EarthTrends: Featured Topic

Title:	**Acid Rain: Downpour in Asia?**
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Although there has been major progress in controlling acid-forming emissions in some countries, the global threat from acid rain is far from over. In fact, the dimensions of the acid rain problem are growing rapidly in Asia, with sulfur dioxide (SO_2) emissions expected to as much as triple from 1990 levels by 2010 if current trends continue. Curtailing the already substantial acid rain damage in Asia and avoiding much heavier damage in the future will require investments in pollution control on the order of those made in Europe and North America over the past 20 years (Downing et al. 1997:11, 27, 48, 54).

Even in developed countries where there have been serious efforts to control acid rain, the story is more complicated than it once appeared. Questions remain as to how much damage has been done to forests, lakes, and streams over the years; whether current progress is sufficient to protect the most vulnerable ecosystems; and how soon acid-damaged areas will recover.

Acid rain emerged as a concern in the 1960s with observations of dying lakes and forest damage in northern Europe, the United States, and Canada. It was one of the first environmental issues to demonstrate a large-scale regional scope. The chief pollutants—oxides of sulfur (SO_x) and nitrogen (NO_x) from combustion of fossil fuels—can be carried hundreds of miles by winds before being washed out of the atmosphere in rain, fog, and snow.

As evidence grew of the links between air pollution and environmental damage, legislation to curb emissions was put in place. The 1979 Geneva Convention on Long-Range Transboundary Air Pollution and its subsequent amendments set targets for reductions of sulfur and nitrogen emissions in Europe that have largely been achieved. The 1970 and 1990 Clean Air Acts have led to similar improvements in the United States.

Scientific uncertainties about acid rain persist, however. In the case of forest damage, the contribution of acid rain is hard to isolate from other stresses such as drought, fire, and pests that figure heavily in forest health. In Canada, for example, losses to fires and insects exceed the volume of timber harvested for industrial use (FAO 1997:157). For this reason, the contribution of air pollution to forest damage is a controversial subject, particularly in North America. A recent and authoritative assessment of forest conditions in Europe reports that 25 percent of trees sampled in more than 30 countries were rated as damaged (having lost more than 25 percent of their leaves). Damage has been increasing over the past 20 years and, while the report notes the difficulty of identifying definitive causes, nearly one half of the countries participating in the survey mentioned air pollution as a cause (EC-UN/ECE 1996:23, 42-43).

Acid rain is now emerging as a major problem in the developing world, especially in parts of Asia and the Pacific region where energy use has surged and the use of sulfur-containing coal and oil—the primary sources of acid emissions—is very high. An estimated 34 million metric tons of SO_2 were emitted in the Asia region in 1990, over 40 percent more than in North America (Downing et al. 1997:38; WRI 1996:331). Acid deposition levels were particularly high in areas such as southeast China, northeast India, Thailand, and the Republic of Korea, which are near or downwind from major urban and industrial centers. The effects are already being felt in the agriculture sector. Researchers in India found that wheat growing near a power plant where SO_2 deposition was almost five times greater than the critical load (the amount the soil can safely absorb without harm) suffered a 49-percent reduction in yield compared with wheat growing 22 kilometers away (Pattel 1997:11). In southwestern China, a study in Guizhou and Sichuan provinces revealed that acid rain fell on some two thirds of the agricultural lands, with 16 percent of the crop area sustaining some level of damage. Other ecosystems are also beginning to suffer. A study of pines and oaks in acid rain-affected areas of the Republic of Korea, both rural and urban, showed significant declines in growth rates since 1970 (Downing et al. 1997:6).

Economic expansion and continued reliance on coal as a primary fuel is likely to increase acid rain in Asia in the next two decades (see figure 1). By 2000, SO_2 emissions in Asia will be greater than those of North America and Europe combined, according to recent World Bank projections, and emissions will continue growing rapidly, unless there are substantial investments in pollution control equipment. By 2020, Asian SO_2 emissions could reach 110 million metric tons if no action is taken beyond current levels of control (Downing et al. 1997:1-3, 11).

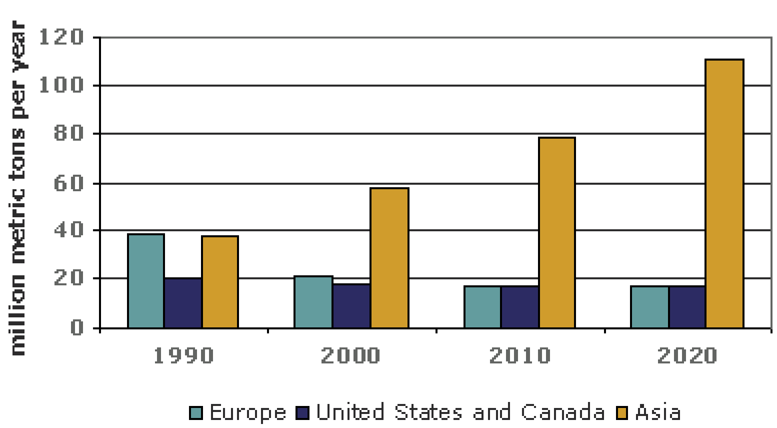
As a result, damage to natural ecosystems and crops is likely to increase dramatically. Large regions of southern and eastern China, northern and central Thailand, and much of the Korean peninsula could experience damaging sulfur deposition levels (Downing et al. 1997:38-39, 54). In some industrialized areas of China, for example, acid deposition levels may some day exceed those experienced in Central Europe's "Black Triangle," a large swath of Poland, the Czech Republic, and southeast Germany where both acid rain levels and forest damage were acute in the 1980s (Downing et al. 1997:3, 39).

