Luquillo Long-Term Ecological Research Program

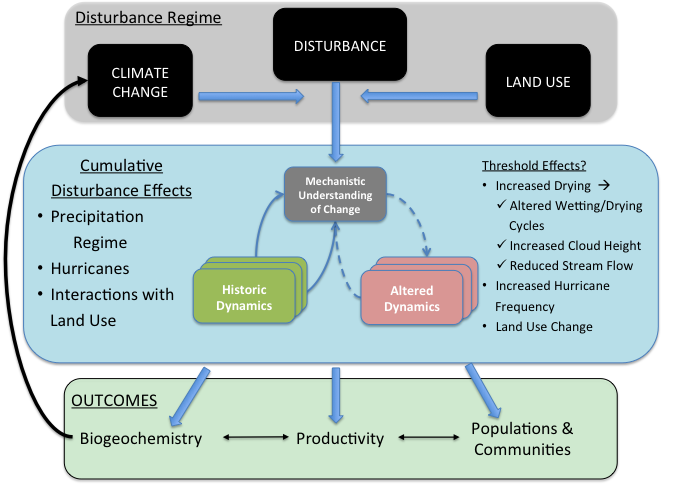
Progress Report to 2017 Site Review Team

March 3, 2017

**Section 1. Site-based Research, including the conceptual model, long-term experiments, modeling as a tool for insight, and the collection of long-term data in the 5 core areas of primary production, population dynamics and trophic structure, organic matter accumulation, inorganic inputs and movements of nutrients through the ecosystem, and patterns and frequency of disturbances.**

As stated in our 2015 proposal, the overarching goal of the Luquillo LTER program is to determine how changing climate and disturbance regimes, alone or in concert, drive changes in the biota and biogeochemistry. An enhanced mechanistic understanding of change in natural and human modified landscapes will supply critical information to manage and conserve tropical forest ecosystems globally.

Our conceptual framework, modified here from our 2015 proposal, explores the development of novel ecosystems resulting from the separate and combined effects of increased drought and hurricane frequency, and mediated by land use legacies (Fig. 1). These novel ecosystems will differ from earlier and current ones in both structure and function and may be achieved via threshold conditions caused by an altered disturbance regime. We use biogeochemistry, productivity, and the composition and structure of biotic populations and communities as the characteristics for quantifying impacts.



Here we provide an overview of our progress in completing the site science described in our latest proposal. Under each question and hypothesis we indicate which portions of the workplan have been completed and major changes. Details of our findings will be presented as a compilation of recent annual reports (forthcoming) and in the field during the site visit. For each hypothesis, we indicate which are the relevant Core Areas and the long-term data sets that inform or are informed by our research. In preparing this we have revised the PIs involved in each hypothesis.

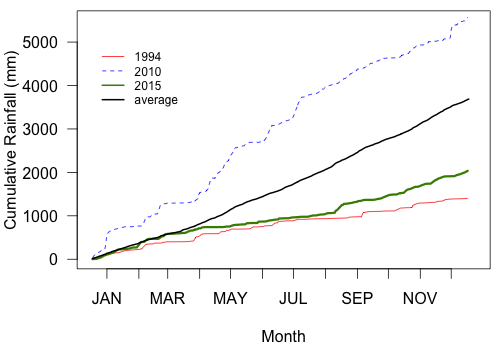
**Question I: What Are the Short- and Long-Term Effects of Drought on Biota and Biogeochemical Cycling in Tropical Forests?**

Immediately following the submission of our proposal in March 2015, Puerto Rico experienced one of the most severe droughts in its history (Fig. 1). The Luquillo LTER was in place to record the impacts of the drought on the biota and biogeochemistry and greatly increased our understanding and ability to project the impacts of drought on tropical ecosystems represented by our site.

