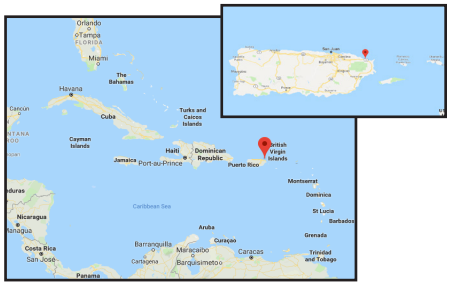
Luquillo LTER

Luquillo (LUQ) LTER is located in the Luquillo Mountains of eastern Puerto Rico, home to the 11,330 hectare Luquillo Experimental Forest. Also known as the El Yunque National Forest, it is the oldest forest preserve in the Western Hemisphere. Struck by three major hurricanes within 30 years, LUQ LTER has transformed current understanding of how tropical forests respond to altered disturbance regimes and highlighted the importance of antecedent events in determining those dynamics. Regional droughts and a warming experiment at LUQ LTER are case studies for the likely impacts of predicted climate change at the end of the century. Work at LUQ LTER illuminates the intricate web of interactions between climate, disturbance, biogeochemistry, and ecological communities, and provides an important laboratory for quantifying the impacts of climate change on tropical forest ecosystems.



Between 2008-2018:

39 investigators

19 institutions represented

37 graduate students

Forest

Principal Investigator:

Jess K. Zimmerman

University of Puerto Rico

Est. 1998

Funding Cycle:

LTER VI

NSF Program:

Biological Sciences/ Division of Environmental Biology

Key Findings

Hurricane frequency impacts forest biodiversity and ecosystem function. The long term Canopy Trimming Experiment revealed many important aspects of hurricane disturbance, particularly that canopy opening caused more change in biota and biogeochemistry than debris deposition. More frequent disturbance led to canopy opening but less debris deposition, and changed forest species composition, which may alter resilience in the face of future disturbances. Frequent hurricane disturbance causes forest ecosystems to retain less carbon and export more nutrients. [Products 1, 4, 6-9]

Drought in rainforests is increasing in a warming world. Drought in tropical wet forest alters greenhouse gas production by soils, affects key nutrient dynamics, and reduces forest productivity. Downscaling studies at LUQ LTER support global models that predict declining precipitation through the end of the century. Current ecosystem drying and warming model projections predict that net forest ecosystem productivity may fall to zero by 2036. A long term streamflow reduction experiment will determine impacts of long term drought on stream functioning. [2, 10]

Climate change will impact lower elevation forests first. Luquillo LTER uses an elevation gradient as a proxy for studying certain aspects of climate change. High elevation cloud forests on mountain summits harbor many endemic species likely to be threatened by the changes in precipitation and temperature projected to impact these areas within 20 years. Recording changes in biota and critical ecosystem function along the elevational gradient through the year 2100 will capture key aspects of the changing climate and disturbance regime. [3, 5]

Photo credits: Rick Prather (left); Aaron Shiels (right)

Partnerships

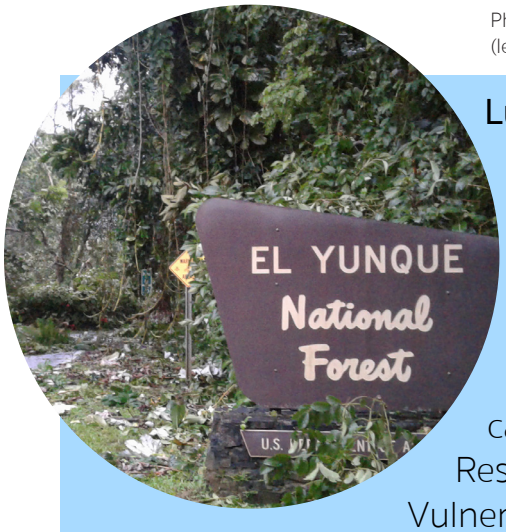
U.S. Forest Service International Institute of Tropical Forestry | Smithsonian ForestGEO | Luquillo Critical Zone Observatory | Department of Energy Next Generation Ecosystem Experiments-Tropics Research Program | PhenoCam Network | University of Puerto Rico

Synthesis

Photo credits: USFS/Joel Olivencia (left); LUQ LTER (top, bottom)

Luquillo LTER contributes to Smithsonian's Center for Tropical Forest Science – Forest Global Earth Observatories which has resulted in numerous cross-site publications comparing forest dynamics at Luquillo to other tropical, temperate, and boreal sites. This collaboration has important implications for understanding controls of biodiversity and for forest management.

