

# HAWAII EXPERIMENTAL TROPICAL FOREST 2016- 2017 ANNUAL REPORT

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Senator Akaka planting an 'ōhi'a lehua at Kupua'e, the 'Ōhi'a Common Garden at the USFS Kahikina Learning Center in Laupāhoehoe.



***Dedicated to Senator Daniel K. Akaka (1924 - 2018)***

*Senator Akaka's devotion, affection and loyalty to Hawaii and its people will be treasured forever. The USFS has been touched and inspired by his passionate support of effective stewardship of the natural world and the communities they sustain. His passion has influenced countless young conservation and natural resource professionals and helped to guide the work of the Institute of Pacific Islands Forestry, based in Hilo. His countless accomplishments throughout his lifetime will forever be remembered, the most predominant was his landmark 1992 Tropical Forest Recovery Act, which ultimately lead to the establishment of the Hawaii Experimental Tropical Forest in 2007.*



## Acknowledgements

The establishment and administration of the Hawai'i Experimental Tropical Forest (HETF) has been successful due to the support and hard work of many individuals. The U.S. Department of Agriculture, Forest Service (USFS) would like to thank the State of Hawai'i including the Board of Land and Natural Resources, the Division of Forestry and Wildlife and State Parks for their cooperation in the administration of the HETF. In particular we would like to thank the following State staff in 2016 & 2017 for their efforts to reach agreements, provide valuable feedback, and help move forward the processes needed to effectively administer the HETF's mission: Nick Agorastos, Steve Bergfeld, Ian Cole, Charmian Dang, Jay Hatayama, Cynthia King, Sheri Mann, Joey Mello, Elliott Parsons, Lyman Perry, Tanya Rubenstein, Lisa Shizuma, Kanalu Sproat, Anya Tagawa, and Dean Takebayashi.

Special thanks to the additional USDA Forest Service employees who have worked to support the HETF's success in their respective capacities in 2016 and 2017 including: Tom Cole, Susan Cordell, Kainana Francisco, Alex Friend, Christian Giardina, Jane Hayes, Ric Lopez, Dean Oshiro, Colleen Schneider, and John Slown.

Additionally, we acknowledge the Laupāhoehoe and Pu'uwa'awa'a Advisory Council members for their important role in the guidance of HETF activities.





**Introduction** The Hawai'i Experimental Tropical Forest (HETF) was established in 2007 via a Cooperative Agreement with the State of Hawai'i, Department of Land and Natural Resources (DLNR). The HETF overlays existing DLNR managed lands and includes two Units: the Laupāhoehoe Wet Forest, totaling 12,343 acres (4,990 ha), and the Pu'uwa'awa'a Dry Forest, totaling 38,885 acres (15,736 ha) (Figure 1). The USDA Forest Service (USFS), Pacific Southwest Research Station in Hilo, Institute of Pacific Islands Forestry (IPIF), works with the DLNR – Division of Forestry and Wildlife (DOFAW) and State Parks to cooperatively manage research and education activities within the HETF. The HETF is part of a network of USFS Experimental Forest and Range units across the United States (<http://www.fs.fed.us/research/efr/>).

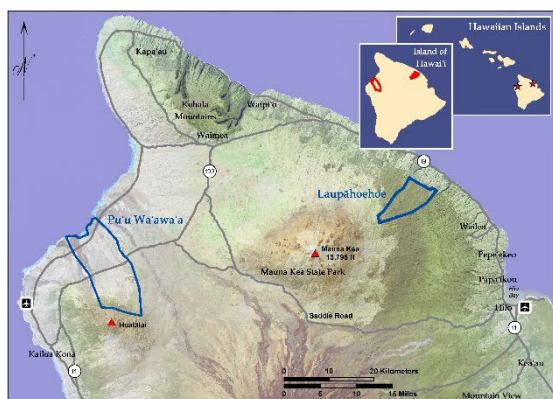


Figure 1: Map of Hawai'i Island highlighting the Pu'uwa'awa'a and Laupāhoehoe Units of the HETF.

The Laupāhoehoe Wet Forest Unit is located on the east side of Hawai'i Island and incorporates 4,449 acres (1,800 ha) of DOFAW managed land designated as Forest Reserve and 7,894 acres (3,195 ha) of land designated as Natural Area Reserve (NAR). This Unit contains native-dominated forested landscapes from lowland forest at 2,300 feet (700 m) above sea level extending through four life zones to almost 6,200 feet (1,890 m) in elevation. Laupāhoehoe contains magnificent examples of

tropical rain forest and is the habitat of numerous endangered plant and animal species.

The Pu'uwa'awa'a Dry Forest Unit is located in North Kona on Hawai'i Island and incorporates three DLNR land designations. Approximately 31,475 acres (12,743 ha) are designated as Forest Reserve and together with the 3,806 acre (1,542 ha) Forest Bird Sanctuary (Wildlife Sanctuary), are managed through DOFAW. The remaining 3,530 acres (1,430 ha) are managed by the DLNR Division of State Parks. In addition there are approximately 74 acres (30 ha) of private inholdings within the HETF boundary. Tropical dry forests are considered among the most endangered forest types in the world, and in Hawai'i the few remaining remnants are severely threatened by wildfire, invasive plant species, and non-native ungulates.

The HETF's mission is to provide landscapes, facilities, and data/information to support research and education activities contributing to a better understanding of how to conserve and manage the biological diversity and functioning of tropical forest and stream ecosystems as well as to understand the human dimensions of natural resources conservation and management. The HETF represents a significant contribution in the global effort to understand and protect some of the most threatened and endangered ecosystems in the world. This is accomplished in the following ways: facilitating research by providing research areas, facilities and information; fostering an environment for interaction and the exchange of information among scientists and to those outside the scientific community, and providing education and demonstration opportunities for those interested in tropical forest studies and management.

The report information herein is focused on the research and education activities that took place within the HETF in 2016 & 2017. Activity data from the previous four years is included in graphical data where relevant. Additional information regarding the HETF's history, future plans and annual reports as well as other resource documents can be found online at [www.hetf.us](http://www.hetf.us).



## Administration Per the HETF

Cooperative Agreement, "owing to the many values and benefits that arise from research, education and demonstration on the HETF and elsewhere, the Parties (the USFS and the State of Hawai'i) further agree they will consult and reach agreements with each other to coordinate research, management, and education activities." The HETF Planning Group was established to fulfill this objective and includes the USFS-HETF Line Officer, the USFS-HETF Science Lead, the USFS-HETF Facilities Manager, the Hawai'i Island DOFAW Branch Manager, the Hawai'i Island Natural Area Reserves Program Manager, the Hawai'i Island Forestry Program Manager, East and West Hawai'i Island Wildlife Biologists, the Pu'uwa'awa'a coordinator, and two to three external partners.

