

Master Plan 2009 -2019

El Verde Field Station

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I. Introduction

El Verde Field Station (El Verde) was built in 1937 as an experimental station to study rainforest ecosystems at El Yunque National Forest. El Verde is a unit within the Institute for Tropical Ecosystem Studies (ITES) of the University of Puerto Rico, Rio Piedras campus. Research at El Verde started to increase since 1988, when the Luquillo Long-Term Ecological Research (LTER) program was funded. Demand for station use has also increased and diversified over time as many new projects have been started by scientists from the LTER program and other programs. In 1995 El Verde developed its first master plan to guide station growth and development for 10 years. The 1995 plan focused on alleviating space and infrastructure limitations that researchers were facing at the time. The current master plan also addresses space and infrastructure limitations, but includes a projected expansion and diversification of station research and education activities for the next 10 years. Under this plan, strategies seek to include support for activities within the El Verde Research Area and also those that will take place within the context of the Luquillo Experimental Forest as a whole, which can be catalyzed by El Verde.

Proposed activities and priorities described on this plan for the next 10 years are divided in two main groups. First, we present those addressing the facilities and administrative needs of facilities located at the El Verde research area (El Verde site). The El Verde site is a conglomerate of facilities made up of the original station facilities (two dormitory buildings and one laboratory facility) and nearby facilities referred to as the Stream House. Development of the El Verde site is divided into facilities needs and administrative needs. Each of these two sections has a series of short-term and long-term goals with short-term goals expected to become long-term activities where appropriate. Second, we present activities and priorities related to the role that El Verde should play regionally in terms of education and in support of atmospheric research at East Peak. Atmospheric research is an inquiry area supported by ITES. The area of East Peak in particular has received international attention as a promising site for the study of phenomena that may affect cloud formation and air quality. El Verde could provide logistic support for these activities.

The 2009-2019 Master Plan was developed based on the results of a workshop conducted at El Verde during October 2008. The workshop was composed of a group of 25 researchers and professionals from a variety of backgrounds: scientific researchers, scientists working on K-12 Education, State and Federal agency officials and managers with direct interest in the Luquillo Experimental Forest, engineers and architects with expertise in research/educational infrastructure development. The new master plan revised the mission and goals for the station and refined the directions that El Verde should take to achieve its full potential in areas related to scientific research, science education and public outreach. Steps include actions, activities, and renovations necessary to accomplish proposed goals and the necessary technological improvements that are needed to modernize and enhance El Verde.

The master plan organizing committee was formed by Dr. Alonso Ramírez (El Verde scientific director), Dr. Elvia Melendez-Ackerman (ITES Director), and Dr. Olga L. Mayol-Bracero (atmospheric sciences

researcher). A steering committee was created to advise the station on how to best accomplish the goals defined in this master plan and how to best deal with potential changes to the plan or new issues that might arise. The steering committee is formed by:

- Josefina Arce, PhD, University of Puerto Rico, ALACIMA program in education
- Nick Brokaw, PhD, University of Puerto Rico, Director of the Luquillo LTER program
- Ariel Lugo, PhD, Director, International Institute of Tropical Forestry, US Forest Service
- Armando Rodriguez, PhD, Interamerican Univ., Director Mata de Platano Field Station
- Brad Weiner, PhD, University of Puerto Rico, Dean of Natural Sciences

Vision

El Verde Field Station supports the advancement of tropical ecology by providing infrastructure to conduct research and education within El Yunque National Forest.

Mission

El Verde Field Station has the mission of supporting research and education in tropical ecology. El Verde strives to achieve this mission by providing the infrastructure necessary to conduct research and education.

Site value

The composition of the vegetation in Puerto Rico is representative of many Neotropical communities. Puerto Rico has six of Holdridge's life zones, five of these (i.e., subtropical moist forest, subtropical wet forest, subtropical rain forest, lower montane wet forest, lower montane rain forest) occurring in the Luquillo Mountains and easily accessed from El Verde. This degree of diversity is difficult to attain in other tropical areas of similar size. In addition, varying precipitation patterns, a steep and complex topography, and diverse soil types produce a highly compressed gradient of forest types in the Luquillo Mountains, compared to similar gradients in other Neotropical sites.

Ecological research in the tropical forests of the island is facilitated by the logistical advantages that set it apart from most other Neotropical sites. Citizens of the United States move freely between the U.S. mainland and the Commonwealth of Puerto Rico without passport or customs considerations. The Luis Muñoz Marín International Airport, with many direct flights from the mainland on major air carriers, is located within an hour's drive of the Luquillo Mountains. Logistic considerations in the field are also enhanced by the proximity of the field station to research plots in Tabonuco (subtropical wet) forest and higher elevation (subtropical wet and rain) forest types. In most cases, field sites can be reached on foot within 15 minutes or can be readily accessed via well-maintained roads.

