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Air pollution and nature

Biodiversity on our planet is decreasing as a result of human activities. Air pollution is not the main cause of this, but certain types of ecosystems are particularly vulnerable and/or affected by it. One of the most serious aspects of air pollution is that its effects reach everywhere – even in nature reserves and areas that are otherwise protected from our interference.

This chapter describes how air pollution affects ecosystems, both globally and regionally. To make it easier to understand the role of air pollution a short introduction is first given to how ecosystems work. The importance of climate for the ecosystems is then described, followed by a run through of the known effects of air pollution on different natural environments. Finally the effects of air pollution are discussed in relation to other types of human influence.

NATURE – HOW IT WORKS

There is a widespread conception that when nature is left in peace by mankind it reaches some sort of equilibrium or "ecological harmony". But this is not the whole truth. There is of course a certain degree of balance in nature. The most important evidence for this is that it still exists. But often balance is equated with lack of change. In fact nature is changing all the time – there is a constant battle to conquer more living space, both within and between species. Who wins the battle varies from one time to the next, depending on variations in climate and other living conditions. Chance also plays a certain role.

The influence of mankind – in the form of hunting, fishing, forestry or air pollution – means that we interfere in the processes of change that are constantly taking place. For instance, if we add nitrogen to a nutrient-poor grass heath we can get a completely new ecosystem, since the competition rules are changed – some species are strongly favoured by this fertilization and are able to displace the others.

It all depends on circumstances

It is not obvious how an individual, such as a spruce tree, will react if it is exposed to air pollution. Firstly, all spruce are genetically unique individuals and have different degrees of inherent resistance to stress (just like us!). And secondly their response depends on other environmental factors.

The term stress is often used to describe the pressure that the surroundings exert on an individual. A plant, for example, can be stressed by drought, lack of nutrients, competition and attack by parasites – and by air pollution.

As a stress factor, air pollution can act in many different ways. Some gases for instance are directly toxic. Acidifying substances can act indirectly by restricting access to nutrients in the soil. Nitrogen fallout makes living conditions more difficult for many species, but improves them for others. Climate-modifying gases can change precipitation patterns and cause greater drought stress, etc.

In each case it is the cumulative effect of the different stress factors that decides whether an organism is harmed or not. A given dose of a pollutant or a specific climate change can therefore have very different effects. The role or air pollutants is further complicated by the fact that they may reinforce or cancel out the effects of each other.

THE IMPORTANCE OF CLIMATE

The present distribution of ecosystems around the world – from the polar ice caps to the equatorial rainforests – is a result of the climate that has prevailed over recent millennia. Viewed over the long term, the climate has always varied widely, but usually at a fairly slow rate. If current fears of global warming become a reality, two main groups of effects can be expected in the natural ecosystems:

- "Transition problems", the extent of which will depend on the rate of warming and the way that the landscape is divided up.
- New zones of colonization, which will be determined by how much the temperature rises overall, how precipitation patterns change, etc.

What makes the current threat of climate warming so special is its speed. Changes that have in the past taken thousands of years could happen in just a few decades.

During the relatively slow course of natural climate variation it is assumed that the majority of plants, including long-lived species such as trees, would manage to migrate with "their" climate zone. Transition problems have probably been fairly minor, although these variations have doubtless wiped out a number of species that were unable to keep up with the fluctuations. Some species that are only able to spread slowly are still moving northwards in Europe in response to the disappearance of the inland ice 10,000 years ago.

By analysing the occurrence of pollen in peat moss and lake sediment researchers have been able to show how different types of vegetation have taken over from each other since the last ice age. It is not certain that these pollen archives reflect the maximum ability of the species to spread. It is however apparent that if the extent of warming is as large as predicted, many species will have difficulty keeping up.

The way that ecosystems move in practice is also worth commenting on. Trees and other plants cannot sprout feet and start heading north. In any given ecosystem there is a gradual process of change during which certain species are left behind, new ones appear and some old ones die off.

One complication in the migration of species is the presence of natural and man-made barriers. The sea is a barrier to many land species, in the same way as the land is to organisms that live in lakes. Our use of land has also fragmented the landscape in such a way that biologically diverse environments are often like isolated islands – e.g. an ancient forest reserve in a sea of cultivated forest or a meadow in a sea of farmland.

