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HETF
ANNUAL REPORT 2018

USDA Forest Service

Pacific Southwest Research Station
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HETF
Hawaii
Experimental
Tropical
Forest

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 2018 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 2018 including: Tom Cole, Susan Cordell, Alex Friend, Christian Giardina, Kainana Francisco, 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/).

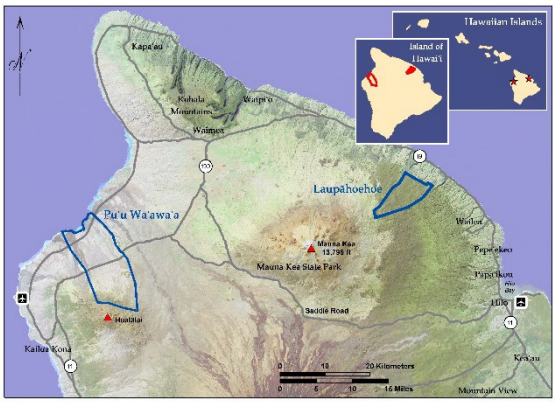


Figure 1: Map of Hawai‘i Island highlighting the Pu‘uwa‘awa‘a and Laupāhoehoe Units of the HETF.

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 2018. 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.

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 lays 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 & Science Lead – **Dr. Susan Cordell**
USFS-*HETF Education Lead* - **Dr. Christian Giardina**
USFS-HETF Facilities Manager - **Jon Mitsuda**
HETF Resource Associate - **Tabetha 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.

Kahikina Learning Center, Laupāhoehoe

Puʻuwaʻawaʻa

In 2018 the facilities planning process has taken a significant directional shift, in that the focus of the efforts will now be to rehabilitate the existing infrastructure (Meeting and Lake houses), owned and operated by the Hawaiʻi State Division of Forestry and Wildlife (DOFAW). Rehabilitation of these existing facilities will greatly benefit all members of the HETF community, providing upgraded, safe, and more useable bunkhouse and meeting facilities.

Conceptual rehabilitation design was completed in September 2018, with a multi-disciplinary group of USFS and DOFAW staff providing input to a USFS - contracted architectural and engineering (A&E) firm. Completion of the final design improvements package is anticipated to be completed in July, 2019. Subsequently, award of the construction contract is planned for September 2019. Construction activities should be complete by mid-2020.

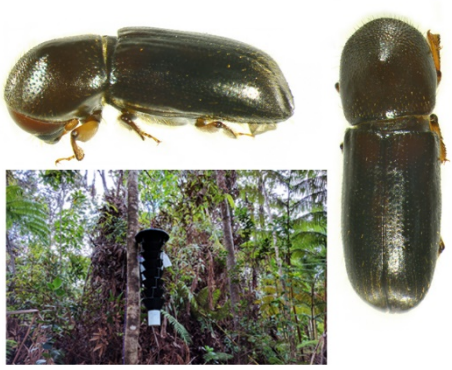
Puʻuwaʻawaʻa Lake House

Puʻuwaʻawaʻa Meeting House

Research Summary

Twelve research applications were submitted and approved in 2018. Eleven projects were initiated (nine renewals and two new), and one project was uninitiated. HETF related journal articles were published in the Coleopterists Bulletin, Science, Global Ecology and Biogeography. A list of publications submitted with annual reports is included at the end of this report. Selected 2018 research projects are highlighted below.

