

Working group title: Quantifying Uncertainty in Atmospheric Deposition

Investigator: Ruth Yanai

Award Year: 2012

Publications

Yanai, R. Levine, C., Green, M. and Campbell, J. 2012. Ecosystem budgets have no error: a progress report on Quantifying Uncertainty in Ecosystem Studies (QUEST). *Journal of Forestry* 110(8): 448-456 (Refereed).

RD Yanai, N Tokuchi, JL Campbell, MB Green, E Matsuzaki, SN Laseter, CL Brown, AS Bailey, P Lyons, CR Levine, DC Buso, GE Likens, J Knoepp, K Fukushima. Sources of uncertainty in stream solute export from headwater catchment. In review at *Hydrological Processes*

Additional Funding Obtained

“RCN: Quantifying Uncertainty in Ecosystem Studies” Ruth D. Yanai, \$500,000; 5 years; National Science Foundation

Workshops

Held an organized Oral Session called “Uncertainty Analysis: A Critical Step in Ecological Synthesis” at the 98th annual meeting of the Ecological Society of America”. Minneapolis, MN August 4-9, 2013.

We are organizing a sub-assembly (*The Importance of Quantifying Uncertainty in Managing Forests*) and a technical session (*Quantifying Uncertainty in Forest Measurements and Models: Approaches and Applications*, 2014 IUFRO meeting and SAF convention, Salt Lake City, UT.

Website

<http://quantifyinguncertainty.org> has been revamped

Presentations

Campbell, John L., Ruth D. Yanai, and Mark B. Green. [Quantifying uncertainty in ecology: Examples from small watershed studies](#). Minneapolis, MN-Ecological Society of America Annual Meeting, August 5, 2012. [OOS 5-2](#).

See, Craig R., Ruth D. Yanai, Mark B. Green, and Douglas I. Moore. [Uncertainty due to gap-filling in long-term hydrologic datasets](#). Minneapolis, MN-Ecological Society of America Annual Meeting, August 5, 2012. [OOS 5-6](#)

Yanai, R.D. Quantifying Uncertainty in Belowground Carbon Turnover. Bordeaux, France—COST Action FP0803, Belowground Carbon Turnover in European Forests, May 13-15, 2013

Yanai, R.D. Quantifying Uncertainty in Ecosystem Studies: Approaches and Applications. Canterbury, NZ— University of Canterbury, Forestry, hosted by Scion, the Forestry Research Institute, July 23, 2013.

Quantifying Uncertainty in Wet Atmospheric Deposition

We are pleased to submit this progress report for the LTER-funded synthesis working group entitled *Quantifying Uncertainty in Wet Atmospheric Deposition*. The goal of this group is to quantify spatial and temporal uncertainty in ecosystem-level estimates of solute deposition. Our products will make these calculations accessible to ecosystem scientists in the LTER network and at other sites around the world, enhancing the reporting of uncertainty in solute input estimates in ecosystem budgets.

The working group met May 21-23 at HJ Andrews Experimental Forest. The first day included presentations on long-term collection of deposition data, variability in monsoon precipitation (Sevilleta LTER), uncertainty in filling gaps in the data record, a hierarchical Bayesian analysis of precipitation patterns, and an analysis of monitoring intensity. Presentations were followed with discussion and planning sessions. For pdfs of the presentations, click [here](#).

The following day included a presentation by Chris Daly (OSU) on the PRISM model, and the uncertainties associated with large-scale spatiotemporal precipitation estimates and predictions. The rest of the time was devoted to planning papers and future workshops. Products coming out of this meeting will include a paper on uncertainty sources in unreplicated measurements (small watersheds), a paper on the effects of monitoring intensity on uncertainty, and a paper on gap filling in long-term hydrologic datasets. Time was also taken to plan the workshop entitled Quantifying Uncertainty in Ecosystem Studies at this year's LTER All Scientists Meeting in September. After discussing precipitation for two days, participants were given a rainy tour of HJ Andrews Experimental Forest.