II. El Verde site

The El Verde site is a conglomerate of facilities that comprise the original El Verde Field Station facilities (one laboratory and two dormitory buildings) and the Stream House (apartment building with offices and adjacent experimental stream facilities), both located on road 186. The following measures should be taken to improve the site:

1. Facilities needs

Short-term

- A. Improve efficiency in space use at El Verde and the Stream House. Spaces at both locations should be improved to make them more efficient and user friendly. There is major need to provide:
 - a. Additional bench space.
 - b. Additional bathrooms, including external facilities accessible after working in the forest.
 - c. Separation among computer space, meeting space, and laboratory space.
 - d. Additional storage areas for research equipment, in particular for long-term projects and to store samples. A separate storage building perhaps at the Stream House could be a solution.
- B. Improve space availability for field courses and group meetings by constructing common areas. There is limited space for field groups to meet and organize. The construction of decks near the kitchen and the apartment building will help alleviate this issue. Also, a large gazebo at the entrance to the forest will help field courses and other users organize their work.
- C. Improve the access road and create additional parking spaces. The access road from Rd 186 to the station (PR903) needs major improvement and to avoid further deterioration this work should be conducted soon. In addition, there is a need to provide parking space at the station and perhaps along the access road. This will help alleviate parking during special activities and regular meetings.
- D. Improve research trails with markings to facilitate location of study areas. The trail network should be named, marked, and mapped to facilitate research work and student projects. In addition, a well-marked trail system will improve security on the forest.

Long-term

- A. Develop additional laboratory and general work spaces. Although current space use can be maximized, to improve working conditions at the station new facilities need to be built. The station should pursue funding to build additional laboratory and work space, either in the form of a new building or by replacing the current laboratory with larger facility. Space at the Stream House should also be considered for construction of new facilities.
- B. Improve the trail system to support forest research and education use. There are areas around El Verde dedicated to research and others with historical value. Therefore, a trail system should be developed to reflect this with certain trails dedicated to research and other trails to education (e.g., living laboratory). This separation will also facilitate division between research and education, reducing the risk of impacts on each other. This goal could be accomplished by developing agreements with the US Forest Service, as they have expertise on trail design and development.
- C. Explore the value of creating a trail from Stream House to El Verde. A long trail, connecting the Stream House with El Verde will provide an educational opportunity for visiting field courses and scientists to experience the changes in the forest along this area. The value of such trail needs to be assessed before pursuing its construction.

2. Administrative needs

Short-term

- A. Users and fees:
 - a. The station should maintain an up-to-date reservation calendar to facilitate interaction among visitors and the programming of activities.
 - b. The fee schedule should be revised to include rates for researchers, field courses, and for extended visits.
 - c. Develop an effective mechanism to capture visitor information (e.g., study title, location, funding) using a database system of user information.
- B. Research projects:
 - a. Maintain an up-to-date research map. The current research map is incomplete and not accessible to all station users hampering research coordination. All research projects should be geolocated, documented, and

- added to the research map. The map should be made available to users to facilitate research coordination.
- b. Enforce a system of data management for all research projects at El Verde, including submitting metadata, archiving data, and making data available to the public after a reasonable period of exclusive use. This should be done in close coordination with the LTER data management.
 - c. Enforce a system to identify and dispose of unneeded markers in the research area and for debris removal following project termination.
- C. Station collections:
- a. Develop and maintain a collection of scientific publications resulting from research at the El Verde area.
 - b. Improve and maintain a reference collection of plants and certain animals commonly found in the El Verde area.
- D. Education and training:
- a. Engage more classes from the University of Puerto Rico. Although El Verde offers a good setting for UPR courses, in particular at the graduate level, only a few are using the station. El Verde educational mission can be accomplished by increasing its support to UPR courses.
 - b. Improve support for the LTER Schoolyard Program. Past workshops at El Verde have shown that the station is capable of supporting this program by facilitating teacher and student training activities. As part of its educational role, the station should seek a closer collaboration with the LTER Schoolyard Program.
 - c. Explore the integration of the field station with newly funded programs such as IGERT and GK-12. As part of research and educational support, El Verde should consider working closely with new graduate training programs at UPR and explore ways in which these programs could use the field station.
 - d. Investigate collaborations with science departments at the University of Puerto Rico system and other institutions to increase their use of El Verde in their teaching and research activities.
 - e. Attract new field courses from mainland universities, primarily as a mechanism to fill out dorms in the off-season.
- E. Explore collaborations within the University of Puerto Rico to:
- a. Support educational activities (e.g., K-12) with the College of Education
 - b. Develop a business plan with the School of Business Administration
 - c. Develop a rehabilitation plan for the El Verde historic building, seek site planner, or trail development with the School of Architecture
 - d. Support educational activities with DEGI and the College of Natural Sciences. They could potentially provide RA/TA support for graduate

students to coordinate, develop, and conduct K-12 education efforts (e.g., teacher training workshops, LTER schoolyard workshops, logistics of pilot programs).