Macintosh HD:Users:jesszimmerman:Library:Mobile Documents:com~apple~CloudDocs:JessWork:LTER:Annual Report 2015:drought monitor:Drought Monitor PR 2015.pdf

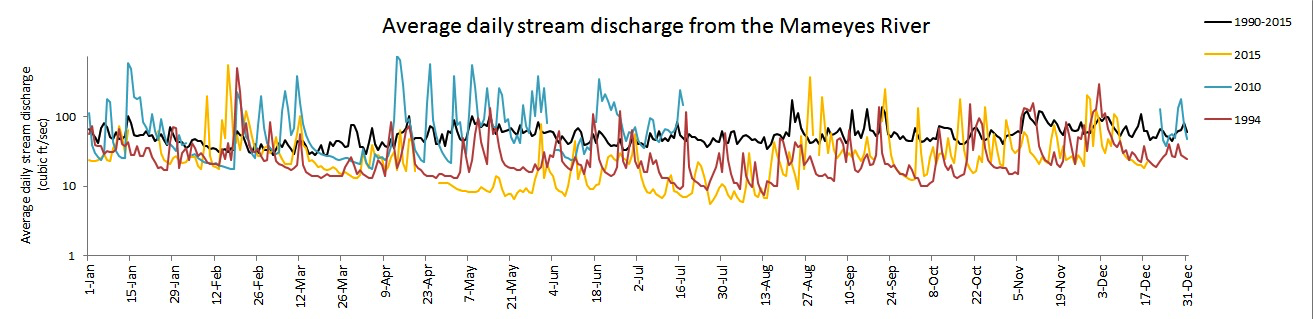
*Fig. 1. Distribution of US Drought Monitor index in Puerto Rico 2015 starting in April when drought conditions first appeared.*

The impact of the drought can be seen in comparison to our long-term records and in contrast to another drought in 1994 and an unusually wet year in 2010. Annual precipitation in 2015 was one-half the 40-year average and similar to the last severe drought, which occurred in 1994.

**

*Fig. 2. Cumulative annual rainfall recorded at El Verde Field Station showing the average (1975-2015) contrasted with 2015 and two other individual years, a significantly dry one (1994) and extremely wet one (2010).*

The impacts on hydrology were evident in comparison of years from one of our focal streams, the Mameyes River. Flows were lower than the 25-year average throughout through the end of the year and similar to that of 1994.



Here is a summary of progress on studying the effects of drought in the Luquillo LTER.

***Hypothesis 1a.*** *Over the short-term, droughts will alter the spatial dynamics of seedling survival and growth along catenas. Drought effects will be exacerbated on well-drained ridges favoring drought tolerant species, while in poorly drained valleys drought will improve soil aeration and generally enhance survival and growth. (Zimmerman, Uriarte, Thompson, Walker)*

* We have delayed the proposed drought experiment on seedlings while we investigate the impact of the 2015 drought on seedlings and adult plants.
* We found over 2007-16 that seedling survival was higher in years of low rainfall and high solar radiation but interspecific variation in these responses was large in both magnitude and direction overwhelming the average community response. Spatial heterogeneity in soil moisture and density of conspecific seedlings were the predominant drivers of seedling survival with the majority of species exhibiting greater survival in moist sites and at low conspecific densities.
* The 2015 drought caused reduced growth but not increased mortality in trees in the Luquillo Forest Dynamics Plot (LFDP) and a series of plots that extend the LFDP to younger forest ages.
* Growth reduction was weakly related the functional traits wood density and leaf mass per area (LMA), suggesting a relationship between drought tolerance and life history as predicted by theory.

***Hypothesis 1b.*** *Over the long-term, increasing frequency of drought will lead to changes in community composition as drought-sensitive wet forest species become locally extinct or restricted to moist soils environments. High elevation forests may suffer more rapid changes in community composition, once a critical threshold of drying has been reached. (Uriarte, Waide, Willig, Zimmerman)*

* We have parameterized a version Ecosystem Demography 2 with the 2015 drought results. The simulations indicate that a scenario of decreasing precipitation and increased temperatures like that predicted by global climate models will reduce net ecosystem productivity to zero within two decades.
* During the past year we began the re-census trees in the Long Term Elevation Plots (LTEP), which, over the long term, will allow us to test the impact of increasing drought frequency or other climate changes on high elevation forests. We plan to implement annual seedling censuses to track year-to-year variation in conditions on seed survival and growth with elevation.

