ATMOSPHERIC TRACE GASES

Burning trees and bridges

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ON page 552 of this issue[1], Lobert *et al.* identify a new and apparently important component of the biogeochemical cycle of nitrogen — pyrodenitrification, the release of N_2 by biomass burning. This process may constitute an increasingly important mechanism for returning biologically fixed nitrogen to the atmosphere, in the form of N_2 and nitrogen-containing trace gases.

Mark Edwards/Still Pictures

Burning the Brazilian rainforest — upsetting the global balance of the nitrogen cycle?

In their laboratory studies, Lobert *et al.* have determined the proportions of nitrogen-containing gases produced relative to the nitrogen content of the pyrolysed biomass fuel: nitrogen oxides (NO and NO_2, denoted as NO_x) account for 12 per cent, ammonia for about 4 per cent, hydrogen cyanide about 2.3 per cent and acetonitrile (CH_3CN) about 1 per cent. Very minor contributions were found from other nitrogen-containing compounds. But this adds up to only about 20 per cent of the original nitrogen content of the fuel. The authors assume that another 20 per cent is contained in organic nitrogen compounds (a very generous estimate), which were not measured in the experiment. This leaves more than half of the nitrogen in the fuel unaccounted for.

Lobert *et al.* suggest that the missing nitrogen is released in the form of N_2. Thus they estimate that production and release of N_2 through global biomass burning could represent an annual loss from the biosphere (to the atmosphere) of $12–28 \times 10^9$ kg (12–28 Tg) of nitrogen as a result of tropical burning. This is equivalent to about 9–20 per cent of the estimated global terrestrial natural nitrogen fixation rate (about 139 Tg yr^{-1}). Nitrogen fixation — the chemical transformation of N_2 into other nitrogen compounds such as NH_3 and NO — can be carried out by a number of microorganisms, either free-living or in association with certain plants. Industrial processes may fix about 45 Tg yr^{-1} (ref. 2), mainly via the Haber process (in which a mixture of N_2 and H_2 is combined to form ammonia). Most industrially fixed nitrogen goes towards the production of fertilizer (in the form of ammonium nitrate). A small amount of nitrogen (less than 10 Tg yr^{-1}) is fixed into NO by the action of atmospheric lightning[3]. But the bulk of atmospheric nitrogen is fixed by biological processes, and this fixation is believed to be balanced by microbial denitrification, a process in which certain bacteria reduce nitrate to N_2, N_2O or NO, with N_2 being the main gaseous product[2]. Microbial denitrification has been thought to be the only significant denitrification process; but now Lobert *et al.* are suggesting that pyrodenitrification must also be considered.

Global biomass burning includes the burning of forests (tropical, temperate and boreal; see figure) for clearing of savanna grasslands, agricultural waste and stubble, and of wood for fuel. Paul Crutzen first identified biomass burning as a significant global source of trace atmospheric gases more than a decade ago[4], and a conference was held recently* to assess and quantify its role and importance as a global source of radiatively active gases (CO_2, CH_4 and N_2O) and chemically active gases (for example CO, NO_x, non-methane hydrocarbons and H_2). M.O. Andreae (Max-Planck-Institut für Chemie, Mainz) estimated that about 8,700 Tg of dry biomass matter are burned each year, releasing 3,940 Tg of carbon to the atmosphere, mostly in the form of CO_2 (3,500 Tg C yr^{-1}) and CO (350 Tg C yr^{-1}). Biomass burning may account for as much as 40 per cent of the total global annual production of CO_2, estimated at 8,700 Tg C yr^{-1} (fossil-fuel combustion producing the remaining 60 per cent) and 32 per cent of the total global annual production of CO, estimated at 1,100 Tg C yr^{-1}. The CO, non-methane hydrocarbons and NO_x produced by biomass burning lead to the photochemical production of 420 Tg of tropospheric ozone (38 per cent of the total global annual production).

Most burning of biomass is the result of human activity, and on a global scale it is increasing. R. A. Houghton (Woods Hole Research Center, Massachusetts) suggested that emissions from biomass burning may have increased by about 50 per cent since 1850. Tropospheric concentrations of CO_2, CO, CH_4, non-methane hydrocarbons and ozone are all increasing with time; global biomass burning may make an important contribution to this increase and thus to potential global climate change.

The nitrogen cycle also can have important climatic effects. Nitrous oxide put into the atmosphere by biomass burning, is a greenhouse gas 250 times more powerful (molecule for molecule) than carbon dioxide. Nitric oxide, as well as being a photochemical precursor of ozone, a major pollutant in the troposphere, produces nitric acid, the fastest-growing component of acid rain. Hence, the new bridge in the nitrogen cycle identified by Lobert *et al.* is of more than mere technical interest. □

* *Global Biomass Burning: Atmospheric Climate and Biospheric Implications*, Williamsburg, Virginia, 19–23 March 1990.

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