Different species have very different abilities to cope with the necessary migration. The ones that do best seem to be those whose strategy is to produce a large number of offspring early in life. These species can quickly colonize new habitats. Things are more difficult for long-lived species that have few offspring and limited ability to spread. The former group includes many species that benefit from disruption and are already favoured by human activity – while the latter includes those that are already hard pressed.

GLOBAL EFFECTS

Biodiversity is generally threatened to a much greater extent by our use of land than by air pollution – at least at present. But a major climate change over a short period could have both far-reaching and lasting consequences. Moreover, air pollution affects all natural environments, including those which, for various reasons, we do not exploit, such as mountain heaths and raised bogs, as well as those we have decided to protect, such as nature reserves and national parks.

Ecosystems under threat

A number of ecosystems have been identified as especially sensitive to changes in temperature and precipitation patterns:

Coral reefs. Coral reefs – the highly diverse ecosystems that exist in the tropical oceans between the Tropics of Capricorn and Cancer – are among the most threatened environments. This is because the coral polyps that build the reefs, in symbiosis with single-celled algae, are very sensitive to temperature. In recent years the tropical oceans have also been unusually warm. The coral polyps are stressed by heat and this has led to coral bleaching in all the tropical oceans. Many of these corals will probably never recover. Some researchers believe that a rise of just one degree in the water temperature is a serious threat to coral reefs worldwide.

Mangrove swamps. The mangrove swamps, thickets of trees on stilt-like legs along the coasts of tropical areas, stabilize the coasts and provide habitats and breeding grounds for a very large number of aquatic species and land species. They are threatened by rising sea levels. There is limited opportunity to retreat inland, since the land there is often already used for other purposes.

Mountain ecosystems. Vegetation does not just vary with climate in the north-south direction. There is also climate-dependent variation with altitude. There are alpine environments on mountain peaks even in warm regions. These can be regarded as islands in a "sea" of surrounding lowlands. If the climate gets warmer and the vegetation zones creep up the mountainsides there is nowhere for the species that live at the top to go.

Boreal forests. The large coniferous forests that form a belt around the Arctic currently cover 17 per cent of the Earth's land surface. The extent of these forests may shrink greatly in the future as a result of climate changes. Heat and drought mean that forests in the south are disappearing or being transformed into temperate forest at a quicker rate than the coniferous forests in the north are able to advance across the tundra. Attack by insects and fungi can be expected to increase since these are favoured by warmer temperatures, and because drought may become a growing problem for trees in many areas, especially the central areas of continents.

Mountain heaths and tundra. The northernmost ecosystems have limited opportunities to move further north if it gets warmer, since the Arctic Ocean forms a boundary. Model calculations indicate that the area of tundra could be halved over the next century, even with a relatively moderate temperature rise.

The Arctic. The ice cap that makes up the Arctic may shrink considerably as a result of warming. This reduces the habitats of those species that are adapted to the current conditions, such as the polar bear.

Rainforests. The temperature change is expected to be relatively small nearest the equator, where the rainforests are located. But on the other hand these forests are home to many highly specialized species that are sensitive even to small changes in temperature and rainfall.

Many species are threatened

The average global temperature does not need to rise particularly dramatically to pose the threat of extinction for many land species due to their habitats changing or disappearing.

In a study presented in the journal Nature in January 2004 a group of researchers showed that a massive 35 per cent of the species studied in a series of areas with a rich biodiversity may be threatened with extinction by the year 2050, even if global warming is limited to 2.5–3.0°C. The researchers fear that well over one million species may be threatened by extinction if the results of the study are applied on a global scale, and that even more species will be added to the list if the temperature rises more than 3°C – although the latter was not covered by the study.

The same study shows, however, that an active climate policy could save many species from the risk of extinction. In a low global warming scenario (0.8–1.7°C) the proportion of threatened species is halved in comparison with the scenario for a temperature rise of 2.5–3.0°C.

Imbalance between light and temperature

Some natural processes are governed by temperature, which may change in the future, and others by the length of day, which is unaffected by greenhouse gases. This means problems for certain species. One example is a species of hummingbird in North America, whose migration is triggered by the length of day. It arrives in its summer home in the Sierra Nevada just as certain alpine plants come into flower, so the bird has plenty of food and the plants get pollinated. However, the flowering of these plants is not controlled by length of day, but by the thawing of the snow, which could happen a full two months earlier if the level of greenhouse gases in the atmosphere doubles. A partnership that has been fine-tuned over millennia could therefore be upset totally within a short period of time.

