Proposal Panel 1 : 2224545

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Agency Name: National Science Foundation

Agency Tracking Number: **2224545**

Panel Summary

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1.) Results of Prior LTER Support: [Comment as to how effectively or appropriately the PI(s) have previously used NSF funds]

Panelists and reviewers described Hubbard Brook (HBR) as a "flagship" and "iconic" LTER site. HBR continues to be very productive, with 195 papers published in the last cycle and direct ties of their work to policy and environmental management. During recent cycles HBR has added exciting new work, including large-scale nutrient manipulations and experimental climate extremes. After more than four decades, HBR continues to make strong contributions to our mechanistic understanding of Northeastern forests and advance theory across ecology.

HBR has long-been integrated with on-the-ground management and environmental policy, which is a strong broader impact. In the most recent cycle, they have added substantial diversity, equity, and inclusion (DEI) programs and outreach to indigenous groups.

2.) Intellectual Merit: [Scientific merit, including specific review criteria; conceptual framework; five core areas; site-based research; integration of project elements; and other research activities including cross-site, non-LTER, and international research]

Strengths:
The current HBR proposal revolves around conceptual framework of "control points" which the authors describe as points in time and space where rapid changes occur. The panel thought that this has potential as a research framework.

HBR is effectively combining observational and experimental approaches. The panelists were especially impressed by the Ca+ addition experiment, the long-running warming/snow manipulation experiment, and experimental icing. These are all novel and directly relevant to policy and management. These experiments are effectively combined with "unplanned experiments" such as changing climate, deacidification, and upcoming emerald ash borer outbreak. HBR's emphasis on spatial variability adds to their inference. For instance, the site is effectively linking where and when changes in tree phenology might have cascading effects for biogeochemistry and variability at higher trophic levels. Moreover, many of the measurements are taken at the catchment scale with a suite of measurements that complement each other well. For instance, combining stream discharge, sap flow measurements, and eddy flux covariance allows HRB to paint a complete picture of catchment-scale hydrology. This strong mechanistic understanding is helping HBR make sense of otherwise counterintuitive ecological changes, such as a recent increase in evapotranspiration.

Because of HBRs association with a U.S. Forest Service site, it has some datasets that predate the LTER program, meaning that some of these data streams are exceptionally long. This gives HBR the ability to provide deep context on the rate and extent to which forests are changing due to human influences. Several reviewers also noted a strong modeling program.

The panel commended HBR for their use of the "10 significant papers"--they show productivity in both bedrock ecological journals and top tier journals across the sciences. They also demonstrated a breadth of work and expertise. Finally, the panel notes impressive recent work tracking changes in

higher trophic levels, such as interactions between phenology and changes in bird and insect populations. These are pressing environmental issues and HBR is serving an important role tracking and understanding these population changes.

Weaknesses:
The panel was broadly critical of the application of control points as a conceptual underpinning for the proposal. Specifically, what are the theoretical conditions under which we expect control points to reveal themselves? Panel members used their own background to infer these mechanisms, such as the idea of "hot spots" in biogeochemistry and "windows of opportunity" in community ecological and resilience theory. However, the authors essentially offer just one paragraph that mentions that there are such areas of theory supporting the existence of control points, without going into the necessary detail to convince the reader.

The panel thought there is room for further integration of the conceptual framework and research components. For instance, the newer work on salamanders was seen as a valuable addition, but it was not as well integrated with the rest of the research, even though it makes reference to control points. Up until this point in the text, the panel had imagined that control points refer to key places or events that cause disproportionately large ecological shifts. But in this example, control point is used to describe a life history transition. This left the panel with the uneasy feeling that HBR had not clearly thought through the conceptual framework—is it so broad that it can apply to almost anything? If so, is this a way to truly pave new intellectual ground?

The panel also wished to see more text explaining how HBR will use empirical approaches to identify control points. Instead, the readers were asked to trust that this would be done correctly. This also applies to the application of machine learning. Machine learning was proposed twice in the proposal, but almost no detail was provided on the inputs, outputs, or approach. Since this is not a trivial exercise, we expected more information on this topic.

3.) Broader Impacts: [Outreach/education including training of undergraduate and graduate students, K-12 Schoolyard, broadening participation, application of results to policy and management, public outreach, or others. If there is a post-doctoral mentoring plan is that plan adequate? If not, what are the weaknesses?]

Strengths:

The breadth of outreach and engagement with managers and other stakeholders was rated very highly. The panel was also impressed by work published by the group on social-ecological resilience. As noted several times above, many of the data-streams and publications have direct connections to human well-being, such as measurements of water availability and water chemistry. Other noted strong points were a well-developed art-science program and many well-described DEI initiatives, including meaningful connections with local indigenous groups. The panel also noted that HRB has published influential work on social-ecological resilience. HBR has effective direct engagement with policy makers as well. The panel found the idea of Critical Ecology to be compelling. It was interesting to think about how power imbalances and colonial history can be major drivers of ecological disturbances.

Weaknesses:
The contributions to undergraduate teaching could be larger given the large number of contributors.

Mentoring plan adequacy:
The panel found mentoring to be strong, with some small notes on areas for improvement.

Mentoring plan deficiencies:
The panel recommended that HBR consider having multiple mentors/mentees per post-doc, which is now considered a best practice. This might be extra important at a place like the Carry Institute, where mentoring related to teaching and other activities typical of a university setting might not be available.

4.) Information management and technology:

Strengths:

The data are used to good effect in local, regional, and global scale syntheses.

HBR has an experienced information manager (IM) and the data management plan is generally well written. We also appreciated the IM's contribution to network-level improvement of data-management.

The IM panel member attempted to access datasets cited in major publications, along with spot-checks of other data. These datasets all proved to be up to date, with proper metadata. Moreover, publications from HBR scientists cite long-term data correctly, with citations to datasets within the main text of papers and in data-availability statements. The panel noted a strong archive of samples. HBR's website is an asset that clearly directs users to relevant datasets in a narrative format.

The metadata procedures could be described a bit more clearly in the data management plan, but looking at actual datasets, all metadata meet current LTER/EDI standards. In response to past reviews, it was recommended that the site use more cloud-based data storage. There seems to be some progress on this front, which we encourage HBR to continue.

Weaknesses:
The narrative elements connecting research to long-term datasets do not make clear which datasets are ongoing and updated regularly. It is also difficult to determine this information in the data catalog, which does impact the ability to find current datasets. A related, but more serious issue, is that some datasets related to experiments (e.g. CCASE) are not being updated according to LTER expectations for making data available two years after collection. Also, the panel found one embargoed dataset from the multiple element manipulation experiment. While this dataset has been collected since 2012, the data are not available on EDI. Finally, the panel asked whether model data will be archived and if so, to what degree?

5.) Project management: [including personnel, fiscal, administrative, institutional and logistical issues]

Strengths:

The panel was generally favorable of the project management plan. This is an experienced team with a long history of research and mentorship.

Weaknesses:
The panel noted that few junior personnel were in leadership roles. Similarly, a large portion of the budget seems to towards supporting a small number of senior faculty.

6.) Basis for Recommendation: [Please concisely summarize the main reasons for the panel's final recommendation.]

The panel recommendation is: Medium Priority

The panel was truly impressed by the work being done at HBR and the new work being proposed. We strongly encourage the team to proceed as planned with all research activities. Looking to the future, we recommend substantial work on the conceptual framework and empirical measurement of control points. The broader impacts were excellent, with especially robust management/policy engagement and DEI components. HBR is making a large a mount of data easily accessible to HBR and non-HBR users.

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

PANEL RECOMMENDATION: Medium Priority