## Permitting

Permit applications for research and education activities are reviewed by a subset of the HETF Planning Group, the Research Technical Committee (RTC), which includes the USFS-HETF Line Officer, the Hawai'i Island DOFAW Branch Manager, the USFS-HETF Science Lead, the Natural Area Reserve Hawai'i Island Manager, the Forest Reserve Hawai'i Island Manager, East and West Hawai'i Island Wildlife Biologists, and the Pu'uwa'awa'a coordinator. Permit processing and tracking is coordinated and administered by HETF staff. Signing authority for all permits within DOFAW managed lands lies with the Hawai'i Island DOFAW Branch Manager. All research permits are valid for one year and require an annual report. In Pu'uwa'awa'a research permitting for the HETF is limited to land activities. Research activities that take place in water including up to the tide line are under the jurisdiction of the DLNR-Division of Aquatic Resources and the Office of Conservation and Coastal lands (OCCL). Permits within State Parks are issued by State Parks Hawai'i Island District Superintendent.

## Community Advisory Councils

Per the HETF Cooperative Agreement, "the Parties will consult with scientists, managers, general citizens, and local community members concerning ongoing research activities. Existing State sanctioned advisory councils may be utilized for this purpose." The Pu'uwa'awa'a Advisory Council (PAC) has been in existence since 2002. The Laupāhoehoe Advisory Council (LAC) was formed in December 2010. Both councils advise on and facilitate HETF related activities, as well as participate in research permit application review and their comments and/or recommendations are provided to the RTC during the review process.

## Support

### USFS Staff

*USFS-HETF Line Officer - Dr. Ric Lopez*

*USFS-HETF Science Lead - Dr. Susan Cordell*

*USFS-HETF Education Lead -*

**Dr. Christian Giardina**

*USFS-HETF Facilities Manager - Dean Oshiro*  
(6/2014-7/2016), position was filled by

**Jon Mitsuda** in January 2018

*HETF Resource Associate - Tabettha Block*

### DOFAW Staff

*Hawai'i Island DOFAW Branch Manager -*  
**Steve Bergfeld**

*Hawai'i Island Natural Area Reserves Program*  
*Manager - Nick Agorastos*

*Hawai'i Island Forestry Program Manager -*  
**Jay Hatayama**

*East Hawai'i Island Wildlife Biologist -*  
**Joey Mello**

*West Hawai'i Island Wildlife Biologist -*  
**Kanalu Sproat**

*Pu'uwa'awa'a Coordinator - Dr. Elliott Parsons*  
*State Parks Hawai'i Island District*  
*Superintendent - Dean Takebayashi*



## State Managed Research Activities

As mentioned previously, HETF lands are managed cooperatively by IPIF, DOFAW and State Parks. State management activities and research and monitoring activities performed by State staff do not require HETF permits and are not tracked within this annual report. Management activity reports for each State land designation (Forest Reserves, NARS, Wildlife Sanctuary and State Parks) are available via annual reports to the Legislature. For information on the aforementioned reports, visit <http://hawaii.gov/dlnr/reports-to-the-legislature>.

## Facilities

### Laupāhoehoe

HETF support facilities for the Laupāhoehoe Unit are present within the town of Laupāhoehoe but outside the forest boundary. The Kahikina Learning Center (Center) is located on 55 acres of old sugar

cane lands within the Laupāhoehoe community, approximately four miles from the HETF boundary. Facilities include a bunkhouse, complete with a full kitchen and classroom/meeting space, a restroom and shower building, and a workshop. The facility site offers opportunities for research, education, and demonstration. A weather station, installed in 2009, is located onsite.

### Pu'uwa'awa'a

There are plans to build dedicated HETF facilities within Pu'uwa'awa'a. As part of this Construction Project – and pending availability of funds, the IPIF is proposing to:

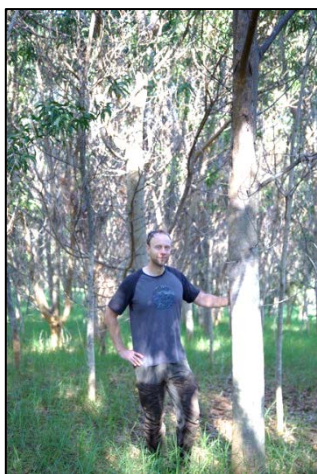
- Construct a bunkhouse building of approximately 1,100 square feet. This building would include double occupancy bunkhouse space for up to 10 visiting scientists, restrooms, kitchen facilities, and common use areas.



## Research Summary

Eighteen research applications were submitted and approved in 2016 and eighteen in 2017. All projects for both years were initiated. HETF-related journal articles were published in *Science*, *Oecologia*, *Science of the Total Environment*, *Biogeosciences*, *Integrative and Comparative Biology* and *Ecosphere*. A list of publications submitted with annual reports is included at the end of this report. Selected 2016 & 2017 research projects are highlighted below.

- ***Effects of non-native ungulate exclusion on fuel loading and modelled fire behavior*** - The interactions of wildfire, non-native invasions, and climate present significant threats to native species and ecosystems in Hawai'i and globally. In Hawai'i, wildfires have increased in scope and intensity from historic conditions due to human ignitions, abundant fuels associated with non-native grasses, and changing climate. For wildfire management, this presents many challenges which are exacerbated by the uncertainties of novel fuel types that occur with the invasion of non-native grasses, and the removal of non-native ungulates that at least partially control fuel loads. Although non-native ungulate removal is a general prerequisite for the effective conservation and restoration of native ecosystems in Hawai'i, it is largely unknown how their removal impacts the drivers of wildfire. Timothy Zhu at the University of Hawaii at Mānoa is studying whether non-native ungulate removal increases fuel loads, and whether potential increases in fuel loads vary as a function of mean annual precipitation (MAP). He hypothesized that ungulate exclusion would increase fuel loads at intermediate MAPs, but have no impact at low or high MAPs. He uses standard fuel transects and sampling to quantify fuel loads inside and outside of 12 non-native ungulate exclosures located across a 2,700 mm MAP gradient on the island of Hawai'i. Results demonstrate that fine fuel loads and heights, primary drivers of wildfire, were higher with ungulate exclusion. However, he found little support for his original hypothesis that this would only be true for intermediate MAPs, as increased fuel loads with ungulate exclusion increased with MAP. This research informs management attempting to balance wildfire and conservation/restoration across tropical landscapes.

