STATEMENT OF QUALIFICATIONS

12/27/2013

Aquatic Biogeochemistry Lab at Utah State University and Wyoming Survey and Analysis Center at the University of Wyoming

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Introduction

We submit for consideration our statement of qualifications to conduct a study to determine the total phosphorus threshold level for statistically significant shifts in algal species composition or biomass in designated scenic rivers in Oklahoma. The research team includes Dr. Michelle Baker of the Aquatic Biogeochemistry Lab at Utah State University, Ms. Nanette Nelson of the University of Wyoming's Wyoming Survey and Analysis Center.

I. Mission Statements

The Mission of the Aquatic Biogeochemistry Lab at Utah State University (USU-ABL) is to conduct scientifically valid data collection aimed at understanding the physical, chemical, and biological processes that affect water quality in streams and rivers. The team provides laboratory analytical services for a variety of chemical constituents in water in addition to field-based studies.

The Wyoming Survey & Analysis Center (WYSAC) at the University of Wyoming seeks to provide clear, accurate, and useful information to decision-makers, on a contract-basis, through applied social science research, scientific polling, information technology services, and rigorous program evaluation. Without bias and with the highest standards of validity, WYSAC collects, manages, analyzes, and reports data for the public and private sectors in Wyoming and throughout the Great Plains and Rocky Mountains and nationally.

Summary of Qualifications

I. Baker/USU-ABL

Michelle Baker is a Professor and Associate Head of Biology, and an Associate of the Ecology Center at Utah State University. She holds a B.S. in Biology from Lafayette College and Ph.D. in Biology from the University of New Mexico. She is an ecosystem ecologist whose research program focuses on hydrological and biogeochemical processes that control material transport and retention in streams and rivers, including the effects of land use on these processes. Current studies investigate biological and hydrological factors that affect nutrient transport in rivers, how stream network configuration and human activity affects nitrogen and organic matter cycling, and how ecological tools can assist with development of nutrient criteria for streams.

Dr. Baker has served on state and regional advisory groups including the Jordan River Technical Advisory Committee for the state of Utah's Department of Environmental Quality, and the Aquatic Ecosystems Workshop Group for the Assessment of Climate Change Effects on Aquatic Ecosystems of the Great Basin-Rocky Mountain Region. She serves on the Editorial Board of the journal Freshwater Science (formerly Journal of the North American Benthological Society), and is a current member of the Board of Directors and Executive Committee for the Society for Freshwater Science.

II. Nelson/WYSAC

Nanette Nelson is an Associate Research Scientist at the Wyoming Survey and Analysis Center at the University of Wyoming. She holds a B.S. in Oceanography from the University of Washington and M.S. Degrees in Agricultural Economics and Conservation Ecology and Sustainable Development from the University of Georgia. Ms. Nelson conducts social science research for a variety of regional and national entities. Recent projects include willingness to pay and economic valuation of water quality in Utah, public health perceptions and taxation of cigarettes in Wyoming, and visitor perception of bear risk in Grand Teton National Park.

As a land-grant, state university, the University of Wyoming has considerable experience in successfully managing federal, state, and private funds. WYSAC, a research unit within the College of Arts and Sciences, is singularly well-qualified to take on a project of this scope. WYSAC's team recently completed an EPA-funded national survey by mail, phone, and web on Willingness to Pay (WTP) for air quality in national parks. In the past two years the WYSAC team has also conducted two other federally funded national surveys – one by mail (WTP on issues of water quality and aquatic invasive species, funded through the National Science Foundation), and one by telephone (WTP for land use, funded through the U.S. Departments of the Interior and Agriculture). Additionally, WYSAC has participated in projects for the National Park Service and several individual national parks, for Wyoming's Department of State Parks and Cultural Resources, and for the Wyoming Game and Fish Department.

WYSAC's professional staff includes 20 researchers with advanced degrees in statistics, economics, political science, psychology, sociology, and other policy related disciplines. In addition, WYSAC has an internal administrative and information technology staff, supported by part-time graduate assistants and undergraduate research aides. WYSAC's technological infrastructure includes WinCATI software for telephone surveys, and Teleform software and high-volume hardware for scanning paper-and-pencil

questionnaires. The call center currently has 22 call stations. WYSAC also has considerable experience in conducting focus groups, internet surveys, and in-person interviews.

Summary of Related Experience

All team members have experience with water quality studies generally, and with numeric nutrient criteria for streams in particular.

I. Baker/USU-ABL

a. Research to inform nutrient endpoints in East Canyon and Spring Creeks, Utah (2006-2008)

This study used functional indicators of stream health including nutrient spiraling, ecosystem metabolism, nutrient limitation, and algal biomass to evaluate nutrient (TP) endpoints for the East Canyon and Spring Creek TMDLs. See example report in appendix.

b. Nutrient limitation of benthic algae in the Jordan River, Utah (2009)

This study was aimed at training employees of the Utah Division of Water Quality (UT-DWQ) how to use nutrient diffusing substrates (NDS) to evaluate nutrient limitation of benthic algae. The USU-ABL and UT-DWQ staff constructed 500+ NDS and deployed these in 20 locations in the Jordan River, UT which is undergoing a phased TMDL. Data were analyzed and a standard protocol was developed for future use by UT-DWQ staff.

c. Stream functional condition measures and a manual for nutrient criteria for Utah's streams (2010-2012)

Following on the 2006-2008 TMDL study, this project provided standard protocols and training of UT-DWQ staff to collect data on functional indicators of nutrient pollution in streams. The protocols were implemented in ~30 stream reaches by UT-DWQ staff, along a wide nutrient gradient, in an effort to identify nutrient thresholds. More traditional bioindicators (macroinvertebrates and algae community composition) were also collected and analyzed from the same sites. Dr. Baker's group was responsible for laboratory chemistry analyses of water samples, protocol development and training, along with initial data analysis as presented at the 2012 Meeting of the Society for Freshwater Science. The UT-DWQ is currently summarizing the findings in collaboration with their stakeholders, with aim to present the information for public comment in 2014. See attached powerpoint from the 2012 SFS meeting and visit http://www.waterquality.utah.gov/nutrient/ecology.htm for additional information.

d. A preliminary organic matter budget for the Jordan River (current)

Our current study is measuring organic matter fluxes, loads, and yields in several segments of the Jordan River, Utah, a eutrophic urban river in central Utah, that is undergoing a phased TMDL for excess organic matter. Our goals are to identify reaches that are potential sources and sinks of excess organic matter that may trigger violation of the dissolved oxygen criterion during the summer months. Field data were collected for water year 2013 and are currently being analyzed for a final report due in spring 2014.

e. Invited expert EPA workshop on nutrient criteria (2013)

Dr. Baker was an invited expert at the 2013 EPA workshop on nutrient indicators. There the group of panelists recommended indicators of nutrient pollution for incorporation into nutrient criteria development studies. These indicators include functional parameters such as ecosystem metabolism, algal biomass and composition, which would be included in a proposal for Oklahoma scenic streams/rivers if our team is chosen for proposal development.

II. Nelson/WYSAC

a. Utah Economic Benefits Study

In collaboration with CH2M Hill, and professors from Utah State University and the University of Colorado, WYSAC successfully bid for a contract with the State of Utah's Department of Water Quality to estimate the economic benefits of implementing numeric nutrient criteria for surface waters in Utah. In 2011 two separate surveys were developed for this study. The first survey, the Total Economic Value (TEV) Survey, which used 20 distinct versions of the questionnaire, was designed to estimate the value that Utah residents place on good water quality for their recreational use and enjoyment and for protecting these resources for future generations of Utahns. The second survey, the Recreation Survey, was designed to estimate how the demand for water-based recreation is affected by perceptions of water quality. The final versions of both surveys were the result of several focus groups and pretests. Six focus group sessions were conducted with the main intent of clarifying the description of the problem – water quality degradation resulting from excess loading of nutrients to surface water – and provided helpful suggestions for rewording or reordering certain questions on the survey instrument. Dillman's tailored design method (Dillman, 2007) was applied for the mailing sequence in the survey administration. The survey instruments were programmed into an Optical Mark Recognition scannable format using Teleform software.

The two surveys were fielded using distinct sampling designs. The TEV survey's target population was all households in Utah regardless of whether or not the household actually recreated on or near waters of the state, thus the sampling frame was a random sample of all households in Utah. WYSAC purchased a sample of 2,700 mailable addresses for the TEV survey. The target population for the Recreation Survey, on the other hand, was all households in Utah that engaged in near-water or water-based recreation. The sampling frame for the Recreation Survey thus used a combination of (1) a "targeted" sample of households believed to engage in water-based recreation and (2) a random sample of the general population. WYSAC purchased samples of 2,600 and 2,000 mailable addresses for the targeted sample and the random sample, respectively.

The TEV Survey was in the field from July through September 2011. The Recreation Survey was in the field from September 2011 through January 2012. A total of 625 and 1,411 completed surveys were obtained for the TEV Survey and Recreation Survey, respectively.

Using data from the TEV Survey, WYSAC developed an econometric model to estimate Utahns' willingness to pay (WTP) for improved water quality from the implementation of numeric nutrient criteria. The referendum format of the WTP scenario – household's respond with a "yes" or "no" vote for a single dollar amount – resulted in estimating the probability of payment given a dollar amount using a logistic model. All models were estimated using the logit procedure in Stata Version 12 with the data weighted to correspond to the Census demographics of Utah households. Resulting estimates from the model were used to calculate monthly

and annual household WTP for improved water quality as well as present value benefits over a 20 year period for the state of Utah.

b. Mode Effects and Other Potential Biases in Panel-Based Internet Surveys

During the spring and summer of 2008 WYSAC directed a national survey by telephone, on the Internet, and by mail, with a total of more than 3,300 respondents nation-wide. The goal of the study was to assist the U.S. Environmental Protection Agency in determining whether a recruited Internet panel of respondents can be used to produce reliable estimates of willingness to pay for goods or services for which no formal market exists. WYSAC developed virtually identical versions of a questionnaire eliciting the public's willingness to pay (WTP) for improved air quality in national parks. The project team provided quarterly reports and the final report on time and within budget. Results were presented at the 2009 American Association of Public Opinion Research's annual conference with a companion article published in the 2009 Joint Statistical Meetings Proceedings.