Data sets:

Core Areas:

***Hypothesis 2a.*** *Increased frequency of drought will enhance soil C storage in the short term due to slower decomposition rates associated with changes in the activity, abundance, and community composition of microorganisms. Greater soil oxygen availability during drought will increase soil P retention over the short-term, and decrease nitrous oxide and methane emissions resulting in a negative feedback to climate change. (Silver, Willig, Bloch, Cantrell, Gonzalez, Lodge, McDowell, Schowalter, Waide)*

* A hillslope array of sensors and chambers, coupled with laboratory incubations, allowed us to determine the impacts of the 2105 drought on soil redox conditions and feedbacks of greenhouse gases to the atmosphere.
* Graduate student Omar Gutiérrez has designed and installed the Throughfall Exclusion Experiment. We have begun pre-treatment measurements.

***Hypothesis 2b.*** *Over the longer term, greater drought frequency in tropical forests will decrease soil C storage. This will result primarily from lower NPP and associated C inputs in response to plant water stress and decreased P availability. (Silver, Willig, McDowell, Bloch, Cantrell, González, Lodge, Schowalter, Waide, Wood)*

* Omar Gutiérrez will be conducting DAYCENT simulations to test this hypothesis as part of his dissertation.
* Implementation of ecosystem and other measurements in the LTEP in 2017 will establish a baseline for measuring the long-term responses along the elevation gradient to future change in the precipitation regime.

Data sets:

Core Areas:

***Hypothesis 3a.*** *Increased frequency of drought will be accompanied by decreased stream discharge, increased leaf-litter subsidies and patchy anoxic conditions in stream pools, resulting in: (i) changes in stream trophic dynamics; (ii) increased rates of leaf decomposition; and (iii) increased production and evasion of CH4 and N2O due to higher nutrient and DOC levels and periodic development of anoxic conditions. (Ramirez, Ballantyne, Covich, Crowl, Heartsill-Scalley, McDowell, Pringle, Ortiz)*

* We have implemented the Stream Flow Reduction Experiment (StreamFRE, named the Stream Drought Experiment in the proposal) and have begun pre-treatment measurements.
* Meanwhile, analysis of the impacts of the 2015 drought have confirmed many of our predictions, including high litter inputs, reduced chlorophyll A and increased insect abundance, and anoxic conditions.

***Hypothesis 3b****. Longer-term, cumulative effects (3-6 y) of increased drought frequency will occur despite brief high discharge events that “reset” the system (in-between droughts), resulting in: (i) reduced subsidies of emergent aquatic insects to forest food webs; (ii) enhanced algal primary production; and (iii) extended periods of increased leaf-litter storage. (Ramirez, Pringle, Ballantyne, Covich, Crowl, McDowell, Ortiz)*

* StreamFRE will be the experimental arena for understanding how the components of drought, reduced flow and increased litter inputs, influence the stream-riparian interactions. Litter manipulations will begin in LTER 6.
* Meanwhile, Ford Ballantyne will be parameterizing a model of the physiochemical and trophic impacts of drought to inform our results and future manipulations.

Data sets:

Core Areas:

**Question II: What are the Effects of Increased Frequency of Intense Hurricanes on Tropical Forest Biota and Biogeochemical Cycling?**

Introductory text and photos from CTE

***Hypothesis 4.*** *An increased frequency of severe storms will increase the dominance of shade intolerant, pioneer plant species. Changes in vegetation composition will induce changes in heterotroph communities, including animals and microbes. (González, Willig, Lodge, Cantrell, Shiels, Zimmerman)*

* In 2014 we implemented a second trim of the Canopy Trimming Experiment, simulating a once every decade hurricane disturbance as described in the proposal. The canopy opening has caused increased recruitment of pioneer species as predicted.
* We continue to track the changes in vegetation and heterotroph communities and will be focusing on interactions of canopy trimming treatments and the 2015 drought in future publications.

Data sets:

Core Areas:

***Hypothesis 5.*** *Soil C stocks will decrease with increasing hurricane frequency because of a lag in recovery of plant litter and woody debris production relative to heterotrophic respiration. Decreased woody litter inputs with increasing frequency of severe storms will change the composition of soil microbial communities and lead to faster turnover times of C in soils. (González, Lodge, Cantrell, McDowell, Silver)*

* We have given special emphasis to the impacts of canopy trimming on the soil-litter interface and will be exploring interactions between canopy opening and the 2015 drought. We have monitored changes in bacterial and fungal community structure through the two years post-trim. We have also utilized state of the art methods (Western Ag Plant Root Stimulator Probes) to determine nutrient fluxes from litter to soil and conducted litter decomposition studies in the CTE.
* Analysis of soils collected from CTE prior to the second trim revealed important impacts of the treatments on soil C distributions. &&&Whendee please add concise summary.