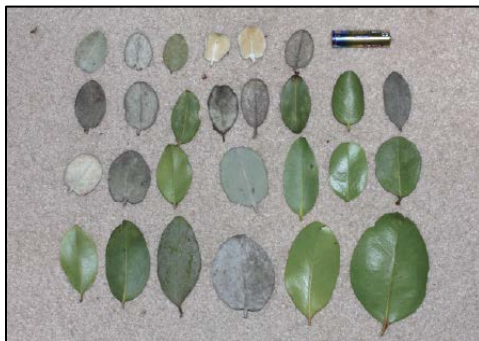


- ***Nursery cultural techniques to promote restoration of *Acacia koa* competing with exotic grass in a dry tropical forest*** - Douglass Jacobs of Purdue University and the Tropical Hardwood Tree Improvement and Regeneration Center (TropHTIRC), is studying *Koa* (*Acacia koa* A. Gray). Cattle grazing and introduced grasses have caused prominent losses of forest cover in the seasonally dry tropical forests of Hawaii. Naturally regenerating seedlings under heavy grazing often fail due to consumption by cattle and competition from introduced exotic grasses. A major challenge to artificial reforestation of *koa* in Hawaii is the introduced exotic kikuyu grass (*Pennisetum clandestinum*), a rapidly growing, rhizomatous plant. We examined use of varying nursery cultural techniques to facilitate establishment of *koa* seedlings amidst dense kikuyu grass on a cinder cone at 1200 m. Seedlings were grown in three



container sizes (49, 164, 656 cm<sup>3</sup>) and with four rates (0, 10, 15, 20 kg m<sup>-3</sup>) of 15-9-12 (NPK) controlled-release fertilizer incorporated into media prior to sowing. After 16 months in the field, seedling survival was greater than 80% for all treatments with the exception of the non-fertilized 49 cm<sup>3</sup> and 164 cm<sup>3</sup> containers (78% and 24% survival, respectively). At 10 years, only these two treatments had significantly lower survival (35% and 10%, respectively) than the other treatments. At 1 year following planting, none of the unfertilized seedlings exhibited phyllodes (vs. the early true leaves) regardless of container size. For the fertilized 656 cm<sup>3</sup> container, 78-85% of seedlings had phyllodes, with mean values increasing by fertilizer rate. In koa, phyllodes are known to confer greater drought resistance, which may help to explain improved survival noted for fertilized trees. Overall, the use of fertilizer was significantly more influential on seedling height and diameter response than container size. However, the greatest container size (656 cm<sup>3</sup>) with addition of fertilizer produced significantly larger trees than all other stocktype treatments during the early regeneration phase; growth differences tended to disappear at 10 years due to inter-tree canopy competition. This data confirms the importance of nursery fertilization in promoting outplanting success of koa, despite the capacity of the species to fix atmospheric nitrogen through rhizobium associations. Nursery cultural techniques may play an important role in restoration of tropical sites invaded by invasive vegetation.

- **Phenotypic and genetic variations of *Metrosideros polymorpha* across environmental gradients on the island of Hawaii** – Yusuke Onoda of Kyoto University, Japan, is studying *Metrosideros polymorpha*, the most dominant native tree species on the island of Hawaii. This study is geared to understanding how this species adapts to various environments and how the population structure is maintained over the island. This research takes a quantitative ecophysiological and genetic approach to understand the current population structure. In the last two years, field work at approximately 50 locations on the island of Hawaii has been done. In 2017, several field sites in HETF were added, in order to cover the full range of habitat conditions of this species. At each study site, a small terminal branch (20-30cm) was collected from the outer crown of 40 mature trees with a pruning pole. The collected branches were



Leaf diversity of *Metrosideros polymorpha*.

used for morphological analyses such as leaf size, leaf thickness and leaf chemistry and genetic analyses. Preliminary results suggest that 70-80% of cross-population variations in several leaf traits were explained by a combination of temperature, aridity and soil age. Within population, variations among individuals were not explained by local micro-environmental factors such as soil depth, but rather by the harshness of environmental conditions (environmental filtering) and the level of environmental heterogeneity (indication of gene flow).

- **Potential changes in infiltration in Hawaiian forests caused by climate change and invasive species** – The overall objective of the study by Lucas Fortini, USGS Pacific Islands Ecosystems Research Center, and Hawaii Cooperative Studies Unit staff (under the direction of Sharon Ziegler-Chong, University of Hawaii





Makani Gregg (HCSU) measuring soil infiltration rates at an invaded understory site.

at Hilo), was to understand how rapidly expanding invasive plant population distributions throughout Hawaii's forests, coupled with changes in inter-species competitive dynamics (caused by projected shifting rainfall patterns) will impact water resources into the future. Local studies have highlighted how invasive plants and disturbance of the ground-cover vegetation by feral ungulates may alter soil characteristics critical to determining runoff and groundwater recharge. Other efforts have suggested that invasive species, both plant and animal, have altered whole watershed water balances and possibly landscape groundwater recharge. However, a landscape-level understanding of the impact of invasive species on water resources both island and state wide is still lacking. This

