

Whole-Ecosystem Restoration through Liming of Acidified Tributary Streams and a Watershed in the
Honedaga Lake Basin

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Introduction

During the 1980's, much research focused on acid deposition occurring in the northeastern US, and the results of this research were a recognition that sulfur and nitrogen oxides mainly from power plants in the Midwest produced precipitation with a pH sometimes below 4.0. The Adirondack Mountains were the first topographic relief the acid laden clouds encountered on their easterly route and much of the acid was deposited across this region. One of the first signs of the impacts of acid deposition was a decrease in fish populations largely because soil pH decreased releasing inorganic monomeric aluminum (Al_{im}) from soil cation exchange sites. When the pH of streams and lakes fell below 5.0, Al_{im} was mobilized, and it was Al toxicity to fish and stream macroinvertebrates that had the greatest impact on aquatic organisms (Gensemer and Playle 1999, Baldigo et al. 2007, 2009). Results of these early studies persuaded lawmakers to pass the Clean Air Act Amendments in 1990 which targeted reductions in sulfur dioxide emissions from power plants. While there has been a decrease in acid deposition levels in the Adirondack Mountains following the 1990 Clean Air Act Amendments (Jenkins et al. 2007, Kahl et al. 2007), the pH of precipitation remains low (4.4-4.6 – Lawrence et al. 2011) and continues to leach calcium and Al from Adirondack forest soils thereby altering nutrient relationships in both terrestrial and aquatic ecosystems (Sullivan et al. 2006, Zaccherio et al. 2007, Johnson et al. 2009, Warby et al. 2009, Nezat et al. 2010). Small, headwater streams are typically the first aquatic environments to receive precipitation after it has passed through the forest canopy and soil, and forest catchments with relatively thin soils low in calcium may not fully neutralize the acid before it reaches streams or lakes, causing the acidification of the aquatic systems (Lawrence et al. 1999, Lawrence 2002, Burns et al. 2006).

The result of this long term acid titration of the Adirondack landscape is a continuing loss of calcium and associated buffering capacity in forest soils (Driscoll et al. 2001). A recent study showed

that 66% of the headwater streams in the western Adirondack region were either episodically or chronically acidic to levels at which toxic Al was mobilized (Lawrence et al. 2011). Headwater streams compose almost 70% of the entire stream/river channel length of river systems in North America, and they are the major integrators of land-water exchanges (Alexander et al. 2007, Freeman et al. 2007). These smaller streams are major sites of nutrient uptake and retention in river systems and significantly affect amounts of nutrients that are transported downstream (Alexander et al. 2007). Disruptions in headwater systems can result in cascading effects in downstream communities which include excess nutrients reaching midregions of river systems that can affect both functional and structural attributes of these systems (Driscoll et al. 2003).

One means of remediating the effects of acid deposition has been the application of calcium carbonate (lime) either directly to stream channels or to entire drainage basins to neutralize acid and raise the pH of both streams and soils (Claire and Hindar 2005)). These mitigation efforts often see rather rapid improvements in water chemistry, but biotic changes are typically slower (Claire and Hindar 2005). In the U.S., experimental whole-watershed calcium-carbonate addition has been done only once previously (Driscoll et al. 1996). Although terrestrial measurements were included, the primary goal of the watershed liming was the restoration of an acidified lake because depletion of soil calcium had not yet been documented when the experiment began in 1989. The only other whole-watershed calcium addition experiment was begun in 1999 using wollastonite, a calcium silicate chosen to enable study of the ecological effects of increasing soil calcium to the estimated pre-acid rain level (Hawley et al. 2006) in a terrestrial system at the Hubbard Brook Experimental Forest, NH.

