LINX II PROJECT SUMMARY (to begin fall 2001)

Human activities are flooding the biosphere with fixed nitrogen (N), changing the biogeochemistry of both terrestrial and aquatic environments by adding biologically available N, primarily from fossil fuel combustion, agricultural fertilizer application and legume cultivation. The fate of much of the anthropogenic N load to the biosphere is uncertain because mass balance studies of major watersheds show that most of the added N is not exported to the oceans but is missing, having disappeared from our accounting somewhere within these watersheds. Despite this, the added N that we can account for produces a N loading to estuaries and coastal oceans that has resulted in increasingly severe eutrophication problems.

Among the several possible fates of the missing N are uptake and denitrification in streams and rivers. Most of the inorganic N entering and transported by streams and rivers is in the form of nitrate. Traditionally, nitrate has been thought to flow freely downstream to lakes and coastal ecosystems once it enters streams. Recently, however, this view has been challenged. Mass balance analyses for the Mississippi River drainage have shown that large quantities of total N and nitrate are lost as water travels through its tributary streams and rivers. This conclusion is consistent with results from our recently completed inter-site ^{15}N-tracer study of ammonium dynamics in streams (LINX). The LINX study demonstrated experimentally that smaller streams are most retentive of ammonium, with shortest ammonium uptake distances (i.e., greatest retention efficiencies) in the smallest streams and uptake distances increasing logarithmically with stream discharge and depth.

We propose an intensive, inter-site study of the fate of nitrate in streams. Our research will evaluate whether streams are indeed important sites of N retention in the landscape and, more importantly, how human disturbances affect that retention. We will use field ^{15}N-tracer experiments to determine the rates and factors controlling nitrate uptake and retention in relatively pristine streams and in streams that have been altered by agriculture or urban development and have elevated nitrate levels. These experiments and associated measurements will allow us to test a variety of hypotheses dealing with the impacts of human disturbances on streams, including effects on channel morphology, hydraulics, biological activity, and N retention. At each of eight sites distributed across diverse biomes throughout the U.S., we will perform tracer-level ^{15}N-nitrate addition experiments to trace the fate of nitrate in nine streams: 3 reference, 3 agricultural and 3 urban streams (for a total of 72 streams across all sites). Each experiment will consist of a 24-h addition of ^{15}N-nitrate and longitudinally distributed measurements of ^{15}N in water and in various benthic organic matter pools to determine *in-situ* rates of nitrification, assimilatory uptake of nitrate, and denitrification in each stream. We will use our experimental results to develop a general, process-based model of nitrate retention in stream reaches. We then will extend our results to much larger spatial scales by combining our stream model with GIS-based information on hydrography and land use to predict nitrate retention in 5th or 6th order river basins at each of the eight study sites. We will test these predictions with synoptic field measurements of stream nitrate concentrations within each basin. The validated river basin model will be an important land-use planning and management tool for controlling the N loading of lakes and coastal ecosystems.

Our proposed research integrates across a large range of spatial scales, from the micro-scale (microelectrode surveys for anoxia, microbial denitrification enzyme assays) to stream reaches (assimilatory uptake and denitrification rates) to landscapes of diverse biomes (nitrate retention throughout the fluvial systems of 5th or 6th order river basins, impacts of land use). Our research also will integrate experimental results using a relatively new technique (^{15}N tracer additions) with modeling at the stream reach and landscape scales. Our work will have broader implications to society by explicitly evaluating the effects of human disturbance on N retention in stream networks, contributing the new knowledge needed for a more sustainable management of watersheds. The many graduate students and postdoctoral fellows funded by the project will gain valuable training and perspective on how large, interdisciplinary team research projects involving multiple sites and institutions are conducted and managed.