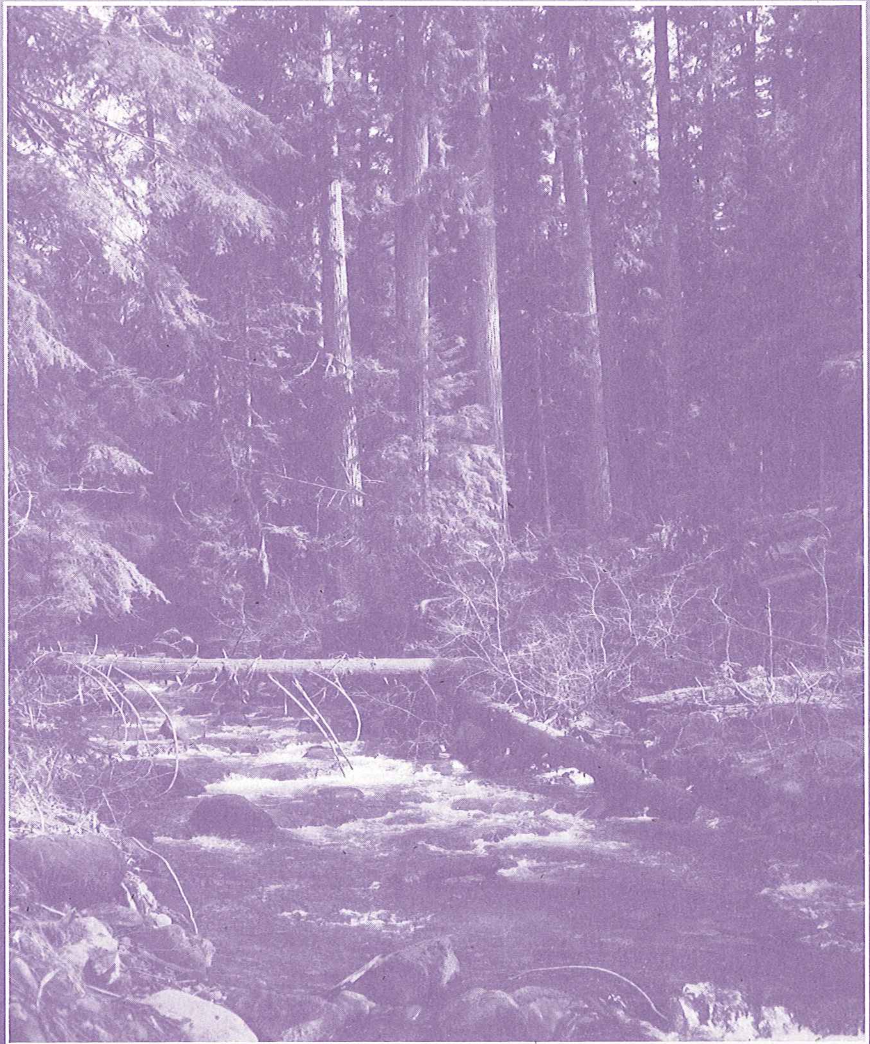
STREAM RESEARCH in the LTER Network



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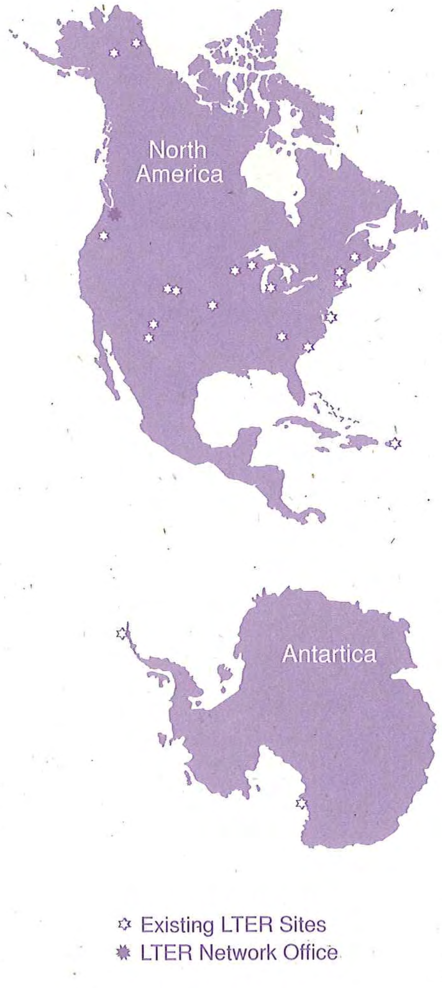
UNITED STATES
Long-Term Ecological Research Network



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Cover photograph: H. J. Andrews Experimental Forest, Oregon, USA. (A. Levno)

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STREAM RESEARCH

in the

Long-Term Ecological Research Network

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Judy Meyer

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Long-Term Ecological Research (LTER) Network Office

Seattle, Washington, USA

July 1993

PREFACE

At the September 1990 All Scientists Meeting sponsored by the Long-Term Ecological Research (LTER) Network in Estes Park, Colorado (USA) stream researchers in the Network recognized a need for a compilation of basic information on the types of streams found at the LTER sites. A smaller group of investigators composed a questionnaire that was sent to each LTER site; the responses were then compiled to form this report.

Not all of the 19 LTER sites are represented in this catalog. Some sites do not have streams: these include Central Plains Experimental Range, Jornada, Palmer Station, and Virginia Coast Reserve. Other sites have streams, but were not supporting LTER stream research at the time this catalog was prepared: the Cedar Creek Natural History Area, Harvard Forest, and the W. K. Kellogg Biological Station.

A broader description of both terrestrial and aquatic research programs at all LTER sites is available in the publication entitled *Long-Term Ecological Research in the United States: A Network of Research Sites, 1991.* A more detailed listing of personnel at LTER sites can be found in the current LTER Personnel Directory, which is also available on-line. Both of these publications are available from the LTER Network Office.

We envision researchers using this catalog to find stream sites in the LTER Network that would be appropriate for answering the research questions they wish to ask. Our hope is that it will both stimulate and facilitate intersite stream research across the Network.

We are publishing this in a format that we hope will permit updating of the information every three years. Inquiries about updates should be directed to the LTER Network Office. Researchers who have comments or suggestions are encouraged to address them to Judy Meyer, Institute of Ecology, University of Georgia, Athens, Georgia, USA 30602.

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Walter Dodds (Konza Prairie)
Stuart Findlay (Hubbard Brook Experimental Forest)
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Diane McKnight (McMurdo Dry Valleys)
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Mark Oswood (Bonanza Creek Experimental Forest)
Deborah Repert (Arctic Tundra)
F. N. Scatena (Luquillo Experimental Forest)
Cathy Tate (*formerly* Konza Prairie, now McMurdo Dry Valley)
Dale Toetz (Niwot Ridge/Green Lakes Valley)

TABLE of CONTENTS

Overview 1

H. J. Andrews Experimental Forest (AND), *Oregon* 17

Arctic Tundra (ARC), *Alaska* 27

Bonanza Creek Experimental Forest (BCR), *Alaska* 39

Coweeta Hydrologic Laboratory (CWT), *North Carolina* 47

Hubbard Brook Experimental Forest (HBR), *New Hampshire* 57

Konza Prairie Research Natural Area (KNZ), *Kansas* 65

Luquillo Experimental Forest (LUQ), *Puerto Rico* 73

McMurdo Dry Valleys (MCM), *Antarctica* 81

Niwot Ridge/Green Lakes Valley (NWT), *Colorado* 87

North Inlet Marsh-Estuary (NIN), *South Carolina* 95

North Temperate Lakes (NTL), *Wisconsin* 101

Sevilleta (SEV), *New Mexico* 107

OVERVIEW

Stream research is currently being conducted at several sites in the Long-Term Ecological Research (LTER) Network, although the primary focus of research at most sites is on terrestrial rather than aquatic ecosystems. To stimulate comparative stream research both inside and outside the Network, we have compiled this data catalog from responses to a questionnaire sent to all LTER sites. In this brief overview, I draw upon information from the following chapters to summarize the range of stream conditions found across the Network.

The extent of stream research conducted at an LTER site varies considerably across the Network as a consequence of differences in research objectives among sites, the number of stream researchers in the project, and site funding priorities. There is presently no set of parameters being measured in all LTER stream projects. Hence, the data in this overview are incomplete in the sense that information was not available for all variables from all sites. Nevertheless, the existing data demonstrate the wide range of stream environments to be found in the LTER Network.

Conceptual Framework

The conceptual framework guiding research also differs at the 12 LTER sites engaged in stream research; however, common themes are considered, including geomorphological and riparian controls of ecosystem function and response to and recovery from disturbance. A review of the following descriptions of stream research at the sites, reveals two different approaches: one in which an interest in factors controlling stream ecosystem function guides the research (nine sites), and one in which a view of streams as pathways for export is the focus (three sites).

Factors Controlling Stream Ecosystem Function

Among sites which focus on factors controlling stream ecosystem function, the factors considered vary widely. The conceptual framework at the H. J. Andrews site is based on the influence of valley landform and riparian plant communities on the stream ecosystem in a landscape while, at the Arctic Tundra site, stream research focuses on understanding the impact of nutrient additions and bottom-up versus top-down controls of stream ecosystem function. Areas studied at the Bonanza Creek site include structure, productivity, and winter ecology of the macroinvertebrate community, as well as controls of detrital processes. The focus at Coweeta is on the influence of streambed geomorphology on ecosystem processes along a longitudinal gradient, the effect of a dominant riparian species on stream ecosystems, and recovery from disturbance.

Researchers at Hubbard Brook are using natural variation or anthropogenic manipulation among catchments to examine the relationship between streams and their catchments and stream recovery from disturbance. An interest in landscape controls on stream chemistry is a focus of stream research at Konza Prairie. The research question at Luquillo is the effect of disturbance on stream geomorphology, hydrology, nutrient-dynamics, primary producers, and aquatic populations. Nutrient dynamics and hydrologic controls on biota are being studied in streams in the McMurdo Dry Valleys. At Sevilleta, the major interest is in the influence of a large-scale weather system (El Niño - Southern Oscillation) on the ecology of streams.

Streams as Transporters of Substances

Research in the second group of sites focuses on the role of streams as transporters of substances within the landscape. Data on element transport is also being collected at the sites previously discussed, but is not the primary focus of their stream work. At Niwot Ridge, streams are studied as vehicles for transport of substances off snowfields. At North Inlet Marsh, they are viewed as a link between freshwaters and the salt marsh and, at North Temperate Lakes, as conduits for substances to lakes.

Physical Characteristics

Only sites reporting data are noted in Figures 1 - 11 on the following pages. Site abbreviations used are: AND (H. J. Andrews Experimental Forest), ARC (Arctic Tundra), BNZ (Bonanza Creek Experimental Forest), CWT (Coweeta Hydrologic Laboratory), HBR (Hubbard Brook Experimental Forest), KNZ (Konza Prairie), LUQ (Luquillo Experimental Forest), MCM (McMurdo Dry Valleys), NWT (Niwot Ridge/Green Lakes Valley), NIN (North Inlet Marsh-Estuary), NTL (North Temperate Lakes), SEV (Sevilleta).

Stream Order

First- through fifth-order streams are currently being studied in the LTER Network. Stream order is an index of stream position in the drainage network, in which a headwater stream is designated first order, and order increases to second- and third-order, etc., as this channel is joined by others of equal order.

Stream discharge is being measured at 11 LTER sites, with the length of record varying from under one to over 50 years. The seasonal pattern of discharge ranges from sites with intermittent and extremely variable discharge (Konza, North Inlet, Sevilleta, McMurdo), to sites where a predictable snowmelt is the major discharge event (Arctic, Niwot, Bonanza, Hubbard Brook), to sites with seasons of high and low flow where unpredictable storms also lead to high discharges (Andrews, Coweeta, Luquillo), to a site where streams have stable discharge dominated by groundwater inputs (North Temperate Lakes). At several sites (Arctic, Bonanza, McMurdo) streams are frozen solid throughout the winter.

For those sites reporting mean annual discharge (Figure 1A), two or three sites fall into each of the following discharge classes: < 10 L/s (Hubbard Brook, North Inlet), 10 - 100 L/s (Coweeta, Konza, McMurdo), 100 - 1,000 L/s (Andrews, Luquillo), and 1,000 - 10,000 L/s (Arctic, Bonanza Creek). Minimum discharges reported are all < 50 L/s, with six sites reporting 0 as a minimum discharge. There is more variability in maximum discharge: 10 - 100 L/s (Hubbard Brook, North Inlet, Niwot Ridge), 100 - 1,000 L/s (Coweeta, McMurdo, North Temperate Lakes), 1,000 - 10,000 L/s (Andrews), and 100,000 to 600,000 L/s (Konza, Luquillo, Sevilleta).

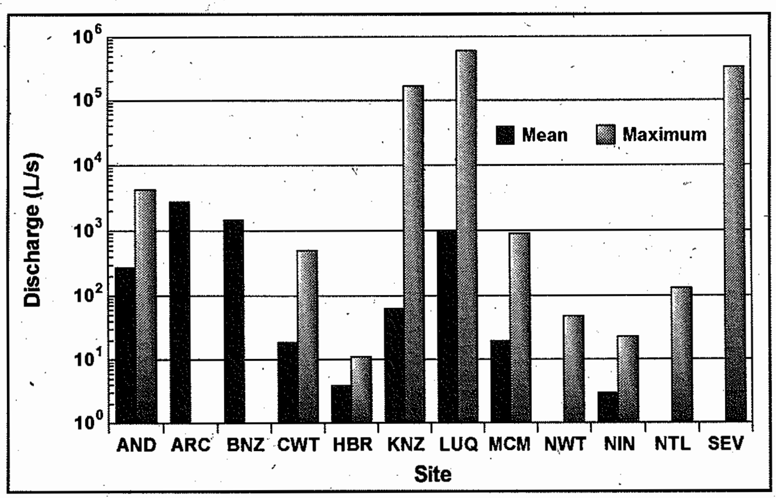


Figure 1A. *Mean annual and maximum discharges of streams in the LTER Network.*

Retention Structures

Retention structures in streams also vary across the Network, with woody debris or tree roots important at some sites (H. J. Andrews, Coweeta, Hubbard Brook, North Inlet, North Temperate Lakes) while, at other sites, more retention is associated with geological features such as boulders or cobbles (Arctic, Konza, Luquillo), channel microtopography (Sevilleta), or shallow ponds (McMurdo). Woody debris in the channel ranges from abundant (Andrews, Coweeta, Hubbard Brook) to rare or absent (Arctic, Bonanza Creek, Konza, Luquillo, Niwot Ridge, North Inlet, Sevilleta).

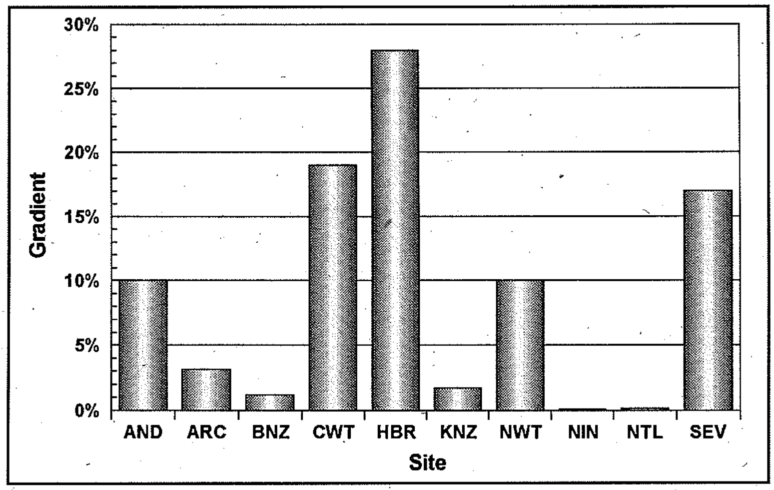


Figure 1B. *Average gradient of streams in the LTER Network.*

The Hyporheic Zone

The extent of the hyporheic zone across the Network ranges from sites where it extends at least one meter into the sediments (Bonanza, Luquillo, North Inlet, North Temperate Lakes) to those where less than 10 cm of sediment lie above bedrock (Coweeta, Hubbard Brook, Niwot Ridge). At the remaining sites (Andrews, Arctic, Konza, McMurdo, Sevilleta) the hyporheic is intermediate in extent. Stream gradient is also highly variable, ranging from 0.1 to nearly 30% (Figure 1B).

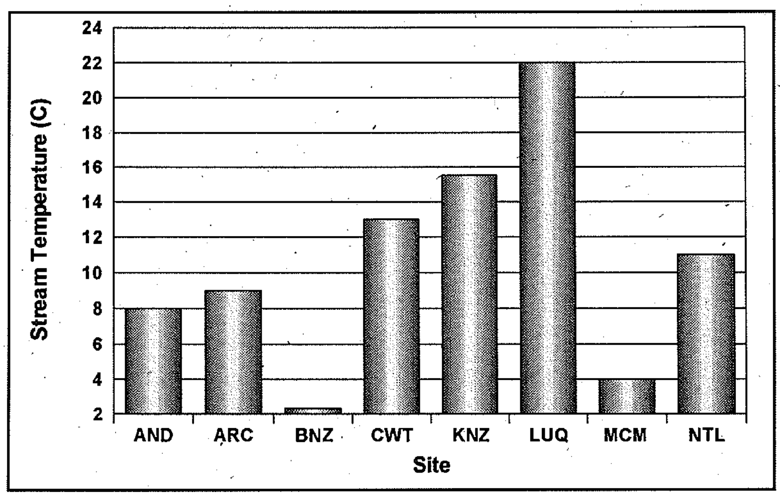


Figure 2A. *Mean water temperature as reported in the data catalog at sites in the LTER Network. For ARC, this is for 15 June-20 August. For MCM, this is a summer mean. All others are annual means.*

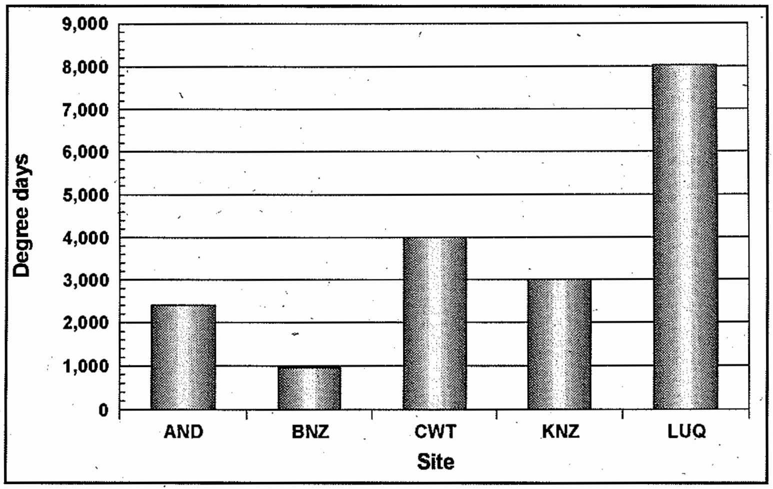


Figure 2B. *Annual degree days in streams at sites in the LTER Network.*

Water Temperature

Data on streamwater temperature are not available from all sites, but the Network offers a wide range of temperature conditions (Figure 2A), with degree days ranging from 950 to 8,030 (Figure 2B) at the limited number of sites where this parameter has been measured.

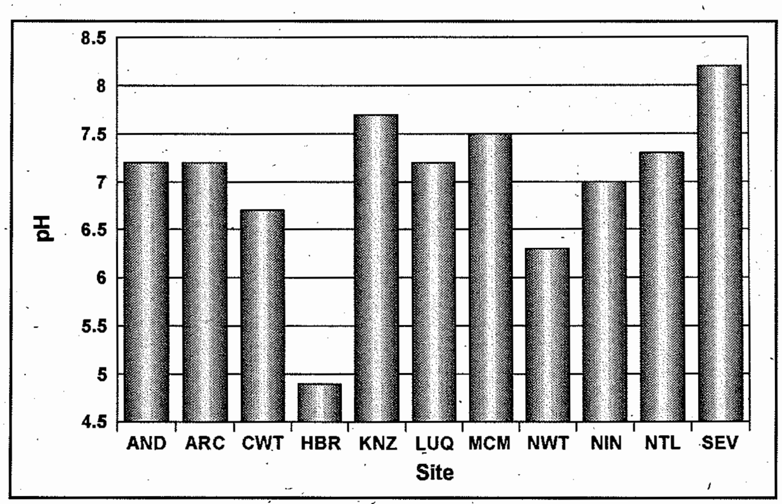


Figure 3A. *Mean pH of streamwater at sites in the LTER Network.*

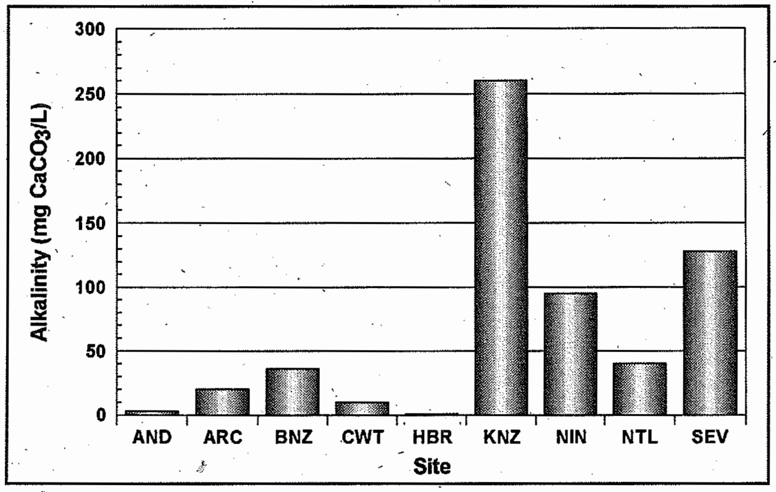


Figure 3B. *Mean alkalinity of streamwater at sites in the LTER Network.*

Chemical Characteristics

The catalog lists means and ranges for several important chemical parameters being measured at the different sites. These values are based on records of vastly different length (varying from a couple of dates to decades). Not all sites have data for each parameter, and not all report both means and ranges. To simplify the figures in this overview, I have used only mean values. In some cases, these means have been volume-weighted. For sites where only ranges were given, I have used an intermediate value between reported maxima and minima. The use of means obscures both seasonal variation (which is considerable at some sites) as well as the long-term trends in streamwater chemistry that have been observed at sites with long records (e.g., Hubbard Brook and Coweeta). Hence, the figures on these pages provide a general impression of how the chemistry of a site compares with others in the Network. Readers should, however, refer to the respective chapter for a particular stream to determine the length of record and the variability of streamwater chemistry before using these data.

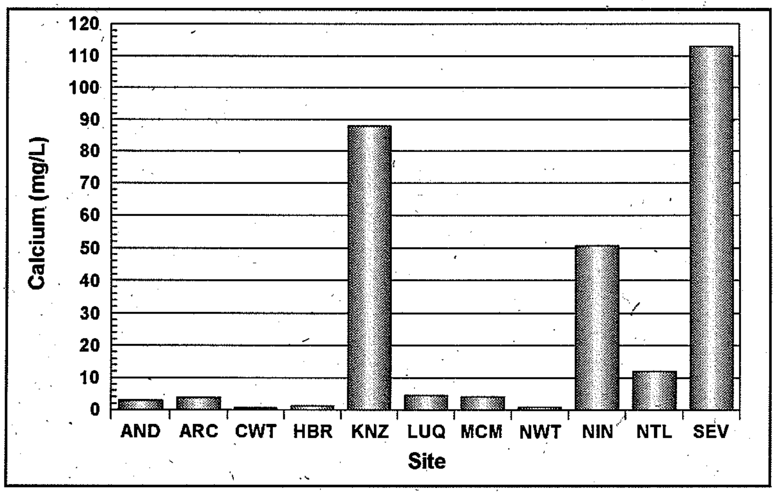


Figure 4A. *Calcium concentration in streamwater at sites in the LTER Network.*

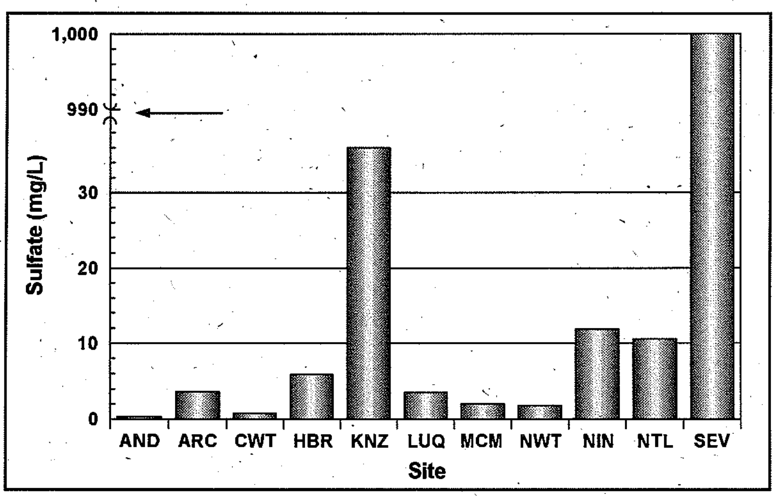


Figure 4B. *Sulfate concentration in streamwater at sites in the LTER Network.*

Streams at most of the sites are circumneutral, but those at Hubbard Brook are more acidic and those at Sevilleta more alkaline (Figure 3A). Although not included in these figures, some LTER streams show extreme ranges in pH (see the North Inlet chapter). Alkalinity is more variable than pH across the Network, varying over two orders of magnitude (Figure 3B). Calcium and sulfate concentrations are below 10 mg/L, except at Konza and North Inlet and Sevilleta where concentrations are considerably higher (Figures 4A, B). The concentration range for ammonium is considerably lower than the range of nitrate or total nitrogen (Figures 5A, B, 6A). Hubbard Brook and Niwot Ridge have high nitrate values (Figure 5B), while North Inlet has high concentrations of total nitrogen, corresponding to a high concentration of dissolved organic carbon (DOC) (Figures 6A, B). Nitrogen concentration is more variable across the Network than is phosphorus (Figures 5, 6, 7). Most streams have low DOC concentrations, but streams with high DOC can also be found. (Figure 6B).