Long-term

- A. Promote more independent research, as well as expansions of the LTER program. The research community and the station will benefit of having a diversity of well-coordinated new research projects. Although ongoing LTER research covers much of the research area, there is still potential for additional LTER and non-LTER research. New research projects will increase station impact on ecological research.
- B. Develop support for the field station by developing a mechanism to accept donations from station friends. There is potential for El Verde to obtain funding via donations from past users. Station training programs (e.g., summer internship, volunteers) are sources of 'station friends' that should be explored to support station activities.
- C. Evaluate the current administrative scheme for the station. Currently a full-time administrator and a part-time scientific director are in charge of the station. There is a need to evaluate whether this scheme is the best option for the long-term development of the station.
- D. Develop a business plan for the station. There is a need to properly assess the cost of operating the station and the sources of income that the station. A business plan will provide a strategy to maintain the station functioning in the long-term.

III. Regional role of El Verde Field Station

1. Educational role

Short-term

- A. Develop agreements with the US Forest Service to participate of their educational programs in K-12.
- B. Investigate possible collaborations with the Department of Education for required research course and the Environmental Science Education Curriculum. El Verde could coordinate workshops and provide housing for teacher training. The development of these types of activities would require a different training venue, other than the field station. Available facilities that can serve as a venue for

education projects include the welcome center at El Portal and the Girls Scout Camp.

- C. Investigate collaborations within the University of Puerto Rico for using the station in their environmental education programs. Possible collaborations might include the program in continuing education, the service component of general sciences, high school requirements, pre-service teachers, and earth science curriculum.

Long-term

- A. Develop education programs that support ITES, LTER, EYNF, and IITF education missions (e.g., transfer of current and past science information to educators).
- B. Explore the use of El Verde in continuing education courses for tourist guides.
- C. Develop courses that can be taken for credit and focused on graduate and undergraduate students. As this activity requires advertising, El Verde could seek partners to develop this component.

2. Atmospheric research

One of ITES goals is to support research and education on atmospheric sciences. El Verde Field Station can help in the achievement of this goal by supporting activities in cloud forest areas of the Luquillo Mountains. This support should be seen as an initial step toward the establishment of a new major research facility at East Peak dedicated to tropical ecosystem research and a center of tropical atmospheric research in the Caribbean.

Short-term

- A. Catalog previous research at East Peak. There is a need to compile information on past and ongoing research at cloud forest locations within the Luquillo Mountains. This information should be made easily accessible to the research community via an on-line database. This goal should be accomplished in collaboration with the LTER data management group and the laboratory of Dr. Mayol-Bracero.
- B. Support the development of an atmospheric research station at East Peak by providing housing and laboratory space and by facilitating communication and information sharing among users (e.g., climatological measurements).
- C. Explore the potential to renovate and manage one of the existing buildings at East Peak as a research facility. El Verde should support and facilitate the evaluation of existing structures at East Peak with involvement of FAA and USFS. This should include evaluation for radioactivity. Buildings of interest are identified as building 3011 and 2048 in prior US. NAVY facilities' floor plan (Appendix 4).

- D. Support the development of collaborative research proposals in areas related to atmospheric science. Collaborators themselves will be asked to serve in as ad-hoc members of El Verde steering committee to advice in the development of East Peak facilities.

Long-term

- A. Support the establishment of an ecological and atmospheric research center at East Peak.

IV. Appendices

Appendix 1. El Verde Field Station general information

Location

El Verde is located within El Yunque National Forest, in northeast Puerto Rico. It is the only location within the United States, other than Hawaii, where tropical rain forest ecosystems available for scientific inquiry. El Yunque National Forest is also known as the Luquillo Experimental Forest, and it is a Biosphere Reserve.

El Verde Field Station is situated at 350 m elevation on the northwestern slope of the Luquillo Mountains. Latitude 18°19'16.83"N, Longitude 65°49'10.13"W.

