INSTITUTION: Institute of Ecosystem Studies
NSF PROGRAM: LONG TERM ECOLOGICAL RESEARCH
PROPOSAL TITLE: LTER: Long Term Ecological Research at the Hubbard Brook Experimental Forest

PANEL SUMMARY:
Panel Summary

Long-Term Ecological Research Program
Spring 2016 Renewal Panel

Results of Prior LTER Support:

The Hubbard Brook (HBR) LTER program focuses on understanding the dynamics of northern US forest ecosystems, and responses to a range of natural and anthropogenic disturbances. A significant portion of their research has focused on the impacts of changing atmospheric chemistry and altered rainfall chemistry on decline and recovery of NE US forests, and more recently on the impacts of climate change. HBR has an excellent record of productivity, with 216 papers during the previous funding cycle. HBR has continued to produce seminal work in ecosystem science and watershed biogeochemistry based on unique whole-watershed manipulations and long-term data collection, including many papers in top-tier general science, ecology, and biogeochemistry journals. The quality of journals featuring HBR community and consumer research was somewhat lower. Several integrative synthesis papers were produced during the last funding cycle, and a book detailing the history, major findings, and future directions of research at HBR was published.

Intellectual Merit:
Strengths:

Prior HBR research revealed some unexpected responses to past disturbances and experimental manipulations, including a cascade of ecosystem responses to a whole watershed calcium addition experiment initiated in 1998. Monitoring of whole watershed N budgets in reference watersheds also raised new questions about ecosystem nutrient retention over successional time and extremely low ionic concentrations in streams draining those watersheds. HBR also documented effects of climate changes, including ice storms, warming, changes in snow accumulation, and the progressively earlier spring thaws that increases the period of microbial activity prior to plant uptake (the "vernal window"). The link between past research results and research questions and activities in the current proposal was strong.

The research questions focused on "surprises" in watershed hydrology and biogeochemistry are exciting. Why are these non-aggrading forests apparently exporting such little nitrogen? Why is the proportion of precipitation inputs transferred to the atmosphere by ET decreasing despite increasing temperature? The HBR program is uniquely poised to address these questions, and to contribute to refinement or development of new ecosystem theory. For example, the proposed "soil N bank" hypothesis is a novel

alternative to current thinking about changes in N budgets during succession. Similarly, the unexpected effects of Ca addition on loss of organic matter and changes in N cycling and availability promise to provide new insights into relationships among nutrient cycles, as well as potential impacts of long-term base cation losses and recovery as a result of air pollution and subsequent enactment of the Clean Air Act.

The current HBR conceptual model is a logical outgrowth of the previous research. The panel thought that the framework adequately encapsulated the current HBR research emphasis on changing atmospheric chemistry, climate and biota, and their effects and feedbacks mediated by a heterogeneous geophysical and historical template. The explicit attention to temporal changes in the template and in ecological responses was also nicely incorporated into the framework. The proposal also relates specific research questions to other conceptual models or theory. For example adoption of the Hierarchical Response Framework seems like a useful way to think about lagged organismal, community and ecosystem responses to a novel disturbance regime.

The models being used are generally appropriate for the questions being addresses, particularly with respect to ecosystem and biogeochemical responses. However, additional models might be useful for addressing community responses to various disturbances or stressors. Multiple disturbances and biotic stressors are likely to change the structure and function of the forest in major ways, and survey plots and gap dynamics seem insufficient for addressing the cascading effects from communities to ecosystems. The impacts of exotic insect pests and plant diseases will allow the HBR team to document responses to loss of species and changes in community composition, and the development of the Spe-CN model will be useful for predicting impacts of those changes on ecosystem C and N dynamics. However, the impacts of tree species changes on consumers and trophic dynamics should also be considered, as these interactions may have a significant impact that is not reflected in the current models. In addition, species-specific tree responses could be considered in relation to other studies of Ca deficiency and regional sugar maple decline.

Weaknesses:
The panel noted a lack of in-stream process-level biogeochemical studies, particularly in relation to observed changes in hydrologic export of nutrients. Such studies could reveal both in-stream responses to changing stream water chemistry and, potentially, processes that might help account for the surprising changes observed over time. It appears that this issue also came up in the last site review. Although the HBR team has added collaborators with stream expertise and some studies of stream biota, the panel felt that additional process-level studies are needed to provide a more complete assessment of changes in watershed-level nutrient dynamics over successional time or in response to nutrient amendments or disturbance. We strongly encourage the site to consider adding such studies.