Attending in person:

- John Campbell (USFS)
- Ruth Yanai (SUNY-ESF)
- Shannon LaDeau (Cary Institute)
- Doug Moore (Sevilleta LTER)
- Adam Skibbe (Konza LTER)
- Craig See (SUNY-ESF)
- Chris Daly (OSU)

Attending remotely (via telecom):

- Kathleen Weathers (Cary Institute)
- Mathew Petrie (University of New Mexico)
- Mark Green (Plymouth State)
- Stephanie Laseter (USFS)
- Jennifer Knoepp (USFS)

- Carrie Rose Levine (SUNY-ESF)



Attendees (left to right): John Campbell, Shannon LaDeau, Ruth Yanai, Doug Moore, Adam Skibbe, Craig See. Not shown: Chris Daly. Attending remotely: Kathie Weathers, Matt Petrie, Mark Green, Stephanie Laseter, Jennifer Knoepp, and Carrie Rose Levine.

QUEST Presentations

Yanai, R., C. Levine, M. Green, and J. Campbell. 2011. Ecosystem budgets have no error: a progress report on Quantifying Uncertainty in forest Ecosystem Studies (QUEST). Rochester, NY—Rochester Academy of Science Meeting, October 29, 2011.

Levine, C.R., R.D. Yanai, J.L. Campbell, M.B. Green. 2012. Quantifying Uncertainty in Ecosystem Studies. Millbrook, NY – Hubbard Brook Cooperators Meeting, January 11, 2012.

Yanai, R., C. Levine, M. Green, and J. Campbell. 2012. Ecosystem budgets have no error: a progress report on Quantifying Uncertainty in forest Ecosystem Studies (QUEST). East Syracuse, NY –New York Society of American Foresters Winter Meeting, January 26, 2012

- Levine, C.R., R.D. Yanai, J.L. Campbell, M.B. Green. 2012. Quantifying Uncertainty in Ecosystem Studies. Troy, NY– Northeast Soil Monitoring Cooperative Annual Meeting, March 13, 2012.
- See, C.R., R.D. Yanai. 2012. Using leave-one-out cross validation to quantify uncertainty in filling data gaps: rain gauges at the Sevilleta NWR. Syracuse, NY– SUNY-ESF Spotlight on Research, April 12, 2012
- Yanai, R.D., C.R. Levine, C.R. See, J.L. Campbell, M.B. Green, S.L. LaDeau. 2012. Certain Progress in Uncertainty Analysis. West Thornton, NH—Hubbard Brook Ecosystem Study Annual Cooperators Meeting, July 11, 2012.
- Yanai, R.D., J. Campbell, S. L. LaDeau, K.C. Weathers, C.R. See, and M.B. Green. 2012. Quantifying Uncertainty in Precipitation Estimates. Portland, OR-Ecological Society of America Annual Meeting, August 8, 2012.
- Levine, C.R., R.D. Yanai, G. Lampman. 2012. Assessing long-term monitoring programs for sulfur. Portland, OR-Ecological Society of America Annual Meeting, August 7, 2012.
- Yanai, Ruth, Carrie R. Levine, Mark B. Green, John L. Campbell, Matthew A. Vadeboncoeur, Steve Hamburg. 2012. Is the missing nitrogen source (or sink) at Hubbard Brook statistically significant? Quantifying Uncertainty in Ecosystem Studies (QUEST). Estes Park, CO-Long Term Ecological Research All Scientists Meeting, September 9-12, 2012.
- Craig See, C., R. Yanai, J. Campbell, D. Moore, G. Likens, E. Matsuzaki. 2012. A proposed cross-site comparison of missing data in long-term hydrologic datasets. Estes Park, CO-Long Term Ecological Research All Scientists Meeting, September 9-12, 2012.
- Levine, C.R., R.D. Yanai, G. Lampman. 2012. Assessment of Long-term Monitoring of Nitrogen, Sulfur, and Mercury Deposition and Environmental Effects in New York State. South Portland, ME -- National Atmospheric Deposition Program Annual Meeting. Oct 2-5, 2012.
- Yanai, R.D. 2012. Uncertainty Analysis of the Phosphorus Budget at the Hubbard Brook Experimental Forest, New Hampshire, University of Tokyo, Laboratory of Forest Hydrology and Erosion Control Engineering, Oct 5, 2012.
- Yanai, R.D. 2012. Improving the Efficiency of Environmental Monitoring using Uncertainty Analysis. Forestry and Forest Products Research Institute, Ibaraki, Japan. December 14, 2012.