Data sets:

Core Areas:

***Hypothesis 6.*** *Increased frequency of intense hurricanes could result in headwater streams shifting from consumer-controlled to producer-controlled ecosystems, due to the increase in stream nutrient concentrations, litter inputs, and light inputs that re-configure terrestrial-aquatic linkages in these headwater streams and riparian forests. (Pringle, Ballantyne, Covich, Crowl, Heartsill, McDowell, Ortiz, Ramirez)*

* Planning continues for canopy manipulations in StreamFRE, paralleling those in the CTE, to test this hypothesis during LTER 6.
* After a review, we will not implement the more detailed monitoring of additional headwater streams as described in the workplan. We feel we already have adequate coverage of stream dynamics at El Verde and the Bisley Experimental Watersheds and will dedicate our time and resources to StreamFRE over the long-term.

Data sets:

Core Areas:

**Question III: How do Changes in Climate Interact with Hurricane Disturbance, Land Cover, and Land Use Legacies to Shape Ecosystems of the Future?**

Introductory text and graphs from Mote.

***Hypothesis 7.*** *A greenhouse gas-enhanced climate will drive changes at the global-to-regional scales, resulting in new, unique climate regimes forcing ecological change. Land use and land cover change (LULCC) will exacerbate the global-to-regional forcing. The additive effect will result in decreased rainfall and increased cloud heights on average but greater extremes in precipitation for the LEF*. (*Mote, González, Waide, Zimmerman)*

* Historic drought in Puerto Rico is associated with atmospheric regimes consisting of high wind shear and dry air in the low- to mid- troposphere across the eastern Caribbean.
* Future atmospheric regimes in Puerto Rico, as predicted by climate models, will introduce new atmospheric conditions, which include drier air in the low- to mid- troposphere.
* The 2015 drought was driven by strong and frequent intrusions of hot, dry air in the low- to mid- troposphere. The Saharan Air Layer is largely responsible for this anomalously hot, dry air that produced very stable air and limited convective activity across multiple scales of motion. The 2015 drought was unlike previous droughts-of-record (e.g., 1994) in that it was most severe over the ecologically valuable eastern portion of the island.
* Future projections of climate change in the CMIP5 model projections indicate that the 2015 drought may represent a precursor to future dry years, in terms of changes in seasonality and magnitude of rainfall departures.

Data sets:

Core Areas:

***Hypothesis 8.*** *Interactions between increased frequency of hurricanes and drought, mediated by land use legacies, will lead to novel biotic communities with altered biogeochemistry. This results from idiosyncratic responses of shade intolerant species to hurricane disturbance and drought, and their feedbacks on heterotroph communities, carbon storage, and nutrient cycling. (Zimmerman, whole group)*

* The proposed modeling activities will be completed at the end of LTER 5, carrying over into the early part of LTER 6.
* Meanwhile, we continue to publish&&&

Data sets:

Core Areas:

2. **Information Management**, including activities that address the 2 essential objectives of Information Management at a LTER site: (1) the collection and analysis of data necessary to complete the proposed research activities and (2) the availability of data and other relevant digital products to science, education, and general public users.

By: Eda C. Meléndez-Colom, LUQ Information Manager

This is a report of the activities performed by LUQ Information Management staff to assist the scientific community in the collection and analysis of data to achieve their proposed research activities and to make data and related digital products available.

The main objective of the LUQ IM is to collaborate with the scientists in the preparation of the data they collect for data analyses and for the publication of data in the two LUQ’s data repository: the LUQ website and the LTER Network’s, PASTA.

Data Collection and Analyses:

At the beginning of a project, when LUQ scientists meet to plan for what, who and how data will be collected, the information manager participates actively in the discussion and proposes templates for data collection at the field, standardization of common measurements valuesand the design of the different data bases that will hold the data to be collected. Also, the LUQ IM staff designs data entry sheets for the collection of data at the field.