Quality Assurance/Quality Control

I. Quality Assurance

a. Policy Statement

The Utah State University Aquatic Biogeochemistry Laboratory (USU-ABL) is committed to provide scientifically valid analytical data for university-sponsored research projects as well as for outside customers, including government agencies and local stakeholders. We aim to produce data in a timely manner following established protocols for analyses of chemical constituents in fresh and saline waters, such as those approved by the Environmental Protection Agency (EPA). Aside from EPA-approved methods, and depending on user needs, we use more state-of-the-art protocols that have been vetted through the scientific peer review process and are in published literature.

Although the USU-ABL is not formally certified by any accreditation program, the lab does follow process used by most certified labs including the following: Lab director and manager have achieved advanced educational degree with background in analytical chemistry, technicians are typically students in a science field with some lab experience before they receive specific training on an analytical instrument, the lab has an up-to-date Chemical Hygiene Plan as well as a lab manual that contains documents describing QA/QC process and specific standard operating procedures (SOPs) for each analysis/measurement. Instruments are calibrated using these SOPs and analyses are verified using certified reference materials appropriate for each analysis. Method detection limits are calculated for each analysis and updated biannually. Data below the method detection limit are reported with a flag. The lab conducts self-audits to ensure compliance with OSHA and university regulations and is inspected annually by USU's safety office and irregularly by EPA.

b. Organizational Structure

The USU-ABL is staffed by a Director (Dr. Michelle Baker) who has nearly 20 years of experience in aquatic biogeochemistry research. A lab manager (Ms. Lisa Ward) coordinates laboratory analyses, oversees QA/QC process, ensures compliance with OSHA and university rules and regulations, trains and supervises graduate and undergraduate student technicians. During any given semester the lab is staffed by 2-3 part-time undergraduate student technicians, as well as 2-3 graduate students.

c. Staff Responsibilities

All personnel employed by the USU-ABL are required to be familiar with policies and procedures outlined in this document, as well as individual standard operating procedures (SOPs) used for specific analyses.

All USU-ABL employees must abide by USU's Personnel Policies. These are available in detail from the Human Resources website (http://www.usu.edu/hr/htm/policies). USU conducts background checks on all new employees. USU operates a strict drug- and alcohol-free workplace.

All USU-ABL employees must complete the following training upon appointment, with renewal at the specified rates:

Training	Administrator	Renewal Period
Laboratory Safety	Environmental Health and Safety Office	Annual
Specific SOPs	USU-ABL	Annual
Drivers Training	Motor Pool	Every other year
Purchasing Card	Purchasing Office	Every three years

Students, post-docs, and classified staff sponsored in whole or in part by funds from the National Science Foundation must complete training in the Responsible Conduct of Research. This training is offered annually by the Office of Compliance Assistance, and satisfies requirements of the America COMPETES Act.

All USU-ABL employees must support scientific integrity as outlined in USU Policy #306. Scientific misconduct defined in USU policy as "any incident of fabrication, falsification, or plagiarism in proposing, conducting, or reporting research. It does not include honest error or honest differences in interpretations or judgments of data. Fabrication refers to the making up of data that were not observed as purported. Falsification includes the changing of data or the way in which observations are reported, and spans a broad spectrum, from omitting observed data points from reported data sets to wholesale changing of data to fit the investigator's hypothesis. Plagiarism is the claiming as one's own material that is the product of someone else's work." Scientific misconduct by USU-ABL employees will not be tolerated and will be grounds for immediate dismissal.

d. Training and Performance Requirements

Employees of USU-ABL must maintain training records as outlined in the table above. Performance will be documented initially and on an on-going basis as outlined below.

i. Initial Demonstration of Capability

Before performing any chemical analysis, USU-ABL employees will conduct an initial demonstration of capability (IDC) to demonstrate that the employee is proficient in the analysis. The IDC includes comparing the calibration standard curve of the new analyst (or method if modified) to that of a previous analyst. Reagent blanks and check standards are also compared within a sample run. Calibration curves should differ by no more than 10%. Reagent blanks should contain no contamination at concentrations ½ of the method detection limit. Percent recovery for check standards should be within acceptance criteria for the given method, typically within $\pm$10%. IDC information should be recorded in the USU-ABL Laboratory manual at the end of the appropriate SOP.

ii. Ongoing Demonstration of Capability

Ongoing capability for a given SOP is demonstrated using reagent blanks, check standards, and quality-control standards prepared from certified reference materials. Check standards made from calibration stock solutions and reagent blanks must be included every 20 samples in a run. Certified reference materials should be analyzed quarterly (or about every 500 samples). Check standards and certified reference materials are analyzed semi-annually for each analyst and method. Each analyst must update signatures on specific SOPs annually as part of their annual performance evaluation.

e. Analytical Capabilities of the ABL

i. Analytical capability includes ion chromatography, total organic carbon and total nitrogen analyses, inorganic and total nitrogen and phosphorus analyses, chlorophyll, biochemical oxygen demand, and gas chromatography with electron capture detection (GC-ECD), flame ionization detection (GC-FID), and thermal conductivity detection (GC-TCD).

ii. Additional services include method development, sample processing for stable isotope analysis, dry mass and ash-free dry mass, total suspended solids, volatile suspended solids.

f. Receiving and Handling Samples, and Chain-of-Custody Procedure

i. Receiving samples and storage

Samples are typically received in a cooler. Samples usually should be transported to the lab on ice; please see individual SOPs for specific details. Each user must fill out an Analysis Order Form (available online or in BNR 142) with name and contact information, sample matrix, number of desired analyses, estimated concentration range, data deadline, and billing information. Samples for nutrient analysis are stored in the freezer in boxes labeled with identification tags (available on each freezer; be sure to note freezer name on Analysis Order Form) that indicate desired analyses. We have found that for most nutrient analyses, samples are stable if stored frozen for several months. Samples for dissolved organic carbon analysis typically are received in amber glass bottles and are acidified to pH<2. These samples should be stored in the dark at room temperature.

ii. Handling samples

Frozen samples should be thawed in a hot water bath prior to analysis. Samples to be analyzed for multiple parameters should be processed for ammonium first since this analyte is most sensitive to repeated freezing and thawing of samples. Total N and P should be done last. Analyst should cross off analyses on the box identification tag after each one is done. When all analyses are complete, and data have been checked and sent to the end-user, samples should be removed from the freezer and returned to the user, or disposed of.

iii. Chain-of-custody

Some users require specific chain-of-custody procedures to verify sample integrity. USU-ABL will work with such clients on an individual basis to ensure proper paperwork is completed. In some cases chain-of-custody is indicated on the sample bottle, so each analyst should sign and date the appropriate space on the bottle on

receipt, and after each analysis is completed. If samples are received with specific chain-of-custody forms, these are to be attached to the Analysis Order Form and signed as appropriate when specific analyses are conducted.

II. Quality Control

a. Calibration, Verification, and Maintenance of Analytical Instrumentation

i. Calibration

Instrument calibration is conducted according to instrument manufacturer's instruction manual and SOP instructions. Initial calibrations are conducted with a minimum of 5 concentrations for linear curves, and 7 concentrations for non-linear curves, each time the instrument is started up for analysis. The calibration range varies by analysis but includes a low standard at or below the method detection limit, and a high concentration at the maximum expected by the end-user as reported on the Analysis Order Form. Calibration is acceptable by linear or nonlinear regression when a minimum correlation coefficient of 0.995 is achieved. For most analyses the correlation coefficient is 0.999. Initial calibration procedure is repeated if calibration criteria are not met within a run or if new reagents are added in the middle of a run.

ii. Verification

Calibration verification within a run is assessed using laboratory-fortified blanks (check standards) prepared in a mid-range concentration. Duplicate check standards should be conducted on a 5% basis, or after every 20 samples. Reagent blanks are run at a minimum at the beginning and end of the run, and more often for certain analyses (see specific SOPs). Calibration verification is calculated as % difference in response factor for check standard compared to initial standard, and as % recovery of check standard. Deviations between 2-5% are flagged in the analysis, deviations greater than 5% require re-run. If contamination is present in reagent blanks (greater than detection limit), source of contamination should be identified and samples re-run.

iii. Maintenance/Troubleshooting

Analysts must follow instrument users manual for maintenance schedules. Typically if initial calibration is not good, try the following: remake reagents, remake calibration standards, check tubing/plumbing integrity and replace as needed. Follow more detailed troubleshooting as recommended by specific instrument manual. Record maintenance conducted in instrument log book.

b. Quality Control Parameters

i. Method Detection Limit

The method detection limit (MDL) is determined at least annually for each method from a minimum of seven replicates of low-level check standard that have been processed through the entire method, across three or more runs. The MDL is calculated as the standard deviation times the t-value from a one-sided t-distribution at the 99% level. For example for 7 replicates, the t-value is 7-1= 6 degrees of freedom = 3.14. The MDL is reported to the end user with each data set.

ii. Repeatability

Sources of variation and bias in analytical measurement include but are not limited to sampling error and preparation, matrix effects, calibration errors, differences among analysts, reagent impurities, and instrument errors (hardware and software). It is usually not possible to minimize all of these errors simultaneously. We have found that sampling error – particularly field filtering of samples can be very large. Contamination of samples in the field, sample bottle, and from the atmosphere can be a large source of error. USU-ABL reports repeatability of measurements from analytical duplicates. End-users are advised to include field duplicates and field blanks with their samples. Analytical replicates that deviate more than 10% are re-run.

c. Data Reporting

i. Data are reported in an excel spreadsheet with these minimum paramaters: analysis date, analyst name, sample identification, concentration, calibration information, reagent blanks, check standards. USU-ABL will work with end-users to provide data in optimal format for their needs.

ii. Data flags

In some instances reported data are qualified by flags indicating that quality control was not achieved. Flags include the following:

BDL = below method detection limit

CON = possible contamination because analyte found in reagent blank or % recovery exceeds expected value by more than 10%.

E = value exceeds high concentration calibrant. Sample is usually diluted and re-run.

RERUN = sample concentration rejected because of contaminant, method performance, etc.

d. Records Archiving

i. Each analyst is responsible for maintaining electronic copies of each analytical run in the appropriate instrument folder. These are duplicated and archived on USU's server, and stored for a minimum of 3 years. Electronic copies of excel spreadsheets should be made quarterly, saved to CD or DVD and stored in BNR 145.

ii. Hard copies of Analytical Order Forms and other data sheets are stored in BNR 145 for a minimum of 3 years.

iii. Lab notebooks should be scanned quarterly and the images stored on USU's server. Hard copies of lab notebooks should be stored indefinitely in BNR 140. Electronic copies of scanned lab notebooks should be saved to CD or DVD and stored in BNR 145.

