BACKGROUND RESEARCH

To be used if internet facilities are unavailable

HINTS

Acid Deposition

Acid rain is formed when sulphur oxides and nitrogen oxides, typically emitted from coal fired power plants and fossil fuel burning sources, are absorbed by water droplets.

Sulphuric and nitric acids can be formed as a result.

The chemical equations:

Sulphur dioxide and water form sulphurous acid (H_2SO_3)
$SO_2(g) + H_2O(l) <--> H_2SO_3(aq)$

Sometimes sulphur dioxide (SO_2) oxidizes to form sulphur trioxide (SO_3)
$2SO_2(g) + O_2(g) -> 2SO_3(g)$

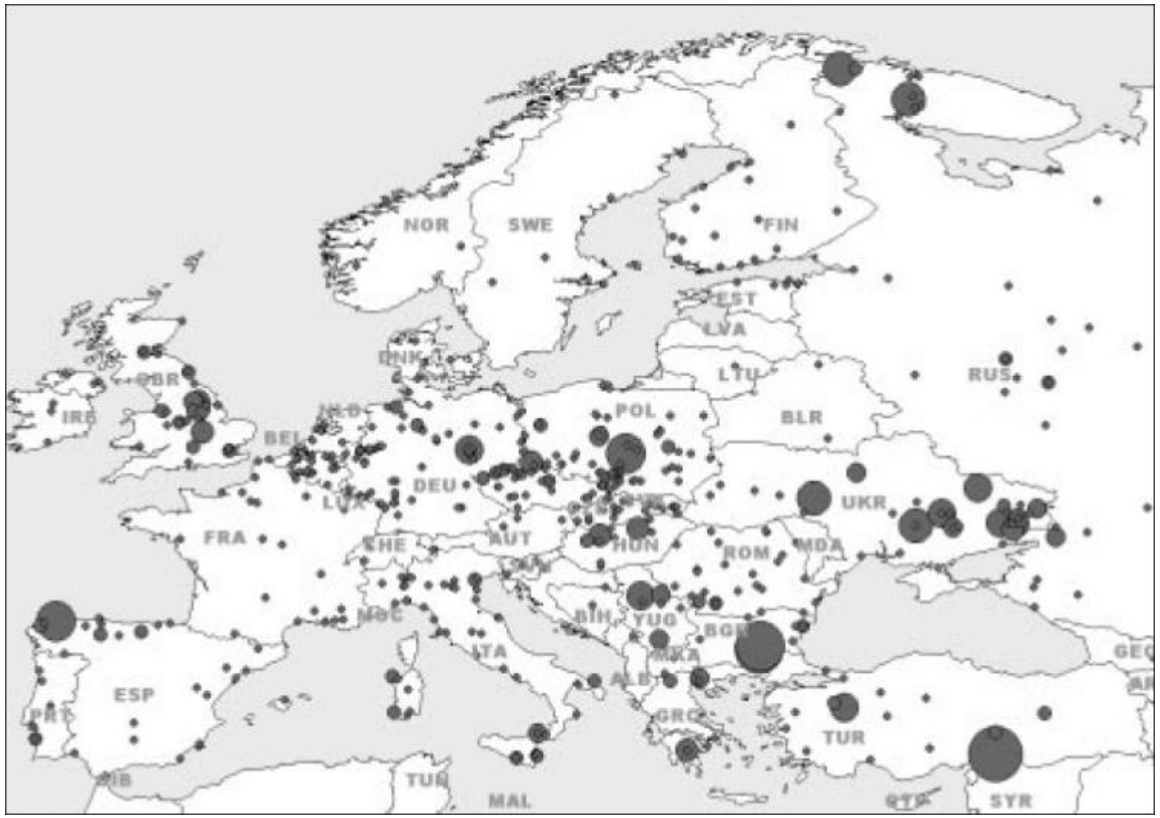
Sulphur trioxide (SO_3) then combines with water to make sulphuric acid (H_2SO_4)
$SO_3(g) + H_2O(l) -> H_2SO_4(aq)$

Oxides of nitrogen can react with water to form nitrous acid (HNO_2) and nitric acid (HNO_3)
$2NO_2(g) + H_2O(l) -> HNO_2(aq) + HNO_3(aq)$

Coal Power Plants to Blame

Scientists have concluded that the air pollution from the burning of fossil fuels is the major cause of acid rain. Power stations, factories and vehicles burning fossil fuels all emit sulphur dioxide and nitrogen oxides. When these combine with atmospheric moisture they form Acid rain or snow. When it falls to earth it is known as Acid Deposition

Coal Power Plants emitted approximately 65% of the SO_2 emitted in Britain in 1998



The map shows the 600 largest emitters of SO_2 in Europe.