LUQ IM encourages and assists the investigator in filling the metadata forms for each of the data sets at the beginning of each individual project. This form not only provides a way to comply with LUQ’s commitment to share and publish data following LUQ data management policybut it is also a tool to organize data and design databases which eventually eases the future processes of data analyses and publication.

LUQ IM is in charge of entering the data in certain databases like the CTE Plant, Seedling and Litterfall data sets and the El Verde precipitation and temperature data. For other projects’ data sets, like the “Bird abundance - point counts”, LUQ IM staff enters data sporadically as requested by the owner of the data set. The information manager prepares simple summary analyses that assist investigators in the quality control process of their data.

The information manager and the data entry person collaborate directly and continuously with the field technicians in their data collection activities. The labels for the weekly collection water sample bottles are printed at the LUQ IM using a relational database management script associated to the water quality data that is entered weekly by the LUQ IM data entry staff. The data entry and field technicians meet regularly to perform quality control processes on the data collected and entered.

Data files are thoroughly evaluated prior to publication in the data repositories and for preparation for data analyses by the information manager. Although investigators perform the analyses of their data, simple data analyses including summary of data and chart preparation of serial data are made, when viable, for data sets. These intermediate products are shared with the investigators for data correction and visualization. This is regularly done for the El Verde meteorological data.

Data Availability and related tools:

Since its beginning in 1988, the LUQIM have been actively developing an information management system that includes the metadata standards, incorporation of network’s controlled vocabulary and researcher’skeywords, and specific templates to manage metadata and data in order to make it available in the data depositories available through time (currently LUQ Website and PASTA). We collaborated with other LTER sites (SEV, Plum, NTL, CAP, Jornada, McMurdo) in the development of a data management system framework called DEIMS which is currently used by 7 sites of the US LTER and other countries like Taiwan, Spain, and Israel.

LUQ IM has developed templates to manipulate, evaluate and transform automatically data. For example, a template to make automatic daily summaries for manually gathered El Verde precipitation data was developed and is currently used to transform the entered data to daily averages before its publication in the depositories. Another example is a set of mysql scritpts and excel templates developed to transform a 178-columns data file to a 7-column one.

LUQ Metadata forms are provided online or directly sent to the investigator prior to their filing of data. The information manager provides assistance to the investigator or student to fill out the metadata forms if requested. No data is received by LUQ IM without its corresponding metadata.

When data is received for publication in the depositories, the information manager assures that the format of the data file(s) received is database-ready and completely and adequately documented. One or more iteration of data and metadata corrections may happen between the information manager and the investigator until the data and metadata passes, without errors, the evaluation of the Networks’ data repository, PASTA.

Once the data is PASTA ready, it is made available in the local website and thePASTA Data Depositories**.** The information manager then sends a communication to the owner of the data set and the LUQ PI about the update or new upload of the their data along with its URLs in the local as well as the PASTA depositories. The PASTA DOI of the just updated or published data set is then transfer to the local data set’s metadata.

In addition to entering, revising and publishing data and metadata, the information manager maintains communication with LUQ scientists and students to inform them and get their feedback about the changes done in the Information Management System which is embedded in LUQ website. Also, investigators with ongoing data sets receive annual notifications from the information manager to update their data.

Throughout time, the information manager has given presentations to different parts of the community related to the LTER Program and the research activities done at the Luquillo LTER. In her participation of conferences related to the development of websites he has presented to other scientific-related technicians the concepts related to the LTER Program and LUQ research.

Currently, the information manager is involved in two projects related to making accessible to the public 386 legacy-UPR owned research papers from 1957 to 1980s.

