



March 31, 2011

Robert B. Waide  
Executive Director, LNO  
Long Term Ecological Research Network Office  
MSC03 2020  
1 University of New Mexico  
Albuquerque, NM 87131-0001

RE: QUEST working group report

Dear Bob,

I am pleased to submit a workshop report for the project titled, "*Quantifying Uncertainty in Ecosystem Studies (QUEST)*" that was funded by the LTER Network Office in January 2011. The goal of this project is to evaluate uncertainty in hydrologic inputs, outputs, and net hydrologic flux of major elements across small watersheds with diverse characteristics. The long-term goal of this project is to contribute to a cultural change in ecology that makes uncertainty analysis an accepted and expected practice in the construction of ecosystem budgets.

To attain these goals, we convened a workshop on March 14-15, 2011, at the Seaport Hotel in Boston, MA. Participants consisted of two scientists with specific expertise in uncertainty analysis and 12 scientists (see attached list of attendees) representing nine small watershed studies: AND, CWT, HBR, LUQ (LTER/US Forest Service), NWT (LTER), Fernow, WV and Marcell, MN Experimental Forests (US Forest Service), and Biscuit Brook, NY and Sleepers River, VT Research Watersheds (US Geological Survey). The purpose of this workshop was to identify sources of uncertainty and develop a computational approach for quantifying the uncertainty across sites. We intentionally held the workshop early in the funding cycle because we felt it was important to determine how to perform the uncertainty calculations and get group consensus before proceeding with the analyses.

To make most efficient use of our time together in Boston, we held a webinar one month prior to the workshop to introduce the participants, provide background information on uncertainty analysis, and to begin to plan how to conduct the uncertainty analyses for this study. The webinar was recorded and posted on-line for those who could not attend, as well as for others who may be interested (see <https://sites.google.com/site/quantifyinguncertainty/home/webinar-videos>). We identified a steering committee and held two subsequent virtual meetings; one that addressed uncertainty in stream flux calculations and another for precipitation. The graduate student funded through this project, Carrie Rose Levine, began to gather data at the onset of the study. Additionally, each site representative filled out an on-line questionnaire (see <http://app.fluidsveys.com/surveys/john-7/quest-webinar/>) to obtain pertinent background information for establishing what data are available and most useful for this project.



Following two full days of discussion, we made some critical decisions about what data to use and how best to proceed. We identified major sources of uncertainty in stream and precipitation flux measurements and established approaches for quantifying that uncertainty. What follows is a list of products that we have completed or planned:

- Carrie Rose Levine (HBR) has begun to develop the QUEST website (<https://sites.google.com/site/quantifyinguncertainty/home>), which includes information such as the list of collaborators, presentations, meeting announcements, and sample code. We recently obtained the domain name “www.quantifyinguncertainty.org” which we anticipate using in the near future.
- The following abstracts have been submitted:

Levine, C.R., Campbell, J.L., Yanai, R.D., Green, M.B., Adams, M.B., Buso, D.C., Harmon, M.E., LaDeau, S.L., Likens, G.E., McDowell, W.H., Sebestyen, S.D., Vose, J.M., and Williams, M.W. 2011. Quantifying Uncertainty in Ecosystem Studies (QUEST): A cross-site comparison of watershed input-output budgets. Oral presentation by Carrie Rose Levine at the 96<sup>th</sup> Annual Meeting, Ecological Society of America, Aug. 7-12, 2011, Austin, TX.

Green, M.B., Buso, D.C., Campbell, J.L. Levine, C.R., and Yanai, R.D. 2011. Long-term trends in uncertainty of element fluxes at the Hubbard Brook Experimental Forest. Oral presentation by Mark Green at the 96<sup>th</sup> Annual Meeting, Ecological Society of America, Aug. 7-12, 2011, Austin, TX.

