LTD assignment:

**Nick Brokaw:** With regard to LTD, my 25-year record on canopy structure shows how forest stands at three elevations differ in resistance and resilience to disturbance.  This relates to the second proposal question, about hurricane impacts.  It connects best with hypothesis 8. //
With regard to LTD, my 25-year record on canopy structure in the Luquillo Mountains shows how forest stands at three elevations differ in resilience after hurricane disturbance.  I will continue recording canopy structure, and one could study why the high-elevation forest is less resilient.  It must be related to the reason why the high-elevation forest is short to begin with, but I do not have a good hypothesis, let alone a way to test it.

**Tim Schowalter:** I’m continuing to collect data on canopy arthropods from 3-4 pairs of plots in the Big Grid.  This dataset currently covers 27 yrs (although missing 1993, 1995, 2006, 2008 and 2010-14).  Clearly, the long-term hurricane and precipitation data have been useful, and included as factors in the canopy arthropod paper now in press.  If we had long-term data on primary production by tree species, that would also be useful to include as a factor.  At this time, though, a major conclusion from the analysis in press is that arthropod community structure at any point in time represents the legacy of previous events and environmental changes.

Krista McGuire: I am using the long-term tree census data to test the hypotheses that 1) Individual tree species have distinctive physical, chemical, phenological, and biological properties that create unique zones of influence, which result in distinct microbial signatures and 2) historical land use is a strong modifier of microbial signatures such that the biotic effects of individual tree species are less pronounced in areas with high historical land use compared to areas with less historical land use. The census data allows us to locate individual target trees that can be selected for based on location in the plot according to historical land use, soil type, DBH, and conspecific neighbor density.

**Xiaoming Zou:** The species occurrence and dynamic changes in the big-grid LTD sets can help me to develop new mechanisms to explain species coexistence. The new mechanism that my team is try to develop is: plant species coexist because each species occupy an ecological niche that is largely defined by calcium supply potentials. This calcium supply potential is associated with almost all soil, climatic, and topographic variables in the physiochemical environment.
 **Adam Wymore:** 1. Long-term stream chemistry data are useful for my research as I able to synthesize datasets across LTER sites (and across environmental gradients and biomes) to look at the coupled cycling of carbon and nitrogen in aquatic ecosystems and how these relationships are changing over time.
2. Long-term stream chemistry data allow me to perform robust concentration-discharge analyses across space and time (e.g. Wymore et al. in review, Water Resources Research)
3. Long-term data provides meaningful background data and information to help inform experimental design and protocol development and site selection.

**Joanne Sharpe:** 75, 186, 187 The original purpose of collecting observational data on phenology (seasonal and annual), leaf and spore production rates, leaf lifespans, and plant sizes of over 1,000 individually marked ferns of more than 20 species from the El Verde forest floor was to explore these never before studied ecological characteristics of tropical ferns. However, since the study spanned the years 1991 (2 years after Hurricane Hugo) through 2010 (including the passage of Hurricane Georges in 1998) the impact of such major disturbances on ferns can also be analyzed. These data, combined with the leaf trait data in data set 186 (leaf areas, SLA, LDMC, shrinkage) and nutrient information in data set 187 (carbon, nitrogen, phosphorus) will provide a temporal and functional dimension to spatial data collected (past and future) on ferns in the seedling plots of the long term forest productivity plot (LFPD), and for the ferns now annually measured in the plant subplots for the canopy trimming project (CTE).

146 The annual monitoring of the diversity of ferns species in the canopy trimming project, begun before the first phase of the canopy trimming experiment (CTE), is expected to provide additional insight into the changes in fern abundance and species composition resulting from hurricane disturbance. Ferns account for about 75% of the forest floor perennials, and the question for phase 2 of the CTE is whether the growth spurts as well as greatly increased spore production observed in response to increased light in the first phase of CTE can re-occur with only a relatively short recovery time since the previous major disturbance. As the important role of ferns as filters of leaf litter as well as the protective role of ferns to organisms beneath their herbaceous layer canopy is recognized, predicting fern responses to multiple disturbance becomes more and more important.

**The Richardsons:** We have monitored long term changes in invertebrate populations in microhabitats such as bromeliad phytotelmata and forest floor litter. The tabonuco forest is impacted by hurricanes which cause cycles of canopy loss and and recovery with consequent changes in light intensity, humidity, and seedling density and diversity on the forest floor. Data on these parameters have allowed us to explain the long term decline in the diversity of bromeliad invertebrates and the loss of two species endemic to bromeliads and the island of Puerto Rico, after twelve years of recovery since Hurricane Georges.

**Alonso Ramirez** - The question on how the LTD we collect is related to the stream drought experiment is fairly straight forward.  I have LTD on aquatic insects, leaf litter inputs, and water level; Todd has shrimp data and Cathy benthic algae.  All of them are critical context for our flow manipulation in Prieta.

Up the mountain, I have the air temperature sensors, they will help us understand long-term changes in temperature at different elevations.