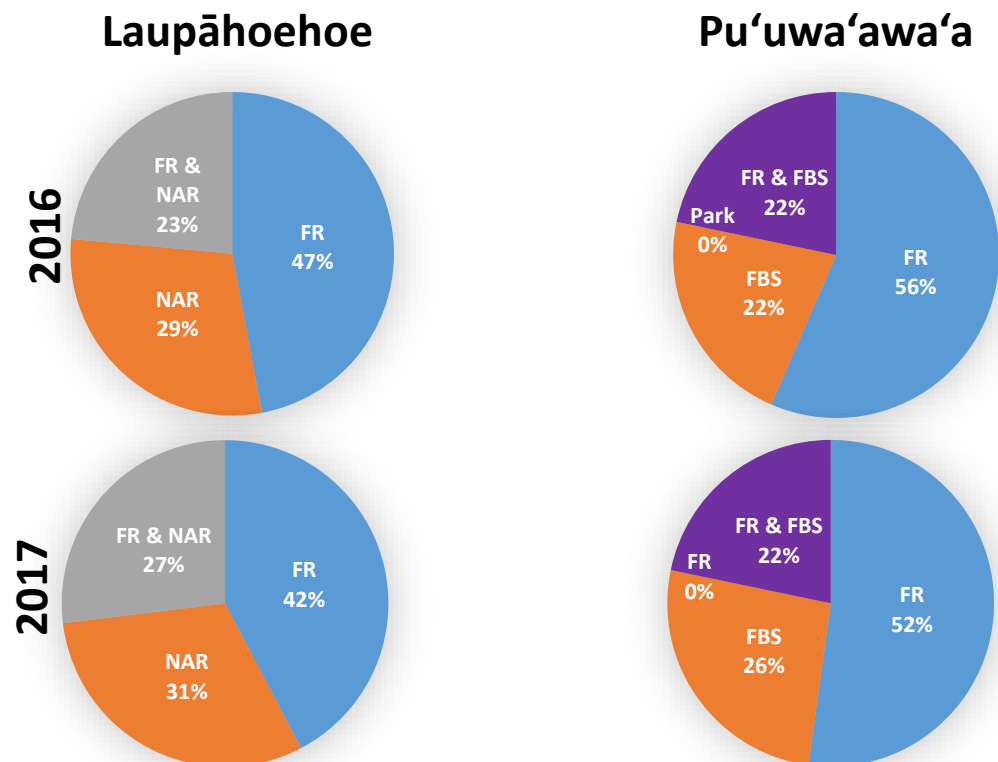
project, supported by the USGS Pacific Island Climate Science Center attempts to quantify differences in groundwater recharge between native and non-native forests, providing information as to how water resources are currently affected by forest type. Information gathered will be used to project future conditions under multiple climate scenarios. This research studied the differences in key soil characteristics that control runoff and groundwater recharge across managed and relatively intact native mesic and wet forest communities. To explore the ecohydrological impact of invasion in these communities, researchers conducted similar sampling in animal disturbed and invasive-dominated community types that most frequently replace the native communities considered. Specifically, the conduction of basic vegetation and forest canopy cover assessments, ungulate surveys; measurements of water infiltration and soil hydrophobicity (repellence of water) rates; small soil samples; and temperature and humidity was collected at all sites. Project findings will be released in 2018.



Research projects can be restricted to specific State land designations or occur within multiple State land designations. Eleven of the 36 projects initiated in 2016/17 were located in the Laupāhoehoe Unit, fifteen occurred within the Pu‘uwa‘awa‘a Unit, and ten research projects were conducted in both Units (Table 1). Figure 2 shows the percentage of 2016 HETF research projects grouped by State land designation. In Pu‘uwa‘awa‘a research permitting for the HETF is limited to land activities. Research activities that take place in water including the tide line are under the jurisdiction of the DLNR-Division of Aquatic Resources. Figure 3 shows research affiliation for projects within the HETF over a five-year period 2013-2017.

*Table 1: Total number of research projects initiated in the HETF per year and grouped by Unit from 2013-2017.*

Year	Laupāhoehoe Unit Only	Pu‘uwa‘awa‘a Unit Only	Both HETF Units	Total # of Projects Initiated
2017	6 (32%)	6 (36%)	6 (32%)	18
2016	5 (28%)	9 (50%)	4 (22%)	18
2015	7 (31%)	13 (58%)	3 (11%)	23
2014	5 (33%)	6 (40%)	4 (27%)	15
2013	15 (52%)	11 (38%)	3 (10%)	29
<b>Total</b>	<b>38</b>	<b>45</b>	<b>20</b>	<b>103</b>



*Figure 2: Percentage of HETF research projects grouped by State land designation in 2016 and 2017. (NAR=Natural Area Reserve, FR=Forest Reserve, FBS=Forest Bird Sanctuary)*



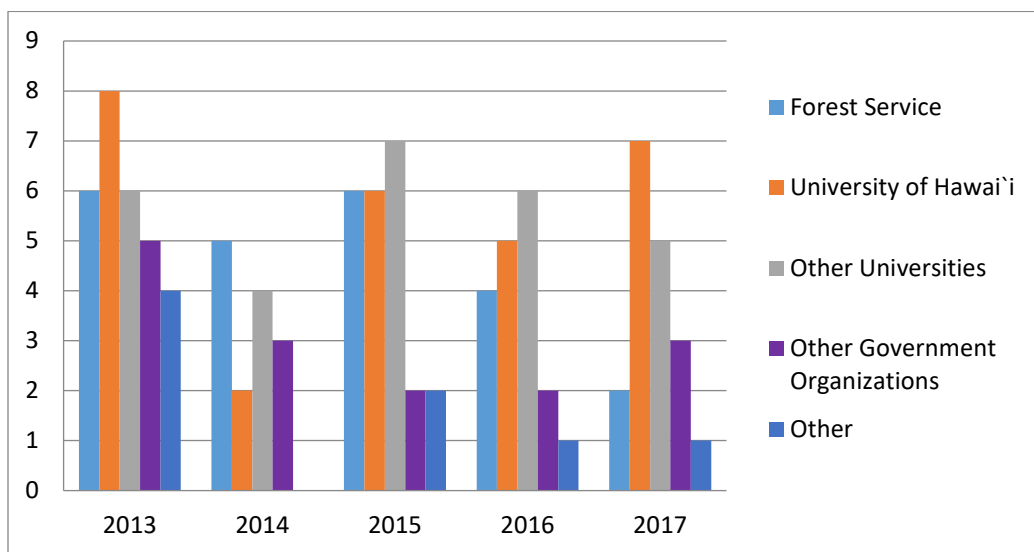


Figure 3: Affiliation for research projects initiated and ongoing within the HETF from 2013-2017.



## Kahikina Learning Center (Center)

As mentioned previously, the Center is housed on 55 acres of old sugar cane lands. HETF infrastructure like the Center are envisioned to provide a center for demonstration, education, training, and outreach on tropical forestry, conservation biology, and natural resources research and management.

### ‘Ōhi’a Common Garden

The ‘Ōhi’a Common Garden was established in the summer of 2014 in conjunction with the education and outreach program Ulu Lehulehu (The Million ‘Ōhi’a Initiative) whose mission is to connect Hawai’i’s youth to ‘Ōhi’a trees. The common garden serves multiple purposes including community engagement and research platform as well as reforestation of degraded lands at the Center. The garden is home to over 800 native ‘Ōhi’a trees.