Previous studies on the impacts of acid deposition on stream communities have focused almost exclusively on structural effects such as the loss of species that are sensitive to increased acidity (Baldigo et al. 2009). Algal communities show shifts to acid tolerant species of diatoms and green algae

as the pH of a stream decreases below 5.0. There is also a shift to increased densities of acidophilic fly larvae and acid tolerant stoneflies in low pH streams, and a loss of snails, crustaceans and mayflies; the former groups require higher calcium concentrations for their shells and exoskeletons, respectively, whereas mayflies suffer from aluminum toxicity because of aluminum precipitation on their gills causing inflammation and decreased respiratory function. These species losses change the community structure of both the algal and macroinvertebrate communities in acid-stressed streams. There have been fewer studies of functional attributes in acid-stressed streams such as decomposition processes, algal productivity (rates of photosynthesis) or rates of nutrient uptake. A few recent studies have shown leaf decomposition rates are lower in chronically acid (Dangles et al. 2004, R. Fuller unpublished data) and episodically acidic streams (Neatrou et al. 2011, R. Fuller unpublished data). Also, Traister et al. (2013) showed no difference in algal productivity among 9 Eastern European streams differentially affected by acid deposition. However, to date there has been no comparison of nutrient uptake rates in streams of different pH and no coordinated comparison of multiple functional metrics across streams of differing acidity..

My proposed research will broaden our understanding of the impacts of acid deposition by determining functional attributes such as leaf decomposition rates, nutrient uptake, microbial activity and algal productivity in streams of differing pH. Methods that examine functional attributes of streams were not available during the early studies that determined the impacts of acid deposition on stream communities, but it is now well recognized that disruptions of functional attributes in headwater streams have consequences for downstream communities (Alexander et al. 2007, Freeman et al. 2007). Loss of species could have significant effects on ecosystem function, but there have been no comprehensive studies that have experimentally addressed how different functional attributes (such as nutrient cycling, detrital processing or productivity) respond to increases in acidity.

The study I describe below is the first to combine repeated in-stream lime applications in multiple streams as well as the terrestrial liming of an entire watershed; this research has significant potential for advancing our understanding of how lime applications can be used for whole-ecosystem restoration of systems that have experienced calcium depletion from acidic deposition. The lime applications have been funded through a grant from the New York Energy and Research Development Authority (NYSERDA), and this is part of a larger study involving scientists from Cornell University, Syracuse University, SUNY-College of Environmental Science and Forestry and the US Geological Survey office in Troy, NY. We received funding from the Picker Interdisciplinary Science Institute in 2010-11 to fund preliminary sampling in aquatic and terrestrial systems prior to securing funding from NYSERDA for the aerial lime application to a whole drainage basin. Unfortunately, NYSERDA was most interested in the examination of mercury dynamics since mercury gets mobilized in more acidic terrestrial and aquatic environments, and so much of the funding from NYSERDA went to terrestrial vegetation analyses, fish population studies and mercury dynamics in both terrestrial and aquatic environments. I received no funding from NYSERDA, but I would like to continue my studies on stream ecosystem structure and function for at least another year with the hope of securing additional funding in the future. For now, it is important to track the aerielly limed stream for comparison with the in-stream liming of two additional streams, and compare both of these to adjacent reference streams (see site description below).

Study Site

The study will take place in the drainage basin of Honnedaga Lake, a 770 acre lake in the southwestern region of the Adirondack Mountains. The lake supports one of 7 remaining heritage or original genetic strains of brook trout designated by the State of New York. By 1980, the lake was chronically acidified (pH <5) with inorganic monomeric aluminum at levels lethal to brook trout (>150

ug/L). Yet during this period of chronic acidification, brook trout were able to sustain populations in several small tributaries to Honnedaga Lake where pH remained >5.

Seventeen of the tributary streams are in catchments with thin soils at the western end of the lake (Fig. 1). Streams draining these watersheds have pH values that remain below 5.0 for most of the year and can be considered chronically acidic. The streams near the eastern end, however are somewhat better buffered with stream pH values > 5 during base flow conditions, but can drop below 5.0 during rainstorm or snowmelt events, and therefore are considered episodically acidic. The forest composition of the lake drainage basin reflects a condition of calcium depletion. Calciphilic species of trees and herbaceous vegetation are absent in nearly all the tributary watersheds, and canopies throughout much of the drainage exhibit excessive stem dieback. However, the presence of sugar maple, a calciphilic tree species, in both the overstory and understory of one watershed (Watershed 9) does indicate relatively high calcium availability in one area of the lake basin.