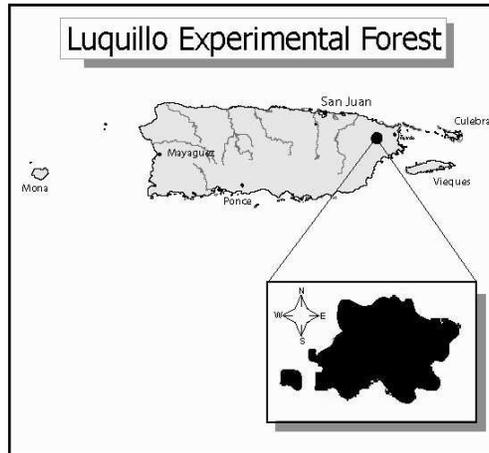


Figure 1. The Luquillo Experimental Forest, location of El Verde Field Station in northeast Puerto Rico.

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History

When Spain ceded Puerto Rico to the United States in 1898, approximately 5,000 hectares of the Luquillo Mountains were under the protection of the Spanish Crown (Brown et al. 1983). The Caribbean National Forest was established in 1903 and has been managed by the USDA Forest Service since 1917. A series of land acquisitions in the 1930s and 40s more than doubled the size of the Caribbean National Forest to 11,350 hectares. The first of these purchases was the El Verde tract in 1934.

Intensive ecological research in the LEF was initiated by the USDA Forest Service in the 1940s, with the establishment of a series of research plots in four vegetation zones at different elevations and aspect positions in the mountains. These plots provide a valuable database to gauge the response of these ecosystems to more recent hurricanes, such as Hurricane Hugo in 1989 (Walker et al. 1991, Zimmerman et al. 1994, Walker et al. 1996a) and Georges in 1998.

Cloud forests, one of the most remarkable of tropical habitats, are located at the summits of the LEF and have been the subject of many studies, including initial surveys by the Arnold Arboretum (e.g., Howard 1968, 1969, Baynton 1968, Lyford 1969) as well as more recent studies (e.g., Weaver et al. 1986, Weaver 1990, Asbury et al. 1994, Walker et al. 1996b, Richardson et al., 2000).

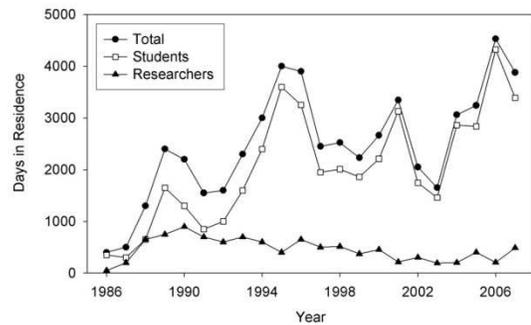
Tabonuco forest, which surrounds El Verde, constitutes the greatest area and has been the most studied of the vegetation zones in the LEF (Brown et al. 1983, Waide and Lugo 1992). The research emphasis at the El Verde site was oriented toward a multi-disciplinary investigation of ecosystem processes during the 5-year Rain Forest Project, sponsored by the Atomic Energy Commission (Odum and Pigeon 1970).

As one of the earliest examples of large-scale ecological studies, this project described the vertical and horizontal structure of Tabonuco forest, focusing on processes such as nutrient cycling, energy flow, and responses to gamma irradiation exposure. Following the termination of the Rain Forest Project, the Terrestrial Ecology Division of the Center for Energy and Environment Research continued research in the areas of nutrient cycling and energy flow. Later, the Rain Forest Cycling and Transport Project (1980-1987), funded by the Department of Energy and the University of Puerto Rico, studied the structure and function of terrestrial and aquatic food webs and their roles in ecosystem processes (Reagan and Waide 1996); nutrient import, export, and immobilization (McDowell et al. 1990, McDowell and Asbury 1994, Asbury et al. 1994); and the structure and activity of fungal decomposers (Lodge 1993).

Research at El Verde has continued with funding from NSF and UPR. In 1988, El Verde became one of two focal research locations for the LUQ-LTER. One emphasis of the LTER program is on disturbance regimes in Tabonuco forest and the role of biota in the recovery of tropical forest ecosystems after disturbance (Waide and Lugo 1992), with an initial emphasis on the effects of Hurricane Hugo (Walker et al. 1991, Zimmerman et al. 1996).

Station Use and Activities

The main users of El Verde are graduate and undergraduate students, technicians, and a smaller number of faculty professors and postdoctoral fellows. The figure below summarizes the total number of visitors, researchers, and students who stayed at the field station between 1986 and 2007. Overall, the figure shows an increase in station use since the initiation of the LUQ-LTER program in 1988. The peaks in student use (i.e., 1989, 1995, 2000, 2005) are the result of projects that enrolled large numbers of volunteers. One of them, the Luquillo Forest Dynamics Plot, enrolls interns from many universities every five years to conduct tree censuses. The LUQ-LTER carried out a large project that enrolled many students for several months during 2004-2005. The steady decrease in “researcher” use (e.g., faculty professors) might change in the future as the result of our new apartment building.