The ‘Ōhi’a Common Garden will help answer interesting science questions about how long-term forest fragmentation (>100 years) affects ‘Ōhi’a genetics. The trees were all created from cuttings taken from ‘Ōhi’a that occur in the center and edge of forest kīpuka, or forest fragments created by lava flows, as well as from ‘Ōhi’a trees colonizing the lava matrix between kīpuka. The team selected these trees because they noticed that there were

differences in trees between sites, and thought these differences could be controlled genetically. Over 1000 ‘Ōhi’a from these different locations were raised in a greenhouse for two years. The team found that location definitely affected genetics. Trees from kīpuka centers grew faster and taller than edge trees or matrix trees even though all the trees were grown in a common environment (same soils and greenhouse). The next step is to see how these differences continue as the trees mature into larger individuals. In the future, the common garden



will allow participants to learn about ‘Ōhi’a and its importance to the health of the forest, participate in service learning opportunities such as outplantings and/or caring for the ‘Ōhi’a (weed/grass control), which supports both the research and education efforts of the ‘Ōhi’a common garden.





## 2016 & 2017 Education, Outreach and Access Activity Summary

*This section highlights various non-research program activities, as well as specific Unit education, outreach, and access details that occurred within the HETF in 2016 & 2017.*

### Youth Conservation Corps (YCC)

Youth Conservation Corps programs in Hawai'i are administered by Kupu, a nonprofit community organization ([www.kupuhawaii.org](http://www.kupuhawaii.org)). IPIF participates in three Kupu AmeriCorps/Youth Conservation Corps (YCC) programs: The Gateway Program is an 8-week summer team experience designed for young adults (ages 17-20). Team members complete hands-on fieldwork at various worksites. The Frontiers Program provides a more in-depth individual 7-week summer experience at a single worksite that best matches the individual's interests. The Extended Internship Program (EIP) offers an intensive entry-level 11-month experience where they assist with projects equip them with job skills and leadership growth opportunities to move ahead in their career. In addition to gaining valuable insight in the conservation field, members also receive a living allowance and an AmeriCorps education award for their time.

2016 and 2017 were the fifth and sixth year the HETF supported YCC Gateway teams. Gateway program members gained introductory experience in all aspects of natural resource management, working in both HETF Units, as well as other conservation areas managed by agency partners, such as the Division of Forestry and Wildlife (DOFAW), Big Island Invasive Species committee (BIISC), Mauna Kea Watershed Alliance (MKWA), and The Nature Conservancy (TNC). IPIF supported one Gateway team as well as five Frontiers interns, and one EIP.

For three years in a row the USFS Gateway team attended the Inter-Tribal Youth Climate Leadership Congress (ITYCLC) in Shepherdstown, West Virginia for a week-long conference on the effects of climate change on tribal communities. The conference was

attended by Alaska Native, American Indian, and Native Hawaiian high school students representing tribes from across the nation. The 2016 USFS team members included: Shari Frias, Jonah Kim, Cody Pacheco, Keolani Teixeira and Nanea Thomas (see photos above). The 2017 USFS team included: Uluwehi Ornellas, La'akea Judd, Dakota Simmons and Kainoa Orris. Attendance to the conference is sponsored by the USFS.



Hawaii YCC participants sharing their native dance (Hula) with fellow participants. Bottom photo: Participants bonding through dance and sharing of native customs.



### Ulu Lehulehu - The Million 'Ōhi'a Initiative

The 'ōhi'a tree (*Metrosideros polymorpha*) is the most bioculturally important tree species in Hawai'i. It is the backbone of Hawai'i's native forests and watersheds, it covers more than one million acres statewide, and it is a foundational element in Hawaiian traditional knowledge systems and cultural practices. Ulu Lehulehu was conceived in 2012. The root words are, ULU, meaning to grow, spread, protect and LEHULEHU, meaning numerous, innumerable, a multitude. This program is a



partnership between the HETF/USFS, Akaka Foundation of Tropical Forests, AmeriCorps, Kupu, and Laupāhoehoe Community Public Charter School (LCPCS). Ulu Lehulehu's initiative inspires the next generation of conservationists by working with Hawai'i communities to develop and strengthen relationships with and create vibrant landscapes abundant in 'ōhi'a. The programs K-12 education work involves bringing the forest into the school classroom, and taking students into the outdoor classroom to learn about native forest ecosystems and watersheds, the importance of knowing your landscapes intimately, and engaging in indigenous Hawai'i lifeways to help kids reconnect with and better understand their places. Ulu Lehulehu bridges science, culture, and community to develop and strengthen people's relationships with and create vibrant landscapes abundant in 'ōhi'a through four integrative approaches of youth education, community outreach, native forest restoration, and urban forestry. During the 2016-2017 academic school year the LCPCS 9<sup>th</sup> grade class was visited twice monthly by program leaders, one in class day, followed by a day outdoors, a fieldtrip to a culturally significant location within the Laupāhoehoe ahupua'a (land division). Ulu Lehulehu's education efforts help to shape the next generation of responsible, engaged, aware, and motivated stewards involved in the conservation and protection of the natural and cultural resources of Hawai'i.

### Laupāhoehoe Unit

There were no visitors to the Laupāhoehoe Unit in 2016. In 2017, thirty eight participants on 3 trips visited the Laupāhoehoe Unit. One of these trips included, *USFS staff* escorting Kupu interns along with a Hawaiian Airlines/Anthology contractor into the Laupāhoehoe Forest for the filming of "The 'Ōhi'a: The story of Hawai'i's Tree", a project by Kupu. The film was used as part of the airlines in-flight programming from April to July 2017, shedding light on the cultural and environmental importance of 'Ōhi'a and helping to spread awareness of Rapid 'Ōhi'a Death (ROD) on Hawai'i Island. Featured speakers in this film included IPIF's research ecologists Christian Giardina and Flint Hughes, along with Natural Resource Specialist Kainana Francisco.

### Pu'uwa'awa'a Unit

Six hundred and seventy one participants on 27 trips visited the Pu'uwa'awa'a Unit in 2016 and 897 on 29 trips visited in 2017. The high number of participants, compared to the Laupāhoehoe Unit, who are able to visit, work, and learn in Pu'uwa'awa'a is in a large part due to the presence and availability of onsite DOFAW staff that lead, participate in, and facilitate these activities. The existing road and facility infrastructure in Pu'uwa'awa'a Forest Reserve also play an important role in making these trips possible. The continued presence and availability of onsite staff is necessary for Pu'uwa'awa'a to be able to continue to support this level of public interaction. A further breakdown participants in the HETF from 2013-2017 is detailed in Figure 4. A few of the 2016 and 2017 HETF education trips to Pu'uwa'awa'a are detailed here.

