

IMAGE UNAVAILABLE FOR COPYRIGHT REASONS

White spruce country in British Columbia, Canada. Here, however, aspen have outcompeted replanted conifers after clear-cutting. Kronzucker and colleagues' explanation¹ for this phenomenon is the conifers' comparative inability to use nitrate, as opposed to ammonium, as a nitrogen source.

these organisms, contributes to DOM and DON, reinitiating the cycle and leading to the same patterns of relative supply rate of different forms of soluble nitrogen. So even though the concentration of DON is quite low in most terrestrial ecosystems, its supply rate always exceeds that of NH_4^+ and NO_3^- , if nitrogen dynamics are dominated by internal recycling of nitrogen. This, of course, is not always the case — there can, for instance, be substantial inflow of inorganic nitrogen into rivers, and some terrestrial ecosystems are subject to large amounts of anthropogenically generated NH_4^+ and NO_3^- .

Preferential consumption of one form of nitrogen by a species modifies the balance of forms available to other species. For example, in ecosystems in which microbial growth and activity are carbon-limited, microbes use DON as a source of both carbon and nitrogen. They then excrete excess NH_4^+ , so that the supply rate of NH_4^+ approaches that of DON. This NH_4^+ is used by plants or nitrifiers, reducing its availability to either group more than would be expected from study of a single group in isolation. So knowledge of both relative supply rate and preferential consumption of specific nitrogen forms by individual species is essential to define the relative availability of different nitrogen forms to other species.

Other factors to consider are plant roots, mycorrhizae and the soil medium itself. Roots hold an energetic purse string that can shift competitive balances for different forms of nitrogen; so, with their more predictable energy supply, plants may be better able to reduce and assimilate nitrate than microbes, although not invariably so^{1,2,10}. Mycorrhizae involve a direct carbon transfer from the plant to its fungal symbiont, often allowing plants access to organically bound nitrogen that is not directly available to roots³. Root exudation and turnover also supply carbon to microbes in the rhizosphere, the soil environment influenced by individual roots, altering both production and consumption

J. G. Worrall
of NH_4^+ and NO_3^- through changes in nitrogen mineralization and immobilization, and protozoan grazing of microbes.

Finally, the heterogeneity of the soil medium strongly influences the interactions among organisms and, consequently, net ecosystem fluxes. Most rhizosphere soils have higher rates of nitrogen transformations and show different net fluxes from bulk soils. At a smaller scale, microsite heterogeneity in carbon and nitrogen supply influences the balance between immobilization and

production by different plant and microbial groups^{2,6}, and therefore the forms of nitrogen available to individual organisms. Ion mobility influences the spatial extent of localized hot spots and depletion zones, with anions such as NO_3^- diffusing more rapidly than NH_4^+ along concentration gradients. At the scale of individual cells, species preference can reflect kinetics of influx and efflux¹, or proximity to sites of production (an example is the absorption of DON by decomposer and mycorrhizal fungi following exoenzymatic breakdown of dead organic matter).

As must now be evident, the challenges in understanding the terrestrial nitrogen cycle remain considerable. For example, as commonly measured, microbial biomass lumps together quite distinct groups — decomposer microbes that can compete with plants for nitrogen, mycorrhizal fungi that funnel nitrogen to plants, nitrifiers that use the product of nitrogen mineralization as their own energy source, and soil microfauna which graze on roots and microbes. The new studies^{1,2} are important in showing that different organisms have radically different capacities to process various forms of nitrogen and carbon. The next step — no easy one — will be to put all of these actors together on the same stage. □

Valerie T. Eviner and F. Stuart Chapin III are in the Department of Integrative Biology, University of California at Berkeley, Berkeley, California 94720-3140, USA.

1. Kronzucker, H. J., Siddiqi, M. Y. & Glass, A. D. M. *Nature* **385**, 59–61 (1997).
2. Stark, J. M. & Hart, S. C. *Nature* **385**, 61–64 (1997).
3. Vitousek, P. M. et al. *Ecol. Monogr.* **52**, 155–177 (1982).
4. Laanbroek, H. J. & Woldendorp, J. W. *Adv. Microb. Ecol.* **14**, 275–304 (1995).
5. Read, D. J. *Experientia* **47**, 376–391 (1991).
6. Norton, J. M. & Firestone, M. K. *Soil Biol. Biochem.* **28**, 351–362 (1996).
7. Recous, S., Mary, B. & Faurie, G. *Soil Biol. Biochem.* **22**, 913–922 (1990).
8. Chapin, F. S. III, Moilanen, L. & Kielland, K. *Nature* **361**, 150–153 (1993).
9. Kielland, K. *Ecology* **75**, 2373–2383 (1994).
10. Davidson, E. A., Stark, J. M. & Firestone, M. K. *Ecology* **71**, 1968–1975 (1990).

Beam alignment

NYLON, polyester and a few other polymers can be orientated. Stretch a sample to a few times its original length, and its long-chain molecules all line up in the stretching direction. The resulting fibre or film has remarkable strength and tenacity in that direction — making it ideal for cord, tape, textiles, packaging, and similar duties. Daedalus now has a scheme to orientate a whole new set of polymers.

Most commercial polymers, of course, are made by coupling small monomer molecules together, either catalytically or by irradiation. Imagine, says Daedalus, a single energetic quantum or particle traversing a monomeric fluid. As in a cloud-chamber, it will leave a trail of free radicals or ionized molecular fragments. Polymeric chains will grow out from these sites in random directions. But if the trail is dense enough, and chain growth is terminated efficiently enough, the chains will just about manage to link up with each other before being quenched. The result will be a single, long, polymeric molecule, with a number of short side-chains, extending along the track of the initiating particle.

A dense enough particle beam should therefore convert the whole specimen into a perfectly aligned parallel-chain polymer. Both the length and direction of the orientated molecules would be determined by the beam characteristics.

A nuclear reactor or synchrotron seems the best source of collimated protons or X-rays; but with luck a laser system will be almost as effective. A whole new range of orientated plastics will result — tough, fibrous solids with a wood-like grain running through them. Even such intractable thermosetting polymers as Bakelite and alkyd resin will show a new, more flexible side to their natures. Like wood, these new structural materials could be broken down by pulping, and made into novel papers, fibres and textiles.

Furthermore, a second irradiation at right angles to the first could crosslink their parallel chains into molecular sheets. Like molecular chains, these would probably crumple and interleave in the melt or in solution, giving a quite new sort of polymeric solid, neither glass, rubber nor monolith. And if the two irradiations were conducted together, they might weave a sort of molecular cloth, with two sets of parallel fibres interdigitated at right angles. As with cloth cut on the bias, you could stretch this cunning product one way, when it would shrink in the other. So a sample cut too short could still be stretched to fit. Clumsy engineers everywhere would rejoice.

David Jones