III. References

i. American Public Health Association (APHA). 1998. Standard methods for the examination of water and wastewater 20th edition. APHA, Washington DC.

Resumes

Michelle A. Baker

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Education

Ph.D.	1998	Biology, University of New Mexico, Albuquerque, NM
B.S.	1992	Biology (with Honors), Lafayette College, Easton, PA

Professional Appointments

2011 -	Professor and Associate Head, Department of Biology, Utah State University
2005 – 2011	Associate Professor, Department of Biology, Utah State University
1999 – 2005	Assistant Professor, Department of Biology, Utah State University
1998 – 1999	Postdoctoral Fellow, Centre d'Ecologie des Systèmes Aquatiques Continentaux, CNRS/Université Paul Sabatier, Toulouse, France

Academic Interests

Biological and hydrological controls of water quality
Stream and watershed ecology and biogeochemistry
Stable isotopes in ecology and hydrology

Professional Affiliations

American Geophysical Union
Ecological Society of America
Society for Freshwater Science

Citations and Indices (Google Scholar, accessed 6 Nov 2013)

Citations (since 1998)	1929
h – index (since 1998)	17
i10 – index (since 1998)	23
m-index (since 1998)	1.13

Awards

Undergraduate Research Mentor of the Year. College of Science, Utah State University, 2013
Best Paper Award, Soil Science Society of America Annual Meeting, for Van Miegroet, H., J. Boettinger, and M. Baker "Soil organic quality in wildland soils: what is it and why is it important?" 2006
USU Mortar Board Top Professor, 2005

Hynes Award for New Investigators, An award recognizing excellence in benthic science for an influential paper published by a young scientist. The North American Benthological Society, 2001

NSF-NATO Postdoctoral Fellowship, 1998

Wildco Award for Best Oral Presentation by a Student in Basic Research, North American Benthological Society, 1998

Outstanding Student Presentation Award, Hydrology Section, American Geophysical Union Fall Meeting, 1996

Willis Roberts Hunt Prize, Awarded to the student showing most promise for a career in Biology, Lafayette College, 1992

Awards to Students

Fellowship to Sam Hochhalter (M.S. 2009). Environmental Protection Agency-Science to Achieve Results Graduate Fellowship. 2008-2009.

James A. and Patty MacMahon Scholarship to Keli Goodman (Ph.D. 2010). 2008.

North American Benthological Society Presidential Endowment Award to Keli Goodman (Ph.D. 2010). 2007.

Fellowship to Keli Goodman (Ph.D. 2010). Inland Northern Research Alliance Subsurface Science Graduate Fellowship 2006-2008.

Fellowship to Christopher Arp (Ph.D. 2006). Environmental Protection Agency-Science to Achieve Results Graduate Fellowship. 2004-2006.

Outstanding Student Poster, Joint meeting of the North American Benthological Society and American Geophysical Union, for Myers, A.K., A.M. Marcarelli, C.D. Arp, W.W. Wurtsbaugh and M.A. Baker "Lake disruptions on sediment mobility and effects on benthic chlorophyll." May 2005.

Fellowship to Christopher Arp (Ph.D. 2006). Inland Northern Research Alliance Subsurface Science Graduate Fellowship 2002-2004.

Peer Reviewed Publications

* Indicates graduate student co-author

‡ Indicates undergraduate student co-author

Articles in Review (manuscript available on request)

Goodman, K.J.*, A.R. Benedetto‡, and **M.A. Baker**. In review. Dissolved organic matter (DOM) photobleaching in subalpine oligotrophic stream-lake systems: implications for DOM bioavailability and heterotrophic processing. Journal of Geophysical Research - Biogeosciences

Manuscripts in Preparation (manuscript available on request)

Baker, M.A., C.D. Arp*, K.J. Goodman*, A.M. Marcarelli*, and W.A. Wurtsbaugh. Stream-lake interactions: effects on stream ecosystem structure and function. In preparation as Chapter 9 in J.B. Jones and E.J. Stanley (eds.). Streams in a Changing Environment. Springer-Verlag.

Kelso, J.E.* and **M.A. Baker**. In preparation for Freshwater Science. Filtering with a drill pump: an efficient and cost effective method to collect suspended sediment and filtrate.

Myers, A.K.*, **M.A. Baker** and C.D. Arp*. In preparation for Journal of Geophysical Research- Biogeoscience. Discriminating between biological and hydrological controls of hyporheic denitrification across a land-use gradient in nine western Wyoming (USA) streams.

S.J. Hochhalter*, **M.A. Baker**, and S.W. Miller. In preparation for Ecological Monographs. Ecosystem engineering by invasive common carp decreases structure and functioning of a eutrophic stream.

Published Articles

Hall, R.O., **M.A. Baker**, E.J. Rosi-Marshall, J.L. Tank, and J.D. Newbold. In press. Solute specific scaling of inorganic nitrogen and phosphorus uptake in streams. Biogeosciences doi:10.5194/bg-10-1-2013. (note an earlier version of this paper was published in Biogeosciences Discussions).

Hall, R.O., **M.A. Baker**, E.J. Rosi-Marshall, and J.L. Tank. 2013. Solute specific scaling of inorganic nitrogen and phosphorus uptake in streams. Biogeosciences Discussions. 10:6671-6693.

Epstein, D.M.*, W.A. Wurtsbaugh, and **M.A. Baker**. 2012 Nitrogen partitioning and transport through a subalpine lake measured with an isotope tracer. Limnology and Oceanography 57:1503-1516.

Goodman, K.J.*, **M.A. Baker**, and W.A. Wurtsbaugh. 2011. Lakes as buffers of stream dissolved organic matter (DOM) variability: Temporal patterns of DOM characteristics in mountain stream-lake systems. Journal of Geophysical Research- Biogeosciences. doi:10.1029/2011JG001709.

Zarnetske, J.P.*, R.D. Haggerty, S.M. Wondzell, and **M.A. Baker**. 2011. Labile dissolved organic carbon supply limits hyporheic denitrification. Journal of Geophysical Research- Biogeosciences. doi:10.1029/2011JG001730.

Washbourne, I.J., C.L. Crenshaw and **M.A. Baker**. 2011. Dissimilatory nitrate reduction pathways in an oligotrophic aquatic ecosystem: spatial and temporal trends. Aquatic Microbial Ecology 65:55-64. doi:10/3354/ame01538.

Zarnetske, J.P.*, R.D. Haggerty, S.M. Wondzell, and **M.A. Baker**. 2011. Dynamics of nitrate production and removal as a function of residence time in the hyporheic zone: a 15N tracer study. Journal of Geophysical Research- Biogeosciences. 116, G01025doi:10.1029/2010JG001356.

Covino, T.*, B. McGlynn, and **M.A. Baker**. 2010. Separating physical and biological nutrient retention and quantifying uptake kinetics from ambient to saturation in successive mountain stream reaches. Journal of Geophysical Research-Biogeosciences. 115, G04010doi:10.1029/2009JG001263.

Goodman, K.J.*, **M.A. Baker**, and W.A. Wurtsbaugh. 2010. Mountain lakes increase stream cellulose decomposition potential. Journal of the North American Benthological Society 29:521-529.

Latta, L.C.IV*, **M.A. Baker**, T. Crowl, J.J. Parnell, B. Weimer, D. DeWald, and M.E. Pfrender. 2010. Species and genotype diversity drive community and ecosystem properties in experimental microcosms. Evolutionary Ecology. doi: 10.1007/s10682-010-9457-3

Hall, R.O. Jr., **M.A Baker**, C.D. Arp*, and B.J. Koch*. 2009. Hydrologic control of nitrogen removal, storage and export in a mountain stream. Limnology and Oceanography 54:2128-2142.

Baker, M.A., G.deGuzman‡, and J. D. Ostermiller. 2009. Differences in nitrate uptake among benthic algal assemblages in a mountain stream. Journal of the North American Benthological Society 28: 24-33.

Biggs, M.A.*, M.N. Gooseff, C.D. Arp*, and **M.A. Baker**. 2009. Informing a stream transient storage model with two-storage zones to discriminate in-channel dead zones and hyporheic exchange. Water Resources Research 45: W00D27 doi:10.1029/2008/WR006959.

Marcarelli, A.M.*, **M.A. Baker** and W.A. Wurtsbaugh. 2008. Is in-stream nitrogen fixation an important nitrogen source for benthic communities and stream ecosystems? Journal of the North American Benthological Society 27:186-211.

Rothlisberger*, J.D., **M.A. Baker**, and P.C. Frost. 2008. Effects of periphyton stoichiometry on mayfly excretion rates and nutrient ratios. Journal of the North American Benthological Society 27:497-508.

Tank, J.L., E.J. Rosi-Marshall, **M.A. Baker**, and R.O. Hall, Jr. 2008. Are rivers just big streams? Using a pulse method to measure nitrogen demand in a large river. Ecology 89:2935-2945.

Vinson, M.R. and **M.A. Baker**. 2008. Poor growth of rainbow trout (*Oncorhynus mykiss*) fed New Zealand mud snails (*Potamopyrgus antipodarum*). North American Journal of Fisheries Management 28:701-709.

Arp*, C.D. and **M.A. Baker**. 2007. Discontinuities in stream nutrient uptake below lakes in mountain drainage networks. Limnology and Oceanography 52: 1978-1990.

Arp*, C.D., J.C. Schmidt, **M.A. Baker**, and A.K. Myers‡. 2007. Stream geomorphology in a mountain lake district: Sediment links, lake-modified hydraulics, and downstream lake effects. Earth Surface Processes and Landforms 32: 525–543.

Myers‡, A.K., A.M. Marcarelli*, C.D. Arp*. **M.A. Baker**, and W. Wurtsbaugh. 2007. Disruptions of stream sediment size and stability by lakes in mountain watersheds: potential effects on periphyton biomass. Journal of the North American Benthological Society 26:234-245.

Arp*, C.D., M.N. Gooseff, **M.A. Baker**, and W. Wurtsbaugh. 2006. Surface-water hydrodynamics and regimes of a small mountain stream-lake ecosystem. Journal of Hydrology. 329:500-513.