- The *Teaching Change Program* began offering field trips to local middle and high school students to the Pu'uwa'awa'a Unit in 2016. Based on the Island of Hawaii, Teaching Change aims to inspire local youth to be environmental stewards and to pursue post-secondary educations and careers in Hawai'i in natural resource management. Through outdoor, immersive learning students get hands on exposure to locally relevant natural resource issues and their management. Teaching Change is a collaboration between the University of Hawai'i at Mānoa, the Institute of Pacific Islands Forestry, and Pacific Resources for Education and Learning, with generous support from a variety of organizations and funders. The program visited Pu'uwa'awa'a four times in 2016 and eight times in 2017. See [www.teaching-change.org](http://www.teaching-change.org) for more information.
- *UHH Geography Department and Geologists of Jackson Hole* students visited Pu'uwa'awa'a to examine the tephra (pyroclastic) deposits associated with the early stages of the eruption of Pu'uwa'awa'a cone. Discussion included the contrast between this eruption and other alkalic late-stage explosive activity taking

place on Hualālai and elsewhere in Hawai‘i. Special attention was be paid to pumice and obsidian samples, with disturbance limited to picking rocks up then setting them down again after handling and examination. There was on-site discussion about past lava flows in Pu‘uwa‘awa‘a as well as the Pu‘u Anahulu trachyte flow, which is beautifully visible in longitudinal profile from the road where it exits the forest on the way back down from the quarry site.

- *IUCN inspired excursion on Hawai‘i Island*, the IPIF and DOFAW partnered to host an IUCN inspired excursion to the Pu‘uwa‘awa‘a ahupua‘a (traditional land division) on Hawai‘i Island. This particular ahupua‘a located in North Kona, is approximately 15,706 hectares of mixed tropical dry and moist forests, mixed savanna, and exotic dominated grasslands, it extends from sea-level to almost 1,951 meters above sea level. Twenty five participants took part in this excursion which provided amazing learning opportunities such as, meeting with cultural practitioners who illustrated the natural beauty and the rich cultural history of the



area. IPIF research ecologists were on site explaining their work currently ongoing in Pu‘uwa‘awa‘a. Participants also planted native trees in a dryland forest restoration area; which serves as a hands-on service learning opportunity year round.

- *Biocultural Blitz* explores Hawaiian dry forest ecology. The Institute of Pacific Islands Forestry in partnership with the Hawaii Division of Forestry and Wildlife, the University of Hawaii at Mānoa and the Forest Service’s National Partnership Office, hosted 250 fourth-graders for a “Bio-Cultural Blitz” at the Pu‘u Wa‘awa‘a Dry Forest Unit. Students were traditionally welcomed by Native Hawaiian descendants of Pu‘u Wa‘awa‘a and spent the day visiting stations highlighting the biocultural significance of Hawaii’s endangered dry forests, from botany and soils to wildlife and insects to cultural geography and indigenous resource management, while engaging in hands-on activities.

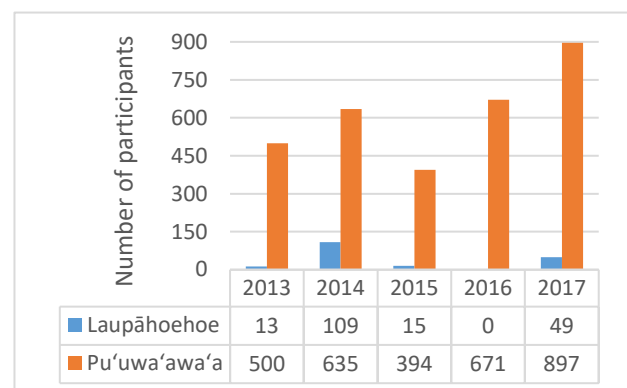


Figure 4: Number of participants to visit the HETF from 2013-2017.



## Kahikina Learning Center (Center)

Eighty eight participants in 2016 and 169 participants in 2017 visited the Kahikina Learning Center (Center) on a variety of trips. A few of the 2016-2017 Center activities are detailed here.

- *U.S. Senator Brian Schatz* held a summit on Rapid 'Ōhi'a Death (ROD) at the Center. The summit brought together many island and state players in the fight against this fungal disease that is currently attacking and killing 'ōhi'a (*Metrosideros polymorpha*), the most abundant native tree in the state of Hawai'i.



- *The Akaka Foundation for Tropical Forests* visited the Center as a retreat for the board of directors of The Akaka Foundation for Tropical Forests. The day was spent sharing presentations and discussions about Ulu Lehulehu "Million 'Ōhi'a Initiative" which promotes the protection, planting and restoration of 'Ōhi'a Lehua (*Metrosideros polymorpha*), a Hawai'i endemic tree and the monarch of Hawaii's natural world; as well as Rapid 'Ōhi'a Death (ROD) a fungal disease that is currently attacking and killing 'ōhi'a, the most abundant native tree in the state of Hawai'i.
- *Native Hawaiian Student Leadership Conference*, spent the day at the Center



learning about the place, forest health issues, research and science in the HETF, Ceratocystis' impacts on the biocultural importance's of 'ōhi'a. The day was wrapped up with a service project in the Kupua'e 'Ōhi'a Common Garden.

- *USFS and the Ulu Lehulehu Program*, hosted the Laupāhoehoe Community Public Charter School at Kupua'e, the 'Ōhi'a Common Garden. Students spent a portion of their day learning about Kupua'e, current forest health issues, research and science, Ceratocystis and its impacts on the biocultural importance's of 'ōhi'a; helping to clean up the garden, weeding around saplings, repairing weedmat where needed and clearing invasive grass around the garden.



## Climate Data Summary

This section contains available summary data for the HETF climate stations located within the Forest Reserve in Laupāhoehoe and the Forest Bird Sanctuary in Pu'uwa'awa'a and associated with the Hawai'i Permanent Plot Network (HIPNET), <http://www.hippnet.hawaii.edu/>. There were two major storms that occurred during the winter of 2017 in the HETF (Table 3).

### Laupāhoehoe

Table 2: Mean annual rainfall, temperature, and humidity at Laupāhoehoe climate station.

