Forest Dynamics Plots Established in Hawai‘i to Track Tree Regeneration Patterns and Climate Change Responses

by Lawren Sack, Ph.D., Associate Professor, Faith Inman-Narahari, Graduate Student, Department of Ecology and Evolutionary Biology and Center for Tropical Research, Institute of the Environment, UCLA, Susan Cordell, Ph.D., Research Ecologist, Christian Giardina, Ph.D., Research Ecologist and Team Leader, Institute of Pacific Islands Forestry, Pacific Southwest Research Station, U.S.D.A. Forest Service, and Rebecca Ostertag, Ph.D., Associate Professor, Department of Biology, University of Hawai‘i at Hilo

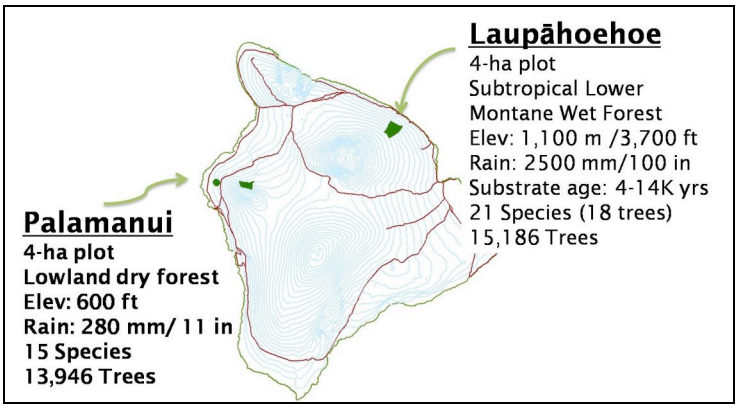
Many ecological questions can be ideally addressed in Hawai‘i due to its exceptional natural resources, including diverse habitats across striking environmental gradients, ecosystems ranging from upland forests to coral reefs, and a rich endemic flora. There is an urgent need to preserve and restore Hawaiian forests which contain a treasure of plant biodiversity and the greatest number of endangered plant species in the United States.

Top (left to right): Species in Hawaiian wet forest at Laupāhoehoe (Metrosideros polymorpha, Acacia koa, *and* Cibotium glaucum).

Bottom (left to right): Species in Hawaiian dry forest at Palamanui (Diospyros sandwicensis, Psydrax odorata, *and* Pleomele hawaiiensis).

The Hawai‘i Permanent Plot Network (HIPPNET) was initiated in 2007 to investigate Hawaiian forest dynamics. Scientists and managers from multiple institutions both within and outside of Hawai‘i were united by a recognition of the pressing need for long-term measurements as well as intensive short-term studies at well-defined sites in this important region. HIPPNET is a collaboration between researchers from UCLA, the University of Hawai‘i, the Institute of Pacific Island Forestry, U.S.D.A. Forest Service, and the Center for Tropical Forest Science, Smithsonian Tropical Research Institute. Graduate and undergraduate students in the laboratory of UCLA Professor Lawren Sack are participating in HIPPNET projects. HIPPNET’s long-term goal is to establish several large-scale, permanent plots in native-dominated forest across elevation and precipitation gradients throughout the Hawaiian Islands.

HIPPNET presents a unique testing ground for ecological theory and patterns found in studies of other forests. In particular, questions can be tested easily because overall tree diversity is much lower in Hawai‘i than in other tropical forests as a result of being the most remote archipelago in the world. The high islands have less than five million years of evolutionary history and over 90% of the native plants are endemic, occurring nowhere else on Earth. The HIPPNET study sites are contributing to research and instruction synergies across institutions and communities in Hawai‘i, as well as on a national and international scale.