Mendelson, J.R. III, E.D. Brodie, Jr., J.M. Malone, M.E. Acevedo, **M.A. Baker**, N.J. Smatresk, and J.A. Campbell. 2005. Amphibian chytridomycosis in Guatemala: Decline of a cloud-forest frog fauna. Revista en Biologia Tropical- Journal of Tropical Biology 54:991-1000.

Van Miegroet, H., J.L. Boettinger, **M.A. Baker**, J. Nielsen‡, D. Evans‡, and A. Stum‡. 2005. Soil carbon distribution and quality in a montane rangeland-forest mosaic in northern Utah. Forest Ecology and Management. 220:284-299.

Valett, H.M., **M.A. Baker**, J.A. Morrice, C.S. Crawford, M.C. Molles, C.N. Dahm, D.L. Moyer, and J.R. Thibault. 2005. The flood pulse in a semi-arid riparian forest: metabolic and biogeochemical responses to inter-flood interval. Ecology 86:220-234.

Baker, M.A. and P. Vervier. 2004. Hydrologic variability, organic matter supply, and denitrification in the Garonne River ecosystem. Freshwater Biology. 49:181-190.

Dahm, C.N., **M.A. Baker**, D.I. Moore, and J.R. Thibault. 2003. Biogeochemistry of surface waters and alluvial ground waters in streams and rivers during drought. Freshwater Biology 48:1219-1231.

Vervier, P., L. Roques, **M.A. Baker**, F. Garabetian and P. Auriol. 2002. Biodegredation of dissolved free simple carbohydrates in surface, hyporheic and riparian waters of a large river. Archiv für Hydrobiologie 153:595-604.

Baker, M.A., H.M. Valett, and C.N. Dahm. 2000. Organic carbon supply and metabolism in a near-stream groundwater ecosystem. Ecology 81:3133-3148.

Baker, M.A., C.N. Dahm, and H.M. Valett. 1999. Acetate retention and metabolism in the hyporheic zone of a mountain stream. Limnology and Oceanography 44:1530-1539.

Valett, H.M., C.N. Dahm, M.E. Campana, J.A. Morrice, **M.A. Baker**, and C.S. Fellows. 1997. Hydrologic influences on groundwater-surface water ecotones: heterogeneity in nutrient composition and retention. Journal of the North American Benthological Society 16:239-247.

Daehler, C.C., **M.A. Baker**, J. Merkle, and S.K. Majumdar. 1994. Elemental processing in leaf litter and sediments in an aquatic system: effects of anthropogenic pollution. International Journal of Ecology and Environmental Sciences 20:287-302.

Baker, M.A., C.C. Daehler, and S.K. Majumdar. 1992. Heterotrophic bacteria and fungi associated with decomposing leaves submerged in a lake in Pennsylvania, USA. International Journal of Ecology and Environmental Sciences 18:1-15.

Bobrin, B.D., R.K. Kang, **M.A. Baker**, G.S. Ahearn, C.C. Daehler, and S.K. Majumdar. 1992. In vitro cytotoxicity of carboplatin on human breast adenocarcinoma and normal fetal lung cells. The Nucleus 34:123-129.

Majumdar, S.K. E.P. Daly, K.M. Kleemeyer, C.C. Daehler, and **M.A. Baker**. 1991. Genotoxic effects of gossypol acetic acid on cultured murine erythroleukemia cells. Environmental and Molecular Mutagenesis 18:212-219.

<u>Book Chapters and Conference Proceedings</u> (peer reviewed)

Wurtsbaugh, W.A., H.P. Gross and **M.A. Baker**. 2008. Lake landscapes buffer nutrient flux and algal production in mountain watersheds. Verh. Internat. Verein. Limnologie. Extended abstract, 1 p.

Wurtsbaugh, W.A., **M.A. Baker**, H.P. Gross, and P.D. Brown‡. 2005. Lakes as nutrient "sources" for watersheds: a landscape analysis of the temporal flux of nitrogen through sub-alpine lakes and streams. Verh. Internat. Verein. Limnologie. 29:645-649.

Baker, M.A., C.N. Dahm, and H.M. Valett. 2000. Anoxia, anaerobic metabolism biogeochemistry of the stream water- ground water interface. Pages 259-284 In J.B. Jones, Jr. and P.J. Mulholland (eds.) Streams and Ground Waters. Academic Press, San Diego.

Baker, M.A., C.N. Dahm, H.M. Valett, J.A. Morrice, M.E. Campana, and G.J. Wroblicky. 1994. Spatial and temporal variation in methane distribution at the ground water- surface water interface in headwater catchments. Pages 29-37 In J.A. Stanford and H.M. Valett (eds.) Proceedings of the Second International Conference on Ground Water Ecology. AWRA, Herndon, VA.

Baker, M.A., J. Merkle, and S.K. Majumdar. 1994. Implications of pollutants on diversity of aquatic bacteria and fungi. Pages 114-122 In S.K. Majumdar, F.J. Brenner, J.E. Lovich, J.F. Schalles, and E.W. Miller (eds.) Biological Diversity: Problems and Challenges. Pennsylvania Academy of Science, Philadelphia, PA.

Wroblicky, G.J., M.E. Campana, C.N. Dahm, H.M. Valett, J.A. Morrice, K.S. Henry, and **M.A. Baker**. 1994. Simulation of stream-groundwater exchange and near-stream flow paths of two first order mountain streams using MODFLOW. Pages 187-198 In J.A. Stanford and H.M. Valett (eds.) Proceedings of the Second International Conference on Ground Water Ecology. AWRA, Herndon, VA.

Miller, E.W., **M.A. Baker**, and S.K. Majumdar. 1992. Epilogue: United Nations sponsored 1992 Earth Summit in Rio de Janeiro- where do we go from here? Pages 551-554 In S.K. Majumdar, L.D. Kalkstein, B.M. Yarnal, E.W. Miller, and L.M. Rosenfeld (eds.) Global Climate Change: Implications, Challenges and Mitigation Measures. Pennsylvania Academy of Science, Philadelphia, PA.

Other Articles and Reports (not peer reviewed)

Baker, M.A., S.J. Hochhalter*, and E.J. Lytle‡. 2009. Final Report: research to inform nutrient endpoints in Spring Creek, Utah. Report to the Utah Division of Water Quality. 81 pages.

Baker, M.A., S.J. Hochhalter*, and E.J. Lytle‡. 2008. Research to inform nutrient endpoints in East Canyon Creek, Utah. Report to the Utah Division of Water Quality. 77 pages.

Baker, M.A. 2003. Improving quantitative understanding using spreadsheet models. Ecology. 83:3524-3525.

Covich, A.P., **M.A. Baker**, R. Behneke, D.W. Blinn, L.M. Carter, J. Chambers, T.A. Crowl, J.P. Dobrowolski, C.P. Hawkins, C. Luecke, J. Miller, L.N. Poff, F.J. Rahel, J.C. Schmidt, S.Selby, A.L. Sheldon, M. Vinson, and F.H. Wagner. 2003. Natural Ecosystems II- Aquatic Ecosystems. Pages 185-205 in Wagner, F.H. (Ed.). Rocky Mountain/Great Basin Regional Climate Change Assessment. Report for the U.S. Global Change Research Program. Logan, UT.

Baker, M.A. 2001. Ecology readings from the University of Wisconsin. Ecology. 82(1):262.

Weiler, C.S. and DIALOG III Participants. 2000. Perspectives on graduate education: Experience in aquatic science. Bulletin of the American Society for Limnology and Oceanography. 9(2):20-22.

Baker, M.A. 1998. Organic carbon retention and metabolism in near-stream groundwater. Ph.D. Dissertation, The University of New Mexico, Albuquerque.

Invited Conferences and Symposia

Gordon Research Conference: The Metabolic Basis of Ecology. Bates, ME. July 2004.

Council on Undergraduate Research Posters on the Hill, Washington, DC. April 2004.

Aquatic Ecosystems Workshop Group. Assessment of Climate Change Effects on Aquatic Ecosystems of the Great Basin-Rocky Mountain Region. February 2000.

DIALOG III Conference for recent Ph.D. recipients in Limnology and Oceanography, St. George, Bermuda. October 1999.

COST Action 67 (European Union) Management Committee - Chemodynamics and water quality protection in natural porous media. Castellon, Spain. November 1998.

Invited Presentations (also senior author of 19 presentations and co-author of 50 presentations at conferences)

Baker, M.A. 2013. Appling tools from ecosystem ecology to water quality management: case studies from Utah. Department of Plant and Wildlife Sciences. Brigham Young University.

Baker, M.A., J.D. Ostermiller, and M.R. Shupryt. 2012. How can metrics from ecosystem ecology inform development of site-specific nutrient criteria for streams and rivers. Annual Meeting of the Society for Freshwater Science. Louisville KY.

Baker, M.A. 2011. Ceci n'est pas une pipe: understanding nutrient transport and removal processes in rivers. Global Change and Ecosystems Center, University of Utah.

Baker, M.A. 2011. Air and water quality concerns along the Wasatch Front: Science for sustainability. Sunrise Session sponsored by BlueCross BlueShield of Utah, Salt Lake City.

Baker, M.A. 2010. Rivulets to rivers: a journey down the continuum with atom Y. Department of Biology Seminar Series, Utah State University.

Baker, M.A. 2010. Understanding hydrologic transport and biogeochemical reaction (HTBR) in streams and lakes: challenges and opportunities. American Society for

Limnology and Oceanography/North American Benthological Society Annual Meeting, Santa Fe, NM.

Baker, M.A. 2009. Nutrient dynamics in streams: known knowns, known unknowns, and why you should care. College of Natural Resources, Utah State University, Logan UT.

Baker, M.A. 2009. Biochemical oxygen demand in rivers. Jordan River Dissolved Oxygen Linkage Symposium, Salt Lake City, UT.

Baker, M.A. 2008. Plenary speaker. Nutrient processes in aquatic ecosystems. Utah Non-Point Source Pollution Annual Conference, Cedar City, UT.

Baker, M.A. 2006. Ecological basis for site-specific TMDL targets in Utah. EPA Region 8 Bioassessment Workshop. Utah State University.