- ***Diversity, distribution, and biology of the native Hawaiian bark beetles (Coleoptera: Scolytinae)*** Dr. Conrad Gillett of the University of Hawaii at Mānoa has found that a total of 6 species of native Hawaiian bark beetles have so far been recorded, including the rediscovery of *Xyleborus pele,* a species which had not been recorded since its description in 1981 (and the last known specimen was collected 89 years ago). Bark beetle surveying through trapping was undertaken in the Laupāhoehoe Unit of the HETF between January 4 and February 15, 2018, and at the Pu'u Wa'awa'a Unit of the HETF between February 5 and April 19, 2018. Four species of native bark beetles in the genus *Xyleborus* were collected at Laupāhoehoe, and 2 species were collected at Pu'u Wa'awa'a. Despite this positive outcome, native *Xyleborus* are far outnumbered by exotic bark beetles. The specimens have been preserved for molecular phylogenetic analyses which will be undertaken during the course of the next year. A manuscript describing the rediscovery of *Xyleborus pele* has been accepted for publication. A manuscript is currently in preparation detailing the survey for native bark beetles on Big Island, including additional sites at Hawaii Volcanoes National Park, with special comparison of the diversity and abundance of native species to those of exotic species.



- ***The genomic and transcriptomic analysis of adults and embryos of Hawaiian Drosophila and Scaptomyza flies*** This study conducted by Joel Atallah of the University of New Orleans, analyzes both genomic DNA and RNA transcripts from the embryos and adults of a range of Hawaiian *Drosophila* and *Scaptomyza* flies from diverse species groups. These species will be collected from within the Laupāhoehoe Unit of the HETF. Researchers will study the transcriptomes of both a very early embryonic stage when RNA is expected to be mostly maternal (embryonic stage 2) and a later stage which will allow us to determine the identities of the first genes to be activated by the zygote. The early stages of Drosophila embryogenesis have been shown to be comparable across diverse species, allowing us to select equivalent stages and compare messenger RNA profiles. Comparisons will be made between the Hawaiian Drosophila transcriptomes from different species with each other and with Scaptomyza, to determine how these lineages have evolved at the genetic level, and to analyze whether the genetic changes we identify are correlated with the diverse morphological adaptations that these flies are famous for. In preliminary work, we have generated transcriptomes for two Hawaiian fly species,

Drosophila grimshawi from the iconic picture-wing clade, and two Hawaiian Scaptomyza species, *Scaptomyza anomala* and *Scaptomyza elmoi*. Our early results suggest that some Hawaiian species may have highly diverged transcriptomes, possibly associated with their exceptional embryonic development.

Joel Atallah from the University of New Orleans, and colleague Don Price from the University of Nevada, Las Vegas with their fly-collecting equipment

Research projects can be restricted to specific State land designations or occur within multiple State land designations. Three of the 12 projects initiated in 2018 were located in the Laupāhoehoe Unit, six occurred within the Pu‘uwa‘awa‘a Unit, and three research projects were conducted in both Units (Table 1). Figure 2 shows the percentage of 2018 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 2014-2018.

Table 1: Total number of research projects initiated in the HETF per year and grouped by Unit from 2014-2018.

Year	Laupāhoehoe Unit Only	Pu‘uwa‘awa‘a Unit Only	Both HETF Units	Total # of Projects Initiated
2018	3 (25%)	6 (50%)	3 (25%)	12
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
Total	**26**	**40**	**20**	**86**

