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## An Example to Follow: Intersite Research among Stream Ecologists at LTER sites

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With the All Scientists Meetng approaching, and its emphasis on intersite activities, it might be useful to review some of the history of LTER intersite activities. For various reasons LTER stream ecologists have been particularly successful with intersite studies. This historical summary of LTER stream intersite research is biased because it only includes activities in which I was involved and which I remember, but I think it is fairly comprehensive.

Collaboration among LTER sites actually began before LTER existed — back in the IBP days. In 1974 a group of Coweeta researchers led by DAC Crossley visited the Andrews site. At the time both sites were planning watershed logging experiments and wanted to insure research comparability. A paper comparing the stream sites was presented at the AIBS meeting that summer (Sedell et al. 1974). In the early days of LTER there was money available for intersite workshops, and the network office funded a series of three meetings of stream ecologists (Table 1).

| LTER Stream Workshop | Date/Location | Organizer | Support |
|---|---|---|---|
| LTER Stream Workshop | 11-13 July 1983 Kansas State University | Dick Marzolf | Supported by LTER |
| LTER Stream Workshop | 29 October 1984 Denver, Colorado | | Supported by LTER |
| LTER Workshop on Stream Organic Matter Budgets | 18-19 October 1985 Franklin, North Carolina | J. Webster | Supported by LTER |
| Workshop on Stream Organic Matter Dynamics | 23-24 May 1993 Calgary, Alberta 1-5 | J. Webster and Judy Meyer | Unsupported* |
| Workshop on Solute Dynamics in Stream Ecosystems | February 1989 Oxford, Mississippi | Nick Aumen | University of Mississippi* |
| Stream solute and 15N workshop | 15-18 July 1995 Coweeta | Donna D'Angelo, Bruce Peterson, and Judy Meyer | Supported by a grant from NSF |

*Page costs for publications from both of these workshops were supported by LTER.

These workshops allowed LTER stream ecologists and stream ecologists from non-LTER sites to get together and generate the collegiality, trust, and appreciation of others' research that is essential for any collaborative research. One product of these workshops was a short paper describing stream research at six of the 11 LTER sites (Webster et al. 1985).

Figure 1. Participants in the Stream Organic Matter Workshop held at Coweeta in October 1985.

The organic matter workshop at Coweeta in 1985 (Fig. 1) began a fruitful intersite collaboration that didn't actually bear fruit for 12 years. At the 1990 All Scientists Meeting in Estes Park, we decided that we should use NABS meetings to continue these efforts since it would save money and allow non-LTER researchers to participate.

A second organic matter workshop was held in Calgary in 1993. This was an actual "working workshop" — we attempted to synthesize data on stream organic matter budgets from a variety of streams throughout North America and a few other sites in Australia, Europe, and Antarctica. I

spent much of the following summer making a preliminary analysis of the results of these efforts. This analysis was then sent to each participant requesting they fill in any missing data from their site and confirm or recalculate any numbers that were clearly outliers. The resubmitted data were then reanalyzed, and eventually we (Webster and Meyer 1997) produced a series of papers describing the 35 streams (7 LTER and 14 other sites) and including 8 synthesis papers on various aspects of organic matter budgets. A clear consensus of this publication was that stream organic matter dynamics reflect the terrestrial setting of the streams.


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Figure 4. The recently funded NPARS (Nitrate Processing And Retention in Streams) project continues the use of 15N to study nitrogen in streams. (H.M. Valett, J.R. Webster, P.J. Mulholland, S.A. Thomas, C.N. Dahm, C.G. Peterson)

Each of the All Scientists Meetings has also been an opportunity for stream researchers to interact and plan collaborative efforts. After the 1990 meeting, Meyer et al. (1993) produced a small book describing characteristics of the streams at each of 12 LTER sites. The intent of this publication was to stimulate intersite research among stream ecologists by helping identify sites with attributes that would permit useful comparisons.

