Impacts of Air Pollution & Acid Rain on Wildlife

Introduction

Animals are exposed to air pollutants via three pathways: 1) inhalation of gases or small particles; 2) ingestion of particles suspended in food or water; or 3) absorption of gases through the skin. In general, only soft-bodied invertebrates (e.g. earthworms), or animals with thin, moist skin (e.g. amphibians) are affected by the absorption of pollutants. An individual's response to a pollutant varies greatly and depends on the type of pollutant involved, the duration and time of exposure, and the amount taken up by the animal. The individual's age, sex, health, and reproductive condition also play a role in its response. There is a great deal of variability between animal classes, species, and even genotypes, in terms of the level of tolerance to a particular pollutant. In this section, the pollutants of concern have been divided into three broad categories: gases, such as ozone and hydrogen sulphide; non-acidic particulates and toxins, like metals, fluoride compounds, and organic and synthetic chemicals; and acidifying agents, specifically nitrates and sulphates.

Gaseous Pollutants

Volatile organic compounds and nitrogen oxides, emitted from industrial processes, undergo chemical transformation in the atmosphere in the presence of sunlight to form ozone. Ozone, sulphur dioxide, and nitrogen dioxide primarily affect the respiratory system, and it is likely that birds are even more susceptible to gaseous pollutant injury than mammals due to their higher respiratory rates.

Non-Acidic Particulates and Toxins

There are a number of air pollutants that are categorised as particulates. Heavy metals (e.g. lead, arsenic, and cadmium) are emitted by smelters; fluoride is emitted in both gaseous and particulate form from aluminium reduction plants and coal-fired power plants; and dioxins, furans, and mercury are emitted by resource recovery facilities. Metals may affect the circulatory, respiratory, gastrointestinal, and central nervous systems of animals. Often organs such as the kidney, liver, and brain are targeted. Entire populations can be affected as metal contamination can cause changes in birth, growth, and death rates.

Fluoride poisoning, or fluorosis, causes gross malformations of bones and teeth. Plants take up gaseous fluoride and store it in their tissues, and fluoride in particulate form is deposited on leaf surfaces and stays there until washed off. Herbivores are best known for exhibiting symptoms of fluoride poisoning. However, earthworms and other soil invertebrates also accumulate fluoride, which is, in turn, passed on to the animals that eat them.

Organic and synthetic chemicals, such as dioxins and organochlorines, affect wildlife. Dioxins bioaccumulate, or build up in the body by concentrating in body fat, and they are resistant to biological breakdown. A study of earthworms showed they accumulated dioxin up to five times the concentration found in the soil, although this dose was not lethal to the worms. Nevertheless, this non-lethal accumulation could have strong ecological implications, since earthworms are a major source of food for a number of bird and small mammal species, many of which have exhibited carcinogenic, reproductive, and immunotoxic effects after exposure to low levels of dioxins.

Nitrates and Sulphates

Sulphur dioxide and nitrogen oxides emitted as a result of fossil fuel combustion undergo chemical transformation in the atmosphere, and occur as sulphate,

nitrate, and hydrogen ions when dissolved in precipitation known as "acid rain". Well-buffered soils can adsorb sulphate and neutralise acidity, resulting in soil water and streamwater composition being maintained in a range acceptable to organisms. The adsorption capacity of even well-buffered soils is limited, however, and long-term deposition of acidic compounds depletes the supply of base cations in the soils that buffer these inputs. The build-up of sulphates and nitrates in soils can result in delayed acidification of surface waters once saturation is reached in sensitive watersheds.

The effects of decreasing pH on aquatic invertebrates and fish have been summarised in a National Acid Precipitation Assessment Program (NAPAP) report. Insect taxa differ greatly in their response to acidity, with some species affected at pH levels near 6.0. In the early stages of acidification, acid-sensitive species are replaced by acid-tolerant ones. However, as pH levels continue to drop, more species are lost.

Many studies have demonstrated that surface water acidification can lead to a decline in, and loss of, fish populations. Below pH 4.5 no fish are likely to survive. Fish loss is occurring in many countries, including Scandinavia, Scotland, Wales and North America. A decrease in pH is often associated with an increase in metal availability, being particularly true for aluminium and mercury. Decreased pH and elevated aluminium have been shown to increase fish mortality, decrease fish growth, decrease egg production and embryo survival, and result in physiological impairment of adult fish. In general, embryos, fry, and juveniles are less acid-tolerant than adult fish. Aluminium can precipitate onto fish gills, inhibiting diffusion and resulting in respiratory stress.

Acid deposition is a possible cause of declines in amphibian populations. The larval stages of aquatic amphibian species are most affected by acidic water. Many frog species use temporary ponds, but these tend to be small and shallow, and are easily affected by precipitation chemistry because their only sources of water are rainfall and snowmelt. Frogs that use large, permanent bodies of water for breeding generally lay their eggs in the summer, so they do not experience the acid pulses from snowmelt. However, the eggs and larvae of these species are even more sensitive to subtle changes in pH levels than those of species that breed in the temporary ponds. As is true with fish, the toxic effect of decreased pH levels on amphibians is complicated when concentrations of metals, such as aluminium, in the water increase, but as a general rule, embryos of sensitive amphibian species are killed by water with a pH of 4.5 or lower, while embryos of tolerant species can survive down to a pH of 3.7.

Indirect Effects

In addition to affecting individual animals or populations directly, air pollutants also affect wildlife indirectly by causing changes in the ecosystem. Vegetation affords cover for protection from predators and weather, provides breeding and nesting habitat, and also serves as a food source. Therefore, any change in vegetation could indirectly affect animal populations. Many studies have found that invertebrates show a preference for, or are better able to establish themselves in, air pollution-injured vegetation.

Fluoride and heavy metals can accumulate in the soil to levels that are toxic to soil invertebrates. Species sensitive to metals are replaced by ones that are more metal-tolerant. For example, soft-bodied species such as earthworms and nematodes seem to be more readily affected by elevated metal concentrations. Invertebrates play an important role in forest floor litter decomposition. As forest floor litter builds up, mineral release is delayed, and the availability of nutrients to plants is reduced. Herbivores are ultimately affected when the quantity or quality of their food supply decreases.

Although birds and mammals are not directly affected by water acidification, they are indirectly affected by changes in the quantity and quality of their food resources. Some birds such as the osprey, find difficulty in living around an acid lake because there are far fewer fish to be found. However, the diver finds hunting easier in an acid lake because the water of an acid lake is clearer than that of a normal lake. In Scotland, Otters are quite rare around acidic streams and rivers, as their main food supply, fish, are reduced.

Calcium is an essential element for both mammals and birds. An adequate dietary supply is crucial during reproduction. Birds need calcium for the proper formation

of eggshells and for skeletal growth of hatchlings, and mammals need calcium for skeletal development of foetuses. Many invertebrate species that contain high concentrations of calcium, such as molluscs and crustaceans, are very sensitive to pH levels and are among the first to disappear during the acidification of wetlands.