Baker, M.A. 2005. Fluvial discontinua- influence on flowpaths and ecosystem processes. Stream Ecology Symposium. Idaho State University.

Baker, M.A. 2002. Ceci n'est pas une pipe- Understanding nutrient uptake and flux in stream ecosystems. Department of Biology. Utah State University.

Baker, M.A. 2001. Hydrologic linkages and ecosystem function. Department of Botany and Range Science, Brigham Young University.

Baker, M.A. 2001. Tricks of the trade: how to succeed in graduate school. Graduate Resources Committee Workshop. North American Benthological Society Annual Meeting, La Crosse, WI.

Dahm, C.N. and **M.A. Baker**. 2000. Dissolved organic carbon dynamics and the groundwater and surface water interface. Geological Society of America 2000 Annual Meeting.

Dahm, C.N. and **M.A. Baker**. 2000. Organic matter dynamics at the groundwater - surface water interface of a mountain stream. American Society of Limnology and Oceanography Aquatic Sciences Meeting, Copenhagen.

Baker, M.A. 2000. Beyond the riparian zone: Aquatic-terrestrial linkages in watersheds. Utah State University, Department of Fisheries and Wildlife, and Civil and Environmental Engineering.

Baker, M.A. 2000. How to begin teaching a course for the first time beginning with nothing…filling the void. Graduate Resources Committee Workshop. North American Benthological Society, Keystone, CO.

Baker, M.A. 1999. Organic carbon retention and metabolism in near-stream groundwater. DIALOG Symposium, American Society for Limnology and Oceanography, BBSR, St. George, Bermuda.

Baker, M.A. 1999. Role of hydrologic linkages in fluvial ecosystem structure and function. University of Washington Tacoma, Utah State University, University of New Hampshire.

Baker, M.A. 1998. Influence de l'hydrodynamique sur la structure et le fonctionnement des écosystèmes fluviaux: des ruisseaux aux grand cours d'eau. Centre d'Ecologie des Systèmes Aquatiques Continentaux, Toulouse, France.

Baker, M.A. 1998. Influence of hydrologic linkages on fluvial ecosystem structure and function. School of Forestry and Environmental Studies, Yale University.

Contracts and Grants

National Ecological Observatory Network — October 2014-2015
Contract for SF6 Analyses (PI) — $64,591

C2HMHill — November 2013-2014
Contract for analytical services (PI) — $28,000

National Science Foundation — August 2012-2017
EPSCoR Track -1 (OIA 12-08732) — $20,000,000
iUTAH – innovative urban transitions and arid region hydro-sustainablity (co-PI)

South Valley Water Reclamation Facility — May 2012-2014
A preliminary organic matter budget for the Jordan River (PI) — $227,500

National Science Foundation — August 2009-2013
Ecosystem Studies Program (DEB 09-22153) — $167,647
Collaborative Research: Using empirical and modeling approaches to quantify the importance of nutrient spiraling in rivers (PI)

Utah Department of Environmental Quality — May 2010-June 2013
Stream functional condition measures and a manual for nutrient criteria for Utah's streams (PI) — $75,855

South Valley Water Reclamation Facility — June 2009- December 2009
Nutrient limitation of benthic algae in the Jordan River (PI) — $31,089

Utah Department of Environmental Quality — December 2006 – June 2009
Research to develop tools for nutrient criteria for streams in Utah (PI) — $125,720

National Science Foundation — September 2005-2010
Ecosystem Studies Program (DEB 05-19327) — $1,043,959
Collaborative Research: Landscape limnology of mountain watersheds: Nutrient retention and ecosystem stability in complex aquatic ecosystems (co-PI) — (plus REU supplements)

National Science Foundation — July 2004-2008
Hydrological Sciences Program (EAR 04-09534) — $191,792
Collaborative Research: Controls on hyporheic nitrate retention- discriminating among transport, reaction rate, and substrate limitation (PI)

National Science Foundation March 2002-2005
Ecosystem Studies Program (DEB 01-32983) $1,008,140
Influence of stream-lake interactions on nutrient (plus REU supplements)
transport and function of aquatic ecosystems (co-PI)

Environmental Protection Agency - STAR January 2003-2006
Testing watershed classifications relevant to $855,515
bioassessment, conservation planning, and watershed
restoration (co-PI; had only minor role in project)

National Science Foundation September 1998-1999
NSF-NATO Postdoctoral Fellowship (DGE 98-04645) $37, 900
Hydrologic variability, organic matter supply, and
denitrification in the Garonne River (PI)

Teaching Experience

Formal Courses

Biology 1010	Biology and the Citizen, 3 credits, ca. 200 students, undergraduate non-majors. Spring semesters (2000-2005)
Biology/NR 2220	General Ecology, 3 credits, 80-120 students, undergraduate majors. Spring semesters (2001-2013, maternity leave 2006, sabbatical leave 2008, maternity leave 2010), Fall semester 2009
Biology 4750/6750	Special Topics, 2-3 credits, ca. 2-10 students, undergraduate and graduate majors. (content varies – past topics included Aquatic Biogeochemistry, Sustainability Science, Ecological Stoichiometry, Groundwater Ecology, Water-Earth-Biota, Interdisciplinary Research in Ecology and Hydrology, Women in Science). Fall semesters (2000-2004, 2008) Spring semesters (2006-present)
Biology 6960	Graduate Ecology, 5 credits, ca. 20 students, graduate ecology majors, team taught. Fall semesters (2001-2006)

Student Mentoring

Graduate Students

* EPA-STAR Fellow

‡ INRA Subsurface Science Fellow

§ Presidential Doctoral Research Fellow

Christopher Arp*,‡ – Ph.D. 2006
Jason Bahr – Ph.D.i n progress
Maura Bozeman – M.S. Transferred to Yale
Joe Crawford – M.S. 2013
Keli Goodman‡ – Ph. D. 2010
Sam Hochhalter* – M.S. 2009
Julie Kelso – Ph.D. in progress
Andrew Myers – M.S. 2008
Elizabeth Ogata§ – Ph.D. in progress
John Rothlisberger – M.S. 2004
Matthew Schroer – M.S. in progress
Scarlett Vallaire – M.S. 2013

Undergraduate Research

* Research Experience for Undergraduates (NSF funding supplement)

‡ USU Minority Science Fellow

§ USU Eccles Undergraduate Research Fellow

Norman Balls – 2005-2006
Angie Benedetto* – 2006-2009
Camisha Booth – 2001
Hayden Campbell – 2013-present
Joe Crawford – 2008 – 2010
Ryan Davis – 2001
Kim Dutter – 2009
Jeff Fransden§ - 2011- present
Glen de Guzman*,‡ – 2002-2003
Lisa Jeffs* – 2001- 2003
Matt Jones - 2001
Evan Lytle§, – 2007-2009
Andrew Myers* – 2003-2005
Julia Nielsen – 2001-2003
Soo-Hyun Park – 2001-2002
Jason Reed* – 2008, 2010 - present
Brandon Spencer – 2000
Lisa Tran – 2005-2006

Professional Service

Assistant to the President, and member Board of Directors, Freshwater Science June 2013-present
Associate Editor, Freshwater Science (formerly JNABS) January 2012 –present
Associate Editor, Journal of the North American Benthological Society, June 2001-2011
Member, Elections and Place Committee, North American Benthological Society, 1996-1997, 2007-present
Member, Program Committee, 2010 ASLO/NABS Joint Annual Meeting, 2008-2010
Panelist, Geosciences Directorate, National Science Foundation, May 2005, March 2007-September 2008
Panelist, Biological Sciences Directorate, National Science Foundation, February 2009, October 2009, April 2011, March 2012
Chair, Special Sessions, Annual Meeting of the North American Benthological Society, 2007-2008
Member, Executive Committee, North American Benthological Society, June 2003-2006
Graduate Resources Committee, North American Benthological Society, 1997-1998
Peer review: Journal of the North American Benthological Society, Limnology and Oceanography, Biogeochemistry, Water Resources Research, Ecology, Jurnal of Geophysical Research, BioScience, Biogeosciences, Proceedings of the National Academy of Science
Ad hoc proposal review: National Science Foundation (EAR- Hydrologic Sciences, DEB-Ecosystem Studies, BE- Coupled Biogeochemical Cycles); Maryland Sea Grant; NIWR-USGS National Competitive Grants Program; European Union Young Investigator Award

University Service

Member, Central Promotion and Tenure Committee, 2012-2014
Associate Head, Biology, October 2011 – present
Representative, College of Science Research and Graduate Advisory Committee, 2011-present
Representative, College of Science, Graduate Council, 2011- present
Representative, Utah State University, Consortium of Universities for the Advancement of Hydrologic Science, Inc. 2011-present
Chair, Tenure Advisory Committee (Biology), 2009-present
Member, Ecology Center Advisory Committee, 2005-present
Member, Graduate Programs Committee (Biology), 2006-2010, 2011- present
Member, Tenure Advisory Committee (Biology), 2005-present, 2009-present (3 total biology faculty)
Member, Tenure Advisory Committee (Civil and Environmental Engineering), 2009-present
Member, Promotion Advisory Committee (Biology, Environment and Society) 2013-present
Representative, College of Natural Resources Strategic Planning Committee, 2011 -2012
Co-Director, Graduate Studies (Biology), 2010-2011
Chair, Ecology Center Director Search Committee, 2010-2011
Member, Tenure Advisory Committee (Biological and Irrigation Engineering), 2008-2010
Member, Water Initiative University Advisory Committee, September 2003- 2011
College of Science Representative, USU Vice Provost Advisory Council, 2008-2010
Member, Women and Gender Research Institute Steering Committee, 2006-2010
College of Science Representative, USU Sustainability Council, 2008-2009
Member, Faculty Senate Ad Hoc Committee to Review the USU Faculty Code, 2008

Member, College of Science Dean Search Committee, 2006
Member, Post-tenure Review Committee (Biology), 2005
Chair, Water Initiative Graduate Program Committee, 2004-2006
Member, Water Initiative Laboratory Watershed Committee, September 2003-2006
Undergraduate Research Mentor, Utah State Minority Science Fellows, 2002-2004
Member, Hydrologist Search Committee, Department of AWER, 2005
Member, Pre-Health Professions Committee, Department of Biology, 2001-2004
Panelist, Scholars Day, Office of Admissions Interview Panel, 2004
Member, Spatial Ecologist Search Committee, Department of Biology, 2004
Member, Water Initiative Task Force for Utah State President Hall, 2002 -2003
Member, Public Health Search Committee, Department of Biology, 2001

