Report for 2003ME21B: The functional role of forested seeps in maintaining hydrology, water quality and biological diversity in a New England watershed

There are no reported publications resulting from this project.

Report Follows

The functional role of forested seeps in maintaining hydrology, water quality and biological diversity in a New England watershed.

Progress Report:

Problem and Research Objectives:

Integrated biogeochemical and hydrologic studies assessing the role of nutrient dynamics in forested catchments are needed to quantify seep landscape function (Cirmo and McDonnell 1997). Seeps are known to be hotspots for rare flora (and possibly fauna), thus reflecting unique edaphic and hydrologic habitat features. Recent research suggests that springs are an important source for nitrogen loading to streams within the Catskill Mountains of New York (Burns et al. 1998, West et al. 2001). However, the slow or lentic water flow in seeps, as compared to springs, may favor denitrification and N loss to the atmosphere. If denitrification is important in these systems, this would influence water quality and nutrient dynamics in streams that receive seep drainage or recharge. Because seeps and springs may integrate the water quality across large areas within a basin, they may provide a simple and inexpensive way to monitor the overall impacts of human activities and natural processes within a watershed (Manga 2001).

The central Maine landscape affords us an opportunity to evaluate baseline hydrologic, biochemical, and ecological functions of hillside seeps in an environment less influenced by anthropogenic influences. Given this, baseline indices of biological or hydrologic integrity may be developed. We propose to study the biogeochemical, hydrologic, and biological processes of forested hillside seeps and to directly address landscape scale functions.

The objectives of this research are:

1) To establish the extent to which seeps sustain low flow conditions in associated streams and the extent to which seeps buffer stream geochemistry.

2) To determine if saturated aerobic soils reflect nitrogen transformations similar to wetland systems and are in fact distinct from associated upland nitrogen cycling.

3) To augment existing forested seepage community data and to assess floral assemblages in seeps and surrounding uplands.

4) To document seasonal habitat preferences by amphibians in headwater catchments containing seeps.

Methodology:

Research will be conducted at two spatial scales. A primary research catchment has been chosen in northwest Hancock County for intensive sampling of three seeps. Additional seeps (thirty) will be chosen within the same physiographic region to assess regional variability.

Hydrological assessment of seeps will be conducted throughout the growing season by bi-monthly groundwater and surface water flow measurements and seasonal collection of groundwater and surface water samples. Groundwater flow and chemistry will be ascertained by installation of at least five groundwater well clusters (17 total) at each of three intensively monitored seepage wetlands. Individual well clusters will be spaced at depth increments of 0.5 to 1.5 m, to establish vertical hydraulic and chemical gradients. Seep surface flow will be measured using V-notch weirs installed at a point where seep surface flow is constrained and channelized.

Discharge through stream channels will be measured at several locations upstream and downstream of the seep to assess the impact of the seep on stream discharge and determine if the stream is gaining or loosing water to the groundwater system. Discharge measurements will be compared to stream stage and an empirical relationship will be developed between stage and discharge for the streams. The hydraulic conductivity of the geologic materials will be determined by measuring the recovery rates in a well after a volume of water is removed from the well. The porosity of sediment samples will be estimated by weight proportion of the split spoon sample when wet and dry, and assuming the volume of water lost is equal to the porosity. Discharge rates and groundwater velocities will be calculated with Darcy's Law using hydraulic head and hydraulic conductivity data.

Water samples will be collected from the surface-water and groundwater monitoring stations three times during the growing season. All water samples will be lab filtered (0.45 micron) and analyzed at the University of Maine's Environmental Chemistry Laboratory (ECL) for major anions (NO_3, SO_4 and Cl) and cations (Ca, Mg, Na, K, Fe, Mn). Nutrient samples will be analyzed at the ECL for inorganic N (NO_2 /NO_3 and NH_4^+), total nitrogen (TDN) and reactive phosphorus. Probes will be used to measure pH, dissolved oxygen, water temperature, and specific conductance bi-monthly in the field. Alkalinity will be measured in the laboratory using standard titration techniques. Collection of this data set will allow data quality to then be assessed through charge-balance calculations.