Damage could be largely avoided if modern pollution control technologies, such as flue-gas scrubbers, are widely adopted and if low-sulfur fuel is substituted where possible. In fact, the World Bank calculates that use of the best available pollution control technologies could cut acid deposition levels in half from 1990 levels by 2020 in Asia, even though energy use is projected to triple during this period. But the price for this level of environmental protection is steep: roughly US$90 billion per year throughout the Asia region, or about 0.6 percent of the region's gross domestic product (Downing et al. 1997:48, 50).

Less ambitious and lower-cost strategies can also cut acid-forming emissions substantially, but the amount of environmental protection these strategies buy is commensurately less and will not protect many areas from serious acid deposition. In the end, perhaps the most cost-effective option for controlling acid rain will be to adopt energy-efficiency measures that cut overall energy use and thus

SO_2 Emissions in Asia Could Triple

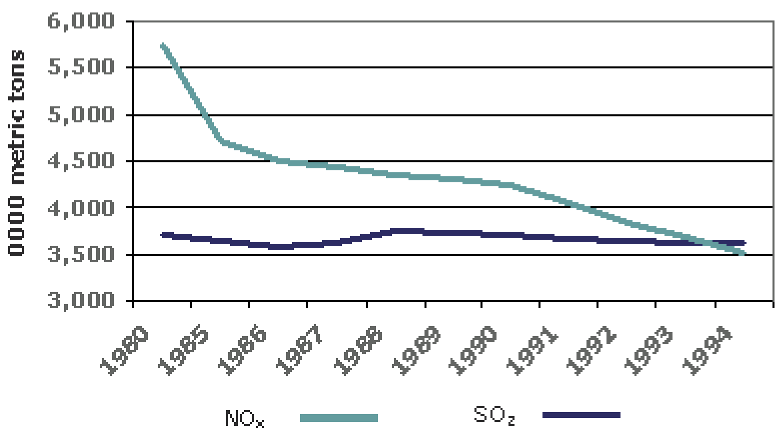
Figure 1: Past and Projected Sulfur Dioxide Emissions for Europe, the United States and Canada, and Asia



Source: Downing et al. 1997.

NO_x Levels Are Still a Problem in North America and Europe

Figure 2: Trends in SO_2 and NO_x Emissions in North America and Europe (OECD Countries Only), 1984-94



Source: OECD 1997; Swedish Secretariat on Acid Rain 1996.

Note: Does not include Australia, Greece, Japan, Mexico, New Zealand, and Turkey due to incomplete data.

reduce emissions. If systematically employed, such energy-saving measures could cut control costs from one quarter to one third, according to the World Bank's analysis. In addition, these measures would yield ancillary benefits such as better air quality and lower greenhouse gas emissions (Downing et al. 1997:38-51).

More To Do in the Developed World

In industrialized countries, environmental regulations restricting sulfur emissions and market forces that favor greater use of natural gas—which contains little sulfur—have proved relatively effective in cutting SO_2 emissions. However, even this success may not be enough in some sensitive areas. A recent Canadian report concluded that SO_2 emissions might have to fall another three quarters if ecosystems in a large area of southeastern Canada were to be adequately protected (Spurgeon 1997:6). In addition, declines in SO_2 emissions are likely to be partially offset in the future by emissions of NO_x, which have remained broadly constant in the OECD countries since 1980. (See Figure 2). In much of Europe, NO_x emissions are now creeping up again, due mainly to increased vehicle numbers and usage (CEC 1996:56).

Overall, however, acid-forming emissions have been largely decoupled from economic growth, and transboundary pollution has fallen substantially in the past 25 years, resulting in less acid rain. It has therefore been somewhat of a mystery why damaged trees, streams, and lakes have not bounced back in those areas where acid rain has diminished.

One possibility is that damage to ecosystems from acid deposition may be more fundamental and long-lasting than was first believed. For example, scientists now report that acid rain leaches as much as 50 percent of the calcium and magnesium from forest soils; these are crucial minerals which buffer or neutralize acids and are essential for plant growth. If soil chemistry is changed dramatically in this way, it may take many decades for all the linked ecosystems to recover (Kaiser 1996:198). A related problem is the continued leaching of heavy metals and other substances that acid rain has mobilized in the soil, providing a persistent source of toxicity to surrounding vegetation and aquatic life.

It is also becoming clear that the long-term impacts of acidification cannot be studied in isolation from other environmental problems. Climate change and acidification have led to decreases in dissolved organic carbon concentrations in North American lakes. Carbon absorbs ultraviolet (UV) radiation, which has, in turn, increased due to depletion of the ozone layer. In combination, these changes have resulted in much deeper penetration of UV radiation into lake waters and higher death and disease rates among fish and aquatic plants (Schindler et al. 1996). This effect can be compounded by drought when sulfur compounds stored in lake sediments oxidize in response to falling water levels (Yan et al. 1996). About 140,000 lakes in North America are estimated to have carbon levels low enough to be at risk of deep UV penetration (Schindler et al. 1996).

These data suggest that the problem of acid rain in developed countries does not end with reduced emission. Although important progress has been made, forest recovery is likely to take decades. Acidification of surface waters in some areas is likely to increase despite falling deposition levels, as ozone depletion continues and the climate continues to warm.

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