Study Description-

I propose to study the impacts of acid deposition on both the structure and function of aquatic ecosystems through comparative studies in 5 tributary streams that vary in resistance to acidification from acid deposition. In October 2013, aerial liming via helicopter of the entire surface area of watershed 16, which harbors a chronically acid stream, was conducted. This will allow a comparison of a chronically acidic reference stream in watershed 24 to the aeriually limed stream in watershed 16 (see Figure 1 and Table 1). In addition, I will study three episodically acidic streams in watersheds 6, 8 and 9 (Figure 1; Table 1). Streams in watersheds 6 and 8 have had lime added directly to the channel during the summer of 2011-2014. Thus, tributaries in watersheds 24 and 9 will act as untreated reference sites (controls) for chronically and episodically acid streams, respectively and can be compared to

experimentally manipulated (limed) tributaries in watershed 16 (chronically acid) versus streams in watershed 6 and 8 (episodically acid).

I have data for all 5 streams prior to the lime application in 2011 (funded by the Picker ISI grant), as well as in summer 2012 and autumn 2012 and 2013. I would like to repeat the summer studies in 2014 because the summer of 2012 was extremely dry and several of the stream channels went almost completely dry. During that summer, leaf decomposition rates were very high perhaps because leaf packs had to be moved to the few pools where there was water and macroinvertebrate densities in those remaining pools were likely very high as macroinvertebrates used these few remaining pools as a refuge from dessication. The summer leaf decomposition rates remained low in chronically acid streams similar to what we observed in autumn, however the magnitude of leaf mass loss was higher in summer in all streams when compared to mass losses in autumn. I would like to repeat the leaf decomposition experiments in summer 2014 and hope we get a more “normal” water year to compare to what we observed in acid stressed streams under drought conditions (summer and autumn 2011).

Stream Biota Methods - We will begin leaf decomposition studies using red maple (*Acer rubrum*) leaf packs placed in all tributaries beginning in late May and again in late August to allow a comparison across streams and seasons. Leaf packs will be constructed by weighing 3 g of dry field collected red maple leaves (these were collected in autumn 2012 in watersheds 16 and 24 during the period of peak leaf abscission) and placing the leaves in large mesh (peanut) bags. We will individually tether 4 leaf packs to each of 5 bricks (20 packs) in each stream and retrieve 1 pack/brick from each stream (5 packs/stream) after 1, 3, 5 and 8 weeks. Each pack will be placed in individual ziplock plastic bags and kept on ice for transport back to the lab. We also will collect 4 L of water from each stream. When we return to the lab, we will remove 1 leaf from each pack and place each leaf in a 300 ml BOD bottle along with water from the stream where leaves were collected. We will measure the oxygen

concentration of the water initially and place all bottles with leaves in an environmental room (24 h dark cycle) set at the average temperature of the 5 streams. After 24 hours, we will measure oxygen concentrations again and any loss of oxygen over 24 h will indicate the degree of microbial respiratory activity. Once finished, leaves from each bottle will be dried and weighed and oxygen consumption will be corrected for the weight of each leaf. The remaining leaves in each pack will be rinsed over a 250 μ m mesh sieve to collect macroinvertebrates, which will be preserved in 70% alcohol for later identification and quantification. The “rinsed” leaves will be air dried in paper bags for 1 week and weighed to determine mass loss rates (the greater the weight loss, the higher the rate of leaf decomposition).

Algal communities will be quantified by introducing unglazed clay tiles into streams (10/stream) in early May, and 5 tiles/stream will be collected at the same time we do nutrient uptake studies (see below). Tiles will be scraped of all attached algae and we will quantify chlorophyll a biomass, ash free dry mass (organic content) and a small aliquot from each sample will be saved and preserved with Lugol’s iodine and algal densities determined microscopically by identifying and counting individual cells. We will also measure algal production by deploying oxygen sensors (PME miniDOT probes) into the streams in early summer. The oxygen sensors will measure increases in oxygen during the day when algae are actively photosynthesizing and will measure oxygen decreases overnight when algae and other organisms will be respiring. With these continuous recordings, we can measure rates of both community production and respiration which we can relate to levels of nutrient uptake in the different streams.