Evaluation of selective nitrogen uptake and cycling will be completed through concurrent, seasonal collection of: throughfall (19 funnel collectors), soils (18 soil sample locations), vegetation (3 dominant species at each site), and water (17 – groundwater well clusters, 6 – surface water points). The isotopic signature of N forms will be determined in each of the four pools by using solid state Isotope Ratio Mass Spectroscopy (IRMS). This data will also be used to assess the redox conditions within the seeps.

Soils will be classified and described at each of the seep study sites. Near each well cluster, soil profile descriptions, and an analysis of organic and mineral horizons (texture, percent organic matter, CEC, and pH) will be characterized and analyzed for nitrate and ammonium by The Maine Soil Testing Service and Analytical Lab.

Floristic inventories of all the study sites will be conducted in spring, mid-summer, and fall along three elevational transects corresponding to seep locations. Data will be collected following the protocol used by the Maine Natural Areas Program (nested plots for trees, saplings, shrubs, herbs/forbs, and bryophytes with cover classes recorded for each species) for inclusion in their database. In addition, data will be collected on tree basal area, vegetation in adjacent uplands (dominant species in each strata), and a volume measurement of standing and down deadwood (coarse woody debris and fine woody debris) using a method adapted from the US Forest service.

The relative abundance of amphibian assemblages will be assessed seasonally using funnel trap arrays, coverboard arrays, and time-constrained searches in all of the seeps and repeated in adjacent uplands along similar elevational gradients. Funnel trap arrays will consist of a series of 10m drift fences arranged in a "T" fashion, within or adjacent to each seep with eight aluminum 0.9x0.2m funnel traps placed near each end of the fence on each side. The traps will contain a sponge (re-wetted upon inspection) and cover objects to reduce amphibian desiccation or mortality. The funnel trap arrays will be opened over two-week intervals throughout the field season. A total of 50 coverboards will be used to identify additional species not apt to be captured by funnel traps. These will be numbered and placed at the wetland/upland boundary along the border of each seep and within vegetation gradients in each seep. The coverboards will be inspected in conjunction with visual encounter surveys conducted following seasonal wet and dry periods concurrent with the sampling periods for soil and water analysis.

Principal Findings:

This grant currently provides support for the 2004 field season. As such, data collection is continuing throughout this year.

Significance for the project:

This funding has allowed the research to continue for a second field season and allow for additional surface water analysis from additional seep sites.

Provide publication citations associated with the research project:

To date no publications are associated with this project.

Additional Project information:

Student Support:

This research currently provides partial support for one full time doctoral candidate. This funding has also allowed employment of four undergraduate student workers. Two work-study students were employed during the spring 2004 academic period to assist data processing, while one work-study and one student worker will assist fieldwork and laboratory activities during the summer of 2004.

Notable Awards and Achievements:

To date, this project has not generated any notable achievements or awards.

Publications from Prior Projects:

To date, there have been n o publications as a result of funding form this source regarding the research.

References Cited:

Burns, D. A., P. S. Murdoch, G.B. Lawrence (1998). "Effect of groundwater springs in nitrate concentrations during summer in Catskill mountain streams." Water Resources Research 34: 1987-1996.

Cirmo, C. and McDonnell, J. (1997). Linking the hydrologic and biogeochemical controls of nitrogen transport in near-stream zones of temperate-forested catchments: a review. Journal of Hydrology, 199:88–120.

Manga, M. (2001). Using springs to study groundwater flow and active geologic processes. Annual Reviews in Earth and Planetary Science, 29:201–228.

West, A., Findlay, S., Burns, D., Weathers, K., and Lovett, G. (2001). Catchment-scale variation in the nitrate concentrations of groundwater seeps in the Catskill Mountains, New York, USA. Water, Air, Soil Pollution, 132:389–400.