Each year, most use occurs during three peak periods: summer, January (winter holidays), and March (spring break) when all available space for visitors is occupied. During peak visitation the workspace is a major limitation. We can only accommodate ~10 researchers at a time if they do not require major space (e.g., one desk only). Laboratory space is a currently a major limitation at the station.

Appendix 2. Master plan workshop participants (October 3-4, 2008)

Name	Institution	Area of expertise
Coordinators		
Alonso Ramirez	ITES – University of Puerto Rico	Ecological Research
Elvia Melendez	ITES – University of Puerto Rico	Ecological Research
Olga L. Mayol-Bracero	ITES – University of Puerto Rico	Atmospheric Sciences
UPR administration		
Brad Weiner	Dean, Natural Sciences, University of Puerto Rico	Administration
Ana Guadalupe	Dean, Graduate Studies and Research	Administration
Francisco Perez	El Verde Field Station	Administration
US Forest Service		
Carolyn Krupp	El Yunque National Forest, USFS	US Forest Service
Felipe Cano	El Yunque National Forest, USFS	US Forest Service
Ecological Research		
Whendee Silver	University of California, Berkeley	Ecological Research
Fred Scatena	University of Pennsylvania, PA, USA	Ecological Research
Mei Yu	ITES – University of Puerto Rico	Ecological Research
Nick Brokaw	ITES – University of Puerto Rico	LTER program
Xiaoming Zou	ITES – University of Puerto Rico	Ecological Research
John Bithorn	ITES – University of Puerto Rico	El Verde personnel
Maria Aponte	ITES – University of Puerto Rico	El Verde personnel
Field Stations		
Rodolfo Novelo	Instituto de Ecologia AC.	Field Stations
Armando Rodriguez	Interamerican University	Field Stations
Jan Hodder	Organization of Biological Field Stations	Field Stations
Paul Foster	Reserva Ecológica Bijagual	Field Stations
Education		
Jorge Ortiz	ITES – University of Puerto Rico	Education
Josefina Arce	Alacima, University of Puerto Rico	Education
Atmospheric Sciences		
Stephan Borrmann	Max Planck Institute for Chemistry	Atmospheric Sciences
Althea Austin-Smith	National Weather Service – Puerto Rico	Atmospheric Sciences
Jeffrey Cupo	National Weather Service – Puerto Rico	Atmospheric Sciences
Betsy Andrews	University of Colorado and NOAA/ESRL/GMD	Atmospheric Sciences

Appendix 3. Summary of 1995 – 2005 Master Plan

El Verde developed a master plan in 1995 with the advice of individuals from biological field stations in the U.S. and Costa Rica. The plan included renovations and new construction, details are provided above as part of the proposed work.

Renovations of existing facilities. Facilities were improved by conducting building maintenance (e.g., painting, replacing of doors, and electrical fixtures). A new generator was installed to provide backup emergency power to all existing structures, including the new dormitory building. Water storage and purifying system were installed to provide drinkable water to the station. The station is connected to a municipal water line and the current water system remains as a backup for emergencies. In addition, the Stream House was renovated. The first floor is composed by four offices, a common area and one apartment. The building includes handicap access.

Experimental stream channels. Six replicate 100-ft artificial streams were constructed to conduct research with stream organisms. The artificial streams run with a 10 horsepower submersible water pump that provides constant water flow to the channels.

Special use permit from the USDA Forest Service. We completed the process and obtained a permit from the USDA Forest Service that contemplates the administration of existing facilities until December 2013, with the possibility of requesting a renewal. The permit also includes the construction of a new laboratory building (contingent upon approval of construction plans) and improvements proposed by the Master Plan.

Apartment building. The construction of an apartment building was a major accomplishment. It has four apartments, each one with two bedrooms and a kitchen to accommodate four-six people. The building was designed not only to increase the housing capacity at the station (from 30 to 40), but also to provide better accommodations by reducing overcrowding of our current dormitory.



Figure 4. New dormitory building at El Verde Field Station, showing the front of the building.

Communications system. El Verde has a modern communications system (a microwave connection) that connects the station with UPR-RP. The system provides the station with much-needed voice and data transfer with the rest of the world. Data transfer is as fast as the one available on campus and the telephone systems uses voice over IP. Telephones at the station are part of the UPR phone system, and offices have extension numbers just as those on campus.

Appendix 4. East Peak site map