The Larger the grey circle – the larger the emitter.

Source: Barrett M., 2000, *The worst and the best. Atmospheric Emissions from Large Point Sources in Europe*, SENCO, UK, Swedish NGO Secretariat on Acid Rain.

Dirty Old Man of Europe

The emissions of Sulphur Dioxide from Power Stations and Industrial Factories in the UK were so high in the 1980s it led to countries in Scandinavia to describe the UK as 'The Dirty Old Man Of Europe'.

Pollution levels have been reduced but the UK still emits high levels compared to many other European countries.

Defra *- Department for Environment, Food and Rural Affairs*

An organisation that monitor pollution levels in the air, land and water in the UK

1998 Gothenburg Protocol

This Protocol requires UK to reduce sulphur emissions to 15% and nitrogen emissions to 51% of the levels emitted in 1980 by 2010 .

To achieve this the UK is using cleaner technology within the power stations, closing coal power station and making cleaner fuels and car engines available.

Thirty Percent Club Update

The group of countries that were committed to reducing their emission levels of sulphur dioxide by 30% between 1980 and 1993. The UK did not join.

Not the movement to ensure 30% of business leaders are female

Eroded Limestone Buildings

Numerous buildings , especially older architecture and statues are built from limestone ($CaCO_3$) – an alkaline material. Acid rain (most commonly H_2SO_4) reacts with the limestone – dissolving it.

$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$

e.g. York Minster & Westminster Abbey

Alarming Health Issues

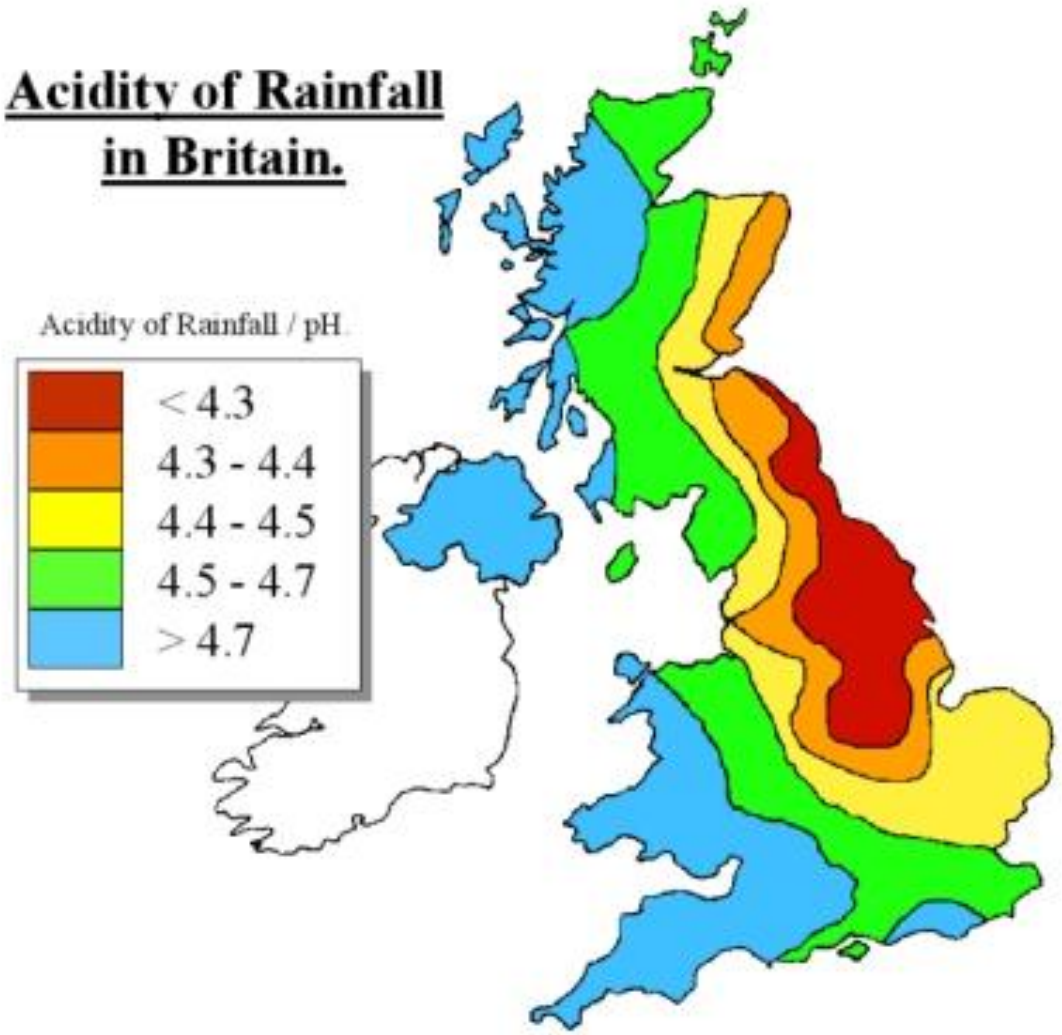
Pollutants that cause acid rain - sulphur dioxide and nitrogen oxides - can damage human health. The pollutants interact in the atmosphere to form fine sulphate and nitrate particles that can be transported long distances by winds and inhaled deep into people's lungs.