The panel also noted a general lack of depth and focus in the HBR studies of terrestrial consumers and trophic interactions. The panel viewed positively the added studies of a key consumer in stream ecosystems and the attention to caterpillar irruptions and effects on both trees and predators. However, the panel also felt that these studies could be improved substantially by focusing on the specific taxa and biotic interactions that are most relevant to HBR overarching research goals and conceptual framework. For example, how does the return of moose alter plant community dynamics and successional trajectories? Do responses of biota and associated trophic interactions to climate change or other

disturbances feedback to affect the drivers of change? What are the relationships between changing biota and other disturbances/treatments? How do these disturbances/treatments interact with one another to affect forest communities? The boom and bust cycles of caterpillars are particularly interesting, and the panel thought there could be more attention to the causes and consequences of these dynamics.

The potential impacts of re-emergence of beech bark disease complex could have huge impacts on community structure, plant-herbivore interactions, and ecosystem processes. HBR should be well poised to study these changes as a result of beech resprouting and recruitment in the understory, but this is not really addressed in the proposal. Interactions of regenerating birch with browsers (e.g., moose) could produce some unique dynamics, and this should be considered.

Although the models used are generally appropriate, they seem to be treated very separately in their application to specific questions. The PIs may want to consider if this will hamper efforts at integration and, if so, how to better link these modeling efforts or results as part of larger synthesis efforts.

Broader Impacts:
Strengths:
The Hubbard Brook Research Foundation is an effective interface for HBR educational and outreach activities. There are a large number of educational activities at all levels. The HBR program provides professional development and training for middle- and high-school teachers through the RET program. The panel noted positively HBR's involvement with Project Learning Tree and the New Hampshire Science Teachers Association, as well the joint REU program with Plymouth College. HBR participation in the Science Links program and the Science Policy Exchange foster translation and dissemination of societally-relevant and policy-relevant results. HBR also proposes to establish an artist-in-residence program. HBR scientists are contributing to many LTER network and cross-site activities.

Weaknesses:
The panel felt that although there were numerous educational activities listed, articulation of clear goals might help maintain greater focus for these diverse activities.

Information management and technology:

Strengths: In general, the panel noted that HBR has a well-developed plan for data management. Descriptions of IM and data management timelines and milestones were very clear. The site has data available through the PASTA data portal. The web site is well designed and includes components expected of LTER sites. HBR includes an IM oversight committee that reports to the HBR executive committee as part of the program management structure.

Weaknesses: There was no specific information on how HBR assures data security. There appears to be no specific plan for model code management (i.e., no version control system). Timeline and milestone were very clear. Data are available in PASTA. One concern is that, based on the information available, the IM seems to function in a support service role, rather than as an equal partner in the HBR team. If this is the case, the panel thinks that better integration of the IM as a formal part of the research team would benefit the program.

Project management
Strengths:
The HBR site underwent a transition in leadership for this funding cycle, which seems to have been relatively seamless. The site seems to have a reasonable and effective management structure. The HBR team has expanded their disciplinary breadth and research expertise by bringing in new investigators. HBR holds quarterly meeting to aid in integration and synthesis. The collaborative management by two "lead PIs" seems to have been effective. There is a plan for succession, which indicates that Groffman (the current "co-lead PI") will assume the lead PI role in the future, with addition of a second "co-lead PI" to assist with managing the program. As noted by a reviewer, that raises some concerns about over-commitment if Groffman also maintains a lead role in the BES program.

Weaknesses:
The COS seems too large and unwieldy to be effective in fostering synthesis, although it appears that management and decision-making is actually done by a smaller group of investigators.

Additional Comments or Areas of Special Concern:

Synthesis and Recommendation:
The panel recognized the unique potential of the HBR LTER program to continue advancing ecology, and particularly ecosystem science and biogeochemistry, though continued long-term experiments, data collection and monitoring. The panel also felt that the impact of the HBR research could be substantially broadened and enhanced by a the addition of stream studies to complement terrestrial biogeochemical studies and by a more detailed and focused consideration of forest community dynamics that explicitly considers the role of key consumer groups and trophic interactions.

The panel's advice to NSF is: Renewal

This summary was read by the assigned panelists and they concurred that the summary accurately reflects the panel discussion.

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PANEL RECOMMENDATION: Renew
PANEL RECOMMENDATION KEY:
DNR:Do Not Renew, P:Probation, R:Renew