PERGAMON

Soil Biology and Biochemistry 31 (1999) 1599–1601

Soil Biology & Biochemistry

www.elsevier.com/locate/soilbio

CWT support

Book Review

***Major Biological Issues Resulting from Anthropogenic Disturbance of the Nitrogen Cycle*; T.A. Mansfield, K.T.W. Goulding, and L.J. Sheppard, Eds. 1998. Cambridge University Press, and New Phytologist 139. 234 pp.**

Nitrogen and its fluxes in the biosphere and associated spheres on earth (atmosphere, hydrosphere, lithosphere, and pedosphere) is proving to be one of the most interesting and problematic of the vital elements necessary for the existence of life. On 3–5 September 1997, the third New Phytologist symposium was held at Lancaster University, to address the anthropogenic aspects of N enrichment: acidification, climate change, eutrophication, and ozone destruction. Because of the intimate association of nitrogen gases with ozone depletion, the symposium included that aspect of the oxygen cycle as well.

The field within this rubric has grown mightily over the last two decades. With such a plethora of activity, is another review volume necessary? Recent publications (Vitousek, 1994; Galloway et al., 1995; Vitousek et al., 1997) have indicated the nature and extent of the problem at regional and global scales. Would a series of papers, several of which approach anthropogenic aspects of N cycling at the level of individual plants, in growth chambers and in field plots, be adequate to address the magnitude of the problem? Fortunately, the editors and session chairs have provided considerable direction in this regard, building from the "ground up", as it were, always keeping the larger picture in mind. There are synthesis comments at the end of each session, which focus and encapsulate the principal concerns of the participants. At the end, an insightful summarization by Howard Thomas sets the entire meeting in context in a most concise fashion.

The volume is presented in seven subsections, as follows: (1) Atmospheric nitrogenous compounds and ozone—is NO_x fixation by plants a possible solution? and NO_x pollution, ozone formation and deposition processes; (2) Ammonia: production, dispersion and deposition, followed by N deposition and its contribution to N cycling and associated soil processes. Session 3 includes Impacts of N deposition on plant functioning, and consequences of high loads of N for spruce and beech forests. Session 4 addresses Ozone effects on forest trees of eastern North America, and effects of ozone on forest trees in Europe; Session 5 considers impacts of nitrogen deposition on upland plant communities, impacts of ozone on native herbaceous plants, and regulation of plant nitrate assimilation; session 6 covers ectomycorrhiza and nitrogen deposition, and N deposition: a component of global change analyses, and finally, Session 7, the past, present and future of nitrogenous compounds in the atmosphere and their interactions with plants.

Viewed from the perspective of a soil scientist/soil ecologist, the volume has much to offer. The following are some comments on a representative subset of papers in the entire volume. Beginning with plant and atmosphere interactions, Wellburn addresses the question of specific plants capable of fixing NO_x being selected for a range of species and genotypes, which might reduce tropospheric concentrations of NO_x significantly and decrease the potential for ozone production. Fowler et al. report on rates of removal of NO and NO_2 by dry deposition, and note that usage of modeled stomatal fluxes rather than exposure might give more reliable estimates of yield loss due to ozone exposure. They suggest that relative grain yield reduction can be estimated as 38 times the stomatal ozone flux above the threshold, summed over the growing season. The interactions of nitrogen oxides and ozone is clearly a very active area of investigation.

Asman et al. extend the discussion to ammonia, noting that global emissions amount to about 54 Megatonnes/y, with about 60% estimated to come from anthropogenic sources. These emission rates are similar to those of NO_x–N, and can come from dry or wet deposition. Dealing with adverse effects will require regional planning to lower the emissions, and also by removing sources close to the ecosystem to be protected. Goulding et al. extend the N cycle to associated soil processes, noting that various trials at the Rothamsted Experimental Station have shown significant changes in deposition rates, and more importantly, decreases in numbers of species in the Park Grass hay meadow, over more than 150 years of long-term monitoring. This has resulted from the acidifica-

PII: S0038-0717(99)00066-8

tion due to increased amounts of nitric acid, ammonia, and ammonium present. The increased deposition rates have risen from 1 and 3 kg N ha^{-1} y^{-1} for nitrate and ammonium N in precipitation, respectively, in 1853, to a maximum of 8 and 10 kg in 1980, decreasing to 4 and 5 hg N ha^{-1} y^{-1} today. Considering ecosystem-level repercussions, the reduction of methane oxidation rates of 15% in arable land, and 30% in woodland, are probably of equal significance to the current N saturation of local woodland ecosystems. Goulding et al. note that, using ^{15}N pool dilution techniques, ratios of gross nitrification: gross immobilization might prove useful indices of N saturation. In the ensuing discussion, Dr Goulding notes that there have been no studies, to date, on specific effects of N deposition on rhizosphere microorganisms; this should be an active area of inquiry over the next several years.