Many scientific studies have identified a relationship between elevated levels of fine particles and increased illness and premature death from heart and lung disorders, such as asthma and bronchitis.

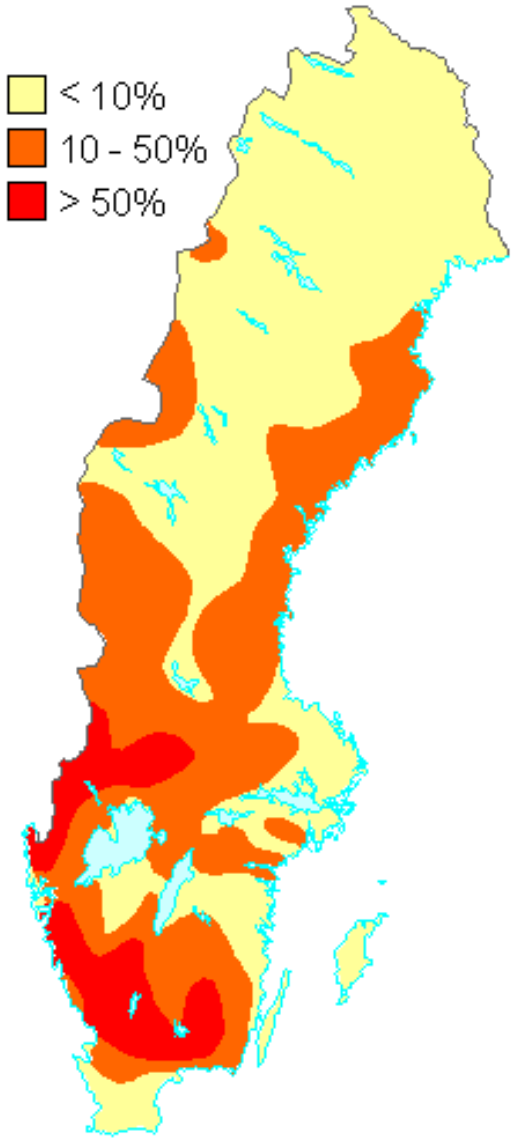
Liming – an Answer for Lakes

Liming is a technique used to treat higher than normal acid levels in ground water (streams and lakes) caused by acid rain and other factors. A “basic” (alkaline) substance – often limestone - is added to neutralize the acid.

The map shows the pH levels of rain falling on the UK in 1998.
Areas in red have a pH of less than 4.3
Non polluted rainwater has a pH of 5.6.



- Any sites burning fossil fuels release Sulphur dioxide. The highest levels are emitted by Power Stations.
- 10,000 people in the UK die from the illnesses caused by particles forming acid rain every year.
- Acid rain is more easily formed as over long distances, meaning most of the pollution from the UK falls as acid rain over North West Europe.
- Acid rain damages buildings and plants – particularly trees and crops.
- Most of the acid rain falling on the UK comes from power stations in southern Europe.



Lakes

If enough acid rain enters a lake, either by rain or snow falling directly into it, or from water flowing into it via rivers or streams, the entire lake can have its acidity level raised significantly.

Low levels of acid in the water may kill fish eggs and cause fish to become ill.

High levels of acid, increasing aluminium levels released from the soil, can kill the fish.

As a result, the food chain can be affected. Birds feeding on ill fish can also become ill. If enough fish die, smaller animals that eat the fish can starve. The lake begins to 'die'.

A 'lifeless lake' is often a vivid blue colour. At least 20000 lakes in Scandinavia have been effected by acid rain and 4000 have such low pH levels that life cannot survive in them.