I also will do nutrient uptake studies in June to compare uptake of different nutrients when forest canopies are intact and light levels are lower which should decrease uptake by the algal community. These same nutrient uptake studies will be done in October when algal productivity should be higher because of a more open canopy and higher light intensities, and when microbial activity (community

respiration) may be higher because of microbial colonization of terrestrial leaf inputs. I will measure stream nutrient uptake for PO_4 , NO_3^- , and NH_4^+ using established methods (Hauer and Lamberti 2006). The more rapidly nitrogen or phosphorus is taken up by the stream organisms, the more retentive the system is and less of each nutrient will then be transported downstream. These uptake studies involve delineating a transect of 60 – 120 m of stream length and then we drip in a dilute solution of one nutrient (PO_4 , NO_3^- , or NH_4^+) at the upstream end along with a chloride solution. We use chloride because it is not taken up by either the microbial or algal community. When the chloride concentration at the downstream end of the transect reaches a peak (measured using a field conductivity probe), we know the nutrient added has reached a saturation level in all areas of the transect. At that time, we take water samples at 6 sites equally spaced along the transect and analyze samples for chloride and each nutrient. We expect chloride to decrease with distance from the upstream addition site due to any input of groundwater along the transect length (dilution effect), and we can compare this chloride proportional decline to the proportional decrease in each nutrient (see Fig 2). If microbial and algal communities are actively taking up the nutrients added, there should be a greater decline in the nutrient over the transect length than chloride. By quantifying this decline, we can calculate a nutrient uptake rate and compare these rates (slopes – see Fig. 2) across streams of different acidity and between streams with different lime applications.

Timeline for Research

I have students (3) working in my lab this semester (using Student Wage Grant funding from the CRC) and at least 2 of them will be putting together leaf packs in April for deployment in late May. I also will place tiles and miniDOT oxygen sensors into the streams in early May. We will begin retrieving leaf packs in June and at the same time will initiate the nutrient uptake experiments. Much of July and August will be spent processing the leaf packs and macroinvertebrate samples. This fall I am

teaching a research tutorial and students in this class will continue to do a second leaf decomposition experiment as well as nutrient uptake studies. My goal is to get the summer samples processed by December and at least the leaf decomposition and nutrient uptake data from summer and fall also completed in December. This will allow the summer students to submit abstracts so they can attend the annual meeting of the Society for Freshwater Science in Milwaukee, WI in May 2015. Once the sample processing is complete and data are analyzed, we will have an excellent set of data over a 4 year period that we will likely use in at least three papers for publication.

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Table 1. Tributary lime application amounts (tons) for Honnedaga Lake. Annual mean and ranges of tributary pH and temperatures from 2001 – 2009. Two different in-stream lime application formulas advise that twice the calculated amount be applied for the first application; doubled values are noted with (*) in parentheses.

| Tributary | Watershed Area acres (ha) | Parameter | Values Mean (Range) | In-stream Limestone |
|--|------------------------------|-----------|------------------------|-----------------------------------|
| | | | | Application Amount (tons) |
| | | | | West Virginia Method ¹ |
| Trib 24 (No Lime) | 43.6 (18.2) | pH | 4.4 (4.2-4.6) | No Lime (Reference) |
| | | Temp | 10.3 (10.0-15.0) | |
| Trib 16 (Aerial Lime) (October 2013) | 72.0 (30.0) | pH | 4.1 (3.6-4.5) | Aerial Lime (150 T) |
| | | Temp | 13.4 (13.0-14.0) | |
| Trib 6 (In-stream Lime Summer 2011-2014) | 177.7 (74.0) | pH | 4.8 (4.3-6.3) | 8.9 (17.8*) |
| | | Temp | 15.6 (0.0-21.0) | |
| Trib 8 (In stream Lime Summer 2011-2014) | 90.0 (37.5) | pH | 5.5 (3.2-6.9) | 4.5 (9.0*) |
| | | Temp | 12.9 (0.5-19.0) | |
| Trib 9 (No Lime) | 23.0 (9.6) | pH | 5.7 (4.5-7.3) | No Lime |
| | | Temp | 12.3 (0.5-16.0) | (Reference) |

¹Schmidt, K.L. and W.E. Sharpe. 2002. Passive treatment methods for acid water in Pennsylvania. Penn State University, State College, PA. 20 pp.