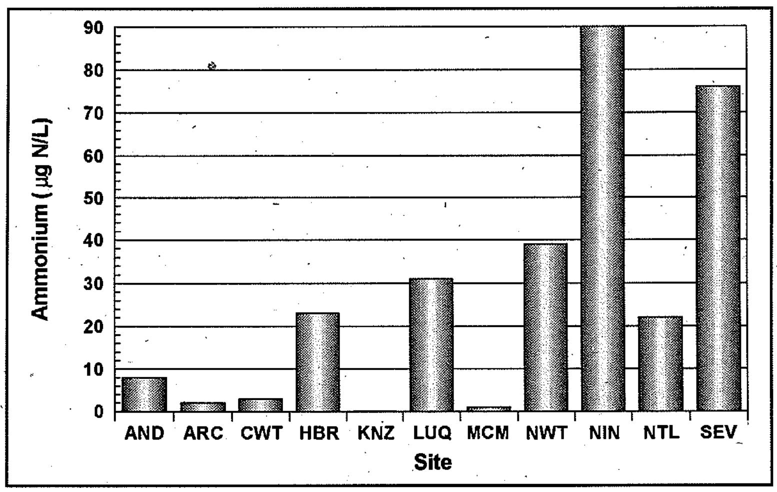


Figure 5A. *Concentrations of inorganic nitrogen (ammonium) in stream water at LTER sites.*

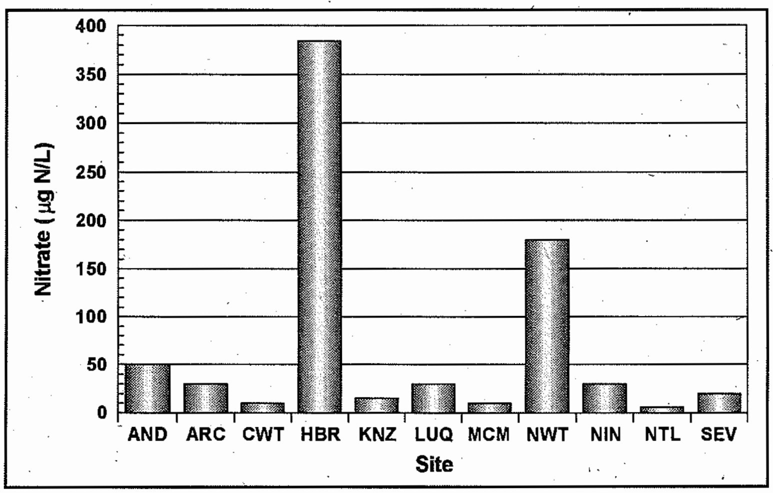


Figure 5B. *Concentration of total dissolved nitrogen (nitrate) at streams in the LTER Network.*

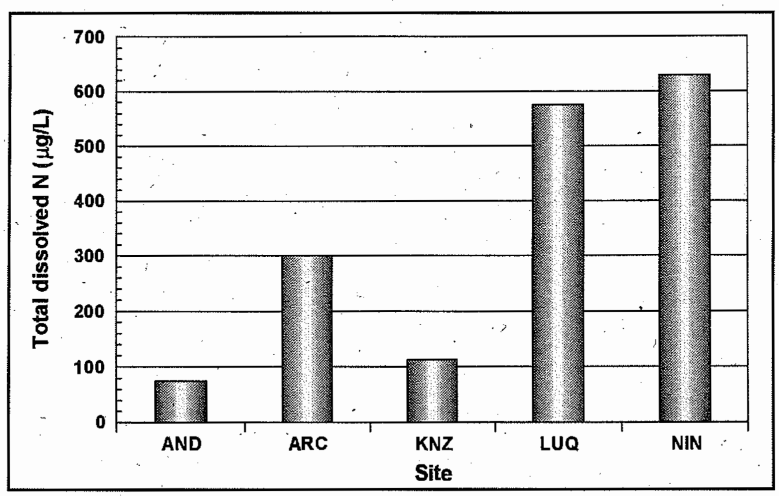


Figure 6A. *Concentration of total dissolved nitrogen at streams in the LTER Network.*

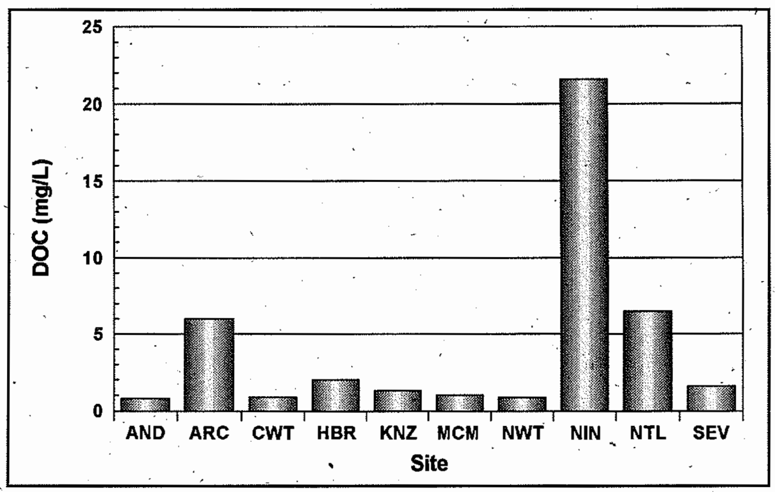


Figure 6B. *Concentration of dissolved organic carbon (DOC) in stream water at LTER sites.*

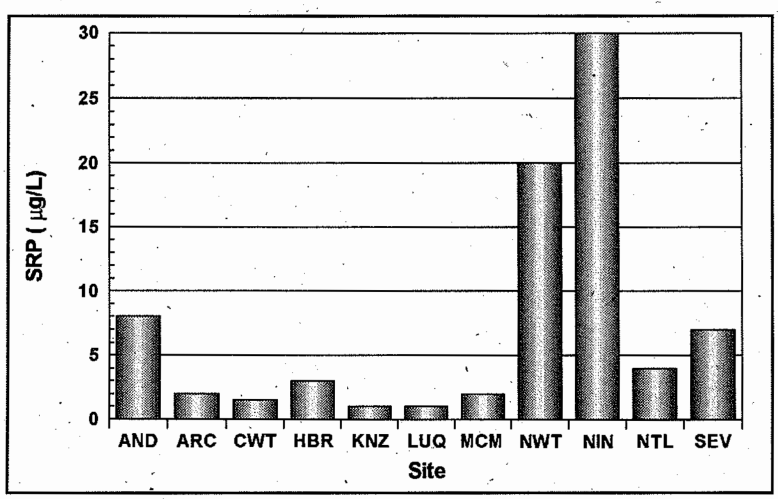


Figure 7A. *Concentration of soluble reactive phosphorus (SRP) in streamwater at LTER sites.*

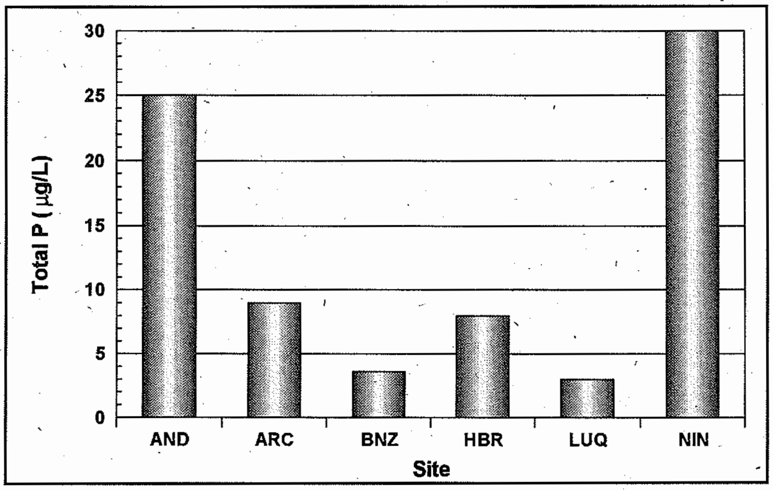


Figure 7B. *Concentration of total phosphorus in streamwater in streams of the LTER Network.*

Biological Characteristics

Table 1 lists the number of sites collecting each type of biological data. More information on algae and macroinvertebrates is being collected than on other biological aspects of streams. Macroinvertebrate standing crop ranges from 0.3 to 6 g/m^2 (Figure 8). Sources of organic matter for the benthic community include both algae and detritus. Algal standing crop varies over two orders of magnitude across the Network (Figure 9A), although data from fertilized sites were not included and would extend the range

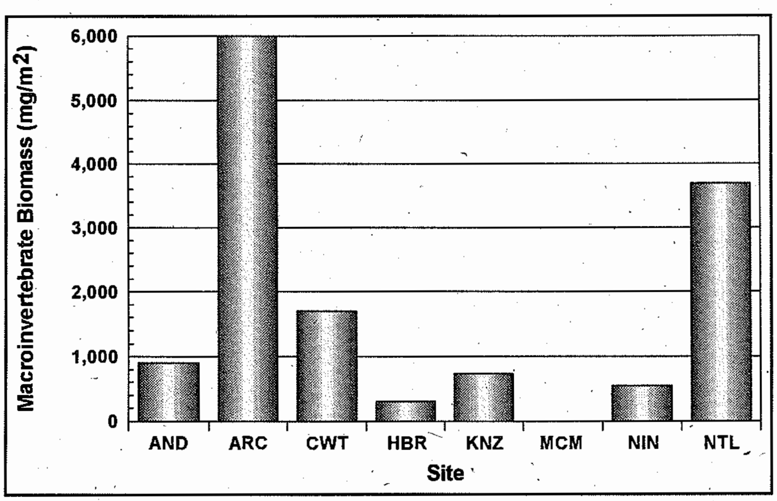


Figure 8. *Macroinvertebrate biomass in streams of the LTER Network.*

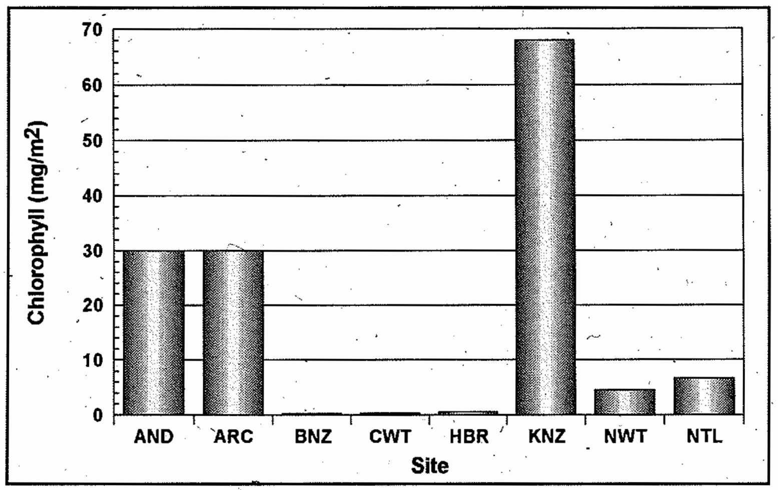


Figure 9A. *Standing stock of chlorophyll of streams in the LTER Network.*

another two orders of magnitude. Light limitation is clearly variable across the Network, since the extent to which riparian vegetation covers the channel ranges from 0 to 100% (Figure 9B).

Leaf litter is an important organic matter source in several, but not all, streams in the Network (Figure 10A). At some sites, direct litterfall is the only reported source of leaf litter whereas, at others, lateral movement of leaf litter is of equal or even greater importance (Figure 10B). Differences in the relative

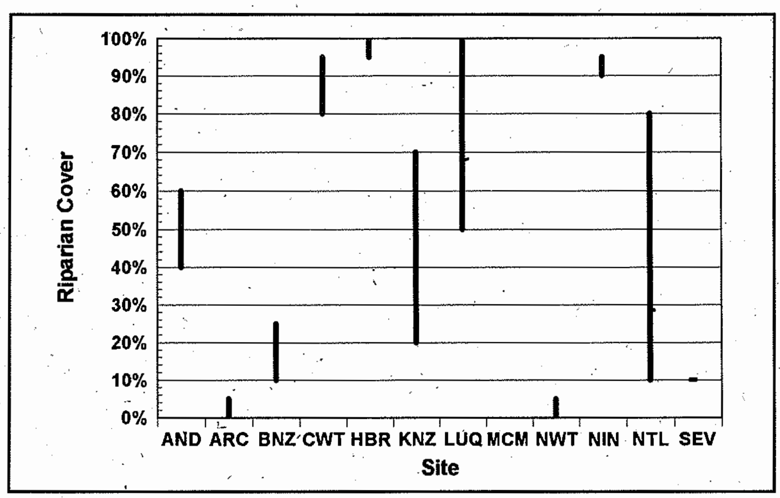


Figure 9B. *Extent of riparian vegetation cover over the channel (bars extend from minimum to maximum cover) of streams in the LTER Network.*

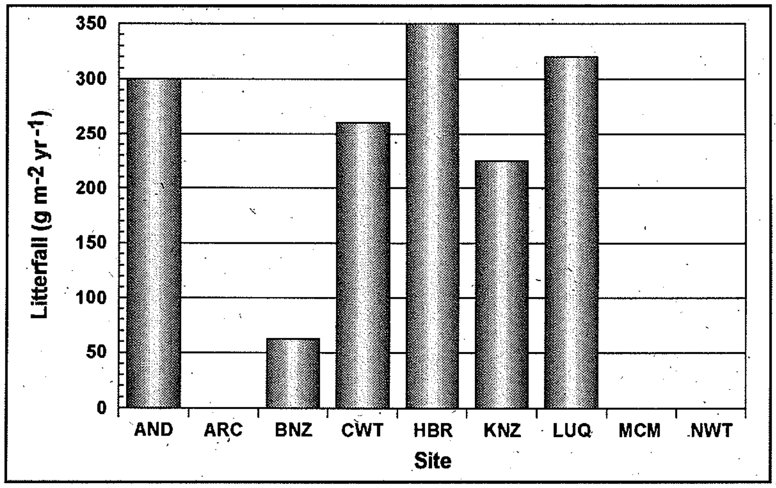


Figure 10A. *Leaf litterfall into streams in the LTER Network.*

importance of litterfall and lateral movement are in part a relation of the inclusion of wood in measurements of lateral movement at some sites. As a consequence of the importance of leaf litter as an energy resource, leaf decay rate is being or has beeen measured at nearly all stream sites (Table 1), although there is no overlap in leaf species used (Table 2).

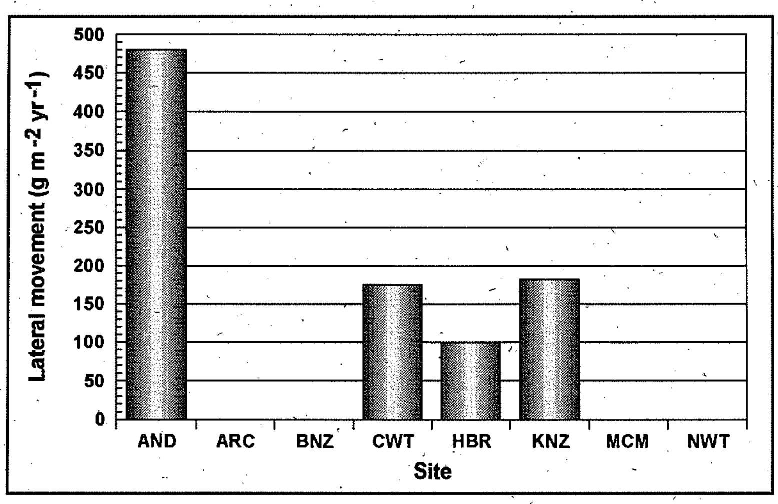


Figure 10B. *Lateral movement of leaf litter into streams in the LTER Network.*

Standing stock of benthic organic matter in stream channels varies from 20 to over 600 g AFDM/m^2 (Figure 11), with Bonanza Creek streams having the least and H. J. Andrews and Hubbard Brook streams the most of the seven sites reporting. This disparity is even greater if standing stock of woody debris in the channel is included. Bonanza Creek streams report little wood, whereas the standing stock of wood in streams at H. J. Andrews is 26 kg AFDM/m^2.

Future Research

The success of this catalog will be measured by the quality of stream research it stimulates. It is clear that streams in the LTER Network offer a range of physical, chemical and biological conditions that could be used to test hypotheses on factors controlling structure and function of a broad range of stream ecosystems.

Judy Meyer
Coweeta Hydrologic Laboratory

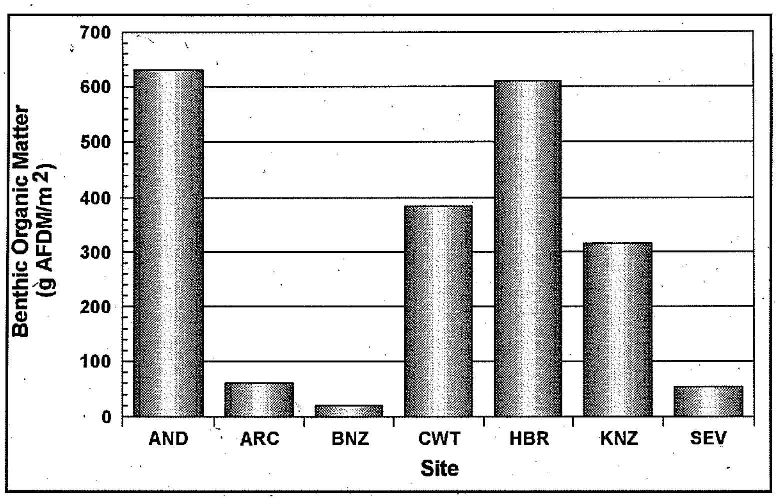


Figure 11. *Standing crop of benthic organic matter in streams of the LTER Network. These values do not include large woody debris.*

Table 1. *Number of sites at which different components of the biological communities and ecological processes in streams are being or have been measured.*

Component or process	Number of sites
Algae	8
Bacteria	4
Fungi	3
Meiofauna	2
Macroinvertebrates	11
Fish	6
Other vertebrates	2
Leaf litter decomposition rate	10
Nutrient uptake	5
Foodweb analyses using stable isotopes	4

Table 2. *Leaf species used in measures of leaf decay rate in streams at LTER sites. Although leaf decomposition studies are in progress at sites not listed, the leaf species being studied are not included here.*

Site	Leaf Species
Andrews	Douglas-fir, red alder, vine maple, bigleaf maple, devil's club
Arctic Tundra	*Betula nana, Carex aquatilis, Eriophorum vaginatum, Salix* sp.
Bonanza Creek	birch, willow, alder
Coweeta	red maple, rhododendron, white oak, dogwood, black locust, sweet birch
Hubbard Brook	sugar maple, yellow birch, American beech (mixed)
Konza	elm, burr oak, hackberry, chinquapin oak, sycamore
North Inlet	live oak, wax myrtle

H. J. ANDREWS EXPERIMENTAL FOREST

I. GENERAL DESCRIPTION

A. Conceptual Framework

The H. J. Andrews Experimental Forest is located in the Cascade Mountain Range of west-central Oregon and was established in 1948 with the objective of developing concepts and tools needed to predict effects of disturbance on ecosystem structure and function. In 1981, the Andrews was designated as a Long-Term Ecological Research (LTER) site, facilitating studies that require a temporal context. The original site research objectives continue and presently focus on the influence of valley landforms and riparian plant communities on stream ecosystems. Emphasis has been placed on the importance of channel complexity, riparian vegetation, and woody debris, on distribution of organisms, rates of nutrient transport and processing, and basin-wide distribution of major vertebrate predators (rainbow and cutthroat trout). Over the next five years, research will continue in these fundamental areas, while expanding spatially to deal with a greater number of landscape-level issues. These will include the influence of natural disturbance, land use, and climate on landscape pattern and function.

Streams in the H. J. Andrews Experimental Forest (AND) range from first through fifth order. As a result, research at AND focuses primarily on streams less than fifth order in size. However, in addition to the substantial research that has been done on small streams, selected studies have been conducted to examine physical and biological characteristics of lotic ecosystems of different sizes. For example, basin surveys have been conducted on Lookout Creek (a fifth-order stream where it enters the Blue River, a tributary of the McKenzie River) and the McKenzie River (seventh-order), to compare physical habitat, algal biomass and productivity, macroinvertebrate density and diversity, and fish abundance. Expansion of stream research, both spatially and temporally, to the landscape level will facilitate further integration of research conducted on and adjacent to the H. J. Andrews Experimental Forest.

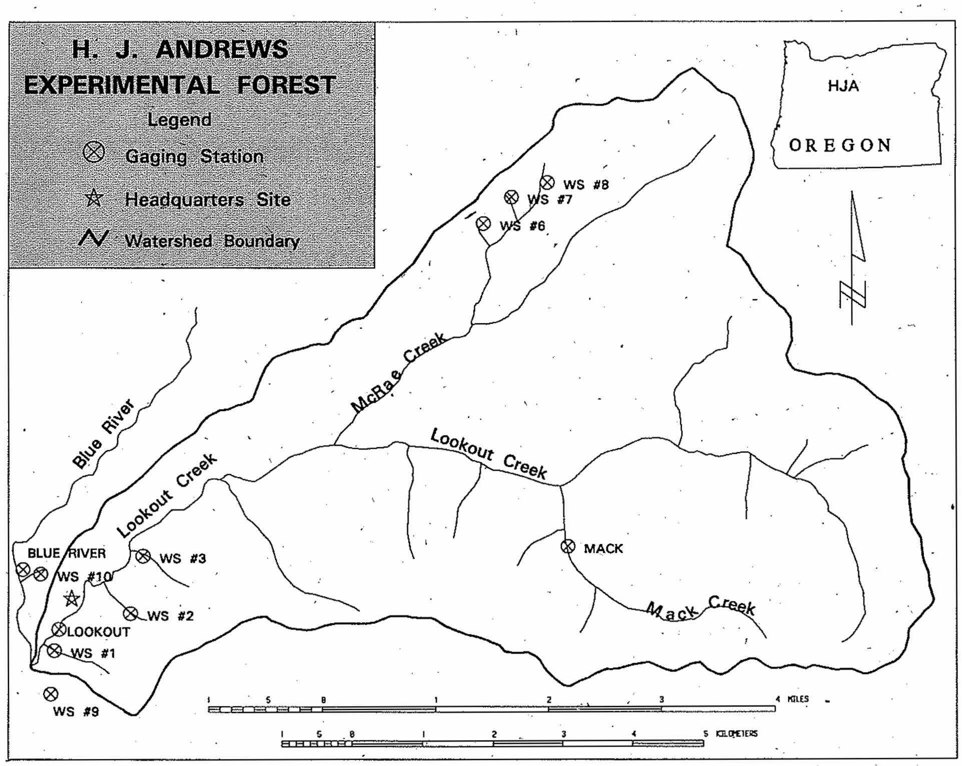
Coarse woody debris in Lookout Creek, H. J. Andrews Experimental Forest, Oregon. (Photograph by Stan Gregory)

B. Site Description

The H. J. Andrews Experimental Forest is comprised of the Lookout Creek drainage basin, which covers 6,400 ha of land ranging in elevation from 412 m to 1,630 m. Vegetation is predominantly Douglas-fir, western hemlock, and western redcedar, with some true firs and mountain hemlock at upper elevations. Climate of the region is mild with average winter and summer temperatures of 4°C and 24°C, respectively. Average rainfall is about 2,500 mm and occurs predominantly in winter. Lookout Creek drainage corresponds with the boundaries of the H. J. Andrews Forest. Lookout Creek is a fifth-order stream with mean summer flows of about 10 cfs and mean winter flows of about 150 cfs. Winter streamflow in Lookout Creek often exceeds summer flow by three orders of magnitude. Two major third-order tributaries, Mack Creek and McCrae Creek, drain into Lookout Creek. Numerous first- and second-order streams drain into Mack and McCrae Creeks or directly into Lookout Creek.