Community Service

Panelist, EPA Workshop on Nutrient Indicators, April 2013
Expert Witness, Colorado Nutrient Rulemaking, March 2012
Technical Advisor, Western Colorado Water Network, 2010- 2012
Member, Jordan River Technical Advisory Committee (Salt Lake City), 2009-present
Research mentor, Undergraduate Posters on Capitol Hill (Salt Lake City), 2003, 2008, 2011
Research mentor for high school students in NASA sponsored Science Camp, USU, 2006
Outreach - SciTech High School, Logan UT, 2006
Research mentor, CUR Posters on the Hill in Washington DC, 2004

NANETTE M. NELSON CURRICULUM VITAE

NAME

Nanette M. Nelson

ADDRESS

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University of Wyoming
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1000 E. University Avenue
Laramie, WY 82071

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EDUCATION

2000	Master of Science, Agricultural Economics, University of Georgia, Athens, GA
2000	Master of Science, Conservation Ecology and Sustainable Development, University of Georgia, Athens, GA
1988	Bachelor of Science, Oceanography, University of Washington, Seattle, WA

ACADEMIC POSITIONS

2011 to Present	Associate Research Scientist, Wyoming Survey & Analysis Center, University of Wyoming
2007 to 2011	Assistant Research Scientist, Wyoming Survey & Analysis Center, University of Wyoming
2001 to 2006	Staff Economist, River Basin Center, University of Georgia

OTHER POSITIONS

1989 to 1995	Research Scientist, Remediation Technologies, Inc. Seattle, WA

CURRENT JOB DESCRIPTION

Associate Research Scientist, WYSAC

PUBLISHED WORKS

Refereed Journal Articles:

Freedman K. S., Nelson N. M., & Feldman L. L. (2012) Smoking initiation among young adults in the United States and Canada, 1998-2010: a systematic review. Prev Chronic Dis, 9:110037.

Non-Refereed Proceedings:

Grandjean, B. D., Nelson, N. M., & Taylor, P. A. (2009). Comparing an Internet Panel Survey to Mail and Phone Willingness to Pay for Environmental Quality: A National Mode Test. In *JSM Proceedings*, Statistical Computing Section. Alexandria, VA: American Statistical Association.

Nelson, N. and A.G. Keeler, (1999). "Valuing Ecosystem Quality through Environmental Indicators," in *1999 Georgia Water Resources Conference,* Kathryn J. Hatcher, ed. Athens: Institute of Ecology, The University of Georgia. Pp. 402-404.

Technical/Research Reports:

Jakus, P., Kealy, M. Loomis, J., Nelson, N., Ostermiller, J., Stanger, C. & Stackelberg, N. (2013). *Economic Benefits of Nutrient Reductions in Utah's Waters*. Salt Lake City, UT: State of Utah, Utah Division of Water Quality.

WYSAC. (2013). *Wyoming women's issues survey, 2012* by B. Harnisch & N. M. Nelson. (WYSAC Technical Report No. SRC-1301). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2012). *The Cost of Substance Abuse in Wyoming 2010* by N. M. Nelson, M. Kato, & H. Costello. (WYSAC Technical Report No. DER-1250). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2012). *Catalog of Environmental Prevention Strategies* by H. Costello, N. M. Nelson, K. Henry, & K. Freedman. (WYSAC Technical Report No. DER-1249). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2012). *Tax Revenue and Cigarette Consumption in Wyoming* A*ccounting for the 2003 State and the 2009 Federal Cigarette Excise Tax Increases* by N. M. Nelson & M. Kato. (WYSAC Technical Report No. DER-1211). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC (2012). *The Burden of Smoking in Wyoming*, by N. M. Nelson, K. S. Freedman, & L. L. Feldman. (WYSAC Technical Report No. DER-1203). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2011). *The Cost of Substance Abuse & Mental Health in Wyoming: Methodology Review,* by H. Costello, N. M. Nelson, and K. S. Freedman. (WYSAC Technical Report No. CHES-1118). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

Technical/Research Reports (Continued)

WYSAC. (2011). *The Impact on Revenue and Consumption in Wyoming (through January 2011) of the 2003 State and the 2009 Federal Cigarette Excise Tax Increases* by N. M. Nelson (WYSAC Technical Report No. CHES-1102). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2011). *Evaluation of Grand Teton National Park's "Be Bear Aware" Message to Visitors,* by N.M. Nelson, P.A. Taylor, T. Hopkins, & A. Rieser. (WYSAC Technical Report No. SRC-1102). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2010). *The Impact on Revenue and Consumption in Wyoming of the 2003 State and the 2009 Federal Cigarette Excise Tax Increases* by N. M. Nelson & M. Leonardson (WYSAC Technical Report No. CHES-1007). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2010) *Preliminary Data Evaluation and Literature Review of Young Adult Smoking Initiation*, by N.M. Nelson, K.S. Freedman, & L.L. Feldman. *(*WYSAC Technical Report No.CHES-1002), Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2009). *Mode Effects and Other Potential Biases in Panel-based Internet Surveys: Final Report* by P. A. Taylor, N. M. Nelson, B. D. Grandjean, B. Anatchkova, & D. Aadland. (WYSAC Technical Report No. SRC-905). Laramie: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2009). *The Impact of Wyoming's 2003 Cigarette Excise Tax Increase: Annual Report FY 2009* by N. M. Nelson & M. Leonardson (WYSAC Technical Report No. CHES-909). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC (2009) *An expanded analysis of the impact of smokefree ordinances in Wyoming: A preliminary evaluation of the economic, health, and social impacts,* by N. M. Nelson, L. Feldman, E. Canen, M. Leonardson, & R. Jenniges. (WYSAC Technical Report No. CHES-904). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2008). *WYSAC System Model of the Wyoming Criminal Justice System,* by Nanette Nelson & Hristiyan Beshkov. (WYSAC Technical Report No. CJR-802). Laramie: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2008). *The Impact of Wyoming's 2003 Cigarette Excise Tax Increase: Second Biannual Report FY 2008* by N. M. Nelson, M. S. McNulty & M. Leonardson (WYSAC Technical Report No. CHES-816). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2008). *The Impact of Wyoming's 2003 Cigarette Excise Tax Increase: First Biannual Report FY 2008* by M. S. McNulty & N. M. Nelson (WYSAC Technical Report No. CHES-803). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2007). *The Impact of Wyoming's 2003 Cigarette Excise Tax Increase: Second Biannual Report FY 2007* by M. S. McNulty & N. M. Nelson (WYSAC Technical Report No. CHES-732). Laramie, WY: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2007). *The Economic Impact of the Laramie and Cheyenne Smokefree Ordinances: Second Biannual Report FY 2007* by M. S. McNulty and N. M. Nelson. (WYSAC Technical Report No. CHES-714). Laramie: Wyoming Survey & Analysis Center, University of Wyoming.

WYSAC. (2007). *The Wyoming Addicted Offenders Accountability Act: ASI Descriptive Analysis,* by N. M. Nelson & M. S. McNulty. (WYSAC Technical Report No. CJR-703). Laramie: Wyoming Survey & Analysis Center, University of Wyoming.

Nelson, N. (2006). *Economic Valuation of Water Resources in the Upper Altamaha*. Athens: River Basin Center, The University of Georgia.

Nelson, N. (2006). *Infiltration Cost Analysis of the Proposed HCP Runoff Limits*. Athens: River Basin Center, The University of Georgia.

Nelson, N., Kramer, E., Dorfman, J., & Bumback, B. (2004). *Estimating the Economic Benefit of Landscape Pattern: An Hedonic Analysis of Spatial Landscape Indices*. Athens: River Basin Center, The University of Georgia. Available from: http://www.rivercenter.uga.edu/publications/pdf/usfs_hedonic.pdf

Nelson, N., Dorfman, J., & Fowler, L. (2002). *The Potential for Community Forests to be Self-Financing: An Hedonic Analysis of the Enhancement Value of Georgia's Trees*. Athens: River Basin Center, The University of Georgia. Available from: http://www.rivercenter.uga.edu/publications/pdf/hedonic.pdf

UNPUBLISHED WORKS:

Nelson, N.M., & Loomis, J.B. (2008). *Economic Methods for Evaluating the Benefits of Nutrient Criteria Implementation*. (Under contract to Tetra Tech, Fairfax, VA)

Nelson, N. (1999). *Valuing Ecosystem Quality in the Upper Etowah River Watershed Through Environmental Indicators* (Unpublished Master's Thesis). Athens: The University of Georgia.

CONTRACTS & GRANTS

Funded Projects as PI

November 2010 to June 2013, Evaluation of the Economic Costs and Benefits of Nutrient Criteria Implementation, CH2M Hill, $250,368.

August 2008 to September 2008. White Paper on the Methods and Approaches Used to Evaluate Costs and Benefits Associated with Nutrient Criteria, Tetra Tech, Inc. $7,500.

Funded Projects as Co-PI

April 2012 to November 2012, Substance Abuse Cost Study and an Environmental Strategy Effectiveness Analysis, H. Costello, Wyoming Department of Health, $114,910.

July 2010 to December 2011, Evaluation of Grand Teton National Park's "Be Bear Aware" Message to Visitors, P.A. Taylor, National Park Service, $5,010.

March 2010 to August 2010, In-situ Uranium Extraction Survey, B. Anatchkova & B. Harnisch, University of Wyoming, School of Energy Resources, $17,190.

September 2009 to July 2011, Safety in Bear Country, P.A. Taylor, National Park Service, $11,750.

September 2009, Draft Survey Instrument to Evaluate "Be Bear Aware" Program, B. Anatchkova & P.A.Taylor, National Park Service, $2,500.

April 2009 to March 2010, Evaluation of GTNP's "Be Bear Aware" Message to Visitors, P.A. Taylor, University of Wyoming National Park Service Research Center, $5,000.

April 2008 to March 2009, Evaluation of GTNP's "Be Bear Aware" Message to Visitors, P.A. Taylor, University of Wyoming National Park Service Research Center, $5,000.

August 2007 to January 2009, EPA Mode Effects and Other Potential Biases in Panel-Based Internet Surveys, B. Grandjean & P.A. Taylor, US Environmental Protection Agency, $303,929.