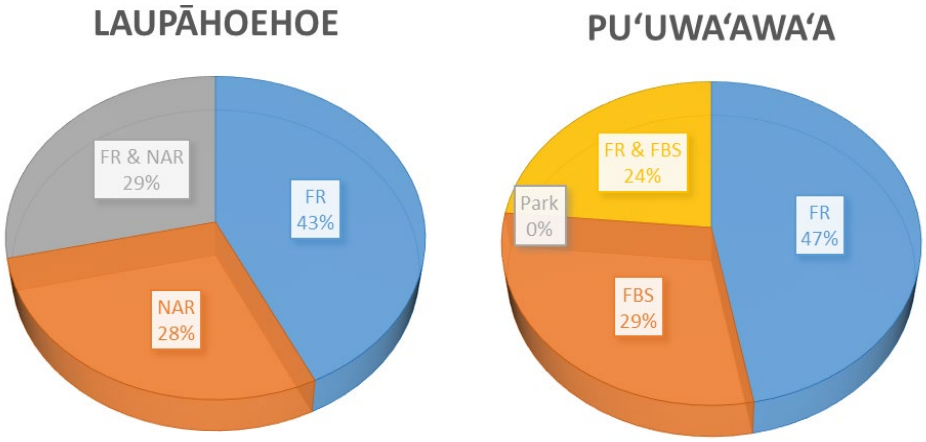


Figure 2: Percentage of HETF research projects grouped by State land designation in 2018. (NAR=Natural Area reserve, FR=Forest Reserve, FBS=Forest Bird Sanctuary)

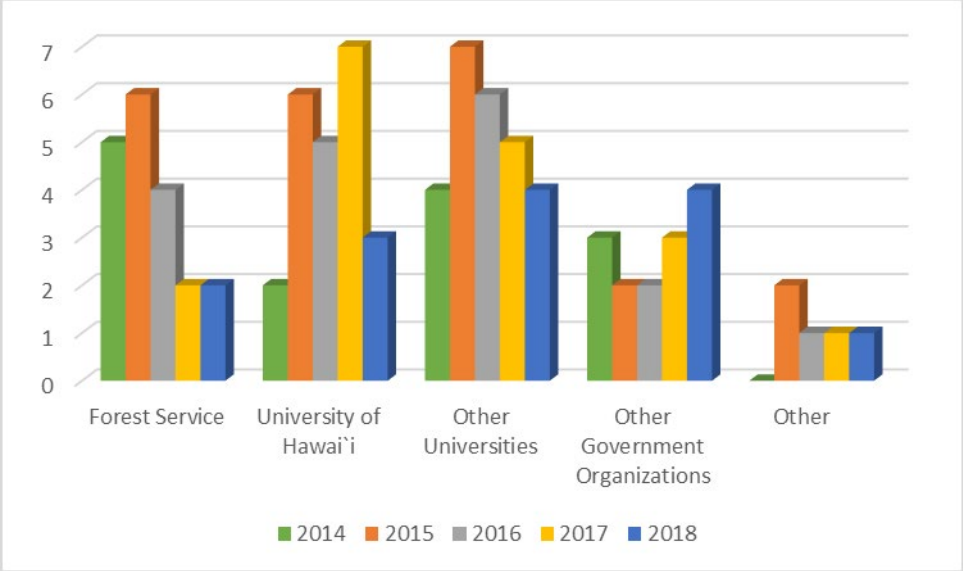


Figure 3: Affiliation for research projects initiated and ongoing within the HETF from 2014-2018.

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.

ʻŌhiʻa Common Garden

The ʻŌhiʻa Common Garden was established in the summer of 2014 in conjunction with the education and outreach program Ulu Lehulehu (The Million ʻŌhiʻa Initiative) whose mission is to connect Hawaiʻi's youth to ʻōhiʻa 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 ʻōhiʻa trees.

The ʻŌhiʻa Common Garden will help answer interesting science questions about how long-term forest fragmentation (>100 years) affects ʻōhiʻa genetics. The trees were all created from cuttings taken from ʻōhiʻa that occur in the center and edge of forest kīpuka, or forest fragments created by lava flows, as well as from ʻōhiʻa 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 ʻōhiʻa 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 ʻōhiʻa and its importance to the health of the forest, participate in service learning opportunities such as outplantings and/or caring for the ʻōhiʻa (weed/grass control), which supports both the research and education efforts of the ʻōhiʻa common garden.