Streams in the Lookout Creek basin are relatively similar, but exhibit a strong longitudinal gradient. Higher-elevation streams are colder, have more riparian cover, less algal productivity, and lower concentrations and discharges. Mack Creek is representative of average or mid-basin conditions. Lower-basin streams (e.g., lower Lookout Creek) typically have less riparian cover, more algal productivity, and higher nutrient concentrations. Distributions of invertebrates and vertebrates and channel and riparian habitat also exhibit longitudinal patterns.

Stream chemistry is partially determined by the geology of the region, which is primarily andesite to basalt. Stream hardness and conductivity are low, nitrogen is often limiting, and phosphorus is typically present in adequate amounts. Canopy cover varies depending on stream size and disturbance history of the area (ranging from undisturbed old growth 60-70 m tall to clearcut). Consequently, productivity may be either light- or nutrient-limited.



The channel structure of undisturbed streams is typically complex with stable banks and substantial channel heterogeneity. Substrate ranges from bedrock to large boulders, with the majority of substrate in the cobble- to boulder-size range. Depth to bedrock is quite variable and ranges from exposed bedrock to several meters.

Information on the biota is available for most streams, although in different amounts and levels of detail. Periphyton in the streams is dominated by diatoms with occasional filamentous green algae. Invertebrates from most orders are represented, and the snail *Juga* is present in high numbers. Vertebrates are represented by the Pacific giant salamander, rainbow and cutthroat trout, dace, and sculpins. Rainbow trout, dace and sculpins occupy the lower portions of the basin, cutthroat trout the upper regions. Salamanders are present basinwide. For an overview of physical and biological characteristics of selected streams in this region, see Swanson et al. 1982 and Triska et al. 1982.

C. For Further Information

1. Contact person: Stan Gregory, Oregon State University (OSU), Department of Fisheries and Wildlife, 104 Nash Hall, Corvallis, OR 97331, 503-737-1951, *sGregory@LTERnet.edu* (Internet)

2. Topographic maps (15-minute quad): Oregon-Carpenter Mountain, Tamoliteh Falls, McKenzie Bridge, Belknap Springs, corner of Blue River

3. Stream researchers at site:

   Norm Anderson, OSU Department of Entomology, Corvallis, OR 97331, 503-737-5494 (aquatic entomology)

   Linda Ashkenas, OSU Department of Fisheries and Wildlife, 503-737-1966 (forest-stream interaction, riparian management)

   Donna D'Angelo, Institute of Ecology, University of Georgia, Athens, GA 30602, 706-542-4366 (nutrient retention, stability and disturbance)

   Stan Gregory, (forest-stream interactions, decomposition, stream ecology)

   Gary Lamberti, Department of Biological Sciences, University of Notre Dame, Notre Dame, IN 46556, 219-631-8075 (stream ecology, forest-stream interactions)

   Dave McIntire, OSU Department of Botany and Plant Pathology, 503-737-5289 (structure and function of periphyton communities, modeling)

Art McKee, OSU Department of Forest Science, Corvallis, OR 97331, 503-750-7350 (forest-stream interactions)

Jim Sedell, USDA Forest Service Pacific Northwest Station, Forestry Sciences Laboratory, 3200 Jefferson Way, Corvallis, OR 97331, 503-750-7315 (forest-stream interactions, disturbance)

Fred Swanson, USDA Forest Service Pacific Northwest Station, Forestry Sciences Laboratory, 3200 Jefferson Way, Corvallis, OR 97331, 503-750-7355 (forest-stream interactions, geomorphology)

D. Five Recent Publications

Gregory, S.V., F. J. Swanson, A. McKee, and K. W. Cummins. 1991. Ecosystem perspectives of riparian zones. *BioScience* 41:540-551.

Lamberti, G. A., S. V. Gregory, L. R. Ashkenas, R. C. Wildman, and K. M. S. Moore. 1991. Stream ecosystem recovery following a catastrophic debris flow. *Canadian Journal of Fisheries and Aquatic Sciences* 48:196-208.

Moore, K. M. and S. V. Gregory. 1988. Summer habitat utilization and ecology of cutthroat trout fry (*Salmo clarki*) in Cascade Mountain streams. *Canadian Journal of Fisheries and Aquatic Sciences* 45:1921-1930.

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Van Sickle, J. and S. V. Gregory. 1990. Modeling inputs of large woody debris to streams from falling trees. *Canadian Journal of Fisheries and Aquatic Sciences* 20:1593-1601.

II. PHYSICAL CHARACTERISTICS

(apply to Mack Creek)

A. General

1. Temperature: maximum, 17°C; minimum, 1°C mean, 8°C

2. Mean annual degree days: 2,300-2,500

3. Watershed area (ha): 660 ha

4. Stream order: third

5. Stream gradient: ~ 10%

6. Elevation range: 2,150-5,275 feet

B. Hydrology

1. Length of record for gaged streams: eight years

2. Mean annual discharge, minimum, maximum: 10 cfs, 1 cfs, 150 cfs (spates 400 cfs)

3. Seasonal pattern: lowest in summer and early fall, highest December-January; rainy season October-March; mean annual precipitation, 100 cm

C. Substrate

1. Major geologic formations: volcanic basalt (andesite)

2. Dominant stream substrate: boulders (>50 cm diameter) and cobble (10-50 cm)

3. Riparian cover over channel: 40-60%, primarily Douglas-fir, western redcedar, western hemlock, some big leaf maple and willow

4. Depth to bedrock: 10-300 cm

5. Woody debris: abundant

6. Retention structures: boulders, woody debris (full-channel debris jams)

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry

Parameter	Mean (Range)	Years of Record	Sampling Frequency
pH	7.2 (6.8-7.5)	8	monthly*
conductivity	25 µmhos (20-40)	8	monthly*
alkalinity	3 mg/L (2-5)	8	monthly*
NH_4	8 µg/L (0-15)	8	monthly*
NO_3	50 µg/L (20-150)	8	monthly*
Total N	75 µg/L (15-200)	8	monthly*
SRP	8 µg/L (5-15)	8	monthly*
Total P	25 µg/L (9-30)	8	monthly*
DOC	0.8 mg/L (0.5-1.5)	8	monthly*
Ca	3 mg/L (2-4)	8	monthly*
SO_4	0.3 mg/L	8	monthly*

**Continuous proportional sampling (flow-weighted) grab samples available 1973-1991*

B. Other cation, anion, or trace element data? Mg, Na, Mn, Cl, Si, Fe

C. Is oxygen ever below saturation? No

IV. BIOLOGICAL CHARACTERISTICS*

A. Kinds of Biological Data Available

Group	Level of Identification	Parameters Measured	Person Working with Group	Reference
algae	genus, species	biomass, production	Stan Gregory	Lyford 1975 Naiman 1980
bacteria	metabolism			Triska et al. 1982
fungi	genus			Triska et al. 1982
meiofauna	family	density	Kelly Moore	Moore 1987
macro-invertebrates	genus, species	density, biomass, production, emergence	Norm Anderson Randy Wildman Chuck Hawkins	Hawkins 1981
fish	species	density, biomass, production	Jim Hall Stan Gregory	Murphy et al. 1981, Murphy 1981, Lamberti et al. 1991
other vertebrates	species	density, biomass, production	Chuck Hawkins Mike Murphy	Murphy 1981

**See (Swanson, et al.1982) and (Triska et al. 1982) for overview information.*

B. Standing Crop: mean (range)

Chlorophyll: 30 mg Chl *a*/m^2 (10-50 mg Chl *a*/m^2)
Detritus: 630 g AFDM/m^2 (87-1706); CPOM (400 g AFDM/m^2) and FPOM (230 g AFDM/m^2); woody debris (>10 cm diameter) 26 kg AFDM/m^2
Meiofauna: Harpacticoid numbers available in Kelly Moore's thesis(Moore 1987)
Macroinvertebrates: 1,500-5,500 individuals/m^2, 900 mg/m^2 (Hawkins et al. 1982)
Fish: 6g/m^2 (3-15 g/m^2)

C. Rate Measurements

1. Primary production
Method and frequency: Chambers - Gran titrations and O_2
Mean (range): 40 mg C/m^2/d (5-90 mg C/m^2/d) monthly; 0.4g O_2/m^2/d (0.2-0.6g O_2/m^2/d) seasonally

2. Respiration
Method and frequency: Chambers - Gran titrations and O_2
Mean (range): 50mg C/m^2/d (5-90 mg C/m^2/d monthly) 0.3g O_2/m^2/d (0.2-0.45g O_2/m^2/d seasonally)

3. Litter input
Litterfall: mean (range); 300 g/m^2/yr (100 cleared - 500 deciduous); 500 g AFDW/m^2/yr woody debris
Lateral movement: mean (range); 480 g/m^2/yr (375-600 g/m^2/yr)

4. Leaf decomposition

Species	K(day^{-1})	Reference*
Douglas-fir	- 0.0061	
red alder	- 0.0200	
vine maple	- 0.0135	
bigleaf maple	- 0.0064	
devil's club	- 0.0960	

**Webster and Benfield 1986*

5. Measures of nutrient uptake
Gregory, Lamberti, D'Angelo—short-term releases, long-term enrichment pending

6. Stable isotope analyses
Gregory—$N^{14/15}$ and $C^{12/13}$ ratios of organisms from different trophic levels, comparison with Luquillo, Konza, Arctic and Andrews, Woods Hole workshop

V. ADDITIONAL REFERENCES CITED

Hawkins, C. P. and J. R. Sedell. 1981. Longitudinal and seasonal changes in functional organization of macroinvertebrate communities in four Oregon streams. *Ecology* 62(2):387-397.

Hawkins, C. P., M. L. Murphy, and N. H. Anderson. 1982. Effects of canopy substrate composition, and gradient on the structure of macroinvertebrate communities in Cascade Range streams of Oregon. *Ecology* 63:1840-1856.

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Lyford, J. H., Jr. and S. V. Gregory. 1975. The dynamics and structure of periphyton communities in three Cascade Mountain streams. *Verh. Internat. Verein. Limnol.* 19:1610-1616.

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Murphy, M. L. and J. D. Hall. 1981. Varied effects of clear-cut logging on predators and their habitats in small streams of the Cascade Mountains, Oregon. *Canadian Journal of Fisheries and Aquatic Sciences* 38:137-145.

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Webster, J. R. and E. F. Benfield. 1986. Vascular plant breakdown in freshwater ecosystems. *Annual Rev. Ecol. Syst.* 17: 567-594.

ARCTIC TUNDRA

I. GENERAL DESCRIPTION

A. Conceptual Framework

Human activity (via addition of sewage effluent and industrial waste, forest cutting, agriculture or development) can change the nutrient and organic matter fluxes of a river ecosystem and, as such, affect many aspects of the way a river ecosystem functions. The objective of Arctic Tundra LTER stream research is to develop a body of knowledge useful for: (1) understanding the impacts of nutrient additions from any source on a river ecosystem; (2) predicting the relative importance of "bottom-up" (via nutrient or other resource supply) versus "top-down" (via predation) controls of river ecosystem function; and (3) managing or manipulating rivers for either aesthetic values or for substance and recreational fisheries. Tests have been conducted to determine the importance of nutrient limitation in regulating productivity and energy flow in a pristine Alaska tundra stream, the Kuparuk River, through whole-river fertilization, adding phosphorus in the years 1983 through 1990, and nitrogen in 1986 and 1989. During those years research tasks on the stream have included baseline monitoring of climate, stream flow, chemistry, and biotic interactions, as well as experimental studies of the controls of ecosystem structure and function by resource limitations and by higher trophic levels. Arctic researchers have intensively studied nutrients, decomposition, heterotrophy, primary production, secondary production and fish production in the river.

Future research will focus on several areas. Studies on the Kuparuk River will continue to examine long-term changes in response to fertilization. In 1991, observations of the patterns of biotic responses to fertilization in a second river, Oksrukuyik Creek, were begun to determine whether the pattern of responses to phosphorus addition found for the Kuparuk are specific to that ecosystem or will hold for other rivers as well. Studies of the patterns of recovery from long-term fertilization are scheduled for both rivers, as well as experimental manipulations of vertebrate and invertebrate predators, and other studies of the stream foodwebs. Monitoring of the natural climatic, physical, chemical and biological patterns of the streams and surrounding areas will continue. Lastly, future research will incorporate ecosystem studies and modeling of land-water interactions for these Arctic watersheds.

Aufeis on the Kuparuk River in July. This ice forms where water from underground aquifers seeps to the surface during the winter. (Photograph by Bruce J. Peterson)

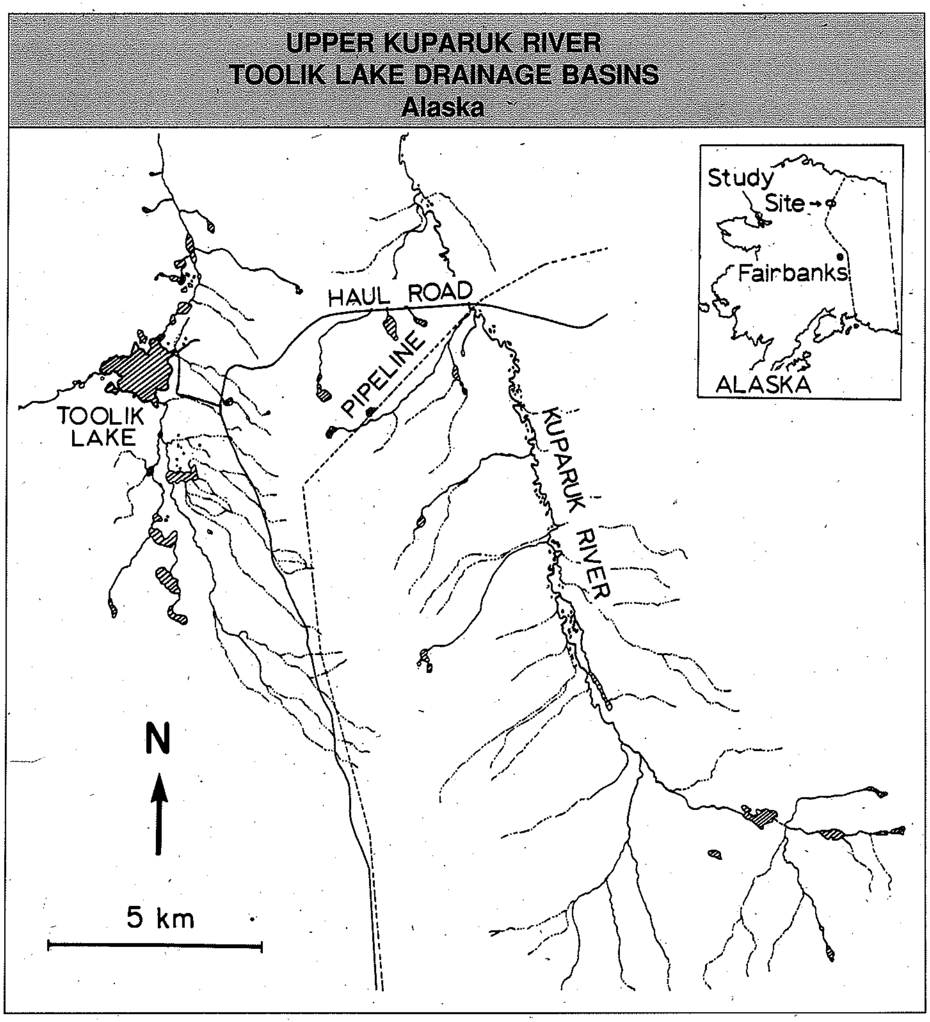
B. Site Description

The Kuparuk River arises in the foothills of the Brooks Range and flows north, draining a large area of the North Slope of Alaska. Only the upper 25 km have been studied by the LTER research group. It is a clear water tundra stream, frozen solid from late September until late May. Discharge at the Dalton Highway crossing has ranged from 0.24 to >30 m^3/sec, and is moderately variable. Nutrients, especially phosphorus, are low, and dissolved organic carbon is high. Most of the carbon in the stream comes from eroding peat or dissolved organic carbon leaching from the tundra.

The primary producers are mostly diatoms, filamentous algae and moss on rocks. Insects are dominated by black flies, a mayfly, chironomids, and a caddisfly. There is one fish species, the arctic grayling (*Thymallus arcticus*), and the entire population migrates to a lake in the headwaters each winter.

The vegetation of the upper Kuparuk drainage consists of alpine communities at the higher elevations and moist tundra communities (predominantly the cotton grass *Eriophorum vaginatum)* in the foothills. Along the stream banks there are patches of dwarf willows and birches, some reaching 1 m in height. The upper layers of the soil of the basin are 30 to 70 cm of peat, underlain by alluvial and glacial deposits consisting of coarse sand and gravel. Permafrost is present throughout the area.

Oksrukuyik Creek, like the Kuparuk, is a clear-water meandering tundra stream (third order). It also has a similar set of dominant insect and fish species. There are, however, some overall differences between the two rivers. Oksrukuyik Creek has a discharge about half as great as that of the Kuparuk, and drains a watershed dominated



by lakes rather than stream channels. Consequently, the variation in discharge is damped and water quality modified by lake passage. Large particulate organic matter (POM) in Oksrukuyik Creek is dominated by grass and detritus from current terrestrial and aquatic production rather than by old peat, as in the Kuparuk. Oksrukuyik Creek pools contain fine sediments and are carpeted by macrophytes, whereas pools in the study reach of the Kuparuk are completely paved with rock.

Phosphorus has been added to the Kuparuk River at a station located upstream from the Dalton Highway every year since 1983, as part of an ongoing whole-river fertilization study. Ammonium was also added to the river in 1986 and 1989. Whole-river fertilization of Oksrukuyik Creek, also with phosphorus, began in 1991.

C. For Further Information

1. Contact person(s): Bruce Peterson, Marine Biological Laboratory (MBL), Ecosystems Center, Woods Hole, MA 02543, 508-548-3705, ext. 484, *bPeterson@LTERnet.edu* (Internet)

   Deborah Repert, MBL, Ecosystems Center, 508-548-3705, ext. 479, *dRepert@LTERnet.edu* (Internet)

2. Topographic map(s): Phillip Smith Mountains Quadrangles (15-minute quad) C - 4, C - 5, D - 4

3. Stream researchers at site:

   W. Breck Bowden, Department of Forest Resources, University of New Hampshire, Durham, NH 03824, 603-862-1020 (nitrogen, hydrology)

   Linda Deegan, MBL, Ecosystems Center, Woods Hole, MA 02543, 508-548-3705 (fish production)

   Anne Hershey, Department of Biological Sciences, University of Minnesota-Duluth, Duluth, MN 55812, 218-726-820 (biotic interactions)

   John Hobbie, MBL, Ecosystems Center, Woods Hole, MA 02543, 508-548-3705 (microbial processing)

George Kling, Department of Biology, University of Michigan, Ann Arbor, MI 48109-1048, 313-747-0894 (biogeochemistry)

Michael Miller, Department of Biological Science, University of Cincinnati, Cincinnati, OH 45221, 513-556-9751 (nutrients, primary production)

Bruce Peterson (biogeochemistry, carbon/nitrogen/phosphorus cycling)

Deborah Repert (nutrient chemistry, chlorophyll, discharge)

D. Five Recent Publications

Hershey, A. E. and A. L. Hiltner. 1988. Effects of caddisfly activity on black fly density: interspecific interactions outweigh food limitation. *Journal of the North American Benthological Society* 7(3):188-196.

Miller, M. C. and J. R. Stout. 1989. Variability of macroinvertebrate community composition in an arctic and subarctic stream. *Hydrobiologia* 172:111-127.

Peterson, B. J., L. Deegan, J. Helfrich, J. E. Hobbie, M. Hullar, B. Moller, T. E. Ford, A. Hershey, A. Hiltner, G. Kipphut, M. A. Lock, D. M. Fiebig, V. McKinley, M. C. Miller, J. R. Vestal, R. Ventullo, and G. Volk. 1993. Biological responses of a tundra river to fertilization. *Ecology* 74:653-672.

Peterson, B. J., J. E. Hobbie, A. E. Hershey, M. A. Lock, T. E. Ford, J. R. Vestal, V. L. McKinley, M. A. J. Hullar, M. C. Miller, R. M. Ventullo and G. S. Volk. 1985. Transformation of a tundra river from heterotrophy to autotrophy by addition of phosphorus. *Science* 229:1383-1386.

Peterson, B. J., J. E. Hobbie and T. L. Corliss. 1986. Carbon flow in a tundra stream ecosystem. *Canadian Journal of Fisheries and Aquatic Sciences* 43(6):1259-1270.

II. PHYSICAL CHARACTERISTICS

(Kuparuk River unless otherwise noted)

A. General

1. Temperature: range, 0-20°C; mean, 8-10°C water temperatures during summer field season (~15 June - 20 August)

2. Mean annual degree days: N/A

3. Watershed area (ha): entire Kuparuk River watershed = 8,107 km^2; study area watershed = 143 km^2

4. Stream order: Kuparuk (at fertilization site), fourth; Oksrukuyik Creek, third

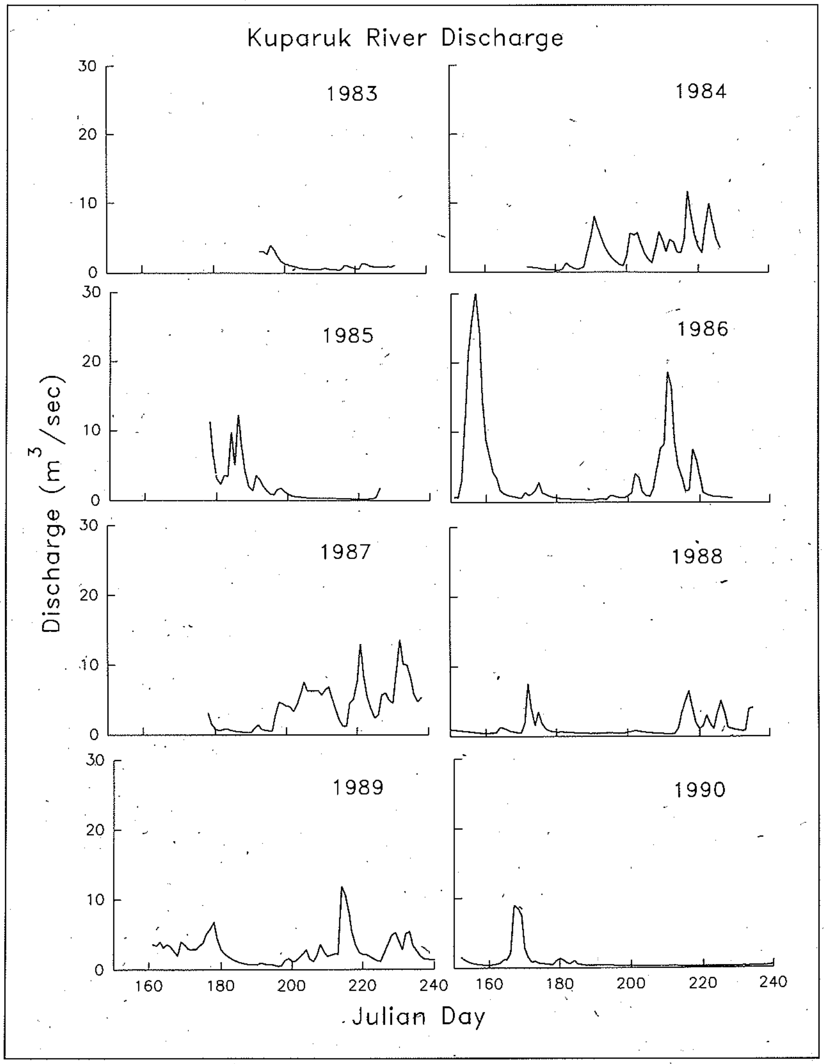
5. Stream gradient: 3.13% over study reach of 25 km

6. Mean elevation: 842 m

B. Hydrology

1. Length of record for gaged streams: Kuparuk, nine years (1983-92); Oksrukuyik Creek, four years (1988-92)

2. Mean annual discharge, minimum, maximum: Kuparuk, 2.8 x 10^3 L/sec (min = 0.1 x 10^3; max = 30 x 10^3) Oksrukuyik Creek, approximately half Kuparuk discharge



Kuparuk River discharge 1983-1990.

3. Seasonal pattern: Both rivers begin flow in mid- to late May with normally high discharge due to snowmelt and spring break-up. Summer discharge patterns are moderately variable, depending on summer precipitation. Flow nearly ceases due to freeze-up by late September, and riffles become dry. Pools freeze solid in October. Flow resumes with snowmelt in May. Oksrukuyik Creek drains a watershed dominated by lakes, so discharge variations seem to be somewhat buffered; whereas, the Kuparuk River watershed is dominated by stream channels and shows greater response to the summer rainfall patterns.