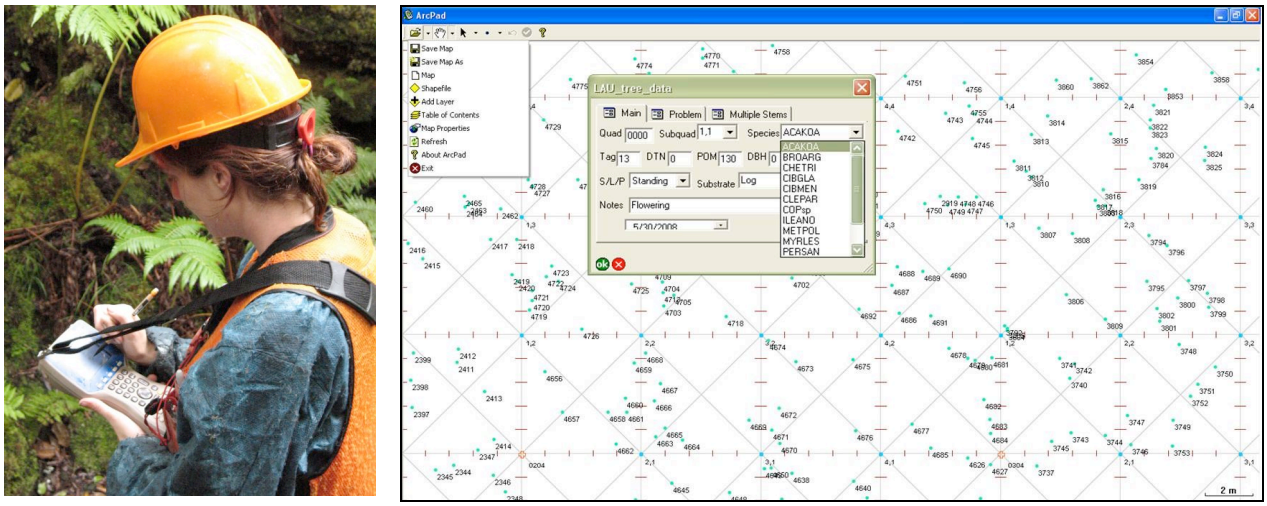


Left: Scientists planning measurements in the HIPPNET plots. Right: Map of the Island of Hawai'i with the location and statistics for the first two HIPPNET plots and the location of the third planned plot.

There are currently two plots in native-dominated forest on the Island of Hawai'i, with future plots planned on this and other high islands. The wet side forest plot, at Laupāhoehoe, is primary rainforest on the slopes of Mauna Kea. It is dominated by 'ōhi'a (*Metrosideros polymorpha*) and koa (*Acacia koa*) trees, with an understory of tree fern (*Cibotium glaucum*), and has a history of ecosystem-level research. The dry side forest plot, at Palamanui, is lowland dry forest on the leeward side of Hualālai Volcano. It is dominated by lama trees (*Diospyros sandwicensis*) and native shrubs, such as alahe'e (*Psydrax odorata*), and includes rare species such as hala pepe (*Pleomele hawaiiensis*).

Views of the forest plots. Left: Laupāhoehoe forest. Right: A large lama tree in the Palamanui forest.

HIPPNET plots are established following Center for Tropical Forest Science (CTFS) protocols employed in tropical and temperate forests worldwide; CTFS currently has 34 forest plots with many more planned around the world. Each HIPPNET plot is at least 4 ha in area (equivalent to seven football fields) with all native woody plants ≥ 1 cm in diameter at breast height, tagged and mapped and repeatedly censused for growth, mortality, and new recruitment. The HIPPNET team has developed a digital data collection and management system, using field-ready handheld computers for more efficient data collection, which may serve as a template for other plots and other projects in the future. These tree data, coupled with the construction of towers for collecting continuous climate data, will increase our understanding of native forest dynamics.



Left: Field crew member Molly Winters collecting tree data with field computer. Right: A screenshot showing forest plot map in progress on field computer.

These plots were established as infrastructure to facilitate answering basic and applied science questions and to promote new discoveries. HIPPNET is inviting researchers to develop additional projects on these or other critical topics in science and conservation:

(1) Global change: climate impacts, community dynamics, invasive species.

(2) Ecohydrology: linkages between forest-water-atmosphere.

(3) Ecosystem services: services vital to our economy, security, and well-being, including abundant supply of freshwater, control of flooding and erosion, forest products, carbon pools, wildlife habitats, pathogen regulation, recreational activities, and many other aesthetic and cultural values.

(4) Remote sensing: modeling of ecosystem dynamics.