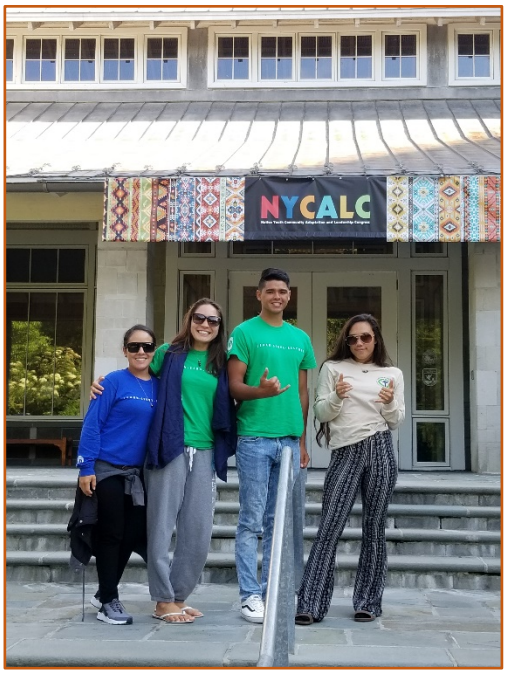
2018 Education, Outreach and Access Activity Summary

This section highlights various non-research program activities, as well as specific Unit education, outreach, and access details that occurred within the HETF in 2018.

Hawaii Youth Conservation Corps (YCC)

Youth Conservation Corps programs in Hawai'i are administered by Kupu, a nonprofit community organization (www.kupuhawaii.org). HETF participates in three Kupu/ AmeriCorps Youth Conservation Corps (YCC) programs: The HYCC Summer Program is a 7-week summer team experience designed for young adults (ages 17-20). Team members complete hands-on fieldwork at various worksites. The Conservation Leadership Development Program (CLDP) Summer experience provides a more in-depth individual 8-week summer experience at a single worksite that best matches the individual's interests. The CLDP, Year Long program offers an intensive entry-level 11-month experience where members assist with projects that 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.

2018 was the seventh year the HETF supported HYCC Summer teams. HYCC Summer program members gained introductory experience in all aspects of natural resource management. In 2018, the HETF hosted one team. This team partnered with an HYCC Kona team, and both teams focused on the Pu'uwa'awa'a Community Forest Program. The teams spent their entire summer stewarding the ahupua'a of Pu'uwa'awa'a, mauka to makai. Activities focused on the community forest fence project, grounds maintenance around the Lake House, Hau'aina Exclosure, and around the reservoir. Fence activities included: clearing the fence line via weed whackers, moving equipment around the Pu'u, pounding and aligning T-post, stretching and clipping fence, inputting fence anchors. Despite not spending as much time fencing as was originally anticipated, and with some help from the Hawaii Volcanoes National Park, Resource Management crew, the HYCC crews succeeded in putting up 1,200 meters of fence in the designated area, about half of the projected fence line was completed.



2018 was the fourth year the USFS/HETF HYCC Summer team attended the Native Youth Community Adaptation and Leadership Congress (NYCALC) in Shepherdstown, West Virginia. This is a week-long conference that discusses 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 2018 USFS team members included: Kawika Fortunato, Kai Smith, Nahe Tachera and ʻAleʻalani Evangelista. Attendance to the conference is sponsored by the USFS.

Ulu Lehulehu - The Million ʻŌhiʻa Initiative

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 (https://akakaforests.org/projects/ululehulehu), AmeriCorps, Kupu, and Laupāhoehoe Community Public Charter School (LCPCS).

Ulu Lehulehu's initiative inspires the next generation of conservationists by working with Hawaiʻi communities to develop and strengthen relationships with and create vibrant landscapes abundant in ʻōhiʻa. 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 Hawaiʻi 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 ʻōhiʻa through four integrative approaches of youth education, community outreach, native forest restoration, and urban forestry.

During the 2017-2018 academic school year the LCPCS 9th 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 ahupuaʻa (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 Hawaiʻi.

Laupāhoehoe Unit

Ninety five participants on 6 trips visited the Laupāhoehoe Unit in 2018. A few of the 2018 HETF education trips to Laupāhoehoe are detailed here.

