The Nanjing Declaration on Management of Reactive Nitrogen

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High levels of reactive nitrogen compounds—nitrates, ammonia, and nitrogen oxides, for example—have become a threat to the environment on many scales. Indications are that the problem will become worse, especially in rapidly developing parts of the world. International agreements are urgently needed to combat the problem. The Third International Nitrogen Conference, which will take place this coming October in Nanjing, China, offers an ideal opportunity to reach agreement on an initial declaration concerning the management of reactive nitrogen. Researchers and officials should make the most of this important occasion.

Although nitrogen makes up about 78 percent of the atmosphere, this pool is almost all in gaseous form, which few organisms can use. Nitrogen gas is converted into usable, reactive forms, however, through both natural and industrial processes. Globally, about 75 percent of the 165 teragrams of reactive nitrogen produced each year is related in some way to agriculture, and the remaining 25 percent results from the combustion of fossil fuels and from industrial uses of nitrogen (Galloway et al. 2003). Reactive nitrogen cascades through different environmental compartments, changing forms as it does so and causing diverse effects.

On the positive side, the greater productivity of agriculture over the past century—driven almost entirely by fertilizers that contain nitrogen—has made it possible to feed growing numbers of humans. Indeed, 40 percent of the world's population would not be alive but for this massive alteration of the natural nitrogen cycle (Smil 2001). Globally, food production uses 110 teragrams of reactive nitrogen every year, most of which is generated when components of natural gas are made to react with atmospheric nitrogen. The manufacture of fertilizer accounts for 5 percent of global natural gas consumption.

On the downside, when released into the atmosphere, reactive forms of nitrogen create smog and aerosols and contribute to global warming and stratospheric ozone depletion. When they fall back to the earth's surface, they contribute to acid rain, which corrodes buildings, harms plants and forests, and acidifies lakes and streams. The excess nitrogen causes eutrophication in aquatic ecosystems, leading to the domination of the plant community by one or a few species—harmful algal blooms are a common consequence—and thus to a reduction of biodiversity. In forests, the combination of acidification and eutrophication is particularly damaging. Acidification decreases the availability of base cations by leaching them from the soil, thus depriving trees of nutrients. Increased nitrogen loads exacerbate the imbalance. Excess reactive nitrogen flows into groundwater reservoirs, rivers, and then the coastal oceans, where it depletes oxygen and so threatens marine life.

The growing requirements for food and energy—especially where there is too little reactive nitrogen, as in Africa—will further fuel the cascade of environmental impacts attributable to reactive nitrogen. Anthropogenic nitrogen exceeds natural levels by a factor of two, but ultimately the source of the nitrogen is unimportant. What is important is the adoption of an integrated approach to combating nitrogen pollution.

International activities

Since 1998, when the First International Nitrogen Conference was organized in the Netherlands (Erisman et al. 1998), researchers and decisionmakers have cooperated in developing integrated approaches to understanding nitrogen-related problems. The Second International Nitrogen Conference, held in 2001 in the United States, further strengthened the scientific findings and saw an exploration of balanced strategies to "increase food and energy production while decreasing environmental impacts" (Cowling et al. 2002). The International Nitrogen Initiative (INI), currently a project of the Scientific Committee on Problems of the Environment and the International Geosphere/Biosphere Programme, was established to continue this work. INI's objectives are to assess the state of knowledge on nitrogen sources, fluxes, and dynamics in ecosystems at regional and global scales and to identify areas where problems have developed or have the potential to develop. The hope is that this will lead to cost-effective, region-specific solutions.

The declaration on the management of reactive nitrogen that my colleagues and I have proposed for consideration at the Nanjing conference aims to allow needed levels of food production and energy use while taking steps that could lead to controls on reactive nitrogen pollution. This will not be simple. If we were to follow the process that was used to create the Framework Convention on Climate Change and its Kyoto Protocol (which deal with carbon dioxide emissions), we could only try to reach agreement on controlling the production of reactive nitrogen from energy use and

agriculture, and it takes years to negotiate international agreements. I feel that we will make better progress if the declaration merely affirms that governments accept the importance of the subject and goes on to formally charge INI with creating scientific and political paths that would lead to measures limiting production of reactive nitrogen.

This phased approach would be similar to that employed successfully in the creation of the Convention on Long-Range Transboundary Air Pollution, which celebrates its 25th anniversary this year. The history of the convention can be traced back to the 1960s, when scientists demonstrated that sulfur emissions in Europe were contributing to the acidification of Scandinavian lakes. The 1972 United Nations Conference on the Human Environment, held in Stockholm, Sweden, signaled the start of international cooperation to combat acidification, and over the next five years several studies confirmed that air pollutants could travel thousands of kilometers before deposition and damage occurred. This implied that international cooperation to limit emissions was needed, and 34 countries had signed the convention by 1979. It has now been ratified by 49 countries, and over the years it has served as a stabilizing factor and as a bridge between different political systems during a period of great change. This product of intergovernmental cooperation has led to reductions of 60 percent in emissions of sulfur dioxide and of 25 percent in emissions of nitrogen oxides. More important, there are indications that terrestrial and aquatic ecosystems have started to recover from the harmful effects of emissions.

The Nanjing declaration

The science of reactive nitrogen in the environment has passed beyond recognition of the seriousness of the problem. Evidence of reactive nitrogen's multiple effects has been presented not only at the two international conferences on the subject but also in many papers published in refereed academic journals. The next phase is to assess the issues in such a way that international cooperation to solve the problems becomes more likely.

The Nanjing declaration should affirm the need for an international protocol to reduce reactive nitrogen to sustainable levels in agricultural systems, estuaries, and ecosystems. This might be achieved by improving utilization of nitrogen in food production, by limiting energy consumption, or by spurring changes in the fuels used as energy carriers. The declaration should also

- Establish a regional center for Asia within INI under the auspices of the United Nations. This part of the world is developing rapidly, and reactive nitrogen is already an important issue. It will become even more important as both population and per capita use of food and energy increase.
- Provide assessments of global and regional problems with reactive nitrogen.
- Establish a framework for international agreements on the management of reactive nitrogen that can be followed up on later.

An international body that would support the future execution of a formal convention on nitrogen should sign the declaration, together with the Chinese government as the initiator. The United Nations and its regional commissions, supported by the United Nations Environment Programme, would be the best option for this role, given the success of earlier conventions. Through such a body, countries all over the world will be able to participate in discussions and, one hopes, come to agreement on a convention on management of reactive nitrogen.

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