Title:LTER: Long Term Ecological Research at the Hubbard Brook Experimental Forest

Institution: Institute of Ecosystem Studies

NSF Program:LONG TERM ECOLOGICAL RESEARCH

Principal Investigator: Lovett, Gary M.

Rating: Very Good

Review:

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

Overview: The HBR LTER program focuses on long-term studies of NE US forest catchments, with an emphasis on understanding how past and current disturbances affect the structure and functioning of forest and stream ecosystems. The theme of responses to natural and anthropogenic disturbances builds on a history of long-term ecological measurements and watershed-level manipulations at the HBR site. This renewal proposal extends those studies to explicitly include biotic disturbances in changes in biota in both forest and stream ecosystems. The research is organized around three specific disturbance types û effects of altered atmospheric chemistry and deposition, effects of climate change, and effects of changing biota. Measured responses to these disturbances or stressors include changes in hydrology, biogeochemistry, productivity and other vegetation dynamics, and altered communities and foodwebs. Ongoing and new research activities are organized by the three disturbance types (atmospheric chemistry, climate change, changing biota) with specific research activities and questions listed in each section. HBR LTER research effectively covers all five LTER core areas with a mix of long-term monitoring and observational studies, experimental manipulations, and modeling. Synthesis and integration is facilitated by framing all research activities around five broad "core research" questions that cut across disciplines, levels of biological organization and individual research projects.

Strengths: The HBR program has a rich history of studying responses to air pollution and changing precipitation chemistry and impacts on forest and stream ecosystems. In total, HBR research has provided important insights into a number of critical environmental changes impacting NE US forests, including biogeochemical dynamics in response to forest disturbance and succession, the impacts of acid rain and elevated N deposition, the effects of calcium amendment to replace long-term losses, and responses to episodic climate events. A significant portion of HBR research is policy and management relevant, and the HBR team has exceled in communicating those results to the scientific community, the public, and to a broad range of stakeholders and policy makers. The HBR record of productivity during the current funding cycle is impressive, and incudes 216 peer-reviewed publications with many impactful papers in top-tier journals. The quality of HBR research is evident in the 10 highlighted publications, which cover a range of subject areas and finding that are relevant to the current renewal proposal. The program has also contributed many recent synthesis publications on specific research foci at HBR, as well as a recent book highlighting the major findings of over 50+ years of Hubbard Brook research.

The current HBR conceptual model is a graphical representation of the three main disturbance categories addressed in the current proposal, the functional responses to those disturbances, and the fact that those responses are played out on a template of geophysical variability and historical legacies, with some internal feedbacks to changes in biota. The model is fairly simple, but does an adequate job of capturing the major research themes of the current HBR program.

One of the hallmarks of the HBR program is their catchment-level research on nutrient budgets and associated whole watershed manipulations. Some of these early manipulations continue to provide a unique and valuable platform for addressing ecosystem theory, such as changes in nutrient retention over successional time, responses to N saturation, effects of long-term acid deposition, etc. One of the most recent of these watershed-level studies is the whole watershed Ca addition experiment, initiated in 1998 to address the effects of long-term base cation depletion as a result of acidic precipitation inputs and elevated N deposition. Responses included enhanced forest productivity, altered biomass allocation above- and below-ground, and increased tree recruitment, as well as some unexpected effects (altered ET, increased late-stage litter decomposition and loss of stored organic matter, and altered ecosystem N fluxes including ongoing elevated loss of NO3). Similarly, long-term monitoring of N budgets in non-aggrading reference watersheds is now providing some surprising results in terms of unexpectedly low hydrologic export of N despite long-term N enrichment and apparent lack of new biological uptake and storage. In both cases, these unexpected results form the basis for some of the new research proposed here. They serve as great examples of the value of continuing these whole watershed experiments and associated long-term monitoring. Some of the most exciting new questions posed in the proposal stem from these unexpected results. How and why is Ca addition accelerating the loss of OM and release of N in the form of NO3? What mechanism(s) underlies the apparent retention or unaccounted losses of N in non-aggrading reference watersheds? New research incorporating isotopic methods (labeled litter additions, 15N-NMR) will test a proposed "soil N bank" hypothesis to account for this. Alternatively, unmeasured gaseous losses of N may be responsible for the low hydrologic export, and new measurements of N gas flux coupled with isotopic fractionation studies and microbial metagenomic analyses by soil depth will address spatial and temporal heterogeneity in microbially-mediated N transformations and N fluxes.