Understanding how participating in the LTER Program has changed the nature of scientists. Luquillo LTER spearheaded the effort by studying a large cross-section of the LTER community and initiating a collection of in-depth analyses of the challenges and accomplishments of long term ecological research.



Luquillo and Florida Coastal Everglades LTER scientists are collaborating to edit a special issue of Ecosphere called "Resistance, Resilience, and Vulnerability to High Energy Storms: A Global Perspective". This effort involves cross-site comparisons with coastal Australia, Dominican Republic, Florida, Guadalupe and Dominica, Louisiana, Mexico, Puerto Rico, and Taiwan.

Data Accessibility

The LUQ LTER Information Management System (LIMS) is a product of continuous collaboration between LUQ LTER information managers and the LTER research community. LIMS complies with LTER Network policies and uses software that serves as both an information management system and a tool for data discovery. Data are posted on the LIMS website and deposited with the Environmental Data Initiative repository.

Broader Impacts

Journey to El Yunque. Teachers use a 4-week bilingual middle school curriculum unit called Journey to El Yunque to engage students. Using LUQ LTER data, students analyze the effects of hurricanes and human activity on Luquillo's ecosystems. The curriculum has leveraged funding from NSF and the Department of Education to investigate modes of student learning, among other things.

Schoolyard LTER. Public and private partners engage schoolteachers and students in Data Jams. Data Jams supports students in exploring, analyzing, and summarizing long term data about the environment. Students then communicate their discoveries to non-scientific audiences through artistic means like dance, poetry, and baking. Teachers who successfully implement the Data Jam are invited to bring their students to El Verde Field Station to learn basic field protocols related to tree growth, soil, and hydrology.

Research and Career Development for Undergraduate Students and Post-baccalaureate Interns. Students involved in Luquillo's Research Experience for Undergraduates (REU) program are incorporated into summer mentored research programs at El Verde Field Station. Natural Resource Career Tracks, funded by USDA-NIFA, engages students from Puerto Rico in summer internships and other career enhancement activities at USDA National Forests and other USDA agencies.

Top Products

1. Brokaw, NVL et al. 2012. A Caribbean forest tapestry: The multidimensional nature of disturbance and response. **Oxford University Press**, New York, New York.
2. Feng, X et al. 2017. Improving predictions of tropical forest response to climate change through integration of field studies and ecosystem modeling. **Global Change Biology**. doi: 10.1111/gcb.13863
3. González, G, Willig, MR, Waide, RB 2013. Advancements in the understanding of spatiotemporal gradients in tropical landscapes: a Luquillo focus and global perspective. **Ecological Gradient Analyses in a Tropical Landscape**. Willig, MR; Waide, RB, eds. Ecological Bulletins 54. Hoboken, NJ: Wiley-Blackwell.
4. McDowell, WH et al. 2013. Interactions between lithology and biology drive the long-term response of stream chemistry to major hurricanes in a tropical landscape. **Biogeochemistry**. doi: 10.1007/s10533-013-9916-3
5. Miller, PW et al. 2018. A 42-Year inference of cloud base height trends in the Luquillo Mountains of northeastern Puerto Rico. **Climate Research**. doi: 10.3354/cr01529
6. Schowalter, TD et al. 2017. Post-hurricane successional dynamics in abundance and diversity of canopy arthropods in a tropical rainforest. **Environmental Entomology**. doi: 10.1093/ee/nvw155
7. Shiels, AB et al. 2015. Cascading effects of canopy opening and debris deposition from a large-scale hurricane experiment in a tropical rainforest. **BioScience**. doi: 10.1093/biosci/biv111
8. Uriarte, M et al. 2012. Multidimensional trade-offs in species responses to disturbance: implications for successional diversity in a subtropical forest. **Ecology**. doi: 10.2307/23144033
9. Willig, MR et al. 2019. Long-term population trends in El Yunque National Forest (Luquillo Experimental Forest) do not provide evidence for declines with increasing temperature or the collapse of food webs. **PNAS**. doi: 10.1073/pnas.1820456116
10. Wood, T.E., and W.L. Silver. 2012. Strong spatial variability in trace gas dynamics following experimental drought in a humid tropical forest. **Global Biogeochemical Cycles**. doi: 10.1029/2010GB004014

Photo credits: LUQ LTER (above and front cover)