YEAR	Rainfall (mm)	Rainfall (inches)	Temperature (C°)	Relative Humidity (%)
2017	4261	167.8	16.5 ( $\pm 0.4$ )	88.1 ( $\pm 1.6$ )
2016	4613	181.6	16.1 ( $\pm 0.3$ )	90.2 ( $\pm 1.2$ )
2015	5067	199.5	16.7 ( $\pm 0.5$ )	89.2 ( $\pm 1.0$ )
2014	4533	178.5	16.6 ( $\pm 0.4$ )	88.3 ( $\pm 1.0$ )
2013	3458	136.1	15.9 ( $\pm 0.4$ )	86.5 ( $\pm 0.9$ )
Mean	4386 ( $\pm 266$ )	172.7 ( $\pm 6.8$ )	16.4 ( $\pm 0.2$ )	88.5 ( $\pm 0.6$ )

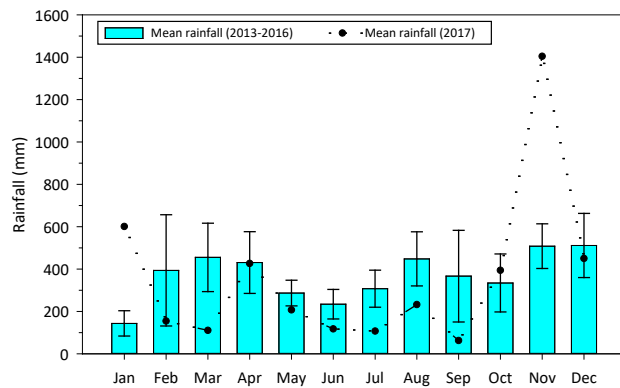


Figure 5: Mean rainfall for 2013-2017 compared to 2017 in Laupāhoehoe.

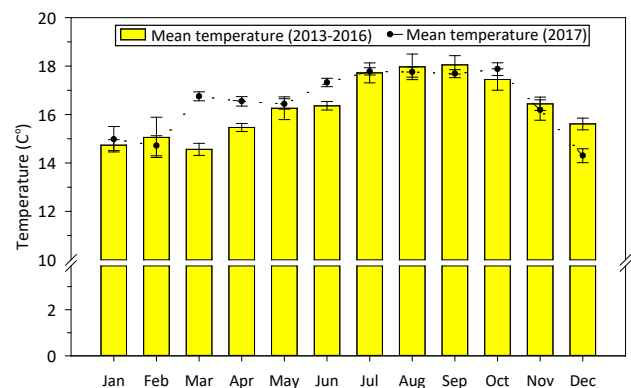


Figure 6: Mean temperature for 2013-2017 compared to 2017 in Laupāhoehoe.

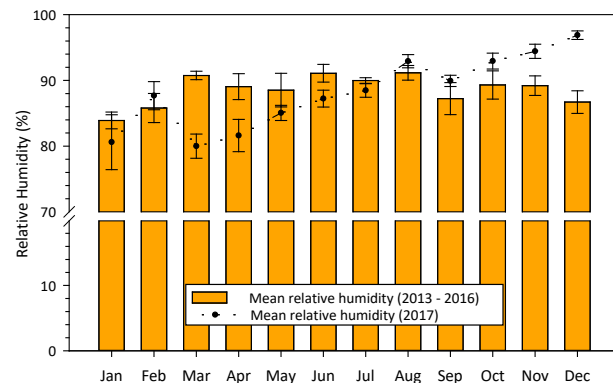


Figure 7: Mean relative humidity for 2013-2017 compared to 2017 in Laupāhoehoe.



## Pu'uwa'awa'a

Table 3: Mean annual rainfall, temperature, and relative humidity at Pu'uwa'awa'a (standard errors in parenthesis).

YEAR	Rainfall (mm)	Rainfall (inches)	Temperature (C°)	Relative Humidity (%)
2017	900	35.4	14.5 ( $\pm 0.3$ )	81.5 ( $\pm 2.4$ )
2016	699	27.5	14.5 ( $\pm 0.4$ )	84.6 ( $\pm 2.0$ )
2015	1531	60.3	14.9 ( $\pm 0.5$ )	83.8 ( $\pm 2.9$ )
2014	815	32.1	14.4 ( $\pm 0.3$ )	84.0 ( $\pm 2.0$ )
2013	477	18.8	13.9 ( $\pm 0.3$ )	83.2 ( $\pm 1.5$ )
Mean	930 ( $\pm 220$ )	34.8 ( $\pm 1.37$ )	14.1 ( $\pm 0.2$ )	83.4 ( $\pm 0.5$ )

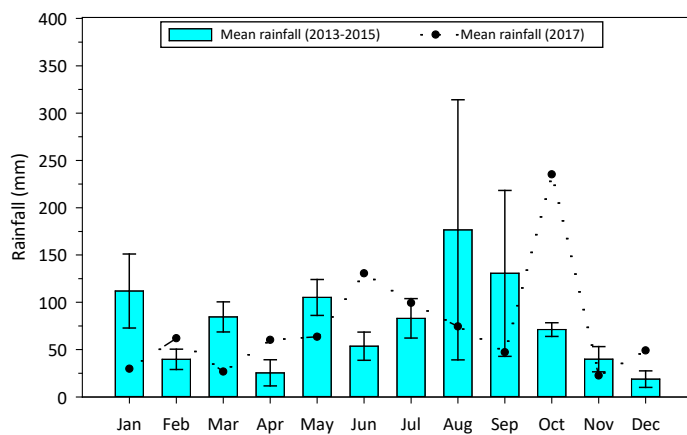


Figure 8: Mean rainfall for 2013-2017 (excluding 2016) compared to 2017 in Pu'uwa'awa'a.

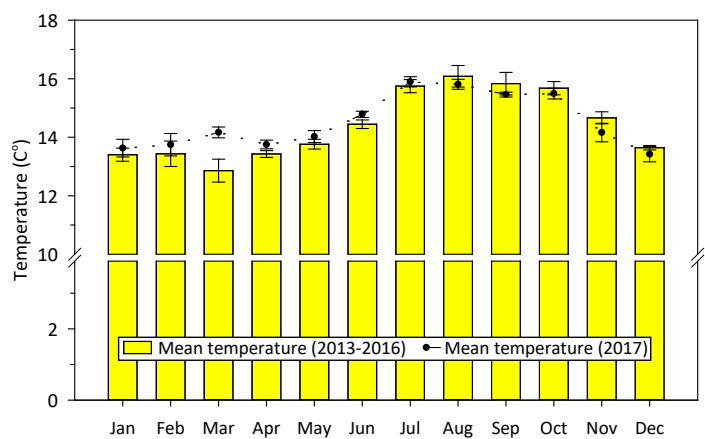


Figure 9: Mean temperature for 2013-2017 compared to 2017 in Pu'uwa'awa'a.