Higher level of carbon dioxide

The rising level of carbon dioxide in the air does not just affect the climate. It also has a direct influence on plants, since they use the carbon dioxide for photosynthesis. Some species are better than others at making use of the increased availability. It is difficult to say how this will affect ecosystems, but there is reason to believe that this "fertilization" with carbon dioxide could shift the balance of competition in a similar way to the increased availability of nitrogen, even if it does not have such dramatic consequences.

The higher level of carbon dioxide in the air also improves the ability of plants to conserve water, since the same amount of carbon dioxide can be absorbed in a shorter time. This means that the stomata on their leaves do not have to be kept open as long, which in turn reduces evaporation.

Other air pollutants

Acidification, eutrophication and ground-level ozone affect ecosystems in many parts of the world, but the effects are primarily regional and local. The following section describes in more detail what is happening in Europe.

REGIONAL EFFECTS

The problems related to air pollution that have had the greatest impact on ecosystems in Europe are the acidification of nutrient-poor fresh water and the acidification and eutrophication of many land environments. These processes have caused major harm and the impoverishment of nature. It is also possible that increased levels of ground-level ozone have affected some plant communities on land.

The extent and scope of all these problems are expected to decrease in coming decades in Europe, not least due to international agreements to reduce emissions of several air pollutants. The biggest question for the future is what will be the effects of the increased levels of greenhouse gases in the atmosphere.

The following describes what has happened so far and what is feared may happen in northern European ecosystems.

The sea

Seawater contains a plentiful supply of buffering substances and is therefore not threatened by acidification.

The atmospheric deposition of nitrogen compounds does however pose a serious problem, in the form of eutrophication. For example, it is calculated that up to one-third of the nitrogen that enters the Baltic Sea originates from airborne fallout. In seawater it is generally the availability of nitrogen that limits biological reproduction, while in fresh water phosphorus is the limiting factor, at least where water is poor in nutrients.

The deposition of nitrogen means that algae, whether mobile or immobile, get a real boost to growth. This changes the entire ecosystem. The increase in biological production in surface water also has consequences lower down. When dead plants and animals eventually reach the bottom it takes a lot of oxygen to decompose them. In unfavourable cases the oxygen may be completely used up, which kills off most of the bottom fauna.

Not much is known about how life in our marine areas is affected by changing climate. It is feared that a warmer climate and increased precipitation will lead to greater leaching of nitrogen from the land to the sea, and hence aggravate the problems of eutrophication.

Lakes and waterways

Acidification is the most important effect of air pollution on bodies of fresh water. Several different mechanisms cause extensive biological changes:

Some organisms are sensitive to low pH. This is true of a number of shell-bearing organisms such as molluscs, mussels

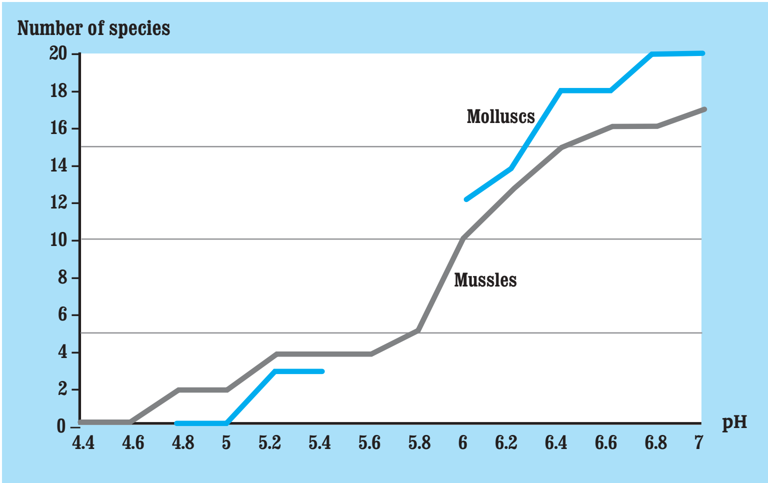

FIGURE 2.1. Molluscs and mussels disappear when the pH drops. (pH-status, No. 4, 1998.)

and many crustaceans, including crayfish. Figure 2.1 shows the relationship between pH and the number of species of molluscs and mussels in Norwegian waters. Mayfly larvae have also been found to be sensitive to changes in pH.