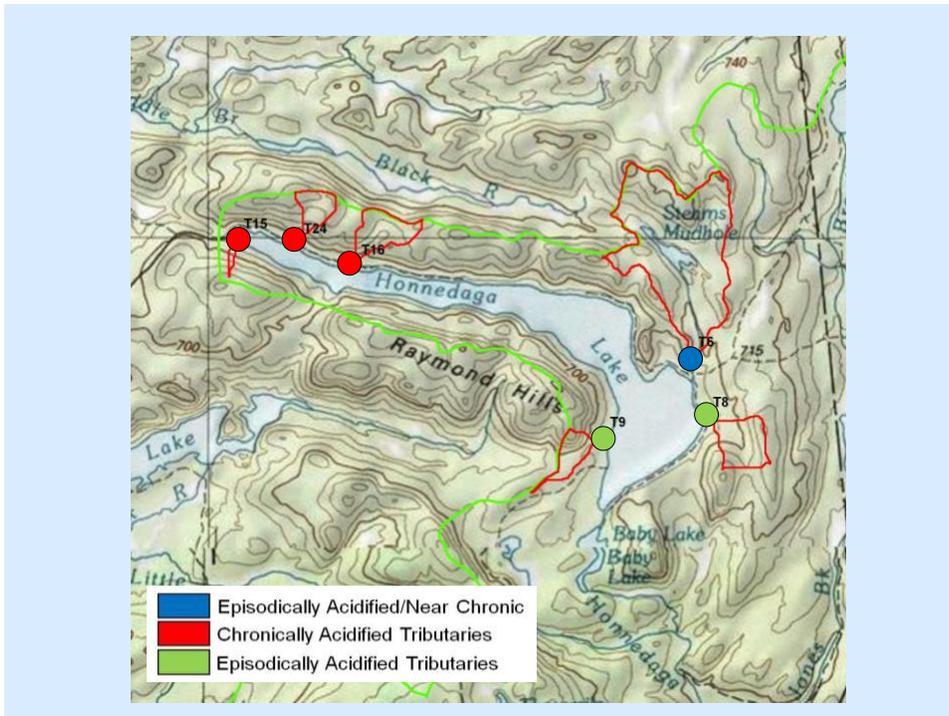


Figure 1. Location of tributary streams in Honnedaga Lake drainage network.