The next session addresses the effects of N oxides deposition on enzymatic pathways, in whole plants, either in maize and other crop plants (Stulen et al.), and also in spruce and beech forests (Rennenberg et al.). The latter note that high loads of N to spruce and beech forests can result in a total inhibition of nitrate uptake by the tree roots. This seems to be due to the accumulation of organic amino compounds in roots originating from phloem transport from shoots to roots. These mechanisms prevent luxury uptake of nitrate by the roots, but that leaves more N available for leaching into the groundwater. One wonders if the soil microbial populations are correspondingly N-saturated, under these conditions. In the Hoeglwald experimental site, >20% of the N input from throughfall into the spruce and beech plots is re-emitted as NO and N_2O. The NO to N_2O ratio is highly dependent on the tree species, with preferences for NO in spruce and for N_2O in beech. Leaching of nitrate into the ground water is high in the spruce, but minute in the beech plot. However, this positive effect of beech on ground water quality is achieved at the expense of an enhanced release of radiatively active N gases into the troposphere.

Chappelka and Samuelson consider ambient ozone effects on forest trees in the eastern USA, noting that decreases in above-ground growth at these ambient levels are in the range of 1–10% per year. In contrast, Skaerby et al., reviewing European forest responses to ozone, conclude that, despite decreased chlorophyll contents and photosynthetic rates, and reductions in biomass, particularly in fast-growing species, the link with forest damage has not been unequivocally proved. Both authors note the very strong need for scaling-up from small plot studies to entire basins and regions.

In a long-term study of experimental application of N compounds to mimic deposition rates, Lee and Caporn studied *Calluna* heathland and acidic and calcareous grasslands for nearly one decade. They followed changes in plant cover, and also microbial utilization of substrates, using the BIOLOG assay method. They found some expected enhancement of plant growth in low-N systems, and, more importantly, some stimulation of amino acids and phosphomonoesters at 8 and 12 $g.m^{-2}.y^{-1}$, but lower rate of utilization of these substrates in the acidic grassland soils at the highest rates of N addition. This is one of the first long-term studies of detailed changes in microbially-mediated processes in natural systems. Bobbink gives a useful synthesis on impacts of airborne nitrogen inputs on semi-natural and natural vegetation in wetlands, species-rich grasslands, heathlands and forest understorey. These are related to key phenomena, namely: eutrophication, acidification and secondary stress, listing indicators of these processes.

One of the more in-depth reviews is provided by Wallenda and Kottke, on impacts of N deposition on ectomycorrhizas (ECM), with well-referenced tabular data. They note that, in numerous culture experiments, many have used easily cultured ECM species, which are adapted to higher N concentrations. Few effects have been seen in the ECM symbiosis, but effects on the ECM mycelium, the principal fungal component in terms of nutrient uptake, are little-known, and deserving of further study. As with other forest tree studies cited earlier, the physiological effects of N deposition on carbon allocation in ECM might be useful early indicators of increasing N inputs on the ECM symbiosis.

The penultimate portion of the volume has two major syntheses by Norby, on Nitrogen deposition as a component of global change analyses, and Raven and Yin, on the past, present and future of nitrogenous compounds in the atmosphere, and their interactions with plants. Norby emphasizes the interactions between N deposition and increasing carbon dioxide concentrations being altered considerably by additional factors, such as N saturation of ecosystems, changes in community composition, and climate change. He reviews results from experiments and contrasts them with results from ecosystem models. Considering the longer-term impacts of carbon by nitrogen interactions, he cites recent work by Gifford, concluding that N supply controls C cycling on a seasonal time-scale, but C controls N acquisition by an ecosystem over the long term. Raven and Yin take a long-term geochemical perspective, extending back to the Archaean, over 3.5 Gyr ago, then coming forward to evolution of a land flora 450 Myr ago, and subsequent impacts of major bolide impacts, e.g., at the Cretaceous–Tertiary boundary, which generated large amounts of nitrogen pollutants in the atmosphere. Notwithstanding these acute impacts, the apparently sustained chronic atmospheric dosages of the biosphere in this century by elevated N and ozone levels are certainly causes for concern.

The volume ends with comments by Howard Thomas, on C skeletons, and NH_x, signals, noting that either metabolism modulates signalling by regulating the stoichiometry of stimulus and receptors, or else entry into metabolic transactions is itself a signalling act; then resources, and injuries, considered within an environmental context. Dogmas are being broken, ranging from how plants respond to NH_x, how ozone acts in cells, effects of visible symptoms related to growth effects, and finally, a plea for more consideration of wild plants, expanding out from a few well-studied species of crop plants. In all cases, much remains to be learned, and the reader of this well-edited and summarised volume will be the richer for carefully reading and studying it.

David C. Coleman
Institute of Ecology, Ecology Annex, University of Georgia, Athens, GA 30602-2360, USA