QUEST Work in Progress

The following papers in progress are all related to uncertainty, and some are related to uncertainty in precipitation (the focus of this LTER SWG). We list them in the order in which we think they will be published.

Yanai, R.D., C.R. Levine, M.B. Green, J.L. Campbell. 2012. Quantifying Uncertainty in Forest Nutrient Budgets. *Journal of Forestry* (In press, attached).

This paper uses the Hubbard Brook N cycle as an example, and focuses primarily on uncertainty in the changes in N content of vegetation and soil. The uncertainty in budget closure remains unsolved.

Yanai, R.D., S.P. Hamburg, M.A. Vadeboncoeur, M.A. Arthur, C.B. Fuss, C.T. Driscoll, P.M. Groffman and T.G. Siccama. From missing source to missing sink: long-term

nitrogen dynamics in the northern hardwood forest. *Ecosystems*. In preparation.
(recently rejected from PNAS)

This paper describes the change over time in the input-output budgets for N, with changes in vegetation storage driving the change from missing source to missing sink. Uncertainty in change in N in the forest floor is reported here for the first time. Uncertainty in the mineral soil is also quantified (it is very large).

Yanai, R.D., E. Matsuzaki, N. Tokuchi, J.L. Campbell, M.B. Green, C.R. Levine, Fukushima, S. Laseter, C. Brown, J. Knoepp, J. Vose, A. Bailey, D. Buso, G.E. Likens. A comparison of uncertainty in stream export of solutes from headwater catchments at Wakayama, Hubbard Brook and Coweeta Experimental Forests. *Hydrological Processes*. In Preparation.

This paper describes many sources of uncertainty in stream export of solutes, using examples from these three sites and nine solutes. It does not attempt to quantify the combined uncertainty from all sources.

Campbell, J.L, R.D. Yanai, M.B. Green, C.R. Levine, M.E. Harmon, J. Vose, M.B. Adams, W.H. McDowell, S. Sebastyen, and M. Williams. Quantifying uncertainty in ecology: examples from small watershed studies. *Frontiers in Ecology and the Environment*. In Preparation.

This paper gives a general introduction to uncertainty in input-output budgets. It will include the hierarchical Bayesian analysis of uncertainty in precipitation presented by Shannon LaDeau at our workshop (which has since been updated). It will provide, for the first time, spatial and temporal variation in precip and streamflow based on replicate watersheds at Hubbard Brook.

See, C.R., R.D. Yanai, D. Moore, and contributors recruited at the upcoming ASM. 2012.
Filling the gaps: a cross-site comparison of the consequences of missing data in hydrologic fluxes.

This paper will describe the extent and causes of gaps in records of precipitation and stream fluxes (water and solutes). We will solicit contributions from other sites at the ASM. For some data sets, we will estimate the uncertainty due to gap filling, using leave-one-out cross validation.

Burns, D.A. Interpolating solute chemistry for estimating stream loads: a comparison of methods at multiple sites and sampling intensities.

This paper will describe how the importance of model selection depends on sampling intensity (declining with the frequency of measurements). We also expect to get different answers for solutes depending on the relationship of concentration to discharge. This study uses data from Hubbard Brook, Biscuit Brook, Panola, Sleepers, and Luquillo.

Levine et al. Evaluating the efficiency of environmental monitoring.

This paper applies uncertainty analysis to monitoring atmospheric deposition, surface waters, biota, and soils, using examples from New York State (funded by NYSERDA) and other sites, including LTER sites.

Green et al. What determines our confidence in ecosystem budgets? Are missing sinks and sources statistically significant?

We will analyze the uncertainty in budget closure terms for a variety of sites, including the water budget and N budget for Hubbard Brook. Japanese sites will likely be included. The most important sources of uncertainty depend on the magnitude of the pools and fluxes but also the methods of measuring them. This information can be used to direct research effort where uncertainty is highest.

Other Products:

Our RCN proposal that will build on this work is tentatively slated to be awarded, pending clarification of some points for the review panel.