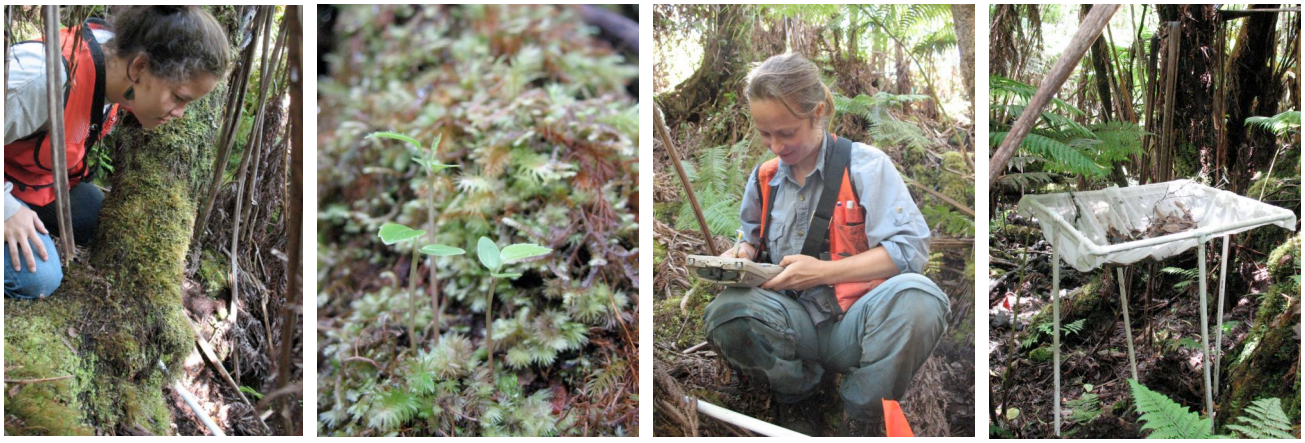
(5) Restoration: recovery of an ecosystem to its historic trajectory (i.e., to a state that resembles a known prior state or to another state that could be expected to develop naturally within the bounds of the historic trajectory), providing a baseline against which environmental changes can be measured to enable preservation of these natural systems.

(6) Comparative forest ecology: comparison of ecological properties of Hawaiian forests with those of forest plots in tropical and temperate forests around the world.

(7) Population genetics and evolutionary ecology: genetics of species broadly represented in plots and correlation with field performance.

(8) Biogeochemical processes: how natural inputs and outputs relate to ecosystem development and function.

The HIPPNET project aims to increase research capacity with infrastructure, student training, and field experience for aspiring scientists. The project continues to develop new opportunities for local Hawaiian students and scientists. HIPPNET is co-led by women scientists at all levels. HIPPNET promotes collaborations both within and outside of Hawai‘i and provides education and outreach through the HIPPNET website, newsletters, and scientific and public presentations.



*One current project in the plots is a detailed study of seedling dynamics and ecophysiology, led by Faith Inman-Narahari, Ph.D. student in Ecology and Evolutionary Biology at UCLA, assisted by Kehauwealani Nelson-Kaula, a student at the University of Hawai'i. Left to right: Kehau looking for seedlings, 'olapa (*Cheirodendron trigynum*) seedlings, Faith collecting data, a seed trap to collect seed rain.*

HIPPNET scientists at work in Hawaiian forests.
Left: (left to right) Lawren Sack, Molly Cavaleri, Lisa Ellsworth, Christian Giardina, Susan Cordell.
Right: (left to right) Susan Cordell, Stuart J. Davies, Albert Cortes, Jonathan Price, Rebecca Ostertag.

Acknowledgements: HIPPNET is supported by the National Science Foundation under EPSCoR Grant 0554657 and by Grant IOB-0546784. Any opinions, findings, conclusions, or recommendations expressed in this article are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Photos for this article were contributed by: Molly Cavaleri, Molly Winters, and Faith Inman-Narahari.

Photos of Wet and Dry Forest Plants at HIPPNET Sites

Wet Forest Plants

Top (left to right): *Brousaissia arguta* (shrub), *Chierodendron trigynum* (tree), *Clermontia parviflora* (shrub), *Coprosma rhynchocarpa* (tree) and *Ilex anomala* (tree). Bottom (left to right): *Melicope clusifolia* (tree), *Myrsine sandwicensis* (tree), *Pipturus albidus* (tree), *Trematolobelia grandiflora* (shrub), and *Vaccinium calycinum* (shrub).

Left to right: *Chierodendron trigynum* (tree) growing on a *Cibotium glaucum* (tree fern), *Cibotium chamissoi* (tree fern), *Cibotium glaucum* (tree fern), *Cibotium menziesii* (tree fern), and *Metrosideros polymorpha* (tree).

Dry Forest Plants

Left to right: *Euphorbia multiformis* (shrub), *Osteomeles anthyllidifolia* (shrub), *Psydrax odorata* (shrub), *Senna gaudichaudii* (shrub), and *Wikstroemia sandwicensis* (shrub).