Related Links Mentioned in this Report:

|  |  |
| --- | --- |
| Document of Site | URL |
| Example of template for a project’s data collection at the field, standardization of common measurements values | <http://luq.lternet.edu/sites/default/files/LTEPDocs-TemplateDatabase-Draft-fromIM.xlsx> |
| LUQ data management policy | <http://luq.lternet.edu/informationmanagement/datapolicy> |
| Query to print labels for bottles collecting water samples | <http://luq.lternet.edu/article/query-prepare-labels-biweekly-water-sample-luquillo-mountains> |
| summary of data and chart preparation of serial data are made | <http://luq.lternet.edu/data/luqmetadata14> |
| incorporation of network’s controlled vocabulary and researcher’s | <http://vocab.lternet.edu/vocab/vocab/index.php> - LTER <http://vocab.lternet.edu/vocab/luq/index.php> - LUQ |
| Templates for manually gathered El Verde precipitation data was developed | <http://luq.lternet.edu/article/2017/02/20/el-verde-precipitation-and-temperature-manual-entry-and-extract-templates> |
| transform a 178-columns data file to a 7-column one. | <http://luq.lternet.edu/article/2017/02/20/luquillo-invertebrates-data-file-transformation-tool> |
| LUQ Metadata forms are provided online or directly sent to the investigator prior to their filing of data. | <http://luq.lternet.edu/IM/rulesProtocolsandTemplatesforDataFiling> |
| PASTA Data Depository | <https://portal.lternet.edu/nis/browseServlet?searchValue=LUQ> |
| LUQ Data Depositories | <http://luq.lternet.edu/datacatalog> |
| Publications and presentations to different parts of the community related to the LTER Program and the LUQ research | <http://luq.lternet.edu/IM/LUQIMPublications> |
| Special Project to recover research papers from 1957 to 1980s | <http://sandbox.ites.upr.edu/viewbiblioyearCEER> |
| Special Project to making accessible the administrative information and related products | <http://sandbox.ites.upr.edu/> |

3. **Network-Level Participation and Synthesis** activities including any cross-site research.

(Participation vs. leadership roles)

CTFS (will host data analysis workshop in July)

CZO (one paper already)

NGEE Tropics (lots)

Caribbean Hurricane Research Group (Ecosphere special issue, RCN proposal plans)

What else?

- Ecosphere special feature from Hurricane group

- Whendee’s LIDET paper

- Macrosystems project from Jim Brown (?) – 5 LTER sites

- Maria’s macrosystems grant

- Research collaboration network on forest restoration

- Cross-LTER site study on organization funded by network office – Couldn’t quite understand this on the recording, ask Mike for more info if needed

4. **Education, Outreach and Training**, including REUs, graduate students, post-doctoral scholars, and the schoolyard LTER activities.

***Schoolyard LTER*** -- For over 20 years, the US Forest Service and the University of Puerto Rico-Río Piedras have collaborated to develop K-12 curriculum in science and mathematics throughout Puerto Rico. These efforts led to the development of the original LUQ Schoolyard LTER program that involved high schools in four rural municipalities. Teachers and their students had established long-term plots on public and private lands near their schools to study forest structure and dynamics. During LUQ IV we institutionalized Schoolyard LTER by hiring an Educational Coordinator, Noelia Baez, for the project.

At the time our last proposal was submitted, we had revised our Schoolyard LTER model to expand the number of schools involved in the program. The primary change was the introduction of a data jam workshop at the beginning of the school year to encourage teacher from new schools to participate in the Schoolyard LTER. During the data jam workshop, teachers work with LUQ data to investigate a basic ecology question using the claim-evidence-reasoning framework. Teachers are then encouraged to implement a data jam with their students. Those teachers who successfully implement the data jam with their students in their schools are invited to participate in a training workshop and internship in the subsequent school year.

***Journey To El Yunque*** -- During LUQ III & IV, we supported the development of a 4-wk bilingual middle school curriculum unit called *Journey to El Yunque* (http://elyunque.net/journey.html). Students use LUQ data to investigate the effects of Hurricanes Hugo and Georges on the Luquillo Mountains and consider the long-term implications of increased hurricane activity. Steven McGee and Jess Zimmerman recently complete a 4-yr grant from the U.S. Department of Education (Ed) to conduct basic research, in collaboration with an educational psychologist, on how the program affects motivation and learning. We are seeking additional funding from the Ed and NSF to significantly revise the web site materials based on new ways to support student learning.

***Research for Undergraduate Students*** – Two undergraduate students are selected each year from UPR or collaborating institutions for a summer research experience. Students and projects are suggested by LUQ researchers or selected as part of a site REU at El Verde Field Station. All REUs are integrated in the undergraduate research training program and share their results at a poster presentation held at the UPR campus in Rio Piedras.