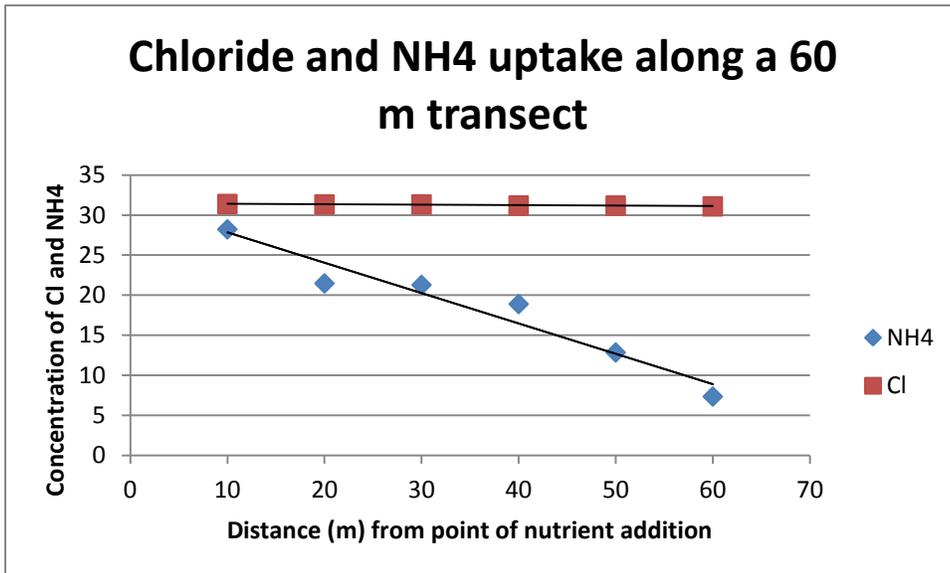


Figure 2. Sample data from an NH₄ uptake experiment done in tributary 24 during autumn 2013 showing minimal decrease in Cl with distance from the addition site (i.e., little dilution over the 60 m transect) and the steeper decline in NH₄ with distance indicating uptake by the biotic community. The slope of the NH₄ line (after correction for slight decline in Cl with distance) gives an estimate of nutrient uptake (amount of nutrient taken up/unit length of stream).

Research Council Budget Form - Major Grant for 2014-15

R. Fuller 2014

| TRAVEL | | description | amount |
|---|-------|--|----------|
| Airfare | | | |
| Airfare 2 | | | |
| Train / Bus fare | | | |
| Taxi / local transit | | | |
| Car rental | | | |
| # miles, Colgate truck: | 2,632 | 14 field trips at 188 mile/trip plus \$25/day truck rental fee | 1,460.76 |
| Tolls | | | |
| Parking | | | |
| Other (describe) | | gas for boat to access sites from lake shore - 14 trips at 2 gallons/trip \$3.69/gal. | 103.32 |
| Other (describe) | | \$25/day truck rental fee from B&G – 12 trips | 450.00 |
| Travel subtotal | | | 2,014.08 |
| LIVING EXPENSES | | # days location / description | amount |
| <i>Per diem, location 1</i> | | | |
| Days 1 - 10 | | | - |
| Days 11 - 30 | | | - |
| Days 31 - 60 | | | - |
| <i>Per diem, location 2</i> | | | |
| Days 1 - 10 | | | - |
| Days 11 - 30 | | | - |
| <i>Per diem, location 3</i> | | | |
| Days 1 - 10 | | | - |
| <i>Other, e.g. lower per diem</i> | | Snacks on return from lake - 10 hour sampling days, but must deal with sample upon return to campus - so, we stop for coffee and a snack. \$12/trip - about \$4/person - myself and 2 students | 168.00 |
| <i>Long-term stays</i> | | | |
| Estimate rent per wk x # wks | | | |
| Est. groceries per wk x # wks | | | |
| Living Expenses subtotal (max. \$7,500) | | | 168.00 |
| STUDENT WAGES | | number of hours (max. 150) and rate | amount |
| Student Wage subtotal | | | - |

| SUPPLIES & SERVICES | | item / description | amount |
|--------------------------------|--|--|-----------------|
| | | Chemicals - Ammonium Molybdate Cat. # R 86969-78 - 3 bottles at \$57/bottle | 171.00 |
| | | Sodium citrate R-88064-07 - \$60.00 | 60.00 |
| | | Stannous chloride reagent II R-88697-42 - \$89.00 | 89.00 |
| | | Dionex poly vials - 3 boxes at \$99/box; Cation standards and anion standards at \$99 each | 495.00 |
| | | Supplies and Services subtotal | 815.00 |
| | | | |
| Supplies (continued) | | item / description | amount |
| | | hip boots - 4 pairs at \$85/pair - Forestry Suppliers | 340.00 |
| | | plastic ziplock bags and paper bags for transport and drying of leaf packs | 25.00 |
| | | EQUIPMENT 3 MiniDOT oxygen sensors for algal production Cat # 6881 (\$995 ea) plus cable & data mgt software (\$35) | 3,065.00 |
| | | Equipment subtotal (max. \$1,500) | 3,430.00 |
| | | | |
| | | TOTAL BUDGET | \$6,427 |
| | | TOTAL REQUEST, if different: | |

