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HUMAN ALTERATION OF THE GLOBAL NITROGEN CYCLE: SOURCES AND CONSEQUENCES

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Abstract. Nitrogen is a key element controlling the species composition, diversity, dynamics, and functioning of many terrestrial, freshwater, and marine ecosystems. Many of the original plant species living in these ecosystems are adapted to, and function optimally in, soils and solutions with low levels of available nitrogen. The growth and dynamics of herbivore populations, and ultimately those of their predators, also are affected by N. Agriculture, combustion of fossil fuels, and other human activities have altered the global cycle of N substantially, generally increasing both the availability and the mobility of N over large regions of Earth. The mobility of N means that while most deliberate applications of N occur locally, their influence spreads regionally and even globally. Moreover, many of the mobile forms of N themselves have environmental consequences. Although most nitrogen inputs serve human needs such as agricultural production, their environmental consequences are serious and long term.

Based on our review of available scientific evidence, we are certain that human alterations of the nitrogen cycle have:

1. approximately doubled the rate of nitrogen input into the terrestrial nitrogen cycle, with these rates still increasing;
2. increased concentrations of the potent greenhouse gas N_2O globally, and increased concentrations of other oxides of nitrogen that drive the formation of photochemical smog over large regions of Earth;
3. caused losses of soil nutrients, such as calcium and potassium, that are essential for the long-term maintenance of soil fertility;
4. contributed substantially to the acidification of soils, streams, and lakes in several regions; and
5. greatly increased the transfer of nitrogen through rivers to estuaries and coastal oceans.

In addition, based on our review of available scientific evidence we are confident that human alterations of the nitrogen cycle have:

1. increased the quantity of organic carbon stored within terrestrial ecosystems;
2. accelerated losses of biological diversity, especially losses of plants adapted to efficient use of nitrogen, and losses of the animals and microorganisms that depend on them; and
3. caused changes in the composition and functioning of estuarine and nearshore ecosystems, and contributed to long-term declines in coastal marine fisheries.

Key words: agriculture and the global N cycle; anthropogenic global change; biological diversity and the nitrogen cycle; ecosystem functioning, control by N; eutrophication of estuaries; global N-cycle alteration, scientific consensus on; nitrogen-containing trace gases; nitrogen cycle, global; nitrogen deposition and nitrogen loss; nitrogen and land–water interactions.