C. Substrate

1. Major geologic formations: morainal material composed mostly of Devonian conglomerates of the Chandalar formation and Cretaceous sandstones; area mostly underlain by permafrost

2. Dominant stream substrate: alluvial and glacial deposits of coarse gravel and rock; little silt accumulation

3. Riparian cover over channel: little to no riparian cover, mainly composed of dwarf willows and birch < 1 m tall

4. Depth to permafrost: 10-100 cm (permafrost may extend to 800 m)

5. Woody debris: abundant peat but no wood

6. Retention structures: stones and peat masses broken off by bank erosion and bound together by roots

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry

(summer values for Kuparuk River)

Parameter	Mean (Range)	Years of Record	Sampling Frequency
pH	7.2 (7.0-7.3)	12	weekly
conductivity	19 µmhos	12	weekly
alkalinity	200 µM	12	weekly
NH_4	3 µg N/L (0 - 5)*	9	weekly
NO_3	30 µg N/L (3 - 112)*	9	weekly
TDN	~300 µg N/L (190-450)	1	weekly
SRP	1.5 µg P/L (0 - 3)*	9	weekly
TDP	~9 µg P/L (1.5-16.8)	1	weekly
DOC	~6 mg/L (3-15 mg/L)	3	weekly
Ca	95µM	4	weekly
SO_4	38µM	4	weekly

**Values reflect N, P addition beginning in 1983; in the control reach SRP ranges from ND-3 µg P/L, nitrate ranges from 7-70 µg N/L and ammonium ranges from 1-3 µg N/L.*

B. Other cation, anion, or trace element data? Ca, Na, K, Mg, Mn, SO_4, Cl; approximately for years 1988-1992, although samples are still being processed.

C Is oxygen ever below saturation? No

IV. BIOLOGICAL CHARACTERISTICS

A. Kinds of Biological Data Available

Group	Level of Identification	Parameters Measured	Person Working with Group	Footnote*
algae	species	biomass, production	Peterson, Miller, Bowden	1
bacteria	counts	biomass, production	Hobbie	2
macro-invertebrates	species	density, biomass, production	Hershey	3
fish	species		Deegan, Peterson	4

*1. *also nitrogen cycling*
2. *scheduled again for 1991 research*
3. *also drift studies*
4. *studies of both adults and larval grayling*

B. Standing Crop: mean (range)

Chlorophyll (epilithic): control reach: 3 μg Chl/cm^2 (1-5 μg Chl/cm^2)
Detritus: 60 g AFDM/m^2; benthic CPOM 28 g AFDM/m^2; benthic FPOM 8 g AFDM/m^2; suspended POM 0.4 g AFDM/m^2; peat 20 g AFDM/m^2
Macrophytes: few in Kuparuk River, present in Oksrukuyik Creek
Macroinvertebrates: 6-19 g/m^2 (dry weight)
Fish: two to five adult grayling per pool (~100 adults/km river)

C. Rate Measurements

1. Primary production
Method and frequency: epilithic algae rocks placed in flow-through chambers; measured three to four times/summer in pools and riffles in control and fertilized reaches
Mean (range): 15.7 mg $O_2m^{-2}h^{-1}$ (control zone), (5-28 mg $O_2m^{-2}h^{-1}$)

2. Respiration
Method and frequency: O_2 consumption of epilithic algae placed in flow-through respiration chambers; measured three to four times per summer in pools and riffles in control and fertilized reaches
Mean (range): 14.7 mg $O_2m^{-2}h^{-1}$ (control zone), (5-62 mg $O_2m^{-2}h^{-1}$)

3. Litter input
Lateral input of C from the tundra is mostly in the form of peat (bank erosion), as there is little movement of litter from the tundra surface.

4. Leaf decomposition

Species	K(day^{-1})
Betula nana	0.039 pool 0.123 riffle
Carex aquatilus	0.030 pool 0.033 riffle
Salix sp.	0.029 pool 0.045 riffle
Eriophorum vaginatum	0.043 pool 0.120 riffle
Peat	0.007 pool

5. Measures of nutrient uptake: W. B. Bowden is measuring N uptake of epilithic algae on river rocks placed in flow-through respiration chambers; calculations are of change in concentration of the nutrient; samples are from pools and riffles in both control and fertilized zones.

6. Stable isotope analyses: Bruce Peterson and George Kling—C and N isotopes on all trophic levels from both rivers

BONANZA CREEK EXPERIMENTAL FOREST

I. GENERAL DESCRIPTION

A. Conceptual Framework

Over a decade ago, several University of Alaska faculty members outlined a long-term study of an exemplary headwater stream (Monument Creek), typical of small streams draining interior Alaska taiga forests. The strategy was to use low-level funding from state management agencies and the University, augmented by intermittent large-scale funding from major granting agencies, to address taxonomic and functional group structure of the invertebrate community, life histories of major insect taxa, primary producer community structure and productivity, detrital ecology (including litter input and decay dynamics), and winter ecology (including detailed information on winter thermal conditions). Most of these goals have been met, although we have little or no information in some areas (notably chironomid taxonomic structure and ecology, primary and secondary production, and water chemistry). Recently, Monument Creek has been the study site for the stream ecology portion of the LTER project. The Bonanza Creek study site (home of all of the terrestrial field work) has no suitable streams; Monument Creek is used as an auxiliary site.

B. Site Description

Monument Creek is a second-order stream (based upon U. S. Geological Survey 1: 63,360 maps) in the Chena River drainage system, near Fairbanks, Alaska. The Chena River is a tributary of the Tanana River which, in turn, enters the Yukon River. Monument Creek is a small (about 16 m wide, 1.5 m^3/s baseflow discharge) stream with substrates ranging from sand to large cobbles. Riparian vegetation is a dense growth of alder and willow shrubs, and scattered birch and poplar with conifers (spruce). The water temperature regime is rigorous, with approximately seven to eight months of ice cover and annual degree days <1,000. Annual input of leaf litter is very low, but rates of litter decomposition compare favorably to streams in

Monument Creek at Chena Hot Springs, near Fairbanks, Alaska. (Photograph by Mark W. Oswood)

temperate regions. Like most high-latitude streams, the invertebrate fauna is dominated by Diptera (especially Chironomidae) and Plecoptera (especially Nemouridae) while other major taxa (e.g., Ephemeroptera and Trichoptera) are at lower relative abundance compared to temperate streams. The two major fish species in small tributaries of the Chena River (such as Monument Creek) are the arctic grayling (*Thymallus arcticus*) and slimy sculpin (*Cottus cognatus*). Round whitefish (*Prosopium cylindraceum*), longnose sucker (*Catostomus catostomus*) and chinook salmon (*Onchorhynchus tshawytscha*) also occur.

C. For Further Information

1. Contact person: Mark W. Oswood, Department of Biology & Wildlife, University of Alaska, Fairbanks, AK 99775-5500, 907-474-7972, *FFMWO@ALASKA* (Bitnet), *mOswood@LTERnet.edu* (Internet)

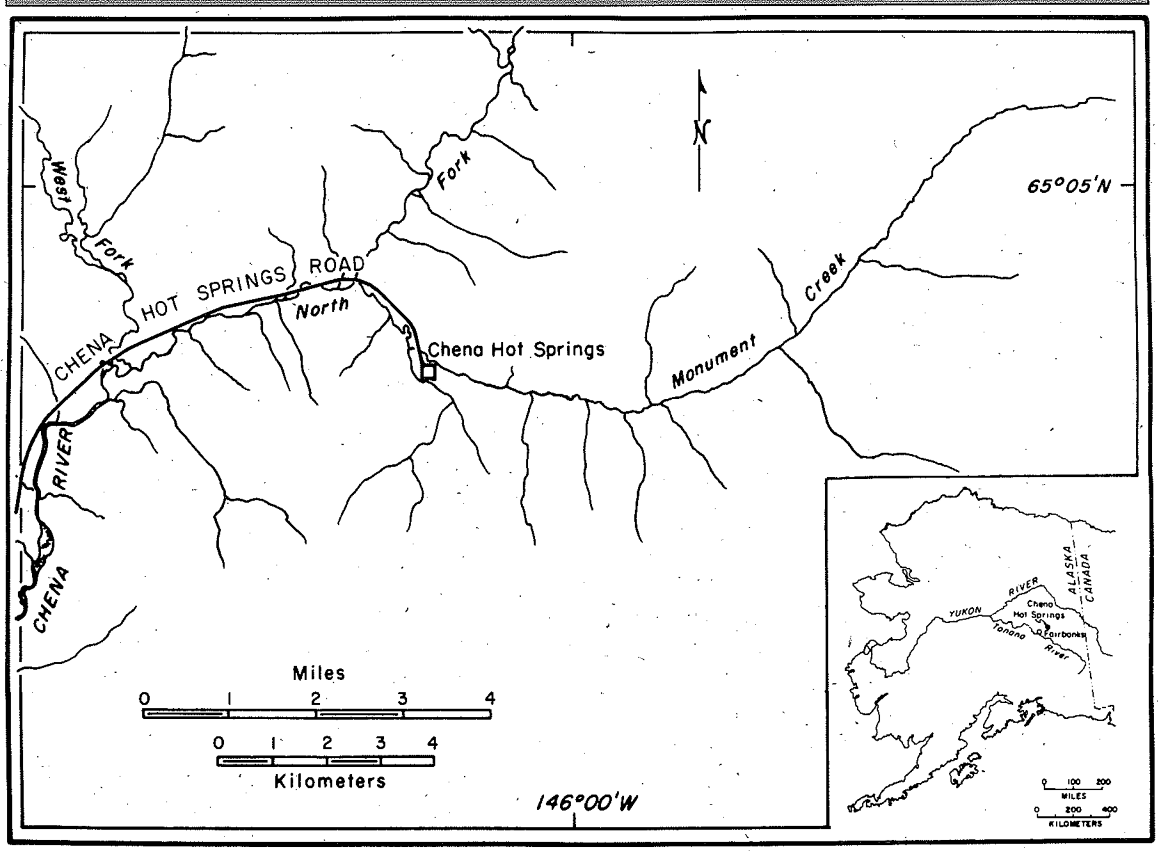
2. Topographic map(s) (7 1/2-minute quad): N/A

3. Stream researchers at site:

   J. G. Irons III, Institute of Northern Forestry, 308 Tanana Drive, Fairbanks, AK 99775-5500, 907-474-3326 (freshwater ecology, biogeochemistry)

   Mark W. Oswood (invertebrates)

UPPER CHENA RIVER DRAINAGE
Monument Creek Study Site, Chena Hot Springs, Alaska



D. Five Recent Publications

Irons, J. G. III, J. P. Bryant and M. W. Oswood. 1991. Effects of moose browsing on decomposition rates of birch litter in a subarctic stream. *Canadian Journal of Fisheries and Aquatic Sciences* 48:442-444.

Irons, J. G. III, M. W. Oswood and J. P. Bryant. 1988. Consumption of leaf litter by a stream shredder: influence of tree species and nutrient status. *Hydrobiologia* 160:53-61.

Irons, J. G. III, S. R. Ray, L. K. Miller and M. W. Oswood. 1989. Spatial and seasonal patterns of streambed water temperatures in an Alaskan subarctic stream. Pages 381-390 *in*: W. W. Woessner and D. F. Potts (eds.): Proceedings, Symposium on Headwaters Hydrology, American Water Resources Association.

LaPerriere, J. D., E. E. Van Nieuwenhuyse and P. A. Anderson. 1989. Benthic algal biomass and production in high subarctic streams, Alaska. *Hydrobiologia* 172:63-75. (Reprinted *in* W. F. Vincent and J. C. Ellis-Evans, eds. *High Latitude Limnology*. Kluwer Academic Publishers).

Oswood, M. W., L. K. Miller and J. G. Irons III. 1991. Overwintering of freshwater benthic invertebrates. Pages 360-375 *in*: R. E. Lee Jr. and D. L. Denlinger (eds.). *Insects at Low Temperatures*. Chapman and Hall.

II. PHYSICAL CHARACTERISTICS

A. General

1. Temperature: maximum, 13.0°C; minimum, < 0°C (frozen through substrate in patches); mean, 2.3°C
2. Mean annual degree days: 950
3. Watershed area (ha): 7,500 ha
4. Stream order: second
5. Stream gradient: 0.012 (at major research site)
6. Elevation: 480 m (at major research site)

B. Hydrology

1. Length of record for gaged streams: no streams gaged

2. Discharge: range of spot measurements, 0.34 - 3.65 $m^3 s^{-1}$

3. Seasonal pattern: high flows predictably occur at spring breakup (April - May). Summer flows are moderate with occasional extreme flows associated with storms. Low flows occur beneath winter ice cover (≈ October - April).

C. Substrate

1. Major geologic formations: N/A

2. Dominant stream substrate: gravel (ranges from sand-silt to large cobble)

3. Riparian cover over channel: 10-25%

4. Depth to bedrock: >1 m

5. Woody debris: rare

6. Retention structures: occasional woody debris, occasional large cobble, pools

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry

Parameter	Mean (Range)	Years of Record	Sampling Frequency
conductivity	86 (33-50)µmhos	1	monthly/ bimonthly
alkalinity	36 ± 5 mg/L^{-1} $CaCO_3$	1	(ice-free season) monthly
Total P	3.6 ± 1.1 mg m^{-3}	1	monthly

B. Other cation, anion, or trace element data? None

C. Is oxygen ever below saturation? Probably not, but we do not have continuous DO records beneath winter ice cover.

IV. BIOLOGICAL CHARACTERISTICS

A. Kinds of Biological Data Available

Group	Level of Identification	Parameters Measured	Person Working with Group	Reference
algae	mostly species, some genus	density, biomass	P. R. Anderson	Anderson 1984
bacteria	microbial respiration		C. A. Buttimore	Buttimore 1983
fungi	microbial respiration, biomass		C. A. Buttimore	Buttimore 1983
macro-invertebrates	mostly genus	density, biomass	Oswood, Irons, Howe	Howe 1981, Irons 1985, Irons1988
fish	species			Sonnichsen 1981

B. Standing Crop: mean (range)
Chlorophyll: 0.204 μg m^{-2} (0.053 - 0.355)
Detritus: Total benthic POM 20.4 g AFDM/m^2 (9.7 - 38.1); CPOM 8.1 g AFDM/m^2; MPOM 7.7 g AFDM/m^2; SPOM 4.5 g AFDM/m^2 (Cowan and Oswood 1983)
Bacteria: microbial respiration, SEM
Fungi: microbial respiration, SEM

C. Rate Measurements:

1. Primary production
   Method and frequency: diel O_2 curve (two times)
   Mean (range): 0.2 (May), 0.5 (October) g O_2 m^{-2} d^{-1}

2. Respiration: N/A

3. Litter input
   Litterfall: mean (range); 62.5 g AFDW/m^2/yr
   Blow-in: mean (range); most as direct litter input to stream surface (Cowan and Oswood 1983)

4. Leaf decomposition

Species	K(day^{-1})	Reference
birch	0.0080	Cowan et al. 1983
willow	0.0063	Cowan et al. 1983
alder	0.0513	Cowan et al. 1983

5. Measures of nutrient uptake: none

6. Stable isotope analyses: none

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Howe, A. L. 1981. Life histories and community structure of Ephemeroptera and Plecoptera in two Alaskan subarctic streams. M. S. Thesis, University of Alaska, Fairbanks, AK.

Irons, J. G., III. 1985. The life histories and community structure of the caddisflies (Trichoptera) of two Alaskan subarctic streams. M. S. Thesis. University of Alaska, Fairbanks, AK.

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COWEETA HYDROLOGIC LABORATORY

I. GENERAL DESCRIPTION

A. Conceptual Framework

Research on stream ecosystems began in the late 1960s at Coweeta Hydrologic Laboratory, expanding the hydrologic data that had been collected since the 1930s. During the 1980, stream research focused on: (1) effects of disturbance (clearcutting, drought, and invertebrate removal) on ecosystem structure and function, (2) recovery from disturbance, and (3) the influence of local geomorphology on structural and functional characteristics of streams, including a long-term experiment involving the addition of debris dams to a stream. Sites for this research were generally first- and second-order streams draining catchments less than 75 ha. In our current and future research, we are expanding the spatial scale to encompass first- through fifth-order streams in the entire Coweeta Basin. We will be addressing changes in stream ecosystem structure and function (nutrient chemistry, detritus dynamics, primary productivity, macroinvertebrate and fish communities) influenced by changes in geomorphology and frequency of different substrate patch types along this 5-km longitudinal and 500-m elevational gradient. A second component of research during the next five years will focus on the riparian zone, which is dominated by rhododendron. We will study nutrient flux through this zone and will begin a rhododendron removal experiment, one part of which will be to determine the impacts of rhododendron removal on the stream ecosystem.

B. Site Description

Most of the 73 km of streams draining the Coweeta Basin are first- and second-order streams. Those that drain undisturbed catchments are heavily shaded by the surrounding deciduous forest composed primarily of several species of oak (*Quercus*), tulip poplar, red maple, and hickory. Rhododendron is extremely dense along most stream margins, so that streams remain heavily shaded throughout the year. A range of anthropogenic disturbance regimes can be found in the 16 currently gaged catchments in the Coweeta Basin: naturally regenerating clearcuts of different ages and clearcutting regimes, selective cuts, white pine plantations, agriculture followed by poplar/pine plantation, and catchments partially defoliated by fall cankerworm in the 1970s.

***Left:** A second-order section of Ball Creek.* ***Right:** A site on Coweeta Creek, just below the confluence of Ball Creek and Shope Fork. (Photographs by Judy L. Meyer.)*

The base of the stream foodweb at Coweeta is leaf litter with minor inputs from autochthonous production. Autochthonous inputs increase after disturbances which allow more light to penetrate to the stream channel. The aquatic insect community is very diverse. Common shredders include *Peltoperla*, *Lepidostoma*, and *Tipula*, and crayfish (*Cambarus*) are also present. Filtering collectors such as *Diplectrona*, *Parapsyche*, and *Arctopsyche* are abundant on rock faces. Chironomids dominate the collector-gatherer community. The meiofauna is composed primarily of copepods and nematodes. Algal feeders in well-lit sites include *Baetis* and *Glossosoma*. Invertebrate predators include stoneflies and dragonflies. The first-order streams do not have fish, and vertebrate predators are larval salamanders. The fishes present in larger streams include *Cottus bairdi*, *Rhinichthys cataractae*, *Clinostomus funduloides*, and *Salmo gairdneri*.

C. For Further Information

1. Contact person: Judy Meyer, Institute of Ecology, University of Georgia, Athens, GA 30602, 706-542-3363, 706-542-4271(Fax), *jMeyer@LTERnet.edu, meyer@zookeeper.zoo.uga.edu* (Internet)

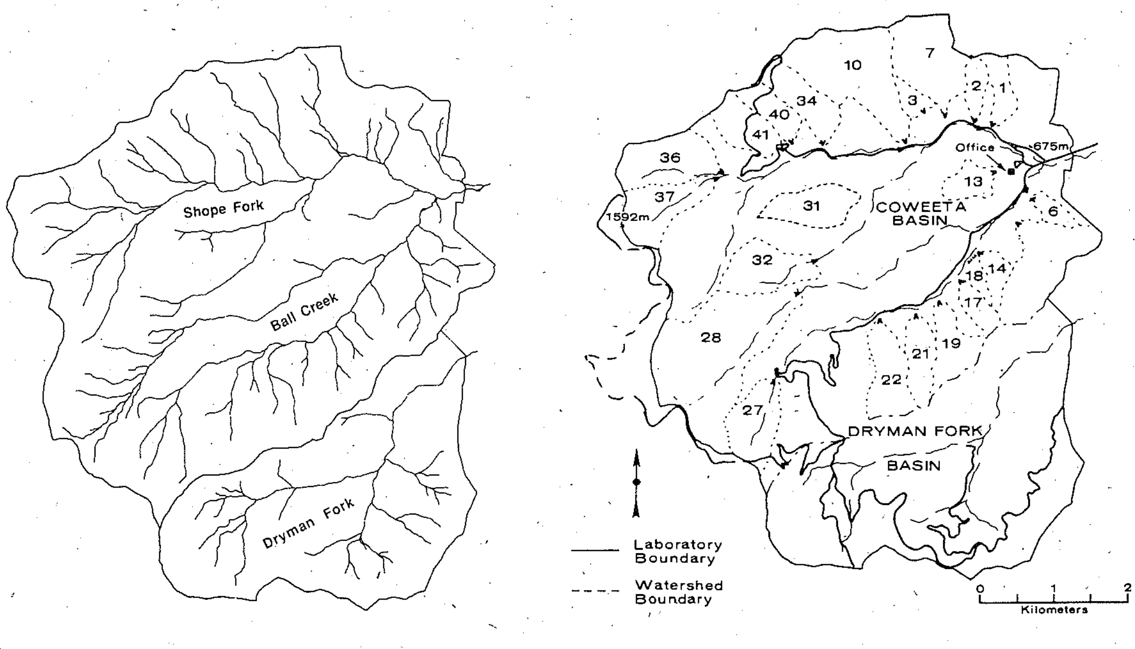
2. Topographic map: Coweeta Hydrologic Laboratory, 1:7200, USDA Forest Service

3. Stream researchers at site:

   E. Fred Benfield, Department of Biology, Virginia Tech, Blacksburg, VA 24061, 703-231-5802 (primary producers, macroinvertebrates, leaf decay)

   Gary Grossman, School of Forest Resources, University of Georgia, Athens, GA 30602, 706-542-1160 (fish)

COWEETA HYDROLOGIC LABORATORY
North Carolina



Judy Meyer (microbes, meiofauna, DOC, nutrient and organic matter dynamics)

J. Bruce Wallace, Department of Entomology, University of Georgia, Athens, GA 30602, 706-542-7886 (macroinvertebrates, leaf decay, organic matter and nutrient transport)

Jackson R. Webster, Department of Biology, Virginia Tech, Blacksburg, VA 24061, 703-231-8941 (organic matter/nutrient dynamics, modeling)

D. Five Recent Publications

Cuffney, T. F., J. B. Wallace, and G. J. Lugthart. 1990. Experimental evidence quantifying the role of benthic invertebrates in organic matter dynamics of headwater streams. *Freshwater Biology* 23:281-299.

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A recent review of Coweeta stream research can be found in Webster, J. R., S. W. Golladay, E. F. Benfield, J. L. Meyer, W. T. Swank and J. B. Wallace. 1992. Catchment disturbance and stream response: An overview of stream research at Coweeta Hydrologic Laboratory. Pages 231-253 *in*: P. J. Boon, P. Calow and G. E. Petts (eds.). *The Conservation and Management of Rivers.* John Wiley and Sons, New York, NY.

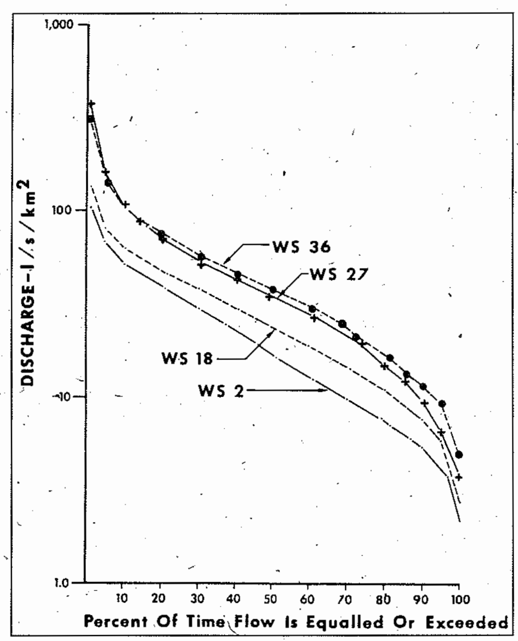
II. PHYSICAL CHARACTERISTICS

A. General

1. Temperature: maximum 19°C; minimum 1°C; mean 13°C (first-order stream)
2. Mean annual degree days: 3,400-4,600
3. Watershed area (ha): gaged catchments range from <10 to 760 ha
4. Stream order: first through fifth
5. Stream gradient: 15-30 cm/m
6. Elevation: 675-1,220 m

B. Hydrology

1. Length of record for gaged streams: variable, but several 1934-present
2. Mean annual discharge, minimum, maximum: a typical second-order stream—19L/s, 4 L/s, 500 L/s



Flow-frequency for four Coweeta streams.

3. Seasonal pattern: Precipitation is fairly evenly distributed throughout the year, so most streams are perennial. Discharge is usually lowest during August and September and highest February-April, although spates can occur in any season.