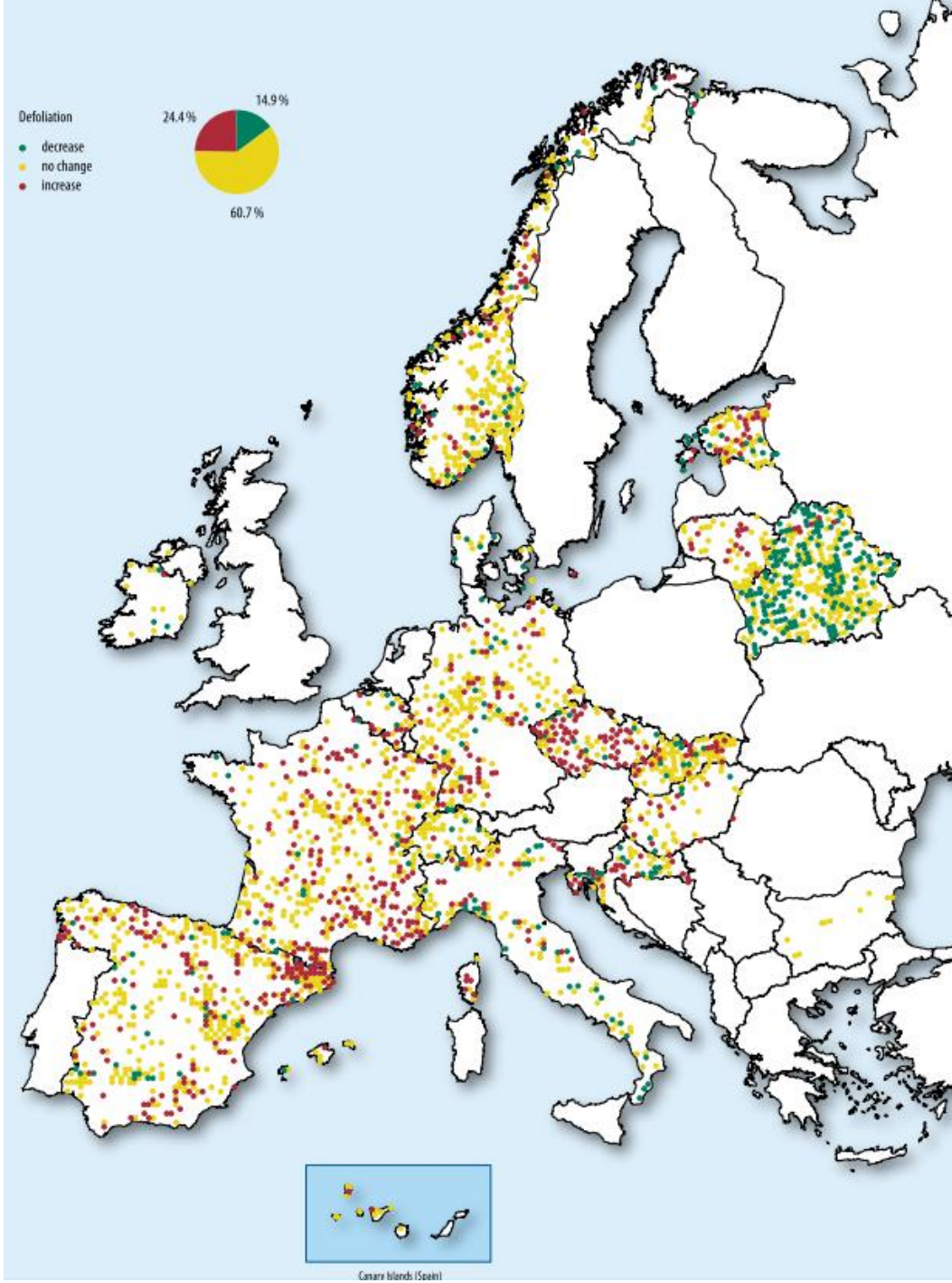
This type of damage has also occurred in the United Kingdom, particularly in Scotland.