- *USFS and Ulu Lehulehu staff* hosted Laupāhoehoe Community Public Charter School (LCPCS) 9th grade students at the Laupāhoehoe Unit. Students focused invasive plant removal, such as *Rubus ellipticus* (yellow Himalayan raspberry), *Clidemia hirta* (Koster's curse), and

Hedychium gardnerianum (kahili ginger) from along both sides of Blair Road (approximately 500 meters total), beginning near the climate station and working their way down the road. Aside from the service portion of this trip, staff shared moʻolelo and history of the area and discussed the ongoing research USFS does to help support the protection and conservation of our natural landscapes and resources.

- *University of Hawaii at Mānoa* students and faculty visited the Laupāhoehoe climate tower. Discussion focused on cloud water interception and how such equipment operates. Participants also performed maintenance on the cloud water interception equipment and collected interception data in general.

- *UC Berkeley* student Natalie Graham conducted an arthropod diversity survey along the elevation gradient along Blair Road. Her survey is focused on the biodiversity of native and invasive Hawaiian arthropods.

Puʻuwaʻawaʻa Unit

Five hundred and forty participants on 25 trips visited the Puʻuwaʻawaʻa Unit in 2018. The high number of participants, compared to the Laupāhoehoe Unit, who are able to visit, work, and learn in Puʻuwaʻawaʻa 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 Puʻuwaʻawaʻa Forest Reserve also play an important role in making these trips possible. The continued presence and availability of onsite staff is necessary for Puʻuwaʻawaʻa to be able to continue to support this level of public interaction. A further breakdown of participants in the HETF from 2014-2018 is detailed in Figure 4. A few of the 2018 HETF education trips to Puʻuwaʻawaʻa are detailed here.

- *Johns Hopkins University* graduate students participating in a special trip to Hawaii, visited the Puʻuwaʻawaʻa Unit to discuss restoration of dryland forests, its challenges and successes, restoration experimentation methods, and ahupua'a resource management.

- *Busy Bee Buddies 4-H Club* members having attended the ʻŌhiʻa Seed Collection workshop, spent a day in the dry forest collecting ʻŌhiʻa seeds for the ʻŌhiʻa Seed Bank Initiative.

- *University of Hawaii at Hilo, Geology Department* advanced Volcanology students measured stratigraphic sections of tephra fall in the shallow quarry at the west end of Puʻuwaʻawaʻa trachyte quarry. Students also measured shapes and sizes of pyroclasts, plus the thickness and extent of the layers for the purpose of reconstructing the sequence of volcanic events leading to deposition of beds in this area.

- *2018 Biocultural Blitz* explores Hawaiian dry forest ecology as well as traditional Hawaiian cultural practices. The Institute of Pacific Islands Forestry and Hawaii Experimental Tropical Forest 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 HETF’s 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.

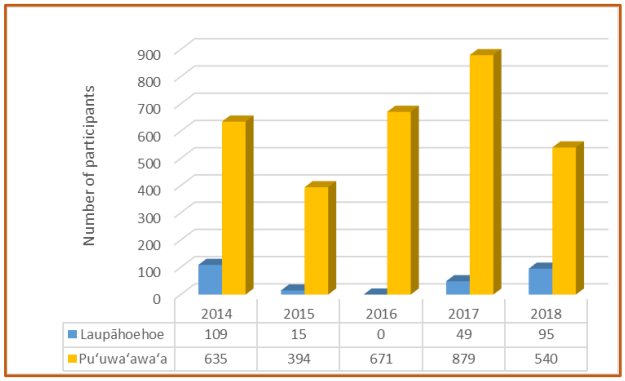


Figure 4: Number of participants to visit the HETF from 2014-2018.

Kahikina Learning Center (Center)

One hundred and twenty seven participants visited the Kahikina Learning Center (Center) on a variety of trips. A few of the 2018 Center activities are detailed here.

- *Kupu Board of Directors* Eighteen participants were part of a Kupu Board of Directors retreat to Laupāhoehoe. Board members and USFS