Campbell, J. Yanai, R., Green, M., Burns, D., LaDeau, S., Adams, M.B., Buso, D., Harmon, M., Keenan, T., Levine, C.R., McDowell, W., Parman, J., Sebestyen, S., Shanley, J., Vose, J. and Williams, M. 2011. Quantifying Uncertainty in Ecosystem Studies (QUEST). Poster presentation by Mary Beth Adams at the North American Forest Ecology Workshop, Jun. 19-23, 2011, Roanoke, VA and the 4<sup>th</sup> Interagency Conference on Research in the Watersheds, Sep. 26-30, 2011, Fairbanks, AK.
- Mark Green (HBR) submitted a proposal to conduct a workshop at ESA in Austin, TX that was accepted and is scheduled for Sunday, Sep 7, 1:00-5:00 pm. The workshop is titled “Quantifying Uncertainty in Ecosystem Studies” and is aimed to get researchers comfortable with conducting uncertainty analyses using the Monte Carlo approach implement in the “R” statistical computing environment.
- Ruth Yanai (HBR) submitted a Research Coordination Network proposal to NSF in January 2011 titled “ RCN: Quantifying Uncertainty in Ecosystem Studies” at \$500,000 over 5 years.

- Mary Beth Adams (Fernow Experimental Forest) drafted a letter to formally introduce the study to US Forest Service leadership. The letter was submitted to the Director of the US Forest Service, Northern Research Station who will distribute it to other Station Directors, Station Experimental Forest and Range Coordinators, the Deputy Chief for Research and Development, and other Washington Office Staff. We are optimistic that increasing awareness about the project within the US Forest Service will open the door to future sources of funding and opportunities for expanding the project to include additional sites and analyses.
- Jordan Parman (NWT) wrote a summary of the QUEST workshop and project for submission to the LTER Network Newsletter. McOwiti Thomas seemed receptive to this topic and we are hopeful that it will appear in the Spring 2011 edition.
- John Campbell (HBR) is planning to write a meeting announcement that describes the QUEST workshop and project for submission to EOS.
- We realized at the workshop that one of the reasons why people do not include uncertainty analyses in their studies is because current software tools are lacking. While we do not currently have funding to pursue development of a broadly applicable uncertainty analysis toolbox, we identified this as a high priority and plan to pursue funding for a programmer.
- Recognizing that the topic of uncertainty analysis is broad, we identified a number of papers that we would like to write. We realize that the list of papers we came up with is probably overly ambitious and extends beyond the scope and timeline of the LTER funding. However, we do feel confident that we will be able to produce at least one peer-reviewed journal article that describes uncertainty in the input-output budgets across sites by January 2012.

We are currently on track for completing our commitment in the allotted time and will keep you informed of our progress and any new publications. We are grateful for the opportunity that the LTER Network Office has provided us to pursue this research and look forward to continued success. If you need clarification or require additional information, please do not hesitate to contact me.

Sincerely,



John L. Campbell  
Research Ecologist

## QUEST Meeting attendees

Mary Beth Adams - *US Forest Service* (Fernow Experimental Forest, WV)  
Doug Burns US - *Geological Survey* (Biscuit Brook, NY)  
Don Buso - *Cary Institute of Ecosystem Studies* (HBR)  
John Campbell - *US Forest Service* (HBR)  
Mark Green - *Plymouth State Univ./US Forest Service* (HBR)  
Mark Harmon - *Oregon State University* (AND)  
Trevor Keenan - *Harvard University*  
Shannon LaDeau - *Cary Institute of Ecosystem Studies*  
Carrie Rose Levine - *SUNY-ESF* (HBR)  
Bill McDowell - *University of New Hampshire* (LUQ)  
Jordan Parman - *University of Colorado* (NWT)  
Steve Sebestyen - *US Forest Service* (Marcell Experimental Forest, MN)  
Jamie Shanley - *US Geological Survey* (Sleepers River Research Watershed, VT)  
Jim Vose - *US Forest Service* (CWT)  
Ruth Yanai - *SUNY-ESF* (HBR)



From left to right are Jamie Shanley, Jim Vose, Don Buso, Stephen Sebestyen, Jordan Parman, Carrie Rose Levine, Mark Green, Shannon LaDeau, Mary Beth Adams, Mark Harmon, Ruth Yanai, Bill McDowell, John Campbell, Doug Burns.