Long term goals of my research

I have comparative data for these chronic and episodically acid streams from 2011 prior to the in-stream liming and have post-liming data for all streams including those in watersheds 6 and 8 from both summer and autumn 2012 as well as autumn 2013. The continued in-stream liming of streams in 2014 and the aerial liming of Watershed 16 will allow me to continue to follow stream responses to in-stream liming (after 3 years of lime applications) as well as assess the impacts of the whole drainage basin lime applications to Watershed 16 after 1 year. Thus, I will have a longer term record of impacts of in-stream liming in episodically acidic streams, and will begin to collect data for a chronically acid stream in a limed drainage basin (T16). The whole drainage basin lime application will determine how soil Ca levels affect stream ecosystem structural (algal and macroinvertebrate species composition) and functional (leaf decomposition and nutrient uptake) attributes and how effective different liming methods can be in restoring stream community structure and function. Ultimately, these efforts will improve our understanding of the effects that acidification and mitigation measures have on stream chemistry and stream ecosystem structure and function, which can only help us better protect these valuable natural resources across the Northeast. The information gathered across the five watersheds before, during, and after liming (in three sub-basins) will allow an assessment of best practices when there is a need in the future to protect high value sites (in this case a heritage strain of brook trout) from potential effects of continued acid deposition. I do hope to obtain external funding to continue this work for at least the next 3 years, but I do not want to miss the opportunity to keep the data set intact through the first few years, especially the first year after the aerial liming of the one chronically acid stream. I also am organizing a special session for the Society for Freshwater Science Meetings in 2015 that highlights 25 years of research after the 1990 Clean Air Act Amendments were passed. The work I am doing now (and hopefully this summer) will form the basis of my presentation, but I am working on

getting other speakers including Gene Likens, Charlie Driscoll, Greg Lawrence as well as others who have been working on acidified systems in the Appalachian and Smoky Mountains.

Previous Grant Support and Other Grant Applications

I have been fortunate to receive Student Wage Grants from the Colgate Research Council in most semesters when I am on campus. I had 2 students working in my lab last semester and will have 3 working in my lab this semester. In 2011 and 2012, we generated many macroinvertebrate samples and we still have one set of benthic samples that we are about half done processing which involves sorting, identifying and counting the macroinvertebrates. I hope to have these done before spring break so I can work on the data over the break. We also have 3 weeks of leaf pack macroinvertebrate samples from this past fall that still require the macroinvertebrates to be sorted, identified and counted. The samples from this fall were taken by my research tutorial students and 3 of them are working on these (one as an independent study). These data will form the basis of one paper on macroinvertebrate dynamics and leaf decomposition rates pre- and post-lime applications in experimental and reference streams. I also had a publication grant last year, and I just received the invoice for the page charges earlier this month so that should be appearing very soon in the Journal of Freshwater Ecology.

I am a Co-PI on an NSF-MRI grant proposal with Roger Rowlett to obtain an instrument that will measure Al in water samples as well as solid matter. If successful, the instrument will allow me to compare Al concentrations among streams as well as on leaves in different streams at different points in time. There is a chance that NYSERDA will have another RFP for environmental monitoring in 2014. If this does occur, I will apply for funding from them to continue this research in Honnedaga tributaries but also expand to other acid-stressed streams in the Adirondacks. This proposal would include collaborators from the Cary Institute of Ecosystem Studies and Lock Haven University, but if we were successful, funds will likely not be available until the fall.

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Professional Preparation:

Michigan State University Fisheries and Wildlife Management, B.S., 1974
University of North Texas Aquatic Ecology, M.S., 1976; with K.W. Stewart
University of Toronto Ecology and Statistics, Ph.D. 1980; with R.J. Mackay
University of Waterloo Stream Ecology, Postdoctoral Fellowship, 1981-1982; with H.B. Noel Hynes

Academic Appointments:

2008-present Professor of Biology and Environmental Studies (joint appointment)
2005-2007 Colgate University Presidential Scholar (2 year rotating endowed Chair)
2005 (Spring) Acting Chair of Biology Department
2003-2006 Director of the Environmental Studies Program
2001-2003 Professor of Biology
1992-2001 Chair of Biology Department
1991-1998 Director of the Environmental Studies Program
1997-Present Colgate University; Full Professor
1989-1997 Colgate University; Associate Professor
1982-1988 Colgate University; Assistant Professor
1981-1982 University of Waterloo: Postdoctoral fellow with Dr.H.B.N. Hynes on predator-prey relations among stream invertebrates and fish.