The elevated levels of dissolved aluminium in water that are caused by acidification affect some organisms. This is the case for the eggs and fry of many species of fish. The adult fish are less vulnerable and may live on, even though the stock has stopped reproducing. Some fish are more sensitive than others. This is illustrated in figure 2.2, along with a number of other changes that take place.

The rise and fall in numbers of some species does not depend directly on acidification (low pH values or high concentrations of dissolved aluminium), but is an indirect effect of fish disappearing. The presence of fish has a strong governing effect on the distribution of species in lakes.

Lake acidification also affects birdlife. Fish-eating birds, such as divers, merganser and osprey are put under pressure, while insect-eaters, such as goldeneye are favoured.

Among plants, certain bog mosses are favoured by acidification, while many plants at the water edge suffer, partly be-

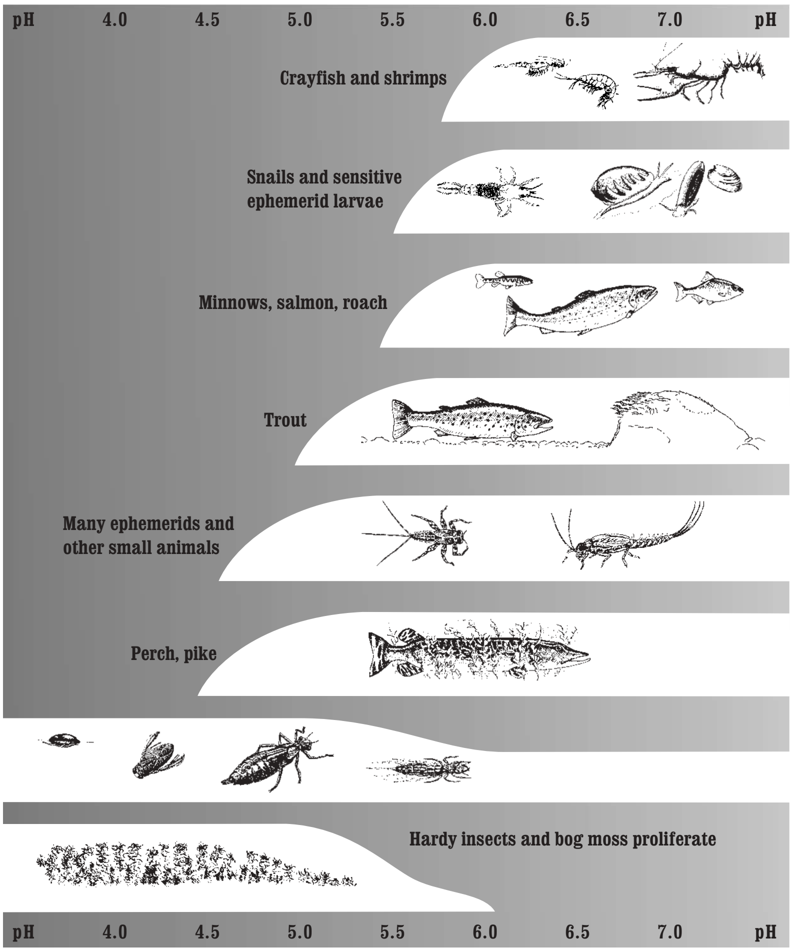

FIGURE 2.2. The sensitivity of different groups of plants and animals to the acidification of lakes and waterways.

cause they are overgrown by mats of bog moss. The number of species of phytoplankton falls dramatically. In nutrient-poor lakes with a pH value above 6 there are normally around fifty species, while only ten or so remain in an acidified lake.

Acidification is largely a problem in naturally nutrient-poor lakes and waterways. Worst affected is water that is high up in the catchment areas.

Eutrophication is another problem that affects surface water, as a rule mostly in agricultural areas. In most cases the eutrophication of fresh water has little to do with air pollution – here it is usually phosphorus that limits growth, and the phosphorus comes mainly from agricultural land and sewage outflows, not from the air.