**QUEST Workshop Agenda**  
March 14-15, 2011  
Seaport Hotel, Boston, MA



**Sunday, March 13**

6:00 pm – Group dinner for those arriving early (meet in hotel lobby)

**Monday, March 14**

***Morning Session – Introduction and site presentations (facilitated by John Campbell)***

8:00 am – Welcome and introductions (John Campbell) (15 min)

8:15 am – Introduction to uncertainty (Mark Harmon) (15 min)

8:30 am – Flow chart – Steps in flux calculation for streamflow and precip (Carrie Rose Levine) (10 min)

8:40 am – Intro. to Kepler (John Campbell) (5 min)

8:45 am – Site presentations - Introduction

8:55 am – Hubbard Brook (Don Buso)

9:05 am – Fernow (Mary Beth Adams)

9:15 am – Coweeta (Jim Vose)

9:25 am – Sleepers River (Jamie Shanley)

**9:35 am – Coffee break (20 min)**

9:55 am – Biscuit Brook (Doug Burns)

10:05 am – Andrews (Mark Harmon)

10:15 am – Luquillo (Bill McDowell)

10:25 am – Marcell (Steve Sebestyen)

10:35 am – Niwot (Jordan Parman)

10:45 am – What data do we have? (Carrie Rose Levine) (30 min)

11:15 am – Forest Service Experimental Forest and Range database (Steve Sebestyen) (15 min)

11:30 am – Discussion (15 min)

**11:45 am – Lunch (1hr 15min)**

***Afternoon Session – Stream flux uncertainty discussion (facilitated by John Campbell)***

1:00 pm – Identify the aspects of uncertainty that we will consider (Ruth Yanai) (20 min)

1:20 pm – Aspects of uncertainty: How will we evaluate uncertainty in each of these aspects:

- HB rating curve example (Ruth Yanai)
- Model uncertainty (Mark Green)
- Instrument uncertainty (stage height, weir calibration, v-notch style) (Doug Burns)
- Analytical uncertainty (chemistry) (Don Buso)

- Stream flux calculations (Jamie Shanley)
- How to deal with groundwater (e.g. Marcell)

### **3:00 pm – Coffee break (20 min)**

3:20 pm – What are we going to do?

- Last 10 years of data only (no change over time)
- We will evaluate all major ions
- Common approach or different approaches or approach comparisons or all of the above

### **5:00 pm – Adjourn**

6:00 pm – Group dinner (meet in hotel lobby)

## **Tuesday, March 15**

### ***Morning Session – Precipitation flux uncertainty discussion (facilitated by Mark Green)***

8:00 am – Identify the aspects of uncertainty that we will consider (Ruth Yanai) (20 min)

- Selection of model: Thiessen polygons, kriging, inverse-distance weighting, Doppler, PRISM, others? (Mark Green)
- Instrument uncertainty: what type of collectors are you using?
- Comparison of chemical collectors
- Bulk vs. wet deposition (co-located NADP and Bulk collectors)
- Blowing snow (e.g. Niwot)

### **9:45 am – Coffee break (20 min)**

10:05 am – What are we going to do?

- Common approach or different approaches or approach comparisons or all of the above
- Last 10 years of data only (no change over time)
- We will evaluate all major ions
- We are not tackling dry deposition

### **11:45 am – Lunch (1hr 15min)**

### ***Afternoon Session – Outcomes and products (Facilitated by Ruth Yanai)***

1:00 pm – Outcomes and Products:

- Discussion of cultural change
- Round robin: What will you do to spread the good word?
- ESA workshop, other opportunities for outreach?
- ESA presentations
- Website (Carrie Rose)

### **3:00 pm – Coffee break (20 min)**

3:20 pm – Authorship and data use (John Campbell)



3:40 pm – Papers

- Hubbard Brook paper (Green, Buso, Campbell, Levine, Likens, Yanai)
- Precipitation
- Streamflow
- Overall input-output budget paper
- Monitoring efficiency?
- Change over time?
- Others?

**5:00 pm – Adjourn**

6:00 pm – Group dinner (meet in hotel lobby)

QUEST Work group meeting – Seaport Hotel, Boston MA