In addition to intersite work on stream organic matter dynamics, collaboration of stream ecologists working on nutrient dynamics began in 1989 with a workshop organized by Nick Aumen at the University of Mississippi. The report of the topics discussed at this meeting (Stream Solute Workshop 1990) has been a useful synthesis of our understanding of nutrient dynamics in streams at that time. This collaboration of stream ecologists interested in nutrients led to a funded NSF proposal by Donna D'Angelo, Bruce Peterson, and Judy Meyer for another workshop at Coweeta (Fig. 2). Again, this was a working workshop with participants actually out in streams getting their feet wet helping with data collection. The workshop included demonstrations of solute injections and data analysis, 15N addition, stable isotope analysis, and nitrogen modeling. One product of this workshop was that the demonstration 15N addition ended up as a published paper (Hall et al. 1998). Another product was a successful intersite proposal to NSF for the LINX project (Lotic Intersite Nitrogen eXperiment, Fig. 3). In this study, we used 6-week 15NH4 additions to streams to determine NH4 uptake length and uptake rate, nitrogen turnover rates, and food web transfer of nitrogen Field research was completed in September 1998. Successful coordination of LINX was achieved through several mechanisms. First, at least one of the principal investigators (Mulholland, Webster, Meyer, Peterson) visited each of the sites during the 15N injection. Second, a post-doctoral associate (Jennifer Tank) went to each of the sites to organize the data collection and insure that the same techniques were used at every site. Third, nearly all of the researchers involved in the LINX regularly attend the NABS meeting, and a day prior to each NABS meeting was set aside for a LINX meeting to compare progress, discuss initial results, and eventually to plan synthesis efforts. As of January 2000, we have presented 36 papers at meetings, four papers are in press, another four are submitted, and many more are planned.

Another intersite stream study is currently underway, the NPARS project (Nitrate Processing And Retention in Streams, Fig. 4). This study is an outgrowth of LINX but is a much more intensive study of six streams at three sites. We are using short-term additions of 15NO3 to examine effects of riparian vegetation, flow regime, and groundwater interaction on nitrate retention.

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The Experiment:

- Physical, chemical and ecological characterization of streams
- Six-week 15NH4 addition to stream water
- Determine NH4 uptake length and rates, N turnover rates, and food web transfer

Successful intersite collaboration depends on eight characteristics. There must be (1) collegiality, (2) trust, and (3) respect among the participants. These relationships are developed through long-term interactions, such as are available through LTER, and through (4) site visits. The opportunity to visit other sites is essential. It not only brings participant together, but it allows everyone to kick the rocks and smell the mud. This first hand acquaintance with other sites cannot be replaced by pictures. In order to develop successful collaboration there must also be (5) incentive for the participants. This incentive may be potential publications (not just a footnote to a workshop-authored paper) or monetary research support. Enthusiasm and bootlegged data collection can only carry an intersite project a short

of N

Figure 3. The LINX (Lotic Intersite Nitrogen eXperiment) study was funded in 1996 to study nitrogen dynamics in streams throughout North America.

ways. Collaborative, intersite research is expensive and achieving significant funding is difficult (Peterson 1993), but the important contributions made by intersite studies such as the River Continuum Study (Minshall et al. 1983) underscore their value.

A (6) baseline of data and prior research is also essential. Because of the existence of this sort of data, the LTER network is a wonderful opportunity for intersite research. Time and patience (7)—Intersite research goes slowly. The synthesis of stream organic matter budgets was finally published 12 years after the first workshop. It take time to develop the essential relationships among collaborators and the synthesis is always limited by the slowest link.

Finally, an intersite effort cannot be successful without (8) effective leadership. Cullen et al. (1999) listed traits of an effective leader of a collaborative effort (Table 2) that apply well to leadership of intersite studies. To this list I add patience and realism — realism that not everyone will contribute equally and patience to work with people who might not have equal enthusiasm. Usually it is the combined efforts of several people that provides effective leadership, and I particularly thank Judy Meyer, Pat Mulholland, Bruce Peterson, Jennifer Tank, and Nick Aumen for their role in leading the interactions among stream ecologists within LTER and within the larger community.

**Table 2. Characteristics of an effective leader of a collaborative effort. Modified from Cullen et al. (1999)**

- Commitment to excellence and an ability to set high standards wStrong knowledge of the subject area
- Skill at synthesizing and seeing the big picture
- Strong appreciation of the importance of collaborative research
- Intellectual curiosity and a vitality for learning across disciplinary boundaries
- Willingness to take risks by presenting tentative solutions and allowing others to build on and correct them
- Ability to stimulate all collaborators to ask questions and to re-examine deeply held assumptions.

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