In certain cases the airborne deposition of nitrogen can also affect life in fresh water. In some lakes, mainly those that are relatively rich in nutrients, growth is limited by the availability of nitrogen. The deposition of nitrogen can then contribute to eutrophication.

A warmer climate also affects life in lakes. If the ice season becomes shorter, the algal bloom occurs earlier in spring, and the distribution of species is affected, including a fall in numbers of diatoms. Bacterial activity is expected to increase, which makes more nutrients available and aggravates the problems of eutrophication. If precipitation increases it will also lead to an increase in the influx of nutrients from the surrounding land.

Warmer water also affects life under the water surface. Fish such as salmon, salmon trout, vendace and char have difficulty finding sufficient cold water in the southern reaches of their natural habitats. Because lakes and waterways are naturally fragmented there is little opportunity for them to seek out more suitable climatic conditions.

Forests

Air pollutants affect forests in many different ways. In the case of trees, the increased level of carbon dioxide in the air favours their growth, as does the deposition of nitrogen. Other substances, such as ozone, are harmful and can make trees more vulnerable to the natural stress that is always present to some degree, in the form of drought or attack by insects or fungi for example.

Many organisms in the forest are much more sensitive to pollutants than the trees. Widespread changes in the distribution of species have been reported in large parts of Europe, primarily in connection with acidification and the deposition of nitrogen – see the factfile on pages 28–29. But it is rarely easy to establish exactly which effects depend on what. At the same time as the level of air pollution has increased there have also been major changes in the forestry practice.

Many reasons for damage to forests

Although trees are not the most sensitive species in the forest they will be given a little more attention here – after all, their survival is a prerequisite for the existence of the forest.

There are a number of examples of forests suffering severe damage and death around large local sources of emissions of sulphur, fluoride, heavy metals and ammonia, which are undoubtedly caused by air pollutants. However, there have been much fewer such cases in Europe in the last few decades.

When it comes to the relationship between air pollutants and damage to forests elsewhere, the picture is complex. These effects must be seen as the result of interaction between different stress factors. It is not possible to point to air pollution as the only culprit for forest damage, such as the thinning of crowns, that has been observed in Europe in recent decades, with the possible exception of those areas where the burden of air pollution has been extremely high.

In many more cases air pollution may be a contributing factor to forest damage. The following are some of the effects of air pollutants, the importance of which varies from place to place:

Direct plant damage, caused by gases and acids in direct contact with leaves and needles. The greatest impact is probably due to ground-level ozone. The levels over almost the whole of Europe are so high during summer that they can damage trees and other plants.

Soil acidification, which is mainly caused by acid fallout, but to some extent also by the harvesting of biomass by the forestry industry. When soil is acidified certain nutrients are leached out, while others are bound more tightly to the soil. The leaching out of base cations (such as potassium, calcium and magnesium) in particular is feared to lead to a shortage or imbalance in nutrients that could threaten the long-term health of the forest. Recent research indicates, however, that coniferous trees seem to be able to counter the shortage of nutrients through symbiosis with mycorrhizal fungi and bacteria in their root systems. Other effects of soil acidification include a rise in the concentration of metals in the soil water, which can cause root damage and slow down decomposition in the soil.

Excess nitrogen, caused by nitrogen deposition (as nitrate and ammonium). Nitrogen is usually a scarce resource in all ecosystems, and airborne deposition generally leads to increased growth. One disadvantage, however, is that the crowns of trees grow faster than their root systems. Because the same root volume has to supply a greater mass of leaves or needles this is thought to increase the risk of desiccation. With a high supply of nitrogen, trees also become more vulnerable to frost and possibly to attack by parasites.

Changes in the occurrence of mycorrhizal fungi may be harmful for trees. This effect is due primarily to the deposition of nitrogen, and to some extent by soil acidification.

Warmer climate has both benefits and drawbacks for trees in the forest. The effects depend on how much the temperature and rainfall change, as well as how fast this happens. Increasing temperatures means that existing vegetation zones would be pushed strongly northwards. In northern Europe broad-leaf trees may flourish at the expense of coniferous trees. In southern Europe there is a risk that higher temperatures and reduced precipitation could knock out entire ecosystems.