August 2007 to January 2009, EPA Mode Effects and Other Potential Biases in Panel-Based Internet Surveys, B. Grandjean & P.A. Taylor, University of Wyoming Research & Economic Development, $9,987.

July 2007 to June 2008, Yearly SAC Award: Enhance the Existing Wyoming SAC Website, H. Beshkov, Bureau of Justice Statistics, $56,036.

HONORS AND AWARDS

2000 Outstanding Master's Student, Department of Agriculture & Applied Economics, University of Georgia, Athens, Georgia

2000 University-wide Fellowship, University of Georgia, Athens, Georgia.

1999 University-wide Fellowship, University of Georgia, Athens, Georgia.

1998 University-wide Fellowship, University of Georgia, Athens, Georgia.

1997 University-wide Fellowship, University of Georgia, Athens, Georgia.

1996 University-wide Fellowship, University of Georgia, Athens, Georgia.

PAPERS PRESENTED/SYMPOSIA/ INVITED LECTURES/ PROFESSIONAL MEETINGS/ WORKSHOPS

2013, W3133: Benefits and Costs of Natural Resource Policies Affecting Public and Private Lands, W3133 Project Annual Meeting, Coeur d'Alene, Idaho.

2012, W2133: Benefits and Costs of Natural Resource Policies Affecting Public and Private Lands, W2133 Project Annual Meeting, Park City, Utah.

2011, Nutrients and Water Quality: A Region 8 Collaborative Workshop, US Environmental Protection Agency, Salt Lake City, Utah.

2008, Cost –Benefit Analysis of the Tobacco Prevention & Control Program in Wyoming, American Evaluation Association, Denver, Colorado.

2008, The Impact of Wyoming's Tobacco Prevention & Control Program on Cigarette Consumption, American Evaluation Association, Denver, Colorado.

2008, Cost –Benefit Analysis of the Tobacco-Free Wyoming Communities Program, Chronic Disease Conference, Wyoming Department of Health, Cheyenne, Wyoming.

Example reports/papers

How can metrics from ecosystem ecology inform development of

NUTRIENT CRITERIA?

MICHELLE **BAKER**
UtahStateUniversity
DEPARTMENT OF BIOLOGY
ECOLOGY CENTER

MIKE **SHUPRYT**
JEFF **OSTERMILLER**
Utah Division of Water Quality

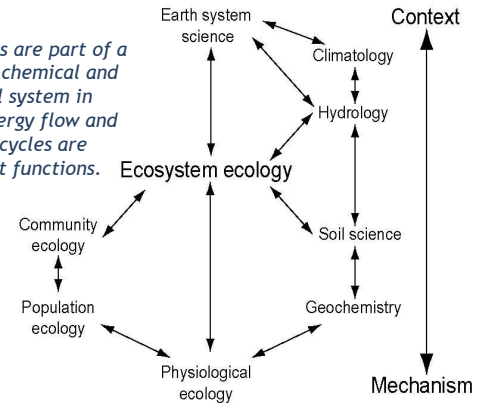
WE HAVE A NUMBER! NOW WHAT?

Bob realized too late that he should have never taken a number.

- Criteria should be scientifically defensible
- Data collection is expensive
- Meeting criteria can be very costly

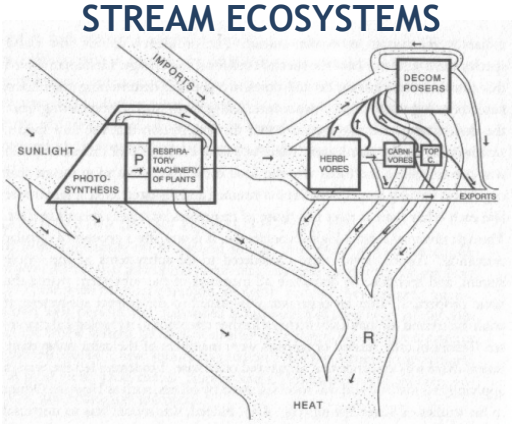
How do you know you have the right number?

Organisms are part of a physical, chemical and biological system in which energy flow and material cycles are important functions.



Chapin et al. 2004

STREAM ECOSYSTEMS

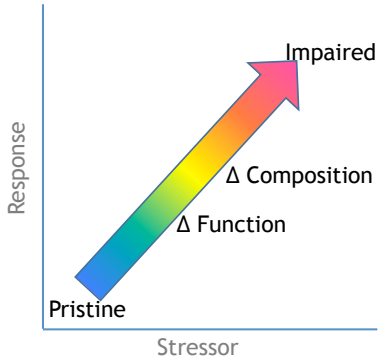


Odum, H.T. 1957. Ecol Monogr. 27:55-112

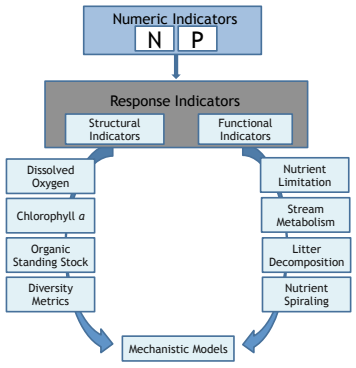
STRUCTURAL VS. FUNCTIONAL ATTRIBUTES OF ECOSYSTEMS

Structure	Function
biomass	metabolism/energy flow
nutrient concentration	nutrient retention,
organism abundance	transformation, transport

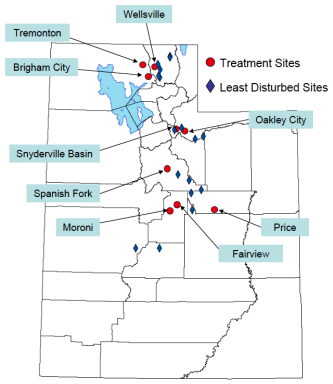
RATIONALE FOR FUNCTIONAL INDICATORS



UTAH'S APPROACH TO CRITERIA DEVELOPMENT



SAMPLING LOCATIONS

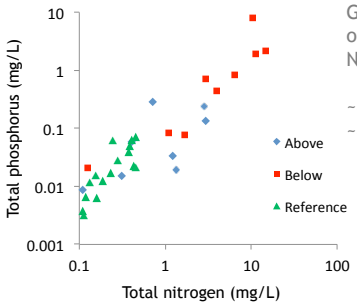


9 Treatment sites (above and below POTWs)

1-2 Reference Sites

Total of 35 sites sampled in 2010

AMBIENT NUTRIENT CHEMISTRY



Gradient captured 2-3 orders of magnitude in N and P.

~85% of TN = NO_3-N
~80% of TP = SRP

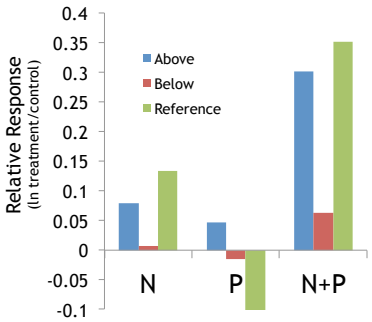
NUTRIENT LIMITATION BIOASSAYS

Which nutrient(s) should we care about?

Control
+N
+P
+N+P
Deployed 3 weeks
Measure chlorophyll *a*

NUTRIENT LIMITATION BIOASSAYS

Which nutrient(s) should we care about?



NUTRIENT LIMITATION BIOASSAYS

Which nutrient(s) should we care about?

	Nutrient Limitation					
Site	None	N	P	N+P	N1 P2	P1 N2
Reference	3	5	0	5	2	0
Above	2	1	2	1	1	0
Below	6	0	0	0	1	0

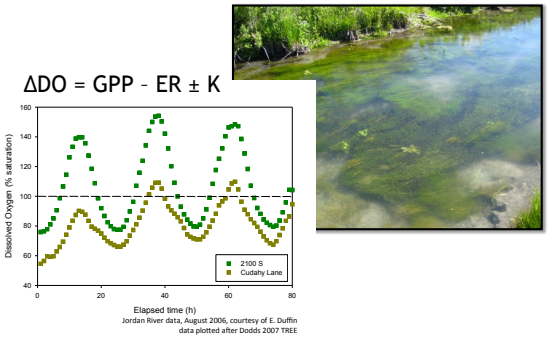
- 80% of reference sites have some form of N limitation
- 6 of 7 High Impact sites are not limited by nutrients

- No limitation likely to occur > 0.42 mg/L TN and > 0.08 mg/L TP

OPEN CHANNEL METABOLISM

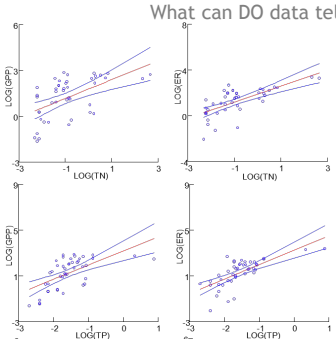
What can DO data tell us?

$\Delta DO = GPP - ER \pm K$



OPEN CHANNEL METABOLISM

What can DO data tell us?



Rates of GPP and ER are correlated to both N and P.

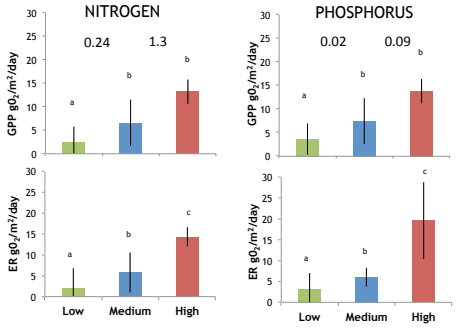
OPEN CHANNEL METABOLISM

What can DO data tell us?

Nutrient	Nutrient Group Thresholds
TN (mg/L)	Low < 0.24 > Medium < 1.28 > High
TP (mg/L)	Low < 0.02 > Medium < 0.09 > High

OPEN CHANNEL METABOLISM

What can DO data tell us?

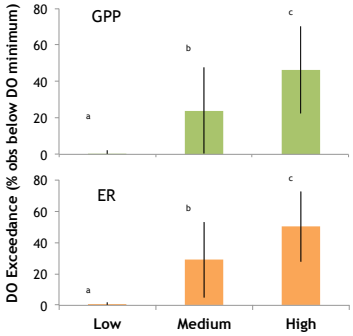


OPEN CHANNEL METABOLISM

What can DO data tell us?