**Maria Uriarte:** My research in the next 6 years will focus on the effects of inter-annual climate variation (drought, radiation and hurricanes) on the distribution and demography of tree species and consequences for forest ecosystem services (carbon and water). We will continue to examine interactions between land use and climate drivers. Specific projects:

        Incorporate hurricanes into ED2 and evaluate impacts on forest for various scenarios of drought and hurricane intensity.
        Regeneration dynamics will be a big focus.  This is a huge unknown in tropical forest research.
        Distribution of species with respect to spatial variation in moisture at the plot level and rainfall at the landscape and island scale.

        Feedbacks between trees and ecosystem processes.
        Effects of drought/hurricanes on vegetation dynamics at EYNF (using remote sensing)
        Effects of drought/hurricanes on water flow and quality in EYNF watersheds.

Data:
        Tree demography data (plots and dendrometers).
        Climate data.
        Species distribution data from GBIF.
        Water data from USGS

**Whendee Silver:** Our work on redox dynamics and drivers of greenhouse gas emissions is informed by long-term precipitation and weather data, which allow us to extrapolate observed patterns across time.  It is also building on an 8-year soil O2 dataset collected along the elevation gradient that allowed us to explore the interactions of rainfall and redox dynamics.

As part of LTER 5-6 we are beginning a drought manipulation experiment which, when combined with our observations of the greenhouse gas emissions during the 2015 drought, build on the above datasets.

Our Fe, P, and C cycling work builds on the same redox and precipitation datasets as above, as well as excellent spatially distributed data on soil chemical and physical characteristics across the watersheds, that also has a temporal component starting in 1988.

Our work on C cycling following hurricanes builds on the CTE experiment, as well as early research before and following Hurricane Hugo.

**Larry Woolbright** - monitoring long-term population trends for a key species in the ecosystem, so hopefully that's a pretty simple answer

**Jill Thompson -** Long term data = LFDP censuses of trees, lianas and seedlings for growth, survival, mortality and species community changes, and canopy cover.  Also LFDP phenology, soil moisture, woody debris and local climate/weather. The nature of tropical forest with long lived trees, slow regeneration and complex structure requires very long term and frequent assessments.

The long term data on forest plant species dynamics, growth and mortality is used for investigations into what maintains and drives biodiversity in tropical forest and the interaction among species, effect of past human disturbance and hurricanes on tropical forest damage and recovery.  This is also important for investigating importance of tropical forest for carbon storage for climate change mitigation, and the potential effects of climate change on forests. Understanding the weather and climate and how this affects tropical forest dynamics is important for future predictions of forest sustainability. The impact of human and natural disturbance provides insights into potential management options for tropical forest recovery following tropical forest destruction which is an increasing pressure on tropical forests across the planet.

**Jean Lodge**- My microbial work in the Canopy Trimming Experiment is related to three long-term data sets within the CTE:

Tree growth and litter production (Zimmerman)

Soil nutrients in the lysimeters (McDowell)

Soil carbon stores (Silver & Omar)

They are more loosely tied to larger landscape-scale long-term data sets:

Tree growth in the LFDP

Stream nutrient (N) export in streams (McDowell)

We were able to capture nutrients leached from the litter and entering the soil in the hurricane treatment using PRS probes.

We think the change from white- to non-white-rot fungi in the hurricane treatment will increase the complexity of carbon entering the soil in the CTE, affecting soil carbon storage.

Whether the carbon is of a type that increases P-availability thereby increasing tree productivity, as predicted by the Century model,  remains to be seen.

The chronosequence of effects of hurricane-felled logs on soil carbon and nutrients indicates that soil C, N and P are elevated beginning within 5 months of treefall, and these carbon and nutrient ‘shadows’ remain for years even after the logs have completely disappeared. The carbon ‘shadows’ from decomposed logs elevates soil carbon even at 20 cm depth, and the deep soil carbon imprint remains even after the carbon imprint in the surface soil has begun to decline towards background levels through decomposition (loss of CO2 and leached DOC). These data will help us interpret the long-term effects of the CTE treatments on soil carbon, and also explain the high heterogeneity among soil samples in tabonuco forest.

Despite the consistently higher concentrations of N and P under than 20-50 cm away from logs, fine tree roots exploited these resources only in some seasons.

**Omar Gutierrez del Arroyo -** My research projects within the Luquillo LTER are highly relevant to the long-term data collection of precipitation in the Tabonuco forest, as well as multiple other data sets related to soil biogeochemistry. Past efforts by Whendee Silver and her lab group since the late 90’s have collected data sets on soil moisture, soil oxygen, and soil carbon and nutrient cycling across the LEF, and my projects will continue some of these data sets, which have been vital for measuring ecosystem responses to infrequent climatic events, such as droughts in a wet tropical forest. As our research goals revolve around constraining the sensitivity of soil biogeochemistry—including greenhouse gas fluxes and nutrient availability—to decreasing soil water availability (i.e., drought), long-term records of both soil microclimate and concurrent biogeochemical measurements are invaluable tools for contextualizing our past and future experimental results.