New HBR research also includes studies to test proposed revisions of long-standing conceptual models in forest ecology. For example, the addition of the Hierarchical Response Framework provides a new way of thinking about compositional changes in these forest ecosystems.

Climate change studies at HBR focus primarily on effects of earlier spring warming and snow melt, and a lengthening of the "vernal window" when microbial activity occurs earlier than plant uptake. This is an interesting and potentially important aspect of climate change for ecosystem nutrient losses. In addition to addressing the ecosystem effects of this temporal asynchrony, new HBR research will assess potential phenological mismatches as a result of earlier spring warming, and the impacts of climate-driven insect herbivore dynamics on forest food webs. Research on changing biota also includes the ecological consequences of current changes in tree species composition (e.g., sugar maple and birch declines) and expected near-future changes as a result of insect invasions (e.g., loss of hemlock and ash). The effects of these changes will be addressed by pre- and post-change data and by species-specific modeling of forest C and N dynamics (the Spe-CN model).

HBR research also includes studies at other sites in the region, including a multi-site N and P addition experiment deigned to test ideas about responses to multiple element limitation.

Modeling efforts at HBR include several modifications of PnET, a species-specific C and N model (Spe-CN, a forest ecosystem demography model, and the Multiple Element Limitation (MEL) model. These models are linked to specific ongoing and proposed research activities, and seem appropriate for addressing the questions to which they are linked. It is also noteworthy that HBR scientists are leading, or participating in, efforts aimed at assessing and quantifying uncertainty in ecosystem measurements and models.

Weaknesses: The adequacy of the approaches for several of the new proposed experiments was difficult to evaluate due to lack of detail. For example, there is no information on where the isotopic litter additions to assess the soil N bank hypothesis will be done, what kind of litter will be added, what size plots or number of replicates will be used, how soil sampling will be done by depth, etc. Is this a one-time addition or repeated over time? Will there be a large enough quantity of litter added with sufficient enrichment to really follow the label through the plant and soil pools proposed? How will the measurement of gaseous N fluxes be expanded to address its role in N budgets? Where and how frequently will measurements be made? I also would have liked to have seem some more detail and rationale for the multi-site N and P fertilization experiment. From the brief description, it appears that each of 13 sites has only four plots, with each plot assigned one of 4 fertilizer treatments (control, N, P and N+P). The lack of treatment replication within sites suggests that results are being analyzed with regression-based or response surface approaches, though that was not described at all. While it is not reasonable to expect a lot of methodological detail in these kinds of proposals, it would have been helpful to provide a few more specifics for some of the newly proposed or expanded studies.

The studies to identify the mechanisms underlying the apparent reduction in forest ET are placed under the theme of climate change, but the connection to ongoing or predicted climate change seems pretty nebulous. How is this related to climate variability or directional climate change in the region? The measurements proposed cover a variety of methods and scales (sap flow sensors, eddy flux towers, isotopic dendrochronology, balance of ppt and stream flow), and they likely will provide better documentation of changes in ET (currently calculated as the difference between ppt inputs and streamflow) and some of the proximal mechanisms, but specific linkages between these measurements and the underlying reason for long-term directional changes in ET were not clearly articulated.

Studies of how changing forest phenology affects C cycling and biosphere-atmosphere exchanges rely on natural variability in climate and phenology and long-term data. Similarly, the studies of changing climate seasonality and variation in the vernal window are based primarily on natural variability and observational data. This is an aspect of climate change that should be amenable to experimental manipulation (e.g., snow manipulations, soil warming, etc.). The PIs note that they are seeking non-LTER funding to conduct such experiments, but I wonder if this should be supported with LTER funding.