***Volunteer Research Interns*** – LUQ has been very successful at recruiting volunteer research assistants to perform field research in the LFDP and CTE. Students are oriented to research goals and trained in field protocols, data entry and management, and identification of tropical biota. Field trips and seminars by local and visiting scientists enhance their field experiences. Working for 3 to 5-month stints, students receive per diem, lodging and free travel to the site in exchange for their research assistance. Since the last proposal, two dozen interns have helped in the recensus of the Luquillo Forest Dynamics Plot and the recensus of the Long-Term Elevation Plots, among other things.

***Graduate Students*** – At the time we submitted our proposal 41 graduate students were involved in LUQ research at 14 institutions. Twenty-two percent are underrepresented minorities, mostly of Puerto Rican origin. During the past year the students selected Omar Gutiérrez to organize student activities at the annual meetings.

During the past year the SEAC reviewed the interaction among graduate students and postdoctorals and the larger project and found that the integration of students and postdoctorals was sufficient given regular teleconferences and participation in on-island meetings.

**5. LTER Site Management including leadership structure and decision making, fiscal accountability and budgets, site security and management, engagement of new investigators, promoting diversity of the scientific team.**

A Management Committee (MC) consisting of the PI and four co-PIs undertakes project management in the Luquillo LTER program (LUQ). Jess Zimmerman is the Lead PI of LUQ, and Nick Brokaw, former Lead PI, continues to serve as co-PI at UPR. The remaining co-PIs are Grizelle González (USDA Forest Service), Whendee Silver (University of California, Berkeley) and Michael Willig (University of Connecticut).

At the time of submission of our last proposal, our plan was that during the next three years UPR would conduct a national search for a senior faculty member to serve as Co-PI, replacing Brokaw. Funding for the new hire was negotiated with President’s office of UPR before the last submission. The idea was the new hire would be mentored by the current Lead PI to take over the Lead PI position toward the end of LUQ 6. We continue on this track, having developed and submitted an advertisement for the new position to the UPR administration. At this time, however, there is a temporary hiring freeze at UPR while the institution restructures its budget in light of the fiscal problems with Puerto Rico’s finances. Once these issues are resolved, we will proceed with the hire.

The MC is in charge of the administration of the project, including managing the budget, reviewing the progress of the science, making changes in administrative policy, and suggesting changes to the bylaws. The MC has regular monthly meetings to discuss the management of the project and at more frequent intervals as necessary. They are assisted by the LTER Coordinator, Sarah Stankavich, who also assists the MC in organizing field work at El Verde Field Station.

The MC is advised by a Science and Education Advisory Committee (SEAC) who were nominated and voted on by LTER researchers (Senior Personnel and Associate Researchers). With these results, the membership of the SEAC was chosen by the MC for a three-year renewable term. In the process some Associate Researchers were elevated to Senior Personnel because of their substantial contributions to the development of site science (Heartsill-Scalley, Shiels, Wood). Each of them are junior scientists and thus represent a new generation of LTER researchers.

In practice the SEAC functions as a consultative body that the MC uses to review critical decisions as they are made. They were critical in finalizing the structure of the last proposal and in questions of how to engage graduate students and post-doctorals in the LTER program. In the coming year they will be critical helping the MC to finalize planning for LTER 6 and in adjusting the scientific team to those goals.

External advisors are utilized to maintain an objective perspective on the development and performance of LUQ. Three external advisors were appointed by the MC prior to the last proposal: Aaron Ellison (HFR), Tim Fahey (HBR), and John Porter (VCR). Both Ellison and Fahey have attended annual or planning meetings on island or via teleconference in the last year and a quarter; each have submitted written reports to the MC following meetings. Porter has not visited the site but has consulted with the IM at times, has he has over the years.

Interactions among the Senior Personnel occur frequently via email and via monthly meetings held during the school year via teleconference. The LTER Coordinator prepares a monthly newsletter noting recent accomplishments and newsworthy events. We conduct planning meetings with researchers each January and host an annual LUQ All-Scientists Meeting each June that involve the entire scientific community. These consist of a day of seminars and posters, a day to review scientific progress and consider future planning, and one-half day for a business meeting among the Senior Personnel.