Alpine environments

In the long term there may be major changes in alpine environments, such as the Scandinavian mountains and the mountain ecosystems of central Europe. In Scandinavia the tree line has already moved north, and with a temperature rise of 3–4 degrees the only areas of bare mountain left would be in the most upland regions in the north. Plant and animal life on the remaining mountain heaths would also change. Among the species whose habitats would shrink are the gyr falcon and arctic fox, which are already threatened.

One consequence of warmer climate is that decomposition speeds up, and the availability of nutrients – mainly nitrogen

– increases, at least for a while. Nitrogen is normally scarce in mountain ecosystems and the changing conditions could therefore lead to dramatic changes in vegetation. This would put slow-growing species at a particular disadvantage.

Open countryside

In Europe there are large areas of open countryside that have rich biological variety. A few of these areas are naturally free of trees, including certain wetlands. Most have been created by man and are part of what we call cultivated landscape: meadowland, pastureland, heaths, etc.

What is common to the latter is that they have developed as a result of long-term use, sometimes over thousands of years. Haymaking, grazing and burning have continuously removed nutrients. Over time, diverse ecosystems have developed in response to the scarcity of nutrients, particularly nitrogen. In the case of naturally open land, raised bogs and poor fens also have a mixture of species that are adapted to the relatively acidic, nutrient-poor conditions.

Less intensive management, and subsequent overgrowth, is the biggest threat to meadowland, pastureland and heaths today. Another problem is the use of artificial fertilizer. The nitrogen that this brings mostly favours various tall grasses and plants, which displace a host of other species.

The nitrogen that is deposited from the air acts in the same way as artificial fertilizer on natural, nitrogen-poor ecosystems – although the dosage is smaller and spread over a long period. The nitrogen accumulates in the plants and in the ground, and sooner or later the flora changes, in some cases gradually, but in others suddenly and dramatically.

In those parts of Europe where nitrogen deposition is especially high, e.g. the Netherlands, Denmark and the UK, major changes have been reported in vegetation due to the atmospheric deposition of nitrogen. This has often occurred in combination with a stress factor, such as attack by insects or fungi. Even raised bogs, which are normally very nutrient-poor environments, are significantly affected by the atmospheric fallout.

The boreal forests of the northern hemisphere are among the ecosystems that may shrink markedly as the climate gets warmer.

The airborne attack by nitrogen is a threat to all open, nutrient-poor land, even where we try to protect and preserve it through good management and the creation of reserves.

Ground-level ozone can also change ecosystems and may to some extent counter the effects of nitrogen. Research has in fact shown that species with an “expansive lifestyle” – those that are favoured most by the deposition of nitrogen – are also the most sensitive and suffer the most damage when the concentration of ground-level ozone increases.

Other air pollutants also have a certain influence on biodiversity in open countryside. The levels of sulphur dioxide and probably also nitrogen oxides affect the growth of lichens. Soil acidification and increased levels of carbon dioxide in the air may disturb the existing balance of competition and hence change the distribution of plant species. See also the factfile on the following pages.

SENSITIVE GROUPS OF ORGANISMS

Here are a few examples of the ways that different groups of plants and animals are affected by acidification, deposition of nitrogen and ground-level ozone:

ALGAE are a diverse group of plants. In fresh water there are many single-celled algae as well as several species of stoneworts (charophyta) that are sensitive to acidification and eutrophication. Some types of algae flourish in acidified lakes. On land there are single-celled green algae, which are favoured by nitrogen.

LICHEN AND MOSSES, unlike the higher plants, do not have a waxy layer to protect the cells from outside influences. They also lack roots and therefore take up water and nutrients directly through their cell walls. This makes them sensitive to air pollutants, especially high levels of sulphur dioxide, and to acidification of the substrate (e.g. bark) they live on. A large number of species in Europe have become much less common and in places have disappeared entirely, at least partly due to air pollution. Some lichens are particularly sensitive, such as lungwort (genus Lobaria). In recent years researchers have reported a slow recolonization by lichens, both in cities and rural areas, mainly as a result of falling levels of sulphur dioxide in the air.

FUNGI and HIGHER PLANTS are affected by air pollution in a similar way. Species that tolerate acid soil conditions – including high concentrations of aluminium ions – are spreading, as are species that are favoured by easy access to nitrogen. There is a general decrease in species that require high pH levels and/or a plentiful supply of base cations in the soil, as well as those that cannot compete in nitrogen-rich environments.