C. Substrate

1. Major geologic formations: Coweeta Group, quartz dionite gneiss and muscovite-biotite schist (Hatcher 1988)

2. Dominant stream substrate: rock outcrops, boulders, cobbles and sand/silt; relative frequency of the different substrates changes along the longitudinal gradient

3. Riparian cover over channel: ~ 90%

4. Depth to bedrock: 0-10 cm

5. Woody debris: abundant

6. Retention structures: debris dams, large boulders

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry
(Volume-weighted annual means from seven reference catchments)*

Parameter	Mean (Range)	Years of Record	Sampling Frequency
pH	6.7	18	weekly
alkalinity	‹10 mg $CaCO_3$/L	18	weekly
NO_3	2-18 µg N/L	18	weekly
NH_4	2-4 µg N/L	18	weekly
SRP	1-2 µg P/L	18	weekly
DOC **	0.9 mg/L (0.3-5)	14	weekly
Ca	0.36-0.69 mg/L	18	weekly
SO_4	0.13-0.38 mg S/L	18	weekly

**Data primarily from Swank and Waide 1988, and Meyer and Tate 1983*
***From a single catchment*

B. Other cation, anion, or trace element data? Cl, K, Na, Mg, SiO_2

C. Is oxygen ever below saturation? No

IV. BIOLOGICAL CHARACTERISTICS

A. Kinds of Biological Data Available

Group	Level of Identification	Parameters Measured	Person Working with Group	Reference
algae	order, some species	biomass, production	E. F. Benfield	Webster et al. 1983
bacteria	AO counts	density	J. L. Meyer	Meyer et al. 1988
fungi	hyphal lengths, some species, ergosterol	spores, biomass	J. L. Meyer K. Suberkropp	
meiofauna	genus, often species	density, biomass, production	P. Vila	O'Doherty 1988, Perl-mutter 1988
macro-invertebrates	species	density, biomass, production	J. B. Wallace	Wallace 1988
fish	species	density, biomass, production	G. Grossman	Freeman et al.1988
other	larval salamanders (species)	density, production	G . J. Lugthart	Lugthart 1991

B. Standing Crop: mean (range):
Chlorophyll: 0.022-0.029 µg chlorophyll *a* /cm^2
Detritus: Fine BOM (< 1 mm) 147 - 166 g AFDM/m^2; coarse BOM (> 1 mm) 213 - 244 g AFDM/m^2; small wood (1 - 5 cm) 300 - 312 g AFDM/m^2; large wood (> 5 cm) 4578 - 5134 g AFDM/m^2; total BOM 5269 - 5825 g AFDM/m^2 (Webster et al. 1990)
Bacteria: 1.6-7.8 x 10^8 cells cm^3 depending on sediment OM content (Meyer 1988)
Meiofauna: in leaves 0-20,000 animals/m^2; in sediments, 7,000 - 38,000/m^2 (O'Doherty 1988)
Macroinvertebrates: 0.6-2.8 g AFDM/m^2 depending on catchment type
Fish: production at three fourth- and fifth-order sites = 200-375 g wet wt/30 m stream (Freeman et al. 1988)

C. Rate Measurements

1. Primary production
Method and frequency: ^{14}C over one year in one stream, but in future will be measured at four sites using 0_2 changes in recirculating chambers.
Mean (range): 0.01 µg C /cm-^{2}/hr (0 to 0.05) (Webster et al. 1983)

2. Respiration
Method and frequency: O_2 consumption in benthic chambers; bimonthly in one study, but in future seasonally at four sites.
Mean (range): leaf: 0.002 - 0.004 g AFDM g^{-1} AFDM d^{-1}; wood: 0.0002 - 0.0007g AFDM g^{-1} AFDM d^{-1}; sediments: 0.0001 - 0.001 g AFDM g^{-1} AFDM d^{-1} (Cuffney et al. 1990)

3. Litter input
Total: 382 - 626 g m-2 yr^{-1} (Golladay et al. 1989)
Litterfall: mean; 260 g m-2 yr^{-1} (Big Hurricane Branch)
Blow-in: mean, 175 g m-2 yr^{-1} (Big Hurricane Branch)

4. Leaf decomposition

Species	K(day^{-1})	Reference
red maple	- 0.0122	Cuffney et al. 1990
rhododendron	- 0.0044	Cuffney et al. 1990
white oak	- 0.0080	Webster and Waide 1982
dogwood	- 0.0235	Webster and Waide 1982
black locust	- 0.0053	Meyer and Johnson 1983
sweet birch	- 0.0036	Meyer and Johnson 1983

5. Measures of nutrient uptake: see papers by Munn and Meyer 1990 and D'Angelo 1990. Adding nutrients plus a conservative tracer (Cl) and measuring uptake.

6. Stable isotope analysis: a one-summer study of ^{13}C- in a stream foodweb after adding ^{13}C -acetate to stream (R. Hall)

V. ADDITIONAL REFERENCES CITED

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HUBBARD BROOK EXPERIMENTAL FOREST

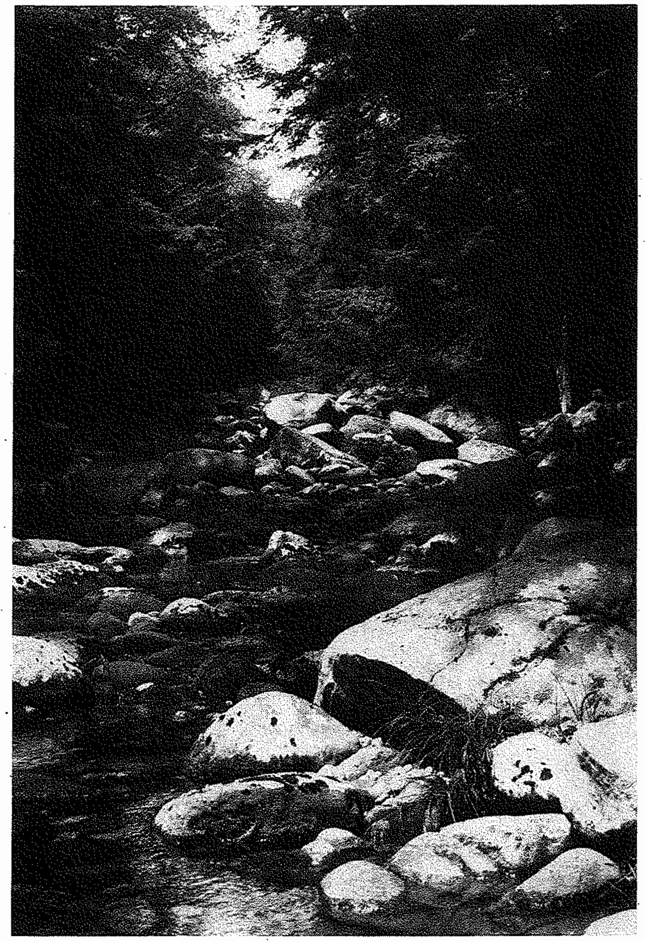
I. GENERAL DESCRIPTION

A. Conceptual Framework

The vast majority of stream research at the Hubbard Brook Experimental Forest has been supported by a series of grants to G. E. Likens and F. H. Bormann. The LTER grant began in 1987. Stream research at Hubbard Brook has used natural variation or anthropogenic manipulations of watersheds to examine the relationships between streams and watersheds. Much of the research has focused on the influence of various forestry practices on stream ecosystems and the effects of changes in precipitation chemistry on watershed material budgets. Manipulations include specific stream experiments such as nutrient addition, acidification and organic matter manipulations. Continued description, documentation and interpretation of long-term trends will undoubtedly be a major part of future work at Hubbard Brook. The LTER component will continue to follow the "recovery" of streams in manipulated watersheds.

B. Site Description

This stream description is applicable to Bear Brook (Watershed 6), a commonly used reference stream at Hubbard Brook. Streams at Hubbard Brook are low in nutrients and buffering capacity. In reference watersheds, streams are completely covered by a high canopy of beech, yellow birch and sugar maple. Woody debris is a common feature. Soils in the watersheds are shallow, and much of the streambed is exposed bedrock. Streamflow is intermittent in the first- and second-order streams, with very low to zero flow during July and August. The biotic community is diverse, with periphyton dominated by diatoms and a wide range of aquatic insects. Biomass and numbers are dominated by chironomids, and mayflies seem to be fairly rare (Burton et al. 1988). The streams are based on allochthonous inputs, but at least some insects rely heavily on what algae are available (Mayer and Likens 1987).



The main branch of the Hubbard Brook, which drains the Hubbard Brook Experimental Forest. (Photograph by G. E. Likens)

C. For Further Information

1. Contact person(s): Stuart Findlay, Institute of Ecosystem Studies (IES), The New York Botanical Garden, Mary Flagler Cary Arboretum, Box AB, Millbrook, NY 12545, 914-677-5343, *CACW@MARIST* (Bitnet)

   Gene Likens, IES, 914-677-5343, *G. Likens* (OMNET)

2. Topographic map(s) (7 1/2-minute quad): Plymouth, NH

3. Stream researchers at site:

Tom Burton, Department of Zoology, Michigan State University, East Lansing, MI 48824, 517-353-4475 (invertebrates, periphyton)

Charles Driscoll, Department of Civil Engineering, Syracuse University, Syracuse, NY 13210, 315-443-3434 (environmental chemistry, modeling, microbial ecology detritus)

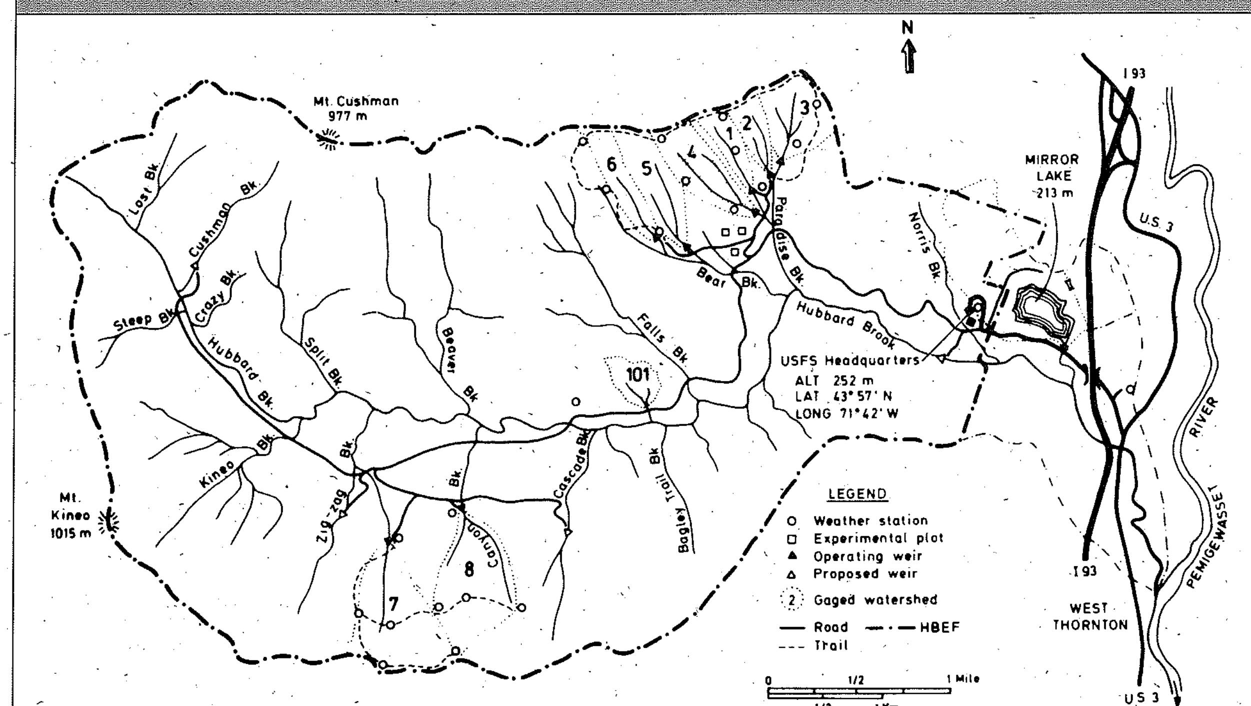
Anthony Federer, USDA Forest Service, Northeastern Forest Experiment Station, Durham NH 03824, 603-868-5576 (hydrology, soils)

Stuart Findlay (stream ecology, microbial ecology, detritus)

Lars Hedin, Kellogg Biological Station, 3700 E. Gull Lake Drive, Hickory Corners, MI 49060, 616-671-2351 (inorganic fluxes)

Gene Likens (aquatic ecology, biogeochemistry, zooplankton)

HUBBARD BROOK EXPERIMENTAL FOREST
West Thornton, New Hampshire



D. Five Recent Publications

Burton, T. et al. 1988. Community dynamics of bacteria, algae, and insects in a first-order stream in New Hampshire, USA. *Verh. Internat. Verein. Limnol.* 23: 1125-1134.

Findlay, S., K. Howe and D. Fontvieille. Bacterial-algal relationships in streams of the Hubbard Brook Experimental Forest. *Ecology* (in press).

Haack, S., et al. 1988. Effects of whole-tree harvest on epilithic bacterial populations in a headwater stream. *Microbial Ecology* 16:165-181.

Hedin, L. 1990. Factors controlling sediment community respiration in woodland stream ecosystems. *Oikos* 57:94-105.

Likens, G. E. 1992. *The Ecosystem Approach: Its Use and Abuse.* Excellence in Ecology, Vol. 3. Ecology Institute, Oldendorf/Luhe, Germany. 167 pp.

II. PHYSICAL CHARACTERISTICS

A. General

1. Temperature (air): maximum, 26°C; minimum, -9°C; mean, 6°C
2. Mean annual degree days: N/A
3. Watershed area (ha): 13.2 ha
4. Stream order: second
5. Stream gradient: 15.8°

B. Hydrology

1. Length of record for gaged streams: up to 35 years
2. Mean annual discharge, minimum, maximum: 3.75 L/s, 0 L/s, 11 L/s
3. Seasonal pattern: maximum in March, April or May, occasionally high flows in October, November; minimum in July-September.

C. Substrate

1. Major geologic formations: glaciated terrain, predominant bedrock types are schist, granite
2. Dominant stream substrate: cobble, rock face, organic debris dams
3. Riparian cover over channel: 100%
4. Depth to bedrock: 0-10 cm
5. Woody debris: common
6. Retention structures: wood

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry

Parameter	Mean (Range)	Years of Record	Sampling Frequency
pH	4.9	17	weekly
alkalinity	<1 mg $CaCO_3$/L	17	weekly
NH_4	0.03 mg NH_4/L	17	weekly
NO_3	1.7 mg NO_3/L	17	weekly
PO_4	0.003 mg PO_4/L	8	weekly
Total P	0.008 (<0.001-0.2>) mg P/L	2	event-based
DOC	2 mg C/L	6	discontinuous
Ca	1.3 mg Ca/L	17	weekly
SO_4	5.9 mg SO_4/L	17	weekly

**Total P data from Meyer and Likens 1979; all other data from Table II B-5 in Likens (ed.) 1985.*

B. Other cation, anion, or trace element data? Base cations, dissolved Si, chloride

C. Is oxygen ever below saturation? No

IV. BIOLOGICAL CHARACTERISTICS

A. Kinds of Biological Data Available

Group	Level of Identification	Parameters Measured	Person Working with Group	Reference
algae	order, some species	biomass, production	Burton & Findlay	
bacteria	density,	biomass, production	Findlay	
fungi	biomass		Findlay	
macro-invertebrates	genus, some species	density, biomass		Burton, Mayer, Hall et al.
fish				Hall et al. 1980
other vertebrates	salamanders	density	Likens	

B. Standing Crop: mean (ranges)
Chlorophyll: 0.5 μg/cm^2 (±0.6, SE)
Detritus: Total benthic 1.1 kg AFDM/m^2; leaves and twigs 0.61 kg; wood (branches) 0.53 kg AFDM/m^2 (Fisher and Likens 1973). These figures probably underestimate organic matter in debris dams.
Macrophytes: see Fisher and Likens 1973
Bacteria: 10^7 cells/cm^2 epilithic
Fungi: 2 μgC/g DW litter
Macroinvertebrates: 300 mg/m^2 Mayer and Likens 1987; about 2 mg/g leaf pack (Burton et al. 1988)

C. Rate Measurements

1. Primary production
Method and frequency: ^{14}C periodically during 1989
Mean (range): 0.01 μgC/cm^2/hr (0 to 0.05)

2. Respiration
Method and frequency: Chambers, Hedin 1990, several streams
Mean (range): 25 to 300 mgC/m^2/d

3. Litter input
Litterfall: mean (range) 350 g DW/m^2/yr, Fisher and Likens 1973
Blow-in: mean (range) 100 g DW/m^2/yr, Fisher and Likens 1973

4. Leaf decomposition

Species	K(day^{-1})	Reference
mixed (sugar maple, yellow birch, beech)	0.0015 to 0.0025 depending on location in stream	Meyer 1980

5. Measures of nutrient uptake: In the late 1970s, PO_4, NH_4, NO_3, and Cl added to stream and uptake measured (Meyer 1979 and Richey et al. 1985)

6. Stable isotope analyses: none

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Meyer, J. L. and G. E. Likens. 1979. Transport and transformation of phosphorus in a forest stream ecosystem. *Ecology* 60:1255-1269.

Richey, J. S., W. H. McDowell, and G. E. Likens. 1985. Nitrogen transformations in a small mountain stream. *Hydrobiologia* 124:129-139.

A complete list of Hubbard Brook publications is available from Phyllis Likens at the Institute of Ecosystem Studies, Box AB, Millbrook, New York 12545.

KONZA PRAIRIE

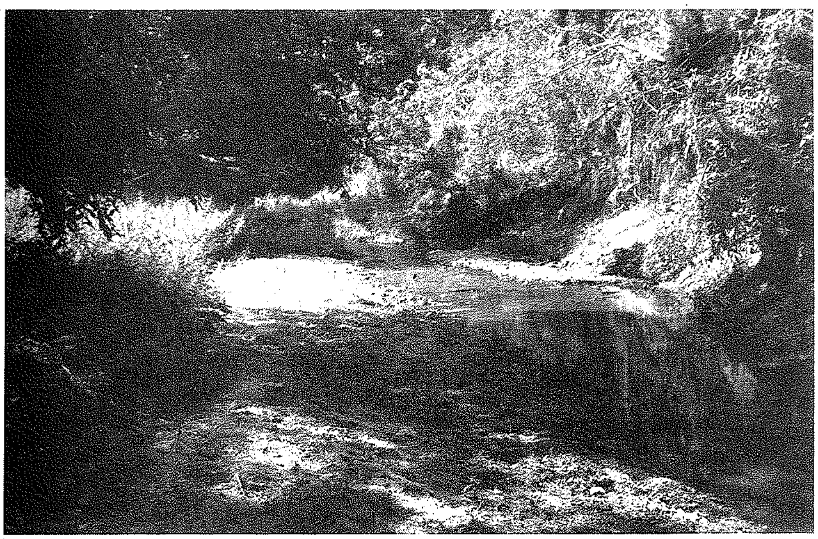
I. GENERAL DESCRIPTION

A. Conceptual Framework

Stream research at Konza Prairie, a tallgrass prairie site in northeast Kansas, is part of an interdisciplinary study of effects of fire and grazing on ecosystem processes of tallgrass prairie. Research focus during 1986-1990 has been the development of a hydrologic model and measurement of nutrient transport from watersheds of different burn frequencies to examine the effect of fire frequency on watershed-stream interactions. It was discovered that the complexity of the Konza landscape and the unstable hydrologic regime characteristic of this region can have more of an impact on ecological processes and biota in prairie streams than watershed burn regimes. In the next five years, the goal is to understand landscape controls and constraints on ecological phenomena by expanding current stream research to include studies of geomorphology, hydrogeology and ground- and surface-water chemistry. A comprehensive model of the geomorphology is under development, and ground- and surface-water chemistry will be measured in order to: (1) identify within-watershed variations in water chemistry; (2) use these variations to evaluate factors controlling groundwater chemistry and identify probable flow paths; and (3) evaluate the extent of ground- and surface-water interactions.

B. Site Description

Kings Creek is an intermittent stream draining a 1,637-ha watershed with channel orders from first to fifth. Within the Kings Creek basin, smaller watersheds have different burn regimes of one-, two-, four- and 10-year burns and unburned. The unpredictable flow regime of Kings Creek has a major impact on ecological processes and biota of this prairie stream. Flow varies spatially and temporally (e.g., annual extremes of flooding to drought). Low-order channels (first-second orders) are ephemeral, except near springs, whereas higher-order channels (third-fifth orders) include both intermittent and perennial reaches. Three zones of riparian vegetation exist in the watershed: (1) grasses in headwater channels (first-second orders), (2) mixtures of grasses, shrubs and small trees in third-order channels, and (3) a gallery forest in fourth- and fifth-order channels. Thus, grassland reaches are open-canopied and dominated by algal communities, whereas gallery forest reaches are shaded and have both algal and detrital energy sources. Kings Creek is a hardwater stream with low



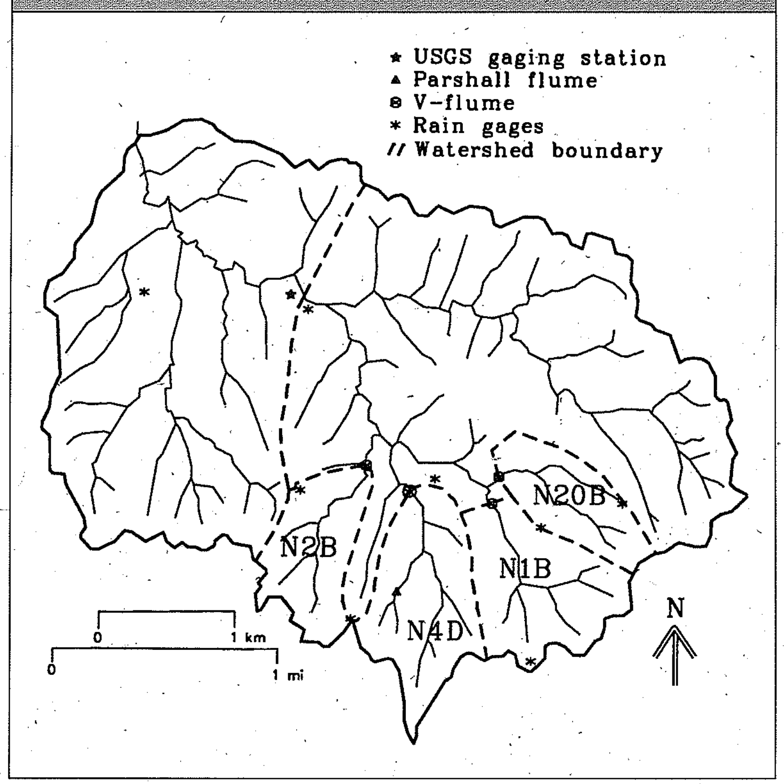
Above: *Kings Creek at Konza Prairie, a permanent spring-fed pool in an upland site with little riparian vegetation.* ***Below:*** *A lowland site on Kings Creek in the gallery forest. (Photographs by Walter Dodds)*

nutrient concentrations such that algal biomass is controlled primarily by nutrient concentrations. Macroinvertebrate communities during stable flow periods are dominated by small, rapid-growing collectors (38% and 58% of total biomass in gallery forest and grassland reaches, respectively; sediment-feeding chironomids and small mayflies) and nearly equal percentages of scrapers (14% snails and mayflies) and predators (27%, Tanypodinae chironomids and ceratopogonids) in both riparian zones. Shredders are greater in the gallery forest (22%, Tipula and Allocapnia) compared to grassland (1%), which correlates with higher allochthonous inputs and storage of detritus in gallery forest channels (Gray and Johnson 1988). Other predators include crayfish, orange-throated darters and creek chubs. Kings Creek represents the only benchmark for studies of the impact of agricultural and industrial practices on surface- and groundwater quality, soil erosion and hydrogeology in this region.

C. For Further Information

1. Contact person: John Briggs, Kansas State University (KSU), Division of Biology, Ackert Hall, Manhattan, KS 66506-4901, 913-532-6629, *JMB@KSUVM.KSU.EDU*, *jBriggs@LTERnet.edu* (Internet)

2. Topographic map (7 1/2- minute quad): Swede Creek Quadrangle



KINGS CREEK WATERSHED
Konza Prairie Research Natural Area

3. Stream researchers at site:

Walter Dodds, KSU Division of Biology, Ackert Hall, Manhattan, KS 66506, 913-532-6998 (microbial ecology, groundwater microscale factors, nutrient transport)

Lawrence Gray, Ottawa University, Department of Biology, Ottawa, KS 66067, 913-242-5200, ext. 5467 (macroinvertebrates)

James K. Koelliker, Department of Civil Engineering, Seaton Hall, Kansas State University, Manhattan, KS 66506, 913-532-5862 (hydrology)

Gwendolyn L. Macpherson, University of Kansas, Department of Geology, 120 Lindley Hall, Lawrence, KS 66045-2124, 913-864-4974 (aqueous geochemistry, origin of formation waters, deep sedimentary basins, origins of trace elements)

Chuck Martin, KSU Department of Geography, Dickens Hall, Manhattan, KS 66506, 913-532-6727 (inorganic fluxes)

Jack Oviatt, KSU Department of Geology, Thompson Hall, Manhattan, KS 66506, 913-532-6724 (disturbance)

Cathy M. Tate, U. S. Geological Survey, Colorado District, Water Resource Division, Box 25046, MS-413, Lakewood, CO 80225-0046, 303-236-4882 (stream ecology)

John Tracy, KSU Department of Civil Engineering, Seaton Hall, Manhattan, KS 66506 (hydrology, environmental engineering, computer applications, water quality)

D. Five Recent Publications

Gray, L. J. 1989. Emergence production and export of aquatic insects from a tallgrass prairie stream. *Southwestern Nat.* 34:313-318.

Gray, L. J. and K. W. Johnson. 1988. Trophic structure of benthic macroinvertebrates in Kings Creek. *Trans. Kans. Acad. Sci.* 91:178-184.

Gurtz, M. E., G. R. Marzolf, K. T. Killingbeck, D. L. Smith and J. V. McArthur. 1987. Hydrologic and riparian influences on the import and storage of coarse particulate organic matter in a prairie stream. *Canadian Journal of Fisheries and Aquatic Sciences* 45:655-665.

Koelliker, J. K. 1988. Considerations in modeling hydrology of Konza Prairie long-term ecological research sites. Pages 377-386 *in: Modeling Agricultural, Forest, and Rangeland Hydrology.* American Society of Agricultural Engineers, St. Joseph, MI.

Tate, C. M. 1990. Patterns and controls of nitrogen in tallgrass prairie streams. *Ecology* 71:2007-2018.

II. PHYSICAL CHARACTERISTICS

A. General

1. Temperature: maximum 30°C; minimum 2.8°C; mean 15.5°C
2. Mean annual degree days: 4,700 with continuous flow, 3,000 assuming typical annual pattern of 200 days with surface flow
3. Watershed area (ha): Kings Creek Basin at USGS site = 10.6 km^2; smaller gaged watersheds 85 to 135 ha
4. Stream order: first-fifth
5. Stream gradient: 17 m/km
6. Elevation: 338-430 m; latitude, 39° 05' N; longitude, 96° 35' W

B. Hydrology

1. Length of record for gaged streams: USGS = 12 years; four small watersheds = 6 years
2. Mean annual discharge, minimum, maximum: USGS = 64.1 L/s, 0 L/s, 168,000 L/s instantaneous
3. Seasonal pattern: Flow in Kings Creek is spatially and temporally variable. Headwaters are ephemeral and remaining channels are intermittent (flow two-10 months/year); however perennial pools and flowing reaches can be found within intermittent reaches. The magnitude and frequency of storm and intermittent flow varies from year to year. Flow generally ceases by late summer and resumes at any time, October to May.

C. Substrate

1. Major geologic formations: Flint Hills Uplands (a dissected upland of hard chert and flint-bearing limestone layers, i.e., thin limestone layers interbedded with thick shale)
2. Dominant stream substrate: riffles - cobble; pools - silt
3. Riparian cover over channel: upland prairies < 20% (first-third order); lowland (gallery forest, fourth-fifth order) > 70%
4. Depth to bedrock: 10-100 cm
5. Woody debris: rare
6. Retention structures: high flow—none; low flow—algae, macrophytes, cobble substrate

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry

Parameter	Mean (Range)	Years of Record	Sampling Frequency
pH	7.0-8.2	12	occasional
conductivity	452 µS/cm	12	occasional
alkalinity	5.2 mq/L	12	occasional
NO_3	4-27µgN/L (<1-1000)	6	weekly
NH_4	none detectable at baseflow	6	weekly
Total N	77 - 148µgN/L	6	weekly
SRP	1µg P/L (<1-5)	6	occasional
DOC	1.3 mgC/L	1	occasional
Ca	87.8 mg/L	1	occasional
SO_4	36 mg SO_4/L	12	occasional

B. Other cation, anion, or trace element data? Mg, Na, K, Cl, SiO_2

C. Is oxygen ever below saturation? Yes, often in sediments.

IV. BIOLOGICAL CHARACTERISTICS

A. Kinds of Biological Data Available

Group	Level of Identification	Parameters Measured	Person Working with Group	Reference
algae	biomass		Tate, Dodds	Tate 1990
macro-invertebrates	family, species	density, biomass, production	Gray	Gray 1989, Gray & Johnson 1988

B. Standing crop: mean (range)
Chlorophyll: 5-132 mg/m² (not measured routinely)
Detritus: mean standing stock 316 g AFDM/m²; coarse particulate matter 37 g AFDM/m²; fine particulate matter unknown; leaf litter standing stock 280 g AFDM/m²
Macroinvertebrates: 1014 mg/m² in gallery forest; 450 mg/m² in prairie

C. Rate Measurements

1. Primary production: 1.67 g 0_2 m^{-2} d^{-1}

2. Respiration: 0.98 g 0_2 m^{-2} d^{-1}

3. Litter input
Litterfall: mean; 100-357 g/m² (prairie-forest)
Blow-in: mean; 5.3-369 g/m² (prairie-forest)

4. Leaf decomposition

Species	K(day^{-1})	Reference
elm	0.0061-0.0211	Tate & Gurtz 1986, Smith 1986 Hooker & Marzolf 1987
burr oak	0.0020-0.0034	Gurtz & Tate 1988, Smith 1986
hackberry	0.0066-0.0252	Gurtz & Tate 1988, Smith 1986 Hooker & Marzolf 1987
chinquapin oak	0.0035-0.0048	Smith 1986
sycamore	0.0030	Smith 1986

5. Measures of nutrient uptake: nitrate injection and natural decrease in nitrate (Cathy Tate); currently measuring nutrient transport at four small flumed sites

6. Stable isotope analyses: none

V. ADDITIONAL REFERENCES CITED

Edler, C. and W. K. Dodds. 1992. Characteristics of a groundwater community dominated by *Caecidotea tridentata* (Isopoda). Pages 91-99 *in*: Stanford, J. A. and J. J. Simons (eds.). Proceedings of the First International Conference on Groundwater Ecology. AWRA, Bethesda, Maryland.

Gurtz, M. E. and C. M. Tate. 1988. Hydrologic influences on leaf decomposition in a channel and adjacent bank of a gallery forest stream. *Am. Midl. Nat.* 120:11-21.

Hooker, K. L. and G. R. Marzolf. 1987. Differential decomposition of leaves in grassland and gallery forest reaches of Kings Creek. *Trans. Kans. Acad. Sci.* 90:17-24.

Smith, D. L. 1986. Leaf litter processing and the associated invertebrate fauna in a tallgrass prairie stream. *Am. Midl. Nat.* 116:78-86.

Tate, C. M. and M. E. Gurtz. 1986. Comparison of mass loss, nutrients and invertebrates associated with elm leaf litter decomposition in perennial and intermittent reaches of tallgrass prairie streams. *Southwestern Nat.* 31:511-520.

LUQUILLO EXPERIMENTAL FOREST

I. GENERAL DESCRIPTION

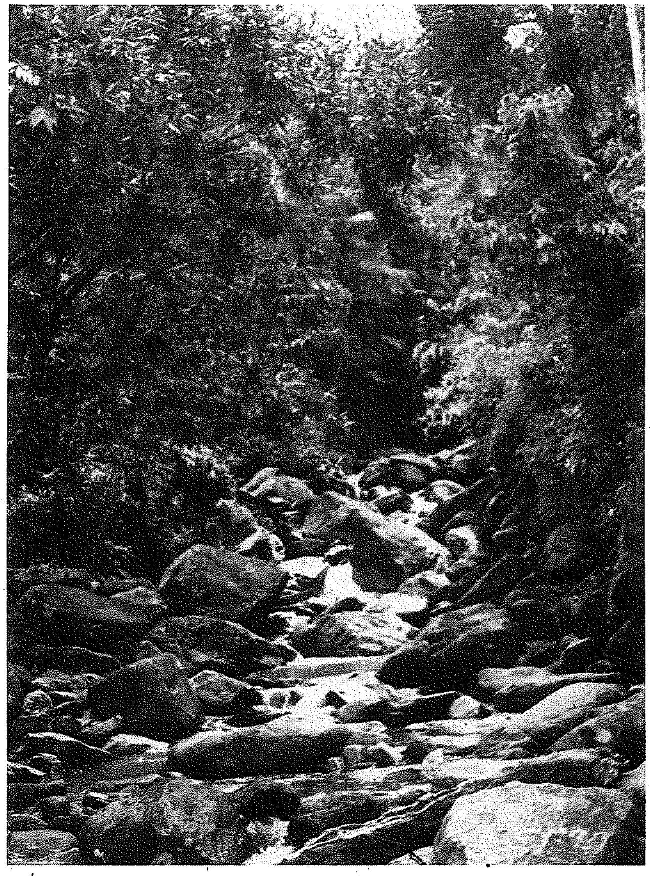
A. Conceptual Framework

Stream research in the Luquillo Experimental Forest is focused on the effects of disturbance on the aquatic habitat, including the impacts of floods, landslides, tree-fall gaps and hurricanes on the geomorphology, hydrology, nutrient dynamics, vegetation and populations of aquatic species. Future research efforts will focus on understanding (1) the aquatic-terrestrial interface, (2) the recovery of aquatic ecosystems following disturbances, and (3) the influence of geomorphology and forest type on aquatic processes. Current and proposed efforts include long-term monitoring, life history studies, and experimental manipulations.

B. Site Description

Streams within the Luquillo LTER site drain four major forest types (Tabonuco, Colorado, Palm, and Dwarf) and two distinct bedrock lithologies (volcanoclastic sandstones and grandiorite). The majority of LTER aquatic research has occurred in the Tabonuco forest underlined by volcanoclastic sandstones.

The stream channel network within the volcanoclastic sandstones consists of steep gradient streams supported by a dense network of ephemeral channels. Perennial channels are boulder-lined, steep gradient streams, with high-flow channels, small isolated floodplains and steep side slopes. Stream channels draining the grandiorite typically have sandy or boulder substrates. Landslide and tree-fall gaps are common features along all channels.



A typical stream draining Tabonuco-type forest, Luquillo Experimental Forest, Puerto Rico. (Photograph by F. N. Scatena)

C. For Further Information

1. Contact person: Robert Waide, Terrestrial Ecology Division, Center for Energy and Environmental Research, P. O. Box 363682, San Juan, Puerto Rico 00936-3682, 809-767-0334, *rWaide@LTERnet.edu* (Internet)

2. Topographic map (15-minute quad): Fajardo, Luquillo, El Yunque

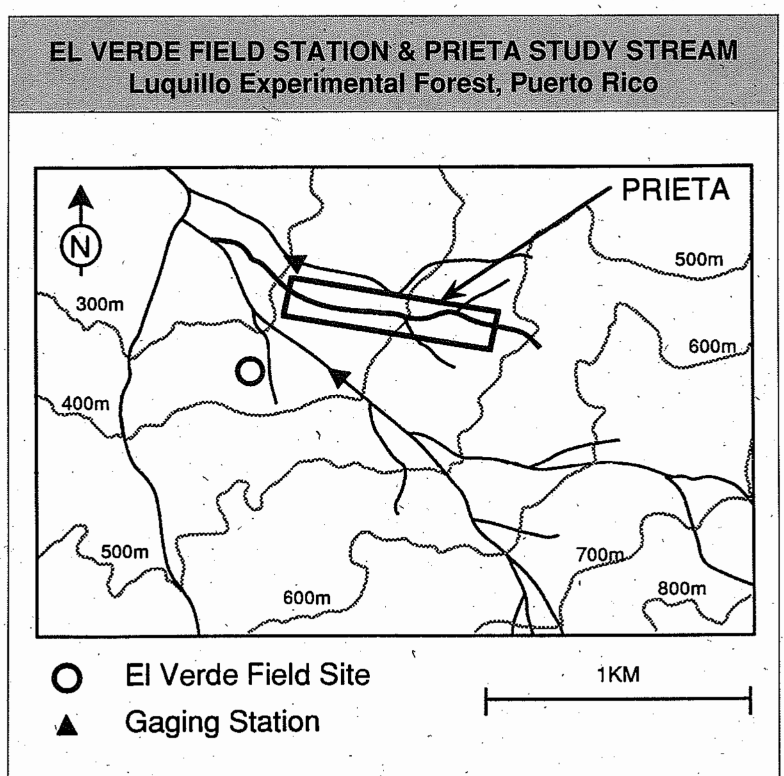
3. Stream researchers at site:

Clyde Asbury, 3424 Dorchester Court, Tallahassee, FL 32312, 809-767-0334 (nutrient cycling, ground and surface waters)

W. Breck Bowden, Department of Forest Resources, University of New Hampshire, Durham, NH 03824, 603-862-1020 (nitrogen, hydrology)

Karen Buzby, SUNY College of Environmental Sciences and Forestry, Illick Hall, Syracuse, NY 13210, 315-470-6812 (invertebrates, trophic structure, modeling)

Alan Covich, Department of Zoology, University of Oklahoma, Norman, OK 73109-0235, 405-325-5901 (wood and leaf decomposition, GIS, stream organisms, shrimp, crab)



Charles Hall, SUNY College of Environmental Sciences and Forestry, Illick Hall, Syracuse, NY 13210, 315-470-6870 (modeling, stream ecology)

Edward C. Masteller, Department of Biology, Pennsylvania State University, Erie, PA 16563-1200, 814-898-6105 (invertebrates, trophic structure)

Bill McDowell, Department of Forest Resources, University of New Hampshire, Durham, NH 03824, 603-862-2249 (inorganic fluxes)

Luis O. Nieves, Department of Biology, Humaco University College, Humaco, PR 00661, 809-852-2525 (invertebrates, vertebrates, trophic structure)

Catherine M. Pringle, Institute of Ecology, University of Georgia, Athens GA 30602, 706-542-4289 (invertebrates, algae, trophic structure)

Fred Scatena, Institute of Tropical Forestry, U. S. Forest Service, Call Box 25000, Rio Piedras, PR 00928-25000, 809-766-5335, extension 58 (geomorphology, nutrient cycling, hydrology)

Kristina Vogt, School of Forestry and Environmental Studies, Yale University, New Haven, CT 06511-2198, 203-432-5942 (roots, belowground productivity, mycorrhizae)

D. Five Recent Publications

Ahmad, R. Scatena F. N. and Gupta, A. 1993. Morphology and sedimentation in Caribbean montane streams: examples from Jamaica and Puerto Rico. *Sedimentary Geology*, in press.

Covich, A. P. and T. A. Crowl. 1990. Effects of hurricane storm flow on transport of woody debris in a rain forest stream. Pages 197-206 *in*: Proceedings of the International Symposium on Tropical Hydrology, American Water Resources Association.

Covich, A. P. 1988. Atyid shrimp in the headwaters of the Luquillo Mountains, Puerto Rico: filter feeding in natural and artificial streams. *Internationale Vereinigung fuer Theoretische und Angewandtl Limnologie, Verhandlungen* 23: 2108-2113.

Frangi, J. L. and A. E. Lugo. 1985. Ecosystem dynamics of a subtropical floodplain forest. *Ecol. Mono.* 55: 351-369.

Hernandez-Deldado, E. A. and G. A. Toranzo. 1990. Isolation of bacteriophages from large volumes of pristine tropical waters and their correlation to fecal contamination. Pages 543-551 *in*: Proceedings of the International Symposium on Tropical Hydrology, American Water Resources Association.

Scatena, F. N. 1990. Selection of riparian buffer zones in humid tropical steeplands. Pages 328-338 *in*: International Association of Hydrological Sciences Publication No. 192.

II. PHYSICAL CHARACTERISTICS

A. General

1. Temperature: air, 20°C - 26°; stream, 21°C - 23°C
2. Mean annual degree days: 8,030
3. Watershed area (ha): 6 ha to 22 km^2
4. Stream order: first-fourth
5. Elevation range: 200-1000 m

B. Hydrology

1. Length of record for gaged streams: four -23 years (12 gages)
2. Mean annual discharge, minimum, maximum: 0.01-1.7 m^3/s; min, 0 m^3/s; max, 600 m^3/s
3. Seasonal pattern: rainfall and runoff in every month, low-flow period February to April, high flows October to December

C. Substrate

1. Major geologic formations: volcanoclastics and grandiorites
2. Dominant stream substrate: boulders and cobbles in volcanoclastic catchments, fine sand in grandiorite catchments
3. Riparian cover over channel: 75-100% over first order; < 50% over second-fourth orders
4. Depth to bedrock: >1 m
5. Woody debris: rare
6. Retention structures: boulders and narrow, incised channels

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry

Parameter	Mean (Range)	Years of Record	Sampling Frequency
pH	7.2 (7-7.7)	4-8	weekly
conductivity	90 (50-100) µmhos	4-8	weekly
NH_4	40 µg/L (4-224 µg/L)	4-8	weekly
NO_3	135 µg/L (0.1-1000 µg/L)	4-8	weekly
Total N	(150-1000 µg/L)	4-8	weekly
SRP	< 1 µg/L	4-8	weekly
Total P	(< 5 µg/L)	4-8	weekly
Ca	4.5 (1-6) mg/L	4-8	weekly
SO_4	3.5 (2.5-5) mg/L	4-8	weekly

IV. BIOLOGICAL CHARACTERISTICS

A. Kinds of Biological Data Available

Group	Level of Identification	Parameters Measured	Person Working with Group
algae	genus	density, biomass	Pringle, Buzby
macro-invertebrates	genus, species	density, biomass	Covich, Buzby, Masteller, Pringle
fish	genus, species	density	Covich, Nieves

B. Standing Crop: mean (range)
N/A

C. Rate Measurements

1. Primary production: N/A

2. Respiration: N/A

3. Litter input
Litterfall: range, 800-1,820 kg/ha/yr (July 89 to August 90)
Riparian: range, 2,840-3570 kg/ha/yr (July 89 to August 90)

4. Leaf decomposition
Information will be available from Kristina A. Vogt

5. Measures of nutrient uptake: algal responses to nutrient additions, but not uptake (Cathy Pringle).

6. Stable isotope analyses: values for preliminary foodweb study (Covich and Asbury) and a fertilizer addition (McDowell and Bowden); values N^{15}, C^{13}

V. ADDITIONAL REFERENCES CITED

Covich, A. P. 1988. Atyid shrimp in the headwaters of the Luquillo Mountains, Puerto Rico: filter feeding in natural and artificial streams. *Internationale Vereinigung fuer theoretische und angewandte Limnologie, Verhandlungen* 23:1135-1141.

Covich, A. P. and T. A. Crowl. 1990. Effects of hurricane storm flow on transport of woody debris in a rain forest stream (Luquillo Experimental Forest, Puerto Rico). Pages 197-205 *in*: Tropical Hydrology and Caribbean Water Resources, Proceeding of the Interna tional Symposium on Tropical Hydrology, American Water Resources Association, Bethesda, MD.

Covich, A. P., T. A. Crowl, S. L. Johnson, D. R. Varza and D. L. Certain. 1991. Post-hurricane Hugo increases in atyid shrimp abundances in a Puerto Rican montane stream. *Biotropica* 23 (4a):448-454.

Ahmad R., F. N. Scatena, A. Gupter. 1993. Morphology and Sedimentation in Caribbean montane streams: examples from Jamaica and Puerto Rico. *Sedimentary Geology*, in press.

McMURDO DRY VALLEYS

I. GENERAL DESCRIPTION

Shortly before this catalog went to press, a 19th LTER site was added to the Network: the McMurdo Dry Valleys in Antarctica. Stream research at McMurdo is planned on nutrient dynamics and hydrologic controls on biota.

A. Conceptual Framework

The streams in the McMurdo Dry Valleys are fed by glacial meltwater generated when the temperatures are above freezing during the austral summer, a season of continuous daylight. Stream discharge can change dramatically over a few hours, and peak flows can move much sediment in some streams. Algal mats and moss beds are found in the streams with lesser sediment transport. This biota survives freezing and dessication during the austral winter and begins photosynthesis within hours of the onset of streamflow. The streams are the source of water for the lakes in the valley floors, and as such are the main link between the climate and the ecology of the lakes. A warming trend has been occurring in the dry valleys, causing increased discharge and rising lake levels. The stream research is based on the hypothesis that this climatic trend will cause a gradual expansion of stream ecosystems as mediated by water, sediment transport and nutrient availability. The research approach has three components: (1) mapping stream biota, tracking changes at established transects, and relating them to measured discharge and water quality; (2) measuring productivity of algal mats and mosses under different conditions; and (3) conducting long-term manipulative experiments by altering distribution of flow in a stream network and routing flow down a relic stream channel.

B. Site Description

The glacial meltwater streams in the Taylor Valley drain both alpine and terminal glaciers, and flow during the austral summer. Because there is no groundwater-fed baseflow, the flow in the streams responds within several hours to changes in air temperature and insolation. Once the alluvium thaws, storage in the alluvium provides for a small baseflow for a few days. The streams are first or second order, and drain into ice-covered lakes in the valley floor. Lakes Fryxell and Bonney each receive discharge from about 12 streams, whereas Lake Hoare receives discharge

The stream gage on Huey Creek, Taylor Valley, Antarctica during high flow. (Photograph by Paul von Guerard/USGS)

from four streams. Some streams are steep gradient and transport much sediment during high flow, whereas some are shallow gradient, flowing through shallow ponds en route to the lakes. There are relic channels present in the valley that may have been active as recently as 20 years ago.

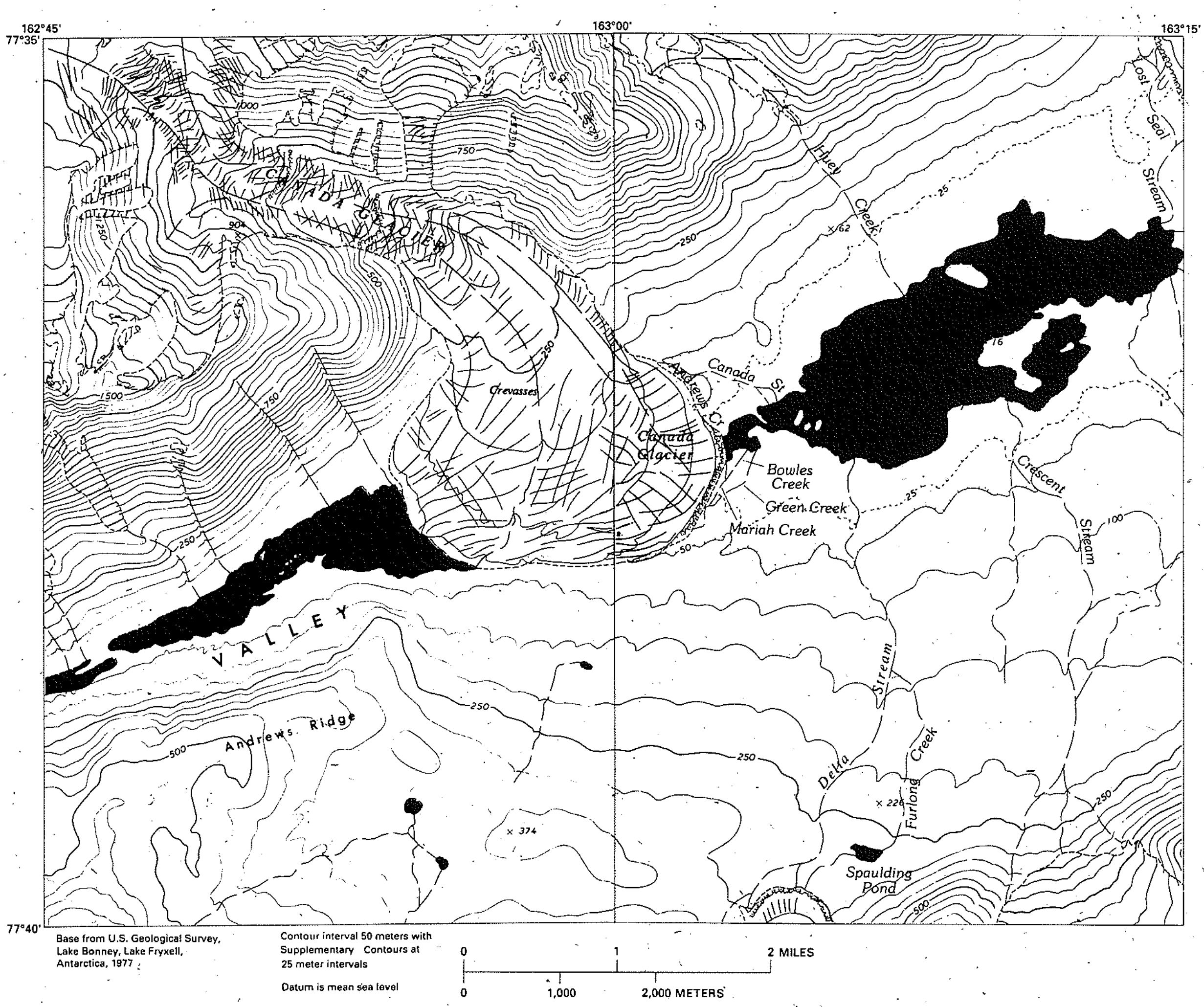
There is essentially no vegetation in the watershed. The soils are ahumic, and permafrost begins 30-50 cm below the surface. Because of the extremely dry climate, lateral inflow of groundwater to the streams apparently does not occur. Hyporheic flow does occur and may be the zone of geochemical reactions controlling stream chemistry. The biotic community in the streams consists of algal mats in the channel and moss beds on the banks. The algal mats are chiefly filamentous cyanobacteria, with *Phormidium* as a common genus. There are essentially no allochthonous energy sources; in fact, the stream community may be a source of organic carbon to the terrestrial community. With the possible exception of warming trends in response to anthropogenic atmospheric changes, there are no anthropogenic disturbances of these streams. Natural disturbances are sediment deposition and scour, in addition to the general regulation of the stream biota by water availability and freezing. Wind ablation during the austral winter may also be a component of the disturbance regime.

C. For Further Information

1. Contact person: Diane McKnight, U.S. Geological Survey, (USGS) Water Resources Division, 3215 Marine Street, Boulder, CO 80303, 303-541-3015, *D.McKnight/OMNET, dMcKnight@LTERnet.edu*

2. Topographic maps: Lake Fryxell and Lake Bonney Quadrangles, 1:50,000 Topographic series - Antarctica

LAKE HOARE & LAKE FRYXELL
Taylor Valley, Antarctica



3. Stream researchers at site:

   Ned Andrews, USGS, Water Resources Division, 3215 Marine Street, Boulder, CO 80303, 303-541-3002 (geomorphology)

   Diane McKnight (limnology)

   Cathy Tate, USGS, Water Resources Division, MS-415, Denver Federal Center, Denver, CO 80225-0046, 303-236-4882 (stream ecology)

   Paul von Guerard, USGS, Suite 200, 201 West 8th Street, Pueblo, CO 81003, 719-544-7155 (hydrology)

II. PHYSICAL CHARACTERISTICS

A. General

1. Temperature: maximum 10° C; minimum 0° C; mean 4° C
2. Mean annual degree days: N/A
3. Watershed area: N/A
4. Stream order: first and second
5. Stream gradient: N/A
6. Elevation range: 10-700 m

B. Hydrology

1. Length of record for eight gaged streams: 1990 - present (four more streams will be gaged in 1994)
2. Mean annual discharge, minimum, maximum: 20 L/s during summer, 0 L/s, 900 L/s
3. Seasonal pattern: discharge occurs only during austral summer when warm enough for generation of meltwater on the glaciers. Flow begins from mid-November to mid-December.

C. Substrate

1. Major geologic formations: quartz and feldspar with minor basalts
2. Dominant stream substrate: sand size in shallow gradient reaches and sand and rocks (up to 50 cm) in steep gradient reaches
3. Riparian cover over channel: none
4. Depth to permafrost: 10-100 cm
5. Woody debris: none
6. Retention structures: shallow ponds are common along the lower gradient streams

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry

Parameter	Estimated Mean (Range)	Years of Record	Sampling Frequency
pH	7.5 (6.5-8.0)	2	weekly
conductivity	120 µmhos (20-600)	2	weekly
NH_4	(ND - 2 µg/L)	<1	occasional
NO_3	(2-18 µg/L)	<1	occasional
SRP	(0.2-6.5 µg/L)	<1	occasional
DOC	1.0 mg/L (0.3-9.0)	2	weekly
Ca	4 mg/L (1-15)	2	weekly
SO_4	2 mg/L (1-20)	2	weekly

B. Other cation, anion, or trace element data? Major ions, Fe, Mn

C. Is oxygen ever below saturation? No

IV. BIOLOGICAL CHARACTERISTICS

A. Kinds of Biological Data Available

No measurements are available at this time. The following major groups are present: algae, macrophytes, bacteria, fungi, and meiofauna. Macroinvertebrates, fish, and other vertebrates are not present.

B. Standing Crop: N/A

C. Rate Measurement

1. Primary production: N/A
2. Respiration: N/A
3. Litter input: no terrestrial vegetation
4. Leaf decomposition: no leaves
5. Measures of nutrient uptake: will be done by Cathy Tate
6. Stable isotope analyses: deuterium and ^{18}O analyzed by Berry Lyons

NIWOT RIDGE / GREEN LAKES VALLEY

I. GENERAL DESCRIPTION

A. Conceptual Framework

Phase III of the Niwot Ridge/Green Lakes Valley LTER research will focus on effects of snow and on Niwot Ridge. Stream studies will be limited to continuing geochemical work on water and solute movement from the Martinell Snowfield.

Stream gauging studies in the Green Lakes Valley will be discontinued, but long-term decomposition studies will continue in the wetland. Biomass of algae in Green Lakes 4 and 5 will be measured.

B. Site Description

The Green Lakes Valley has two ecological units: (1) the alpine zone adjacent to Green Lakes 4 and 5, and (2) the forest-tundra ecotone adjacent to Lake Albion. Dominant plants in the alpine tundra site are *Carex foenea, Acomastylis rossii* ssp. *turbinata, Potentilla diversifolia, Cerastium arvense, Dischampsia caespitosa*, and *Trifolum parryii.* Dominant plants in the forest-tundra ecotone are *Picea engelmannii* and *Abies lasiocarpa.* The principle parent materials are Albion monzonite, Boulder Creek granite, and biotite gneiss. The soils are moderately developed. Annual precipitation at D-1 (3,048 m) on Niwot Ridge averages approximately 930 mm, 80% of which falls as snow from September to May; the mean annual temperature is 1°C (3048 m, D-1).

North Boulder Creek connects Lake Albion and Green Lakes 2, 3, 4 and 5 in linear sequence up the valley. Green Lake 1 is offset (See map on page 89, where gauging stations are indicated.) A steep headwall separates the lower valley from the upper valley. The creek is 2 m wide and 0.5 m deep at station A-1 at full discharge. The stream in the upper valley is best described as first- through second-order brooks. The wetland described below contains a slowly moving first-order stream. North Boulder Creek is unshaded; its bottom is rocky with little woody debris.

The 2-ha wetland is in upper Green Lakes Valley between Green Lakes 4 and 5 at an elevation of 3,595 m. Dominant plants in the wetland are willow (*Salix* spp.) and sedge (*Carex* spp). Five study pools (A, B, C, D, and outlet) have been identified in the wetland. Water flows from snow patches into Pool A, and then to the outlet. Discharges from the wetland are highest during spring and early summer, diminishing

Upper Green Lakes Valley in June. Green Lake 5 is the main valley floor feature, the wetland study area is to the south (left) of its outlet stream. (Photograph by N. Caine)

to almost zero by September. The wetland pools have a maximum depth of 0.2 to 0.5 m and are less than 1-2 m wide. Total surface area is about 236 m^2. Pools A and B have silty clay sediment (50% clay, 43% silt). They are primarily sedimentation basins. Pools C, D, and outlet contain large angular rocks set at irregular angles. The sediment in angular depressions between rock is a clay-silt (36% clay and 48% silt). The total organic matter in pools A-D was 18.7, 22.2, 28.3, and 35.8% dry weight, respectively. Ages of surface sediments are circa 1200 ±120 years BP. Water temperatures are 0-10°C, pH is 6.5-7.1, and outlet discharge is 0-2 m^3/min. The water is not stained by humic materials.

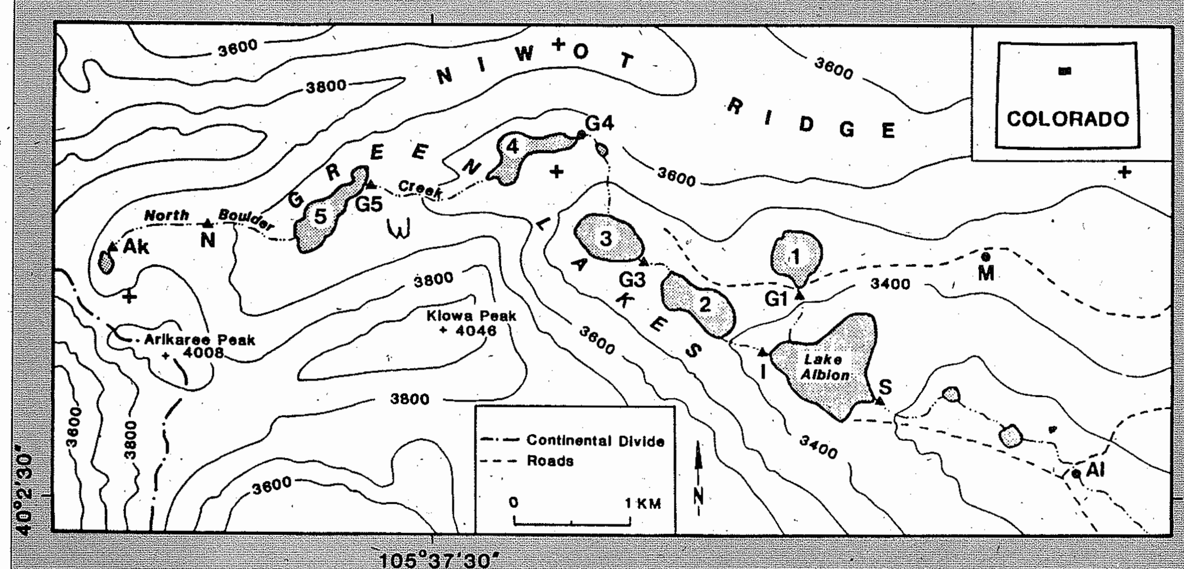
An intensive study of discharge and solutes in the Green Lakes Valley watershed has been completed over a period of eight years by Caine and Thurman (1990). Solutes generally increased with cumulative catchment size, except for ions subject to biological activity such as nitrate. Caine and Thurman also present summary data for solutes in precipitation. Diurnal changes in discharge and solute chemistry have been studied in the Martinelli catchment by Caine (1989).

This site has a long history of climate records, paleoecological studies, hydrological studies and records of solute chemistry of precipitation. This database is important to the understanding of acid deposition and global climate change. Disturbance takes the form of changes in discharge from lakes in the lower valley only, according to the needs of the water supply system. Natural disturbances during 1985-1990 took the form of a debris flow from the adjacent valley wall and a flood event caused by the breaking of an ice dam on Green Lake 5.

The biota of aquatic communities has been studied in the initial inventory of the lakes and streams (1980-1985). The benthic macroinvertebrates have received the most attention in studies by Bushnell (streams and lakes) and Toetz (wetland). All macroinvertebrates are small in size. Dominant groups are the Chironomids and Trichopterans. Diversity of macroinvertebrates in the wetland is about two. Algae have been less intensely studied, but species lists are available for Lake Albion and Green Lakes 4 and 5.

Algae on tiles in the wetland attain a biomass of 0.4 to 0.5 micrograms chlorophyll/ cm^2 in 35 days. A complete species list of aquatic macroinvertebrates and a species list of algae has been compiled for the wetland. There are about 16 to 20 algal taxa. The flora is often dominated by a gelatinous colonal green, *Tetraspora* sp., other green algae (five species), diatoms (12 species), blue-green algae (eight species) and three minor phyla. Nitrogen fixation by benthic algae is nil.

NIWOT RIDGE - GREEN LAKES VALLEY
Colorado Front Range



Sample sites: *Al - Albion; S - Spillway; I - L. Albion Inlet; M - Martinelli; Gl - Green L. 1; G3 - Green L. 3; G4 - Green L. 4; G5 - Green L. 5; N - Navajo; Ak - Arikaree; W - Wetland.*

The only fish in the system is the brook charr, *Salvelinus fontinalis*, which occurs only in the lower valley (but none in Green Lake 1). It has been unexploited for 50 years. A detailed study of its population structure in Green Lake 3 has been published. The wetland food chain is short, ending at the secondary consumer level.

C. For Further Information

1. Contact person: Dale Toetz, Zoology Department, Oklahoma State University, Stillwater, OK 74078-0459, 405-744-5555, 405-744-7673 (Fax), *dToetz@LTERnet.edu* (Internet)

2. Topographic map(s) (7 1/2-minute quad): Ward, Colorado and Monarch Lake, Colorado

3. Stream researchers at site:

   Nel Caine, INSTAAR, Campus Box 450, University of Colorado, Boulder, CO 80309, 303-492-5053 (material flows, hydrology, geochemistry, time/space variability)

   Dale Toetz (aquatic productivity, nutrient balances, limnology)

II. PHYSICAL CHARACTERISTICS

A. General

1. Temperature (air): maximum, 14.2°C; minimum, -19.8°C; mean, -3.7°C at 3750 m

2. Mean annual degree days: N/A

3. Watershed area (ha): Above 3,345 m elevation, catchment area is 5.46 km^2 of which 0.4 km^2 is in six permanent lakes. The upper Green Lakes Valley is 2.1 km^2; the lower valley is 3.36 km^2.

4. Stream order: North Boulder Creek above Green Lake 3 is a first-order stream

5. Stream gradient: approximately 10%

6. Elevation: 3250-3615 m (Green Lake 5)

B. Hydrology

1. Length of record for gaged streams: eight years (1981-1989)

2. Discharge (June-September at Albion): minimum 15,300 ft^3/day; maximum 146,400 ft^3/day

3. Seasonal pattern: low flow in fall and winter, marked increase at outset of snow melt, slow diminution during summer

C. Substrate

1. Major geologic formations: granite, biotite gneiss, monzonite

2. Dominant stream substrate: rocky

3. Riparian cover over channel: none

4. Depth to bedrock: 0-10 cm

5. Woody debris: rare

6. Retention structures: Green Lakes 1, 2, and 3 and Albion have artificially raised by man-made dams. Green Lakes 4 and 5 have been lowered.

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry

Parameter	Mean (Range)	Years of Record	Sampling Frequency
pH*	(6.1-6.9)	9	weekly in summer
conductivity (µS/cm)*	(19.2-30.0)	9	weekly in summer
NH_4 (mg/L as N)**	(0.001-0.080)	9	weekly in summer
NO_3 (mg/L as NO_3)**	(0.5-1.1)	9	weekly in summer
SRP (mg/L as P)**	(0.01-0.03)	9	weekly in summer
DOC (mg/L)***	(0.62-1.11)	9	weekly in summer
Ca (mg/L)**	(0.59-1.02)	9	weekly in summer
SO_4 (mg/L)**	(1.55-2.00)	9	weekly in summer

** Lake Albion 1982, 21 dates 2/11/82 - 12/16/82, Nel Caine, Data Report March 1987*
*** Green Lake 4 outlet, 9 dates 1989, DWT, unpublished*
**** Wetland outlet, 5 dates 1988, DWT, unpublished*

B. Other cation, anion, or trace element data? Mg, Cl, K, HCO_3, F, Si, iron (wetland)

C. Is oxygen ever below saturation? Not likely, but measurements have not been taken.

IV. BIOLOGICAL CHARACTERISTICS

A. Kinds of Biological Data Available

Group	Level of Identification	Parameters Measured	Person Working with Group	Reference
algae	species	biomass	Toetz	unpublished
macro-invertebrates	species	phenology	Toetz, Sublette, Bushnell	Mihuc 1989
fish	species	growth, diet	Toetz, Windell	Toetz et al. 1991

B. Standing Crop: mean (range)

Chlorophyll: 0.4-0.5 µg Chl *a*/cm^2 on tiles
Detritus: N/A

C. Rate Measurements

1. Primary production: N/A
2. Respiration: N/A
3. Litter input: N/A
4. Leaf decomposition: in progress
5. Measures of nutrient uptake: Dale Toetz measured N and S uptake in wetland using a nutrient budget approach, and also completed N_2 fixation studies.
6. Stable isotope analyses: Dale Toetz studied wetland (C and N) and Green Lake 3 foodwebs (N only).

V. ADDITIONAL REFERENCES CITED

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Caine, N. 1989. Diurnal variations in the quality of water draining from an alpine snowpatch. *Catena* 16: 153-162.

Caine, N. and E. Thurman. 1990. Temporal and spatial variations in the solute content of an alpine stream, Colorado Front Range. *Geomorphology* 4:55-72.

Mihuc, T. 1989. Aquatic macroinvertebrate life history and phenology in an alpine wetland, Green Lakes Valley, Colorado, Front Range. M.S. Thesis. Oklahoma State University. 58 pp.

Reddy, M. and N. Caine. 1988. A small alpine basin budget: Front Range, Colorado. Pages 370-385 *in*: I. Poppoff, C. Goldman, S. Loeb, and L. Leopold (eds.). International Mountain Watershed Symposium. Tahoe Resource Conservation District, South Lake Tahoe, California 95731.

Toetz, D. 1992. Use of mass spectroscopy to investigate the diet of brook trout (*Salvelinus fontinalis*) in an alpine lake. *Journal of Freshwater Ecology* 7(3):251-256.

Toetz, D., M. Mounecke and J. Windell. 1991. Age, growth and condition of brook trout (*Salvelinus fontinalis*) from an unexploited alpine lake. *Northwest Science* 65(3):89-92.

NORTH INLET MARSH -ESTUARY

I. GENERAL DESCRIPTION

A. Conceptual Framework

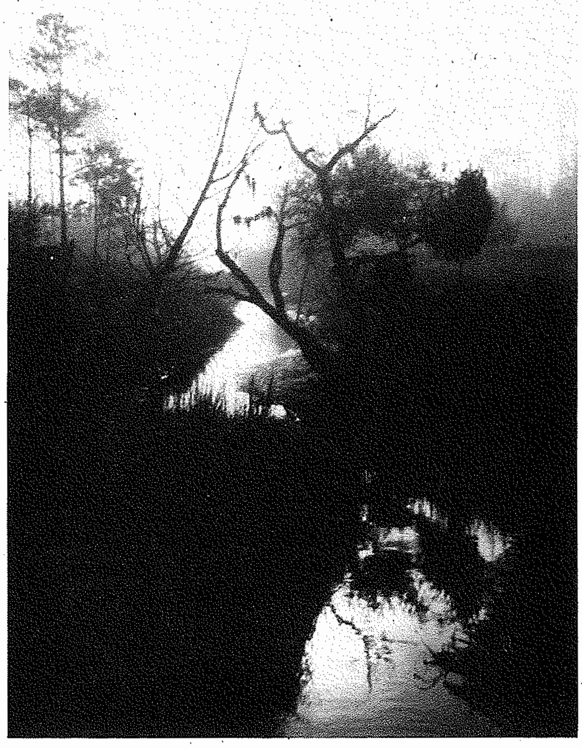
Stream research at the North Inlet Marsh LTER site focuses on the concept of the streams as links between forests and the adjacent salt marsh. The majority of the research is concerned with biogeochemistry, in particular, the flux of nutrients and other ions from the forest to the marshes via the streams. Research on detritus dynamics has emphasized leaf processing and organic matter storage and the transport of this material to the estuary. Macroinvertebrate communities have been studied within the framework of determining the extent of invertebrate utilization of allochthonous detritus and the transport of the resulting secondary production, either by drift or predation by estuarine fish, to the estuary. Additional research has focused on the extent of disturbance and the subsequent recovery from the impact of Hurricane Hugo in 1989.

B. Site Description

Streams at North Inlet flow through low-lying coastal forest that developed on sandy Pleistocene beach ridges and swales. Highest elevation at the site is only about 6 m above mean sea level (MSL); one-third of the forest is at less than 3 m above MSL. The riparian forest consists primarily of pine (*Pinus palustris* and *P. taeda*) on ridges and black gum (*Nyssa sylvatica*) and various oaks, including especially live oak (*Quercus virginiana*) in the swales.

Streams are primarily first-order, blackwater streams that drain the forest directly into the adjacent *Spartina*-dominated salt marsh. Stream channels vary from less than one meter to about 10 to 15 m wide, but wetted perimeters are no more than 2 to 4 m except immediately following heavy rainfall. Discharge is variable between streams and years; seasonally intermittent flow is common. Saltwater intrusion is common in the lower sections of some of the streams. The sediment consists of fine sand or deposits of detritus. Hyporheic areas in sandy channels have large deposits of stored organic matter, but are frequently anoxic only 3 to 5 cm below the surface. Downed wood in the channels varies in abundance.

Allochthonous inputs are the primary energy source for the stream communities. Macroinvertebrate species composition and richness vary greatly depending on permanence of flow and time since the last saltwater intrusion. The predominant macroin-



Bly Creek, North Inlet, South Carolina is an intermittant blackwater stream that drains low-gradient coastal forest dominated by Loblolly pine and bottomland hardwood wetlands. (The Baruch Institute)

vertebrate is the amphipod *Gammarus tigrinus*, a very salt-tolerant species that functions as a facultative shredder/collector-gatherer. It can compose up to 95% of the macroinvertebrate biomass of some streams. Isopods, chironomids and ostracods may also be common. The orders Ephemeroptera, Plecoptera, Odonata, Megaloptera and Trichoptera are very species poor in North Inlet streams. The predominant fish in the streams, including especially *Fundulus heteroclitus*, are estuarine, moving into the streams to feed.

C. For Further Information

1. Contact person: Elizabeth Blood, Joseph W. Jones Ecological Research Center, Route 2, Box 2324, Newton GA 31770, 912-734-4706, *eBlood@LTERnet.edu* (Internet)

2. Topographic map (7.5-minute quad): North Island, SC; 33079-C2-TF-024

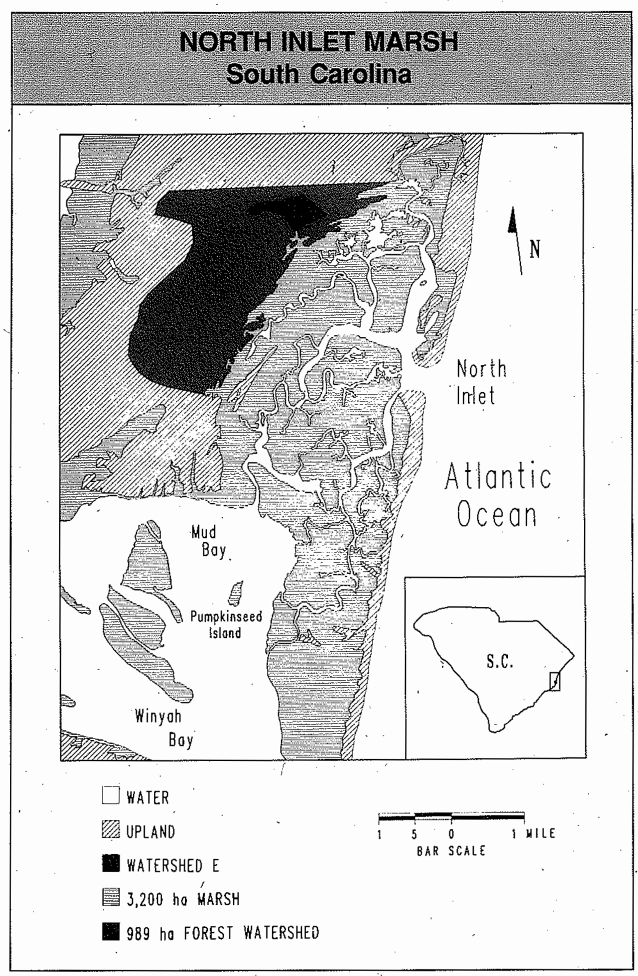
3. Stream researchers at site:

Elizabeth Blood (aquatic ecology, nutrient dynamics)

Hank McKellar, Department of Environmental Health Sciences, University of South Carolina, Columbia, SC 29208, 803-777-6994 (modeling, nutrients, organic matter)

Leonard Smock, Department of Biology, Virginia Commonwealth University, P. O. Box 2012, Richmond, VA 23284, 804-367-1562 (macroinvertebrates, carbon transport)

Thomas Williams, Baruch Institute, P. O. Box 596, Georgetown, SC 29441, 803-546-6318 (groundwater hydrology, nutrient cycling)



II. PHYSICAL CHARACTERISTICS

A. General

1. Temperature (air): maximum, 24°C; minimum, 12°C; mean, 18°C
2. Mean annual degree days: N/A
3. Watershed area (ha): 53 ha
4. Stream order: first or second
5. Stream gradient: < 1m/km
6. Elevation: 1-3 m above MSL

B. Hydrology

1. Length of record for gaged streams: 1987-present, 1989-1990 missing
2. Mean annual discharge, minimum, maximum: mean, 0.1 cfs; minimum, no flow; maximum, .8 cfs
3. Seasonal pattern: no flow May to October, peak flow in February

C. Substrate

1. Major geologic formations: sand
2. Dominant stream substrate: sand
3. Riparian cover over channel: 90%
4. Depth to bedrock: >1 m
5. Woody debris: rare
6. Retention structures: roots, sandy sediment

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry

Parameter	Mean (Range)	Years of Record	Sampling Frequency*
pH	7.0 (3.8 - 8.8)	8	occasional
conductivity (µmhos)	(650 - 40,000)	8	occasional
alkalinity (mg $CaCO_3$/L)	95 (19 - 238)	8	occasional
NH_4 (mg N/L)	0.09 (0.01 - 0.61)	8	occasional
NO_3 (mg N/L)	0.03 (nd - 0.27)	8	occasional
Total N (mg N/L)	0.63 (0.26 - 1.08)	8	occasional
SRP (mg P/L)	0.03 (nd - 0.11)	8	occasional
Total P (mg P/L)	0.03 (nd - 0.18)	8	occasional
DOC (mg/L)	21.61 (3.8 - 61.7)	8	occasional
Ca (mg/L)	50.6 (5 - 141)	8	occasional
SO_4 (mg/L)	11.8 (1 - 133)	8	occasional

**event-related sampling*

B. Other cation, anion, or trace element data? Cl, Mg, K, Na

C. Is oxygen ever below saturation? Yes, and frequently anoxic in sediments.

IV. BIOLOGICAL CHARACTERISTICS

A. Kinds of Biological Data Available

Group	Level of Identification	Parameters Measured	Person Working with Group
macro-invertebrates	genus, some species	density, biomass, production	Leonard Smock

B. Standing Crop: mean (range)

Chlorophyll: N/A
Detritus: N/A
Macroinvertebrates: density: 6,317 individuals/m^2; biomass: 542 mg/m^2

C. Rate Measurements

1. Primary production: N/A
2. Respiration: N/A
3. Litter input: N/A
4. Leaf decomposition:

Species	K(day^{-1})
Live oak	0.0012
Wax Myrtle	0.0020

5. Measures of nutrient uptake: N/A
6. Stable isotope analyses: N/A

V. ADDITIONAL REFERENCES CITED

Garner, Edward. 1991. Role of the hyporheic zone in coastal stream processes. M. S. Thesis. University of South Carolina, Columbia, South Carolina.

Wolaver, T. G. and T. M. Williams. 1986. Stream chemistry of a small forested watershed on the South Carolina coast. *Southeastern Geology* 27:45-52.

NORTH TEMPERATE LAKES

I. GENERAL DESCRIPTION

A. Conceptual Framework

Research at the North Temperate Lakes LTER site is oriented around five themes: perception of long-term trends; determination of interactions among physical, chemical, and biological processes; analysis of temporal responses to disturbance and stress; evaluation of interactions between spatial heterogeneity and temporal variance; and regionalization of results to broader geographic areas. Work is focused around seven primary study lakes and their surrounding areas.

Although stream research has not been emphasized in the past, increased opportunities will undoubtedly develop in the future. For example, North Temperate Lakes has recently been selected as one of the U. S. Geological Survey Water, Energy and Biogeochemical Budget (WEBB) sites. Each of the five streams entering or leaving Trout Lake were gauged in spring 1991, allowing assessment of the importance of the streams to the hydrologic and chemical budgets of the lake. Understanding the relative importance of streamflow as a conduit for nutrients and other chemical constituents to the lake will have management implications for the streams' watersheds. In addition to the budget work, geochemical processes occurring in the streams will also be studied.

B. Site Description

The field site of the North Temperate Lakes LTER project is the Northern Highland Lake District in northern Wisconsin (latitude 46°00'N, longitude 89°40'W). Within the lake district there are more than 150 streams with a total length of over 650 km. Streams in this region are lake inlet or outlet streams. Streams are low gradient, groundwater dominated, and have relatively stable flow. Streams typically flow through watersheds consisting, in part, of wetlands. Shaded sections have riparian vegetation composed of aspen, birch and conifers. Reaches in wetland areas have riparian vegetation of alder and grass. Substrates range from sand, silt and fine organic matter to sand mixed with cobbles and pebbles. Macrophytes are abundant and include *Sparganium* and *Elodea*. Energy sources include both autochthonous (algae) and allochthonous (detrital material) sources. The invertebrate community is diverse and dominated by Hydropsychidae, Simuliidae, Chironomidae, Leptoceridae, snails, leeches, and crayfish. These streams are of ecological interest because the stable flow

Mann Creek, a typical northern Wisconsin forest stream, undergoes relatively little fluctuation in flow throughout the season. (Photograph by Timothy Kratz)

regime allows for greater biotic interactions not found in other LTER stream ecosystems with less stable flow regimes. Five streams are of particular interest, four of which—Allequash Creek, Mann Creek, North Creek, and Stevenson Creek—are inlets to Trout Lake. The fifth, Trout River, is the outlet to Trout Lake. Each of these streams are gauged and will be study systems for the WEBB project.

C. For Further Information

1. Contact person: John Magnuson, Center for Limnology, University of Wisconsin, 680 N Park Street, Madison, WI 53706, 608-262-2840, *jMagnuson@vms.macc.wisc.edu* or *jMagnuson@LTERnet.edu* (Internet)

2. Topographic Maps: 7.5- minute quadrangles—Boulder Junction, White Sand Lake, Woodruff

3. Stream researchers at site:

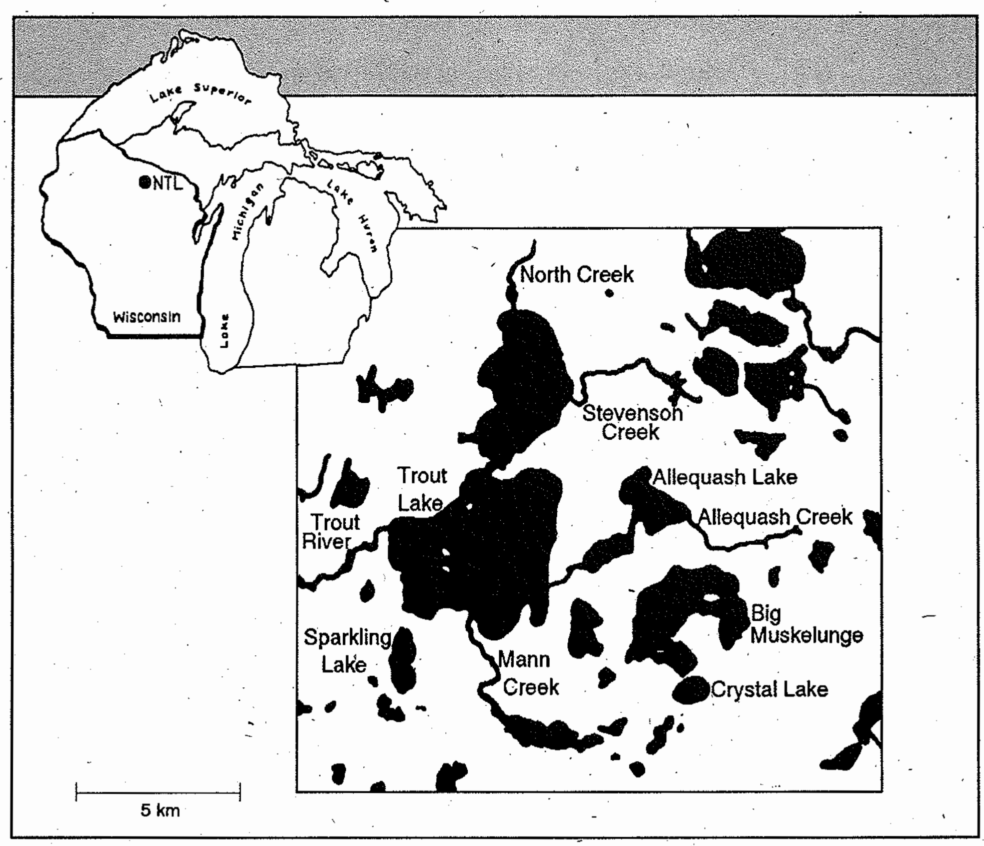
John Elder, U. S. Geological Survey (USGS), 6417 Normandy Lane, Madison, WI 53719, 608-276-3854 (metal fluxes, metal toxicology)

Dave Krabbenhoft, USGS, 6417 Normandy Lane, Madison, WI 53719, 608-276-3843 (groundwater geochemistry, hydrology)

Gary Lamberti, Department of Biological Sciences, University of Notre Dame, Notre Dame, IN 46556, 219-631-6552 or 8075 (stream ecology)

Cathy Tate, USGS, Colorado District, Water Resource Division, Box 25046, MS-413, Denver, CO 80225-0046, 303-236-4882 (formerly associated with NTL) (stream ecology)

John Walker, USGS, 6417 Normandy Lane, Madison, WI 53719, 608-276-3853 (surface water hydrology, statistical analysis, modeling)



II. PHYSICAL CHARACTERISTICS

A. General

1. Temperature: range, -2°C to 22°C

2. Mean annual degree days: N/A

3. Watershed area (ha):
   Allequash Creek: 843 ha (20.2 adjoining wetland)
   Mann Creek: 583 ha (32.4 adjoining wetland)
   North Creek: 311 ha (50.6 ha adjoining wetlands)
   Stevensons Creek: 453 ha (84.8 adjoining wetland)

4. Stream order: N/A

5. Stream gradient: 0.0013 m/m

6. Elevation: 500 m; latitude, 46° 00' N; longitude, 89° 40' W

B. Hydrology

1. Length of record for gaged streams: less than one year

2. Mean annual discharge, minimum, maximum: range, 32-131 L/s

3. Seasonal pattern: Flow in streams is groundwater dominated and thus is fairly stable. Flow is greatest during spring snowmelt. Storm flows rarely scour stream channel.

C. Substrate

1. Major geologic formations: 30-50 m glacial till over impervious precambrium granite and metamorphic rock

2. Dominant stream substrate: sandy substrate dominates; occasionally have sand mixed with cobbles and pebbles

3. Riparian cover over channel: wetland areas < 10%; forested areas > 80%

4. Depth to bedrock: > 1 m

5. Woody debris: common

6. Retention structures: wood and macrophytes

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry

Parameter	Mean (Range)	Years of Record	Sampling Frequency
pH	(7.1-7.6)	1	occasional
conductivity	(83-104 µS/cm)	1	occasional
alkalinity	(0.65-0.96 meq/L)	1	occasional
NH_4	22 µg N/L	1	occasional
NO_3	6 µg NO_3-N/L	1	occasional
SRP	4 µg P/L	1	occasional
DOC	(5-8 mg C/L)	1	occasional
Ca	(11.2-13 mg Ca/L)	1	occasional
SO_4	(2.6-4.4 mg S/L)	1	occasional

B. Other cation, anion, or trace element data? Mg, Na, K, Cl, SiO_2

C. Is oxygen ever below saturation? Rare in stream channel; possible in adjacent floodplain.

IV. BIOLOGICAL CHARACTERISTICS

A. Kinds of Biological Data Available: N/A

B. Standing crop: mean (range)
Detritus: N/A
Chlorophyll: 0.664 µg/cm^2 (0.056-1.87 µg/cm^2) on artificial substrates
Macroinvertebrates: 369 µg/cm^2 (0.125-2490 µg/cm^2)

C. Rate Measurements: N/A

V. ADDITIONAL REFERENCES CITED

Magnuson, J. J. and C. J. Bowser. 1990. A network for long-term ecological research in the United States. *Freshwater Biology* 23:137-143.

SEVILLETA

I. GENERAL DESCRIPTION

A. Conceptual Framework

The primary focus of stream research at the Sevilleta Long-Term Ecological Research site is on the influence of the El Niño Southern Oscillation (ENSO) phenomenon, a large-scale weather system, on the ecology and hydrology of streams. Sevilleta stream researchers are particularly interested in using the variation in regional weather caused by ENSO to study the responsiveness of streams in semi-arid regions to climate change. The goal is to use the unusually wet and dry periods (years to decades) caused by ENSO as large-scale experiments on climate change. Nested within this general framework is an interest in the influences of temporal and spatial scaling on responsiveness. With this in mind, researchers are studying aquatic systems ranging temporally from perennial waters to highly ephemeral streams, and ranging spatially from small springs to the Rio Grande. To date, a flow-monitoring network has been established in a nested series of intermittent and ephemeral stream basins ranging from 1 ha to 350,000 ha. The mainstay of this network is a series of programmable video cameras used to monitor intermittent and ephemeral surface flows in basins of 10,075 and 350,000 ha. The largest water course on the site is the Rio Grande with a basin area of 55,000 square kilometers upstream from the Sevilleta LTER. Other ongoing studies to explore responsiveness to climatic variability are (1) monumented transverse profiles at each flow-monitoring site to study sediment dynamics, (2) marked dowels and corks to study organic matter transport, (3) litter bags to study decomposition, and (4) litter traps in the riparian zone to study litter production. Future plans include studies of hyporheic communities and processes and benthic population and community responses to climatic variation along an elevation and climatic gradient ranging from Chihuahuan desert (1,400 m) to subalpine mixed conifer (3,000 m).

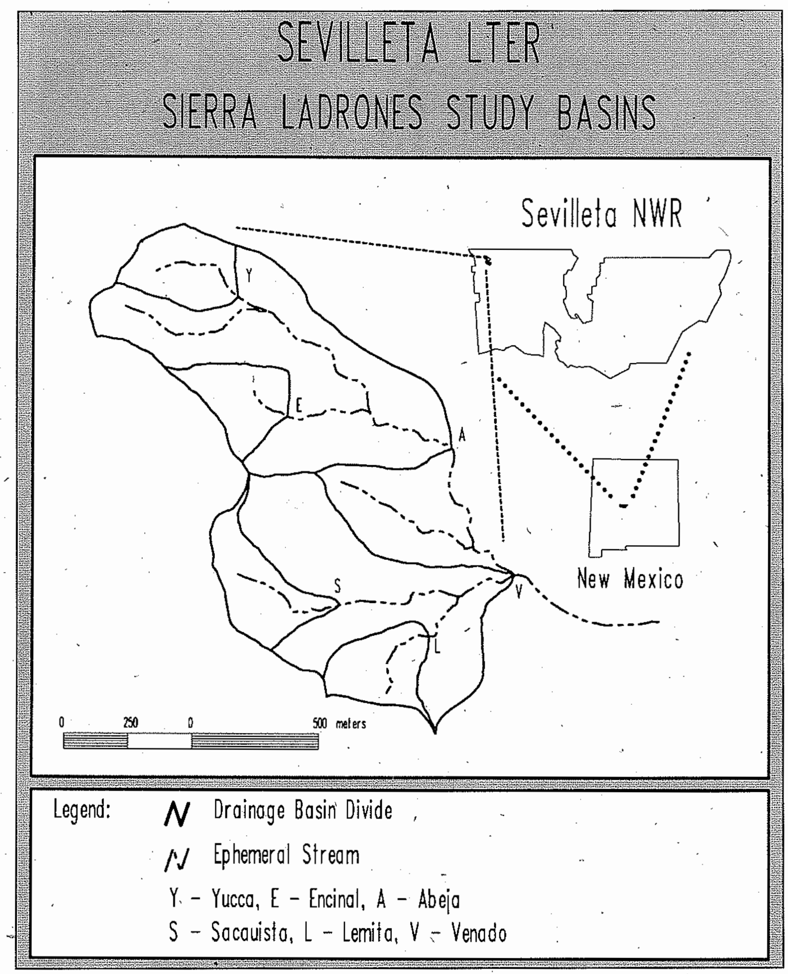
The Rio Salado, a few kilometers above its confluence with the Rio Grande, Sevilleta National Wildlife Refuge, New Mexico. (Photograph by Nina P. Hadley)

B. Site Description

The Sevilleta LTER site includes the Rio Salado and the stream network comprising the Cañada Popatosa, a tributary of the Rio Salado. The Rio Salado contains intermittent and perennial reaches and has large, sudden flows during the summer monsoon season. The nested streams of the Cañada Popatosa are ephemeral with surface flow following some summer thunderstorms. The Cañada Popatosa basin occurs in juniper woodland. Major species are *Juniperus monosperma, Quercus turbinela,* and *Cercocarpus montanus.* Riparian vegetation includes *Falugia paradoxa, Juniperus monosperma, Quercus turbinela, Brickellia brackphylla, Cercocarpus montanus* and *Nolina micorcarpa.* Herbs and grasses occur in the streambeds. In contrast, the riparian woody vegetation of the Rio Salado is dominated by *Tamarix pentandra* and *Eleagnus angustifolia,* both exotics.

The Rio Salado basin contains a few small villages and ranches. The Rio Salado is the largest free-running river in New Mexico, with no flow constraints or irrigation diversions. Cattle grazing ceased in the Cañada Popatosa basin in the early 1970s; however, a diversion dam and small ponding areas remain. Research sites are located above these structures.

The most notable natural disturbances are regional droughts and local floods. Many hillslopes in the Cañada Popatosa basin are covered by standing dead juniper trees which died during droughts between the mid-1940s through the 1950s. This resulted in a change from juniper woodland to grassland communities in some areas. A spring drought occurred in 1989, a La Niña year. The only seepage in the Cañada Popatosa continued to provide some surface water until the following spring, when it dried, perhaps a delayed response to the drought. Algae and aquatic insects disappeared and vertebrate visitation patterns shifted from frequent to rare use.



M. TAD CROCKER

Ephemeral flows range from the introduction of sheetflow from hillsides, which infiltrates sediments locally, to "wall of water" type of channel-forming floods. The latter has the potential to alter riparian vegetation, redistribute particulate organic matter, and remove or add hyporheic zones through scouring and redeposition processes.

C. For Further Information:

1. Contact person: Manuel C. Molles, Jr., Department of Biology, University of New Mexico, Albuquerque, NM 87131, 505-277-3050, *mMolles@LTERnet.edu* (Internet), MOLLES@LTERnet (Bitnet)

2. Topographic map(s) (7 1/2-minute quad): What follows is a list of names of the 35 USGS 7.5-minute topographic quad sheets which cover the extent of the Rio Salado drainage basin. The Rio Salado basin is approximately 350,000 ha in area and is located in central New Mexico. The Rio Salado joins the Rio Grande at the Sevilleta National Wildlife Refuge LTER site, north of Soccorro, New Mexico.

   The order of names generally follows a north-to-south and east-to-west pattern: San Acacia, Ladron Peak, Silver Creek, San Lorenzo Springs, Riley, Carbon Springs, Granite Mountain, Magdalena, Chicken Mountain, Puerto De La Cavadores, La Jara Peak, Mesa Cencerro, Silver Hill, Arroyo Landavaso, Cerro Del Oro, Field Ranch, Puertocito, Indian Springs Canyon, Gallinas Peak, Tres Montosas, Broom Mountain, Pueblo Viejo Mesa, Table Mountain, Indian Mesa, Wiley Mesa, D Cross Mountain, Dog Springs, Wild Horse Canyon, Pasture Canyon, Cal Ship Mesa, Bonnie Canyon, Third Canyon, Madre Mountain, Tres Lagunas, Red Flats. The Cañada Popatosa drainage basin, a nested series of sub-basins of the Rio Salado, is covered by Ladron Peak and Silver Creek quad sheets.

3. Stream researchers at site:

All may be contacted at the Department of Biology, University of New Mexico, Albuquerque, NM 87131

M. Tad Crocker, 505-277-0868/5732 *TCrocker@Sevilleta.unm.edu* (Internet) (stream ecology, organic processes, climate variability)

Clifford N. Dahm, 505-277-2850, *CDahm@Sevilleta. unm.edu* (Internet) (stream riparian ecology, regional climatology, hyporheic zone processes)

Manuel Molles (stream and riparian ecology, climatology)

D. Recent Publications

Dahm, C. N. and M. C. Molles, Jr. 1992. Streams in semi-arid regions as sensitive indicators of global climate change. Pages 250-260 *in:* S. Fisher and P. Firth (eds.). *Global Warming and Freshwater Ecosystems.* Springer-Verlag, New York, NY. 321 pp.

Molles, M. C., Jr., C. N. Dahm, and M. T. Crocker. 1992. Climatic variability and streams and rivers in semi-arid regions. Pages 197-202 *in:* R. D. Robarts and M. L. Bothwell (eds.). *Aquatic Ecosystems in Semi-Arid Regions: Implications for Resource Management.* N. H. R. I. Symposium Series 7, Environment Canada, Saskatoon.

Molles, M. C., Jr. and C. N. Dahm. 1990. A perspective on El Niño and La Niña: global implications for stream ecology. *Journal of the North American Benthological Society.* 9(1):68-76.

II. PHYSICAL CHARACTERISTICS

A. General

1. Temperature: N/A

2. Mean Annual degree days: N/A

3. Watershed area: Cañada Popatosa - 250 ha; Rio Salado - 350,000 ha

4. Stream order: Cañada Popatosa - N/A; Rio Salado - N/A

5. Stream gradient: Cañada Popatosa 0.27-0.07; Rio Salado N/A

B. Hydrology

1. Length of record for gaged streams: 36 years (Rio Salado 1948-1984)

2. Mean annual discharge, minimum, maximum: N/A, 0, ca. 332,000 L/s

3. Seasonal pattern: ephemeral flows following thunderstorms, May-October

C. Substrate

1. Major geologic formations: Cañada Popatosa; granite (Ladron quartz monzonite) in upper elevations and Capriote granites in the lower elevations

2. Dominant stream substrate: alluvial sand/gravel derived from coarse- to medium-grained granite

3. Riparian cover over channel: 10%

4. Depth to bedrock: varies with basin

5. Woody debris: rare

6. Retention structures: (1) microtopographic changes in the streambed (especially terraces), (2) perennial shrubs and trees (living and dead) in the streambed, (3) cobble or boulder bars, and (4) the streambed as the terminal point of surface water is approached

III. CHEMICAL CHARACTERISTICS

A. Basic Stream Chemistry (data are preliminary)

Parameter	Mean (Range)	Years of Record	Sampling Frequency
DOC (mg/L)	1.6	0	2/11/92
NO_3-N (ppb)	20.1	0	6/26/92
NH_4-N (ppb)	76.2	0	6/26/92
Cl (ppm)	778	0	2/9/92
Na (ppm)	660	0	2/9/92
K (ppm)	22.0	0	2/9/92
Ca (ppm)	113	0	2/9/92
Alk ($CaCO_3$)	128.3 mg/L	0	6/26/92
Cond. micro-S	3850	0	6/26/92

B. Other cation, anion, or trace element data? N/A

C. Is oxygen ever below saturation? Both aerobic and anaerobic conditions within the hyporheic zone of the Rio Salado.

IV. BIOLOGICAL CHARACTERISTICS

A. Kinds of Biological Data Available

Group	Level of Identification	Parameters Measured	Person Working with Group
macrophytes	species	no data	Troy Maddux
macro-invertebrates	family	no data	Manuel Molles
frogs, toads, lizards, snakes	no data		

B. Standing Crop: algal and organic matter studies are in progress
Detritus: total BOM 53 g AFDM/m^2 (range 5 - 128); leaves 28 g AFDM/m^2; sticks 14 g AFDM/m^2; other 11 g AFDM/m^2 (data for Arroyo de las Abejas, T. Crocker, unpublished)

C. Rate Measurements

1. Primary production: studies in progress
2. Respiration: N/A
3. Litter input: N/A
4. Leaf decomposition: studies in progress
5. Measures of nutrient uptake: N/A
6. Stable isotope analyses: N/A

LTER NETWORK OFFICE PUBLICATIONS

No. 1: Long-Term Ecological Research. James T. Callahan. *BioScience*, 1984.

No. 2: The Climates of the Long-Term Ecological Research sites. University of Colorado, Institute of Arctic and Alpine Research (INSTAAR). Occasional Paper 44. 1987.

No. 3: Standardized Meteorological Measurements for Long-Term Ecological Research Sites. *Bulletin of the Ecological Society of America*. 1987.

No. 4: 1990s Global Change Action Plan. 1990.

No. 5: Long-Term Ecological Research Network Core Data Set Catalog. Belle W. Baruch Institute and LTER Network Office. 1990. (Out of print. On-line access information available.)

No. 6: Climate Variability and Ecosystem Response. UDSA Forest Service SE Experiment Station and LTER Network Office. 1990.

No. 7: Internet Connectivity in the Long-Term Ecological Research Network. 1990.

No. 8: Contributions of the Long-Term Ecological Research Network. *BioScience*, July/August 1990.

No. 9: Long-Term Ecological Research and the Invisible Present, *BioScience*, July/August 1990; Long-Term Ecological Research and the Invisible Place. *BioScience*, July/August 1990 (three articles, including No. 8)

No. 10: Proceedings, LTER Data Management Workshop, Snowbird, UT. 1990.

No. 11: Long-Term Ecological Research in the United States: A Network of Research Sites (6th edition, revised). 1991.

No. 12: Technology Development in the Long-Term Ecological Research Network: Status of Geographic Information Systems, Remote Sensing, Internet Connectivity, Archival Storage & Global Positioning Systems. 1991.

No. 13: Proceedings, LTER Data Management Workshop, San Antonio, TX. 1991.

No. 14: Guidelines and Sample Protocol for Sampling Forest Gaps. USDA Forest Service Pacific Northwest Research Station and the LTER Network Office. PNW-GTR-283, 1992.

No. 15: Stream Research in the LTER Network. 1993.

Publications, LTER Network Office
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