High rates of GPP and ER lead to more minimum DO impairments

Direct tie to aquatic life uses

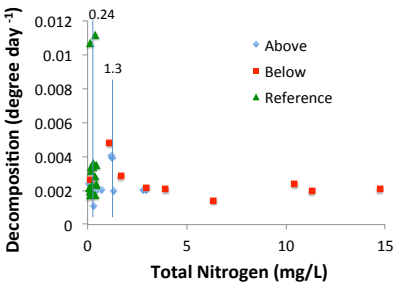


LEAF LITTER DECOMPOSITION

How about those heterotrophs?

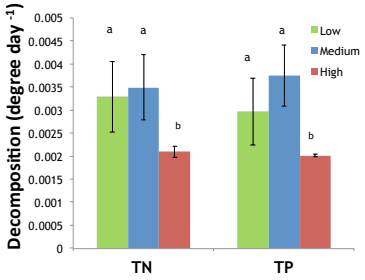
LEAF LITTER DECOMPOSITION

How about those heterotrophs?



LEAF LITTER DECOMPOSITION

How about those heterotrophs?



GIMME THE NUMBERS!

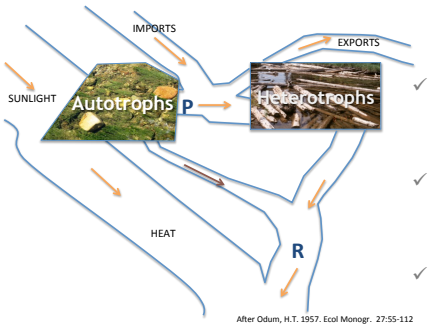
- TN

Possible Criteria (mg/L)	Percent Impaired	Stream Miles Impaired	
Min 0.24	50%	~6700	*Too Low??*
Medium 0.45	30%	~4000	*Maybe??*
Max 1.3	10%	~1300	*Too High??*

- TP

Possible Criteria (mg/L)	Percent Impaired	Stream Miles Impaired	
Min 0.02	~60%	~8000	*Too Low??*
Medium 0.045	25%	~3400	*Maybe??*
Max 0.08	10%	~1300	*Too High??*

ECOSYSTEM SCIENCE CAN INFORM CRITERIA DEVELOPMENT



After Odum, H.T. 1957. Ecol Monogr. 27:55-112

- ✓ Nutrient limitation status
- ✓ Metabolism rates (GPP and ER)
- ✓ Litter decomposition

THANK YOU !

DWQ: Emilie Flemer, Susan Tahir, Jared Terry, Kate Tipple, Alex Anderson, Ben Holcomb

USU: Ian Washbourne, Beth Nielsen, Andrew Ho, Joe Crawford, Jeff Frandsen

$$$: Utah Water Board, EPA, USU Ecology Center

Interim Report
Research to Inform Nutrient Endpoints in East Canyon Creek, Utah

25 April 2008

Prepared for:

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ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

The TMDL for East Canyon Creek was last conducted in 2000. Since then, improvements to the Snyderville Basin Water Reclamation Facility on East Canyon Creek (WWTP) have resulted in reduced phosphorus (P) loads to the stream. This study was designed to evaluate relationships among nutrient concentrations, primary producers, and nutrient cycling in support of revisions to the TMDL.

Our results provide several lines of evidence that P is not the only nutrient of concern to water quality. First, stoichiometric ratios of autotrophs in comparison to ratios of nutrient resources (water and sediments) indicate that nitrogen (N) is more limiting to macrophytes and algae. Second, nutrient diffusing bioassays showed greater response to N or N+P than P. In one instance P addition suppressed algal growth. Third, the stream biota at a reach scale exhibit greater demand for N in comparison to P. Fourth, N cycling rates were more strongly related to production than was P. These patterns held regardless of location relative to the WWTP.

Despite improvements to the WWTP, macrophyte cover has not changed appreciably since the TMDL was completed in 2000. Furthermore, three sites had macrophyte cover >50%, and two of the sites were above the WWTP. Macrophyte cover did not explain differences in nutrient cycling or production, but these sites were the only ones that had dissolved oxygen (DO) concentrations below the 4.0 mg/L threshold. Further study is needed to ascertain whether this is due to the macrophytes directly through their metabolic processes or indirectly through trapping of organic-rich sediments.

Few differences in the parameters we measured were associated with position relative to the WWTP. Concentrations of total N and NO_3-N were higher below the WWTP compared to above. Chlorophyll *a* on artificial substrates was generally higher (some cases 10X higher) below the WWTP than above the WWTP and was correlated to nutrient concentrations in June.

Eroding stream banks have the potential to contribute large amounts of organic matter, N and P to the stream throughout the watershed. Actively eroding banks were sampled at all sites. In comparison to sediments in the stream bed, banks were higher in organic matter, N and P, indicating some amount of processing once the bank sediment reached the stream channel. That we found no difference attributable to position relative to the WWTP for most variables suggests that more diffuse and watershed-wide factors such as erosion contribute to current water quality issues in East Canyon Creek. Restoration efforts to reduce sediment loads to the stream may improve water quality, and any efforts in that regard should be monitored through time.

Our empirical data support a recommended endpoint for TP of 0.046 mg/L, similar to the value implemented during the 2000 TMDL. Changes to this endpoint are not likely to be effective at attaining the DO standard.

TABLE OF CONTENTS

INTRODUCTION

Project goals and motivation

The overall goals of this study are to examine relationships between water quality parameters (namely nutrients), aquatic primary producers, and metabolic processes in East Canyon Creek above East Canyon Reservoir. Specifically we were asked by the Utah Division of Water Quality (UTDWQ) to evaluate whether the total phosphorus (TP) endpoints set as a result of the 2000 Total Maximum Daily Load (TMDL) analysis (UTDWQ 2000) would impact primary production in the stream, thereby allowing attainment of indicators for dissolved oxygen (DO).

East Canyon Creek has been listed since 1992 on the UTDWQ's Clean Water Act Section 303(d) list as partially supporting its 3A beneficial use classification (cold water fishery) because of high TP concentrations (UTDWQ 2000). The 1998 listing further added low DO concentrations as a cause for impairment (UTDWQ 2000, Olson and Stamp 2000). A TMDL was completed and approved by the US Environmental Protection Agency (EPA) in 2000, which set target endpoints for TP of 0.04 mg/L above the Snyderville Basin Water Reclamation District's facility (WWTP) and 0.05 mg/L below the WWTP. Sources of TP to the stream were identified as both non-point (especially storm runoff) and point sources. The 2000 TMDL report described five variables that could allow for attainment of the target endpoints, including reduction of WWTP effluent concentration and flows during summer months, augmenting flow during summer months, reducing non-point TP sources through best management practices (BMPs), and stream enhancements such as bank stabilization, tree plantings, and channel modifications. Recent improvements to the WWTP have decreased effluent concentrations, and flow augmentation on the order of 2 cfs began in August 2007. Still, the creek is described in the most recent 305b Integrated Report as non-supporting of its 3A beneficial use because of high P concentrations and organic enrichments/low DO (UTDWQ 2006). The data presented in this report result from study of the creek in summer 2007 as part of monitoring the effect of efforts to reduce TP to the stream.

Research questions and study objectives

Academic research in aquatic ecosystem ecology focuses largely on ecological processes that affect the biogeochemical cycles of major nutrients. These include 1) trophic state or energy balance of streams, 2) availability of nutrients and stoichiometric requirements to drive trophic state and 3) rates of nutrient cycling. In a nutrient management context, the autotrophic state (high algal and plant production) has been a major target, with particular emphasis on P concentrations and loads. Empirical evidence for streams shows that P is not often the nutrient most limiting to stream organisms (Tank and Dodds 2003). Rather streams are more often limited by N or co-limited by N and P (Tank and Dodds 2003), necessitating a stoichiometric or ratio-based approach to nutrient management (Dodds

2007). At the same time, most streams are not autotrophic in terms of net energy balance (Mulholland et al. 2001, Bott et al. 2006), thus heterotrophic processes and allochthonous (external) organic inputs should be considered in water quality studies (Dodds 2007). Finally both autotrophic and heterotrophic processes in streams require inorganic nutrients and regulate to some extent water column concentrations (Peterson et al. 2001, Dodds 2003, Mulholland et al. in press). Accordingly, our work asked the following questions to address the effects of changes to the stream as a result of the 2000 TMDL:

How do ecosystem-level processes in streams relate to nutrient levels, primary producers and dissolved oxygen?

and

How can we use tools from ecosystem ecology to inform development of nutrient endpoints in streams?

There were a number of objectives to address these research questions. These have been organized into work elements as outlined below. Conceptual background underlying these objectives is outlined in the Background section that follows.

Work Element A – Measure nutrient stoichiometry and experimentally assess nutrient limitation

1) Water column nutrient sampling – including TP, total nitrogen (TN), soluble reactive phosphorus (SRP) or phosphate-P (PO_4-P), nitrate-nitrogen (NO_3-N), ammonium-nitrogen (NH_4-N) and dissolved organic carbon (DOC)

2) Periphyton biomass sampling – including ash-free dry mass (AFDM), chlorophyll *a*, and nutrient content (carbon (C), N and P) of epilithon (biofilm on rocks) and epiphyton (biofilm on macrophytes)

3) Macrophyte biomass sampling – including AFDM and nutrient (C, N, P) content

4) Sediment nutrient sampling – including AFDM, and nutrient (C, N, P) content of stream sediments and stream banks

5) Nutrient diffusing substrates – an experimental bioassay to assess nutrient limitation of periphyton

Work Element B – Quantify reach-scale inorganic nutrient (NO_3-N and PO_4-P) demand

1) Use solute injection techniques to measure nutrient uptake parameters across space

2) Use incremental solute injection techniques to measure response of nutrient uptake to different doses of inorganic nutrients

Work Element C – Measure reach-scale metabolic processes and relate these to stream water, sediment and producer nutrient contents and nutrient demand

1) Measure reach-scale oxygen exchange (reaeration) between the atmosphere and stream using sulfur-hexafluoride (SF6) volatile tracer injections

2) Calculate gross primary production (GPP), community respiration (CR), and reaeration from DO data obtained UTDWQ/Snyderville WWTP sonde deployments

3) Relate reach-scale metabolic processes to nutrient data and uptake obtained in work elements A and B