For fungi and higher plants the deposition of nitrogen compounds is likely to be a greater threat to diversity than soil acidification. The composition of natural ecosystems is largely determined by the availability of nitrogen in forms that plants can use, which in most cases is a scarce resource. When this is supplied to nitrogen-poor ecosystems it allows a few species to thrive at the expense of others, and entire ecosystems are disrupted.

Fungi that live in co-operation (symbiosis) with higher plants – mycorrhizal fungi – are generally sensitive to the deposition of nitrogen, although there are some exceptions. Mycorrhizal fungi are very important for a whole host of higher plants. Their root filaments act as an extended root system that helps the plant to take up water and nutrients. New research has shown that the hyphae of fungi do not just take up the nutrients that are dissolved in soil water, but are also able to “eat rock”, i.e. they can produce their own acids that break down the minerals in the soil and release base cations.

SENSITIVE GROUPS OF ORGANISMS, continued

In exchange for water and nutrients the fungi get carbohydrates, which the plant manufactures by using sunlight for photosynthesis. Mycorrhizal fungi also provide biological defence for the tree – as long as they are present they can protect the roots from attack by other fungi.

In field trials it has been shown that fertilization with nitrogen has little effect on the quantity of mycorrhiza in the soil, but that the number of species drops sharply, as does the formation of fruiting bodies. We do not yet know how this affects ecosystems.

INVERTEBRATES. A variety of changes are taking place in acidified lakes, see page 20 ff. and figure 2.2. On land many types of molluscs have declined in acidified areas. A range of soil organisms, including earthworms, are also sensitive to reductions in pH.

The increased availability of nitrogen favours those organisms that live and feed on the plants that are thriving. This is the case with the shield bug, a beetle that lives on wild chervil. On the other hand species that depend on plants that are in decline are put at a disadvantage.

FISH. Some species are very sensitive to acidification, others more tolerant. See figure 2.2.

FROGS. Reproduction problems can occur in acidified water, and eggs do not develop if the pH is too low.

BIRDS. Red-throated and black-throated divers, osprey and dippers get their food from water. Their numbers have all been found to decline in acidified areas. Researchers have also reported thinning of the eggshells of certain bird species, probably because they have ingested more aluminium and less calcium as a result of acidification.

MAMMALS. Elevated levels of cadmium have been found in the livers and kidneys of elk, deer and other mammals in areas of Sweden with acidification problems. One reason for this may be soil acidification, which increases the mobility of cadmium and some other metals in the soil. Whether this affects the health and reproductive ability of these animals is not known. The otter is negatively affected by the reduced availability of fish in acidified waterways.

DECOMPOSERS. A variety of worms, microorganisms and fungi play a vital role for the function of ecosystems. They live by breaking down dead plant and animal matter, and by doing so make the nutrients that were originally taken from the soil available again. Decomposition takes longer in an acid environment, partly because earthworms disappear when the pH drops. However there are big gaps in our knowledge of how microorganisms react to the changes in soil chemistry caused by air pollution.

Climate changes are another threat to the biodiversity of open countryside. Despite the expected rise in global precipitation the climate models indicate that conditions in southern Europe will become much warmer and drier – almost desert-like in places. Coastal meadows and wetlands are threatened by the rise in sea level. They may become flooded, and in the worst case disappear entirely, if farmland, settlement or the lay of the land prevent them from migrating inland. Other rare natural environments are similarly threatened if they cannot propagate naturally through the modern cultivated landscape.

MAN AND NATURE

Let us end this chapter where we began, by looking again at the way that nature is constantly changing. Air pollution adds a new factor to the game in which all species are striving to maximize their living space. Some are favoured by it, others disadvantaged. Mankind has always influenced its surroundings in a similar way, through cultivation, forestry and other forms of development.

This should not be seen as an attempt to dismiss the effects that air pollution has on us and the world around us. It has already put great pressure on a host of sensitive species, and many more are at risk. The important conclusion is that mankind's influence on the environment cannot be considered in isolation from the other processes that are constantly at play in nature. What is new and more serious about the situation today is the extent, the intensity and the speed of our influence.