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Overview

Terrestrial nutrient cycles

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Are the cycles of major nutrients in all forests different or are they so similar that no significant differences occur, within our ability to measure? Or, is the manner in which nutrients move through different ecosystems (forests, grasslands, shrublands, deserts etc.) markedly different but the overall effect similar?

Ecosystem production of aboveground organic matter is widely different, even within similar climates. As one moves from polar to tropical climates, aboveground biomass production is known to generally increase, along with rainfall and temperature. However, if one compares production within climate or vegetation type versus that across a range of climates or vegetation, differences in aboveground ecosystem production are not so great nor so easy to explain. In the case of a dry tropical savanna or forest compared with semiarid savannas or forests, aboveground biomass production is not so different. The manner in which biomass production is calculated in different systems is also important. If both above- and belowground plant, microbial and faunal production were assessed, it is possible that total ecosystem production in boreal and tropical forests, boreal and tropical grasslands (tundra versus savanna), shrublands, deserts and so forth, would be more similar than they appear to be given current estimates. The real differences probably lie in the allocation of elements to different parts of an ecosystem, the subsequent movement of the elements through the system and the pattern, timing and method of nutrient loss and gain in each system.

Biotic factors that affect nutrient cycles, such as net primary production, root production, microbial biomass and turnover, and soil fauna grazing, have been quantified in some ecosystems and the influences and interactions that these factors have in nutrient cycling identified. However, we do not understand how biotic factors and interactions change with climate and vegetation and thus integration of these factors with abiotic models has been limited. These types of considerations have been answered largely in the past by attempting to find a simple, one factor answer by invoking Liebig's Law of the Minimum. Thus, the split into research on N, P, or S cycling or micronutrients, etc.

More recently, we have realized that each cycle does not work independently but that many elements, more than just C, N, P and S, control processes in other cycles. In particular ecosystems, certain controls are easy to determine and elucidate but seem unimportant in other systems. The SCOPE conference in 1984 detailed the elemental cycles on global scales with some attention paid to the fact that flow rates were notably different in different parts of the globe. The problem is to integrate processes occurring in the rhizosphere with global carbon fluxes. The "level of resolution" conference in the Fall of 1985 (IGBP, SCOPE, St. Petersburg, FL) dealt at length with this problem. Atmospheric scientists deal with processes over areas thousands of km^2 while microbial processes occur at and vary significantly over the micrometer level. Where do these areas of research integrate? One possible way to integrate global and microsite processes is to compartmentalize the globe into smaller units and generalize the microsite processes over broader areas. These areas could meet at the ecosystem (landscape) level.

Purpose of the CNSP workshop

This workshop had the basic underlying question: Could a model of nutrient element cycles, soil chemistry, physics, soil structure, microbial and faunal processes in soil be developed for each ecosystem? Is there enough similarity between ecosystems in various continents, such as mesic deciduous forests in Canada and Australia, or between savannas in West Africa, Argentina and the American West that nutrient cycles and interactions in these systems could be combined? As one goes from tundra, to shortgrass to tallgrass to tropical monsoon grasslands, is there a discernible trend in nutrient flows, as well as in abiotic factors?

Specific details, both dissimilarities and similarities among each type of system, are desired. Therefore, the workshop gathered workers from around the world and included specialists in native grasslands, agricultural systems, and forest ecosystems. The resulting papers all stress the interactions between two or more element cycles either within a specific ecosystem type or among ecosystems. The following are some of the themes arising from these papers:

1. Element interactions within forests differ from those in other terrestrial ecosystems because of the greater allocation of carbon to structural material and the greater storage of elements in biomass.
2. The turnover of organic matter in soils is controlled mainly by water

availability and temperature but is modified by a variety of other biotic and abiotic factors.
3. Parent material and soil development both strongly influence element cycles and their interactions.
4. Clay mineralogy and charge status is of major importance in governing nutrient availability and organic matter quality.
5. There are arrays of C:N and C:P ratios in major soil groups in temperate and tropical regions which lead to expectations about major nutrient cycling processes.
6. Positive feedback as well as negative feedback processes play important roles in several terrestrial ecosystems.
7. Fine root and mycorrhizal turnover is important but seldom calculable under field conditions; this seems to be a useful area for interfacing models and experimentation.
8. Inter-seasonal dynamics of both organisms and organic matter quality can play a key role in subsequent nutrient dynamics.
9. Most existing models of element interactions in terrestrial ecosystems consider either the organic transformation and fluxes or the adsorptive and hydrologic fluxes, but not both.

In summary, we suggest that basic nutrient cycles may indeed be similar over all climates and vegetation types with the understanding that a control of the path through which nutrients move or energy does or does not flow depends on nutrient limitations, the complete food web present, and abiotic factors. We hope the reader enjoys the papers as much as the attendees did participating.