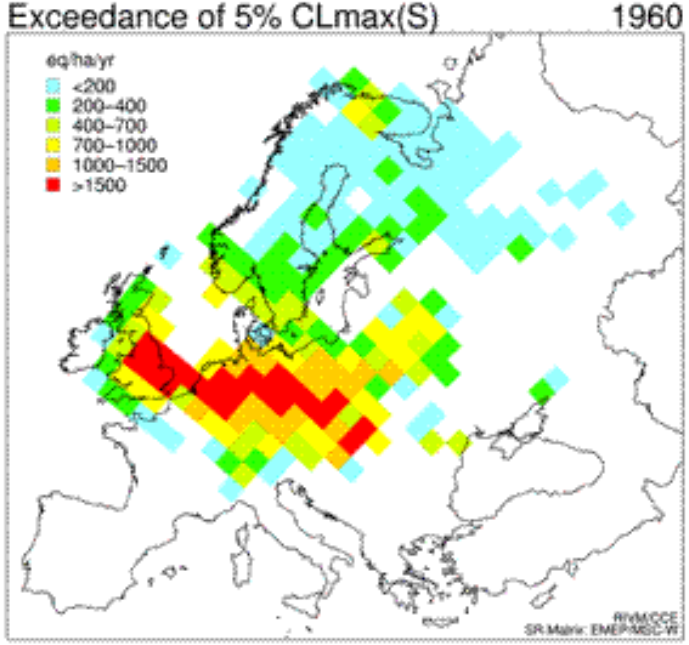
Trees Defoliated

In the early 1980s, a dramatic deterioration in forest condition was observed in Europe and this initiated the implementation of **forest condition monitoring** under the Convention on Long-range Transboundary Air Pollution (CLRTAP).

In 1995, the United Nations Economic Commission for Europe (UNECE) Forest Survey revealed that 42% of UK trees were healthy, 45% were slightly defoliated and 13% were damaged. Both coniferous and broadleaf trees showed the same degree of damage.

Acid rain does not usually kill trees directly. Instead, it is more likely to weaken trees by damaging their leaves, limiting the nutrients available to them, or exposing them to toxic substances slowly released from the soil.



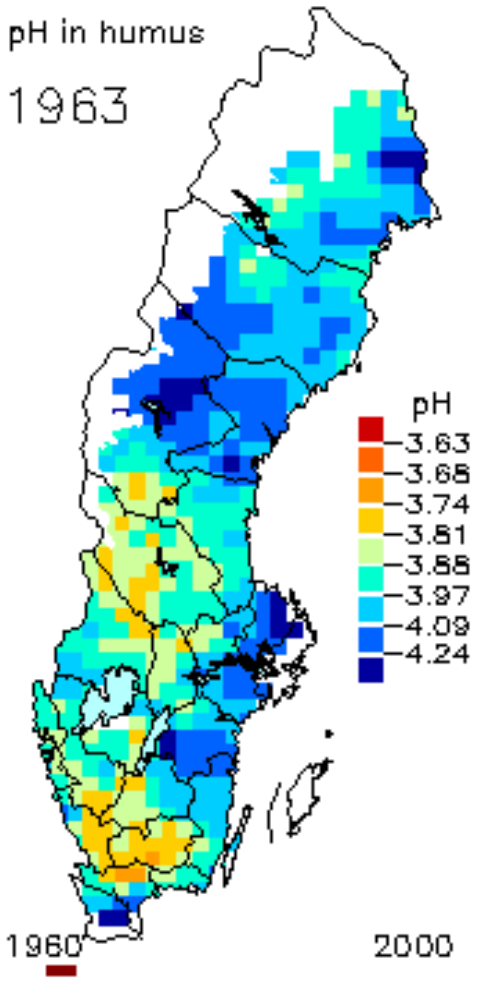


Sequence of eight maps showing where the 5th percentile maximum critical load of sulphur (acidity critical load) has or will be exceeded between 1960 and 2010. Red areas show where sulphur deposition is much greater than the amount allowed. In these areas the acidifying effect of sulphur is the largest.

In Europe in 1990 around 93 million hectares of land were affected by levels of acid deposition that exceeded the critical load. To achieve the desired limits and reduce the damage caused by acid rain, it is necessary to reduce acidifying pollution in parts of Europe by 80-90% compared with 1990 levels.

The heavily industralised regions in Northern and Central Europe are at most risk of damage from acid rain because the sources of pollution are close. Rain in these areas is generally acidic (pH 4.1 to 5.1). Comparison of Figures 1. and 2. shows that even though the Scandinavian Countries don't emit much SO_2, they are also threatened by acid rain.

author: Anita Bokwa - Jagiellonian University, Cracow, Poland



The pH level in the humus layer in Sweden. The animation shows changes since 1963. Author: Ake Nilsson, Swedish University of Agricultural Sciences. Source: Swedish Environmental Protection Agency.

In Sweden, in most of the country, the soils are composed of slow-weathering minerals from Scandinavia's Precambrian bedrock. The result is that the maximum amount of acid that the soil is capable of neutralising (the critical acid load) is low. Sweden is, therefore, more sensitive to acid deposition than most other countries.