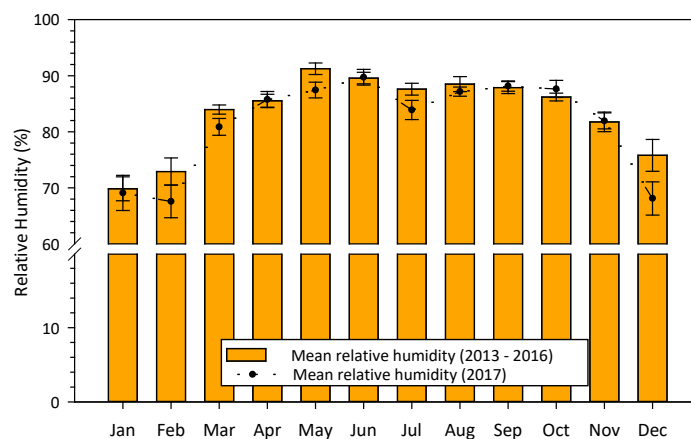


Figure 10: Mean relative humidity for 2013-2017 compared to 2017 in Pu'uwa'awa'a.

## Major storms

### Laupāhoehoe

A month long storm occurred in November 2017. Total rainfall during the period was 1705 mm (67 in) or 57 mm/day (2.2 in/day). This single storm represented 40% of the annual rainfall. There were only 2 days that had no rainfall during the storm. The greatest daily rain fell on 11/24/17 when 302 mm/day (11.9 in/day) was recorded, close behind was rainfall recorded on 11/29/17 when 270 mm/day (10.6 in/day) was collected. The single greatest rainfall reading during the storm was 11.4 mm/10 min (0.4 in/10 min). The greatest 10-minute rainfall reading during the 7-years the climate station has been at Laupāhoehoe occurred on 12/30/13 when 18.3 mm/10 min (0.7 in/10 min) fell.

Table 4: Major storms occurring within the HETF Laupāhoehoe and Pu'uwa'awa'a Units in 2017.

HETF Unit	Storm Dates	Storm Duration (days)	Total RF (mm)	Total RF (inches)	Daily RF (mm/day)	Daily RF (inches/day)	Single Day Max RF (mm/day)	Max RF Intensity (mm/10 min)	Max RF Intensity (mm/hour)
LAU	11/4/17 - 12/3/17	30	1705	67	57	2.2	302	11	27
PWW	10/23/17 - 10/30/17	8	201	7.9	25	0.9	153	24	64

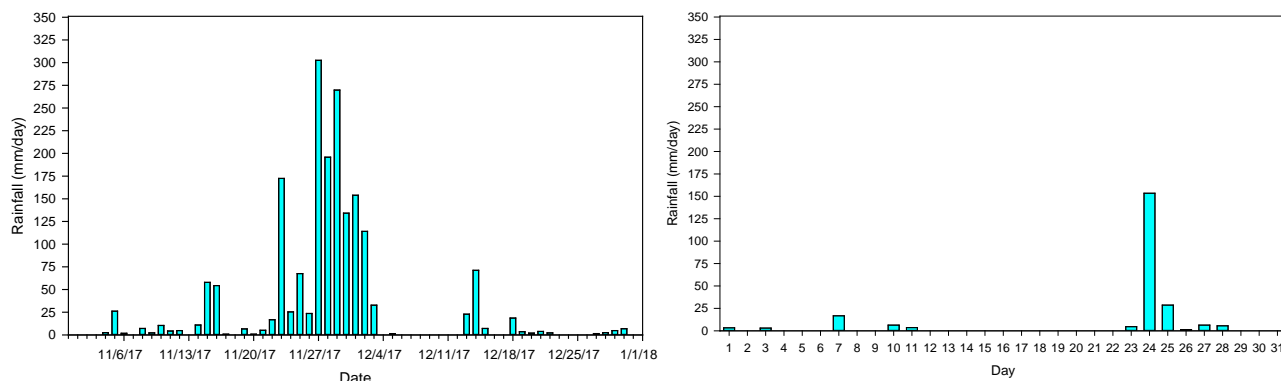


Figure 11: Recorded rainfall in Laupāhoehoe and Pu'uwa'awa'a during storm events.

### Pu'uwa'awa'a

An 8-day storm occurred in October, 2017. During the storm, a total of 201 mm (7.9 in) or 25 mm/day (1.0 in) fell. During this single storm, 22% of the annual rainfall fell. Most of the rain fell on a single day, 10/24/17, when 153 mm/day (6 in/day) was recorded. The single greatest rainfall reading during the storm was 24 mm/10 min (0.9 in/10 min). This is the greatest 10-minute rainfall reading during the 6-years the climate station has been recording data at PWW. The prior maximum rainfall intensity was recorded on 8/14/15, 21.6 mm/10 min (0.8 in/10 min).



## HETF Related Citations

Citations listed below have been submitted since the publication of the 2015 HETF Annual Report through either project annual reports or direct submission. Only published research is listed below. Visit the HETF website <http://www.hetf.us/page/publications/> for a complete list of citations received to date.

### *Submitted with 2016 annual reports:*

Bern, C.R., O.A. Chadwick, C. Kendall, and M.J. Pribil. 2015. Steep spatial gradients of volcanic and marine sulfur in Hawaiian rainfall and ecosystems. *Science of the Total Environment* 514: 250-260.

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Selmants, P.C., Adair, K.L., Litton, C.M., Giardina, C.P., Schwartz, E. 2016. Increases in mean annual temperature do not alter soil bacterial community structure in tropical montane wet forests. *Ecosphere* 7:e01296.

### *Submitted with 2017 annual reports:*

Ritzenthaler, C.A. 2017. The effect of soil micronutrient variation along an elevational gradient in a wet montane forest. MS Thesis. Bowling Green State University, Bowling Green, OH.

Ritzenthaler, C.A., Litton, C.M., Giardina, C.P. and Pelini, S.L. 2016. Soil moisture and millipede abundance are more important drivers of macroinvertebrate diversity than temperature in Hawaiian forest. *Integrative and Comparative Biology* 56: E357.

Selmants, P.C., Adair, K.L., Litton, C.M., Giardina, C.P., Schwartz, E. 2016. Increases in mean annual temperature do not alter soil bacterial community structure in tropical montane wet forests. *Ecosphere* 7:e01296.

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[www.hetf.us](http://www.hetf.us) or <https://www.fs.fed.us/psw/ef/hawaii/>.