech R.	•				•	•
Estonia (4)	•					•
Hungary	•	•	•	•	•	•
Latvia (5)	•		•			
Lithuania(4)	•		•			•
Poland	•					
Romania	•					
Slovenia	•					
Slovakia	•					

(CS = contaminated sites, PCS = potentially contaminated sites)

(1) Belgium: applies only to the Flemish region; (2) Italy: a preliminary survey of potentially contaminated sites and their clean-up costs had been completed for most of the Italian regions by 1997; (3) Sweden: CS policy is underway; (4) Estonia, Lithuania: cost estimates apply to the clean-up of ex-Soviet bases; (5) Latvia: a test inventory was set up in 1996.

Source: EEA-ETC/S