Research under Theme 4 (Geophysical and historical template and ecosystem responses) will likely add new insights into spatial heterogeneity and scaling of the HBR watershed studies to the larger HBR valley landscape. However, this seems very site-specific. How will this research apply to other ecosystems and address broader questions beyond the HBR site?

In general, I thought the consumer and food web studies were one of the weakest aspects of the proposal. In total, this seemed to be a loose mix of studies on different consumer groups based primarily on long-term observation and correlational studies. I was left wondering if some of these studies were sufficient to address responses to climate-driven changes. For example, is annual sampling of soil invertebrates sufficient to assess responses to climate or vegetation change? What was the rationale for including bats in these studies? Studies of stream consumer responses to climate seem rather superficial. I wonder if measuring insect emergence 3 times during the 6-year LTER funding cycle is sufficient, given the potentially high temporal variability in stream insect communities and emergence. Likewise, the estimation of % leaf removal by insect herbivory using end-of-season samples is likely to miss a lot of early season herbivory as leaves are consumed or shed early as "greenfall". I think the question of forest food web responses to climate change might be better addressed by a more careful and in depth assessment of the responses of a few key taxa.

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

The education, outreach and broader impacts of the HBR program are excellent. Some of the unique or noteworthy aspects of the program, in addition to the SLTER, RET and REU programs, include partnerships with other educational and training programs (Project Learning Tree, GLOBE, etc.) and participation in roundtable discussions with a range of land owners, managers, and stakeholders. The Science Links program facilitates translation of policy-relevant results at regional to national levels. The newer Science Policy Exchange collaboration with other LTER sites and regional universities targets production of scientific synthesis papers coupled with outreach aimed at media, land managers and policy makers. The proposal also includes plans to expand the HBR Arts & Sciences initiative by establishing an HBR artist-in-residence program. HBR scientists are also very active and contribute in many ways to LTER network and cross-site activities.

Please evaluate the strengths and
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if applicable

Program Management: The HBR has a formal program management structure that appears to work well for them. The Committee of Scientists is comprised of 67 members, which seems too large to be effective in decision making. However, the decisions are made primarily by a smaller 7-member Scientific Coordinating Committee, which is chaired by election of one member from within the group. The COS meets quarterly, and this provides an opportunity for science synthesis as well as HBR business.
The inclusion of an annual Cooperators' Meeting to broaden participation and communication with individuals outside the HBR research group is a great idea. This annual meeting also includes undergraduate and graduate students. It was unclear to me if this is the only time that students participate in the HBR meetings. If so, I think that's a problem. The COS meetings should be open to graduate students, too.

The HBR program recently transitioned from leader ship by Fahey/Driscoll to Lovett/Groffman. There is a plan for future transition as well, with Groffman to stay on as lead for the next funding cycle with addition of a second co-PI to co-lead the program. This two-person co-management structure seems to have been very effective in the past, and should continue to serve them well. One potential issue for future consideration is whether Groffman will be over-committed by assuming the role of lead PI of the HBR program while maintaining a management role on the BES program. Of the 36 listed co-PIs and senior personnel, 16 (44%) are women and 9 (25%) received their PhDs within the last 10 years. This renewal proposal added 13 co-PIs or senior personnel that were not involved in previous funding cycles. The program is making an effort to increase diversity and involve earlier career scientists.

Summary Statement

The HBR program has an outstanding record of high quality research and productivity on the ecology of forest ecosystems and responses to natural and anthropogenic disturbances. The long-term watershed and plot-level experiments, and associated measurements, are unique and important resources for assessing responses to current and future environmental changes. The program is well poised to expand their research focus to address continuing impacts of climate change, and to address the effects of impending changes in forest structure and function as expansion of insect pests leads to major compositional changes. Some particularly strong aspects of the proposal are the use of long-term watershed nutrient budgets to identify temporal trends and the small catchment experiments that are producing unexpected results leading to a rethinking of some fundamental ecosystem concepts. While the program has also aimed to increase studies of forest consumers and food web dynamics, much of that research seemed to be less focused and grounded in theory.