Publications- 5 most recent:

Fuller, R.L., C. Griego*, J.D. Meuhlbauer, J. Dennison* and M.W. Doyle. 2010. Response of stream macroinvertebrates in flow refugia and high scour areas to a series of floods: A reciprocal replacement study. *J. North American Benthological Society* 29:750-760. DOI 10.1899/09-107-1.

Fuller, R.L., E. Shope*, S. Doyle*, L. Levy*, J. Owens*, L. Vo*, B. Wolyniak*, M. Small and M. Doyle. 2011. Impact of frequent water releases from Abanakee Dam on periphyton and macroinvertebrate communities in Adirondack Mountain Rivers. *River Research and Applications* DOI: 10.1002/rra.1385-1400.

Martin W. Doyle and Randall L. Fuller. 2011. Quantitatively evaluating restoration scenarios for rivers with recreational flow releases. *In: Stream Restoration in Dynamic Fluvial Systems: Scientific Approaches, Analyses, and Tools. Edited by: Andrew Simon, Sean J. Bennett, and Janinie M. Castro. American Geophysical Monograph Series, 194:*

Neatrour, M., R. Fuller, M. Lynch* and J. Crossett*. 2011. Leaf breakdown in neighboring Adirondack streams affected by episodic acidification. *J. Freshwater Ecology* 26: 365-379.
DOI:10.1080/02705060.2011.561999

Fuller, R.L., E. Shope, S. Doyle*, L. Levy*, J. Owens*, L. Vo*, B. Wolyniak*, and M. Doyle. *In Press*. Impact of recreational releases from Abanakee Dam on organic matter transport in four Adirondack Mountain Rivers. *Journal of Freshwater Ecology*.

Other Publications:

Fuller, R.L., B. Kennedy* and C. Nielsen*. 2004. Macroinvertebrate responses to algal and bacterial manipulations in streams. *Hydrobiologia* 523: 113-126.

Fuller, R.L., C. Visscher, M. Anastasi*, J. Molina*, H. Salcido* and S. Ward*. 2008. Influence of canopy cover and insect life history stage on the recovery of stream communities after a spate. *Hydrobiologia* 598: 47-57.

Small, M.J., M.W. Doyle, R.L. Fuller and R.B. Manners. 2008. Hydrologic vs. geomorphic limitation on CPOM storage in stream ecosystems. *Freshwater Biology* 53: 1618-1631.

Randy Fuller and Martin Doyle. 2010. JNABS Article Spotlight: Recreational flow releases and bridging disciplines. June 2010 - North American Benthological Society: *In the Drift Newsletter*.

* Denotes undergraduate student co-authors.

Synergistic Activities:

President (2013-14) Society for Freshwater Science (formerly North American Benthological Society) and member of Board of Directors (2012-2014)

Chair, (2010-2011) Executive Committee, North American Benthological Society – member of Executive Committee 2009-2012

Chair, (2001-2009) Education and Diversity Committee, North American Benthological Society – member of committee 1999-present.

Collaborators and Other Affiliations:

I. Collaborators

Dr. Martin Doyle, Nicholas School of the Environment, Duke University, Durham, NC

Drs. Tim McCay and Rich April, Colgate University, Hamilton, NY

Dr. Cliff Kraft, Department of Ecology and Systematics, Cornell University, Ithaca, NY

Dr. Greg Lawrence, US Geological Survey, Troy, NY

Dr. Emma Rosi-Marshall, Cary Institute of Ecosystem Studies, Millbrook, NY

II. Graduate and Postdoctoral Advisors

M.Sc. – Dr. K.W. Stewart, Department of Biological Sciences, University of North Texas

Ph.D. – Dr. Rosemary J. Mackay, Department of Zoology, University of Toronto

Postdoctoral – Dr. H.B.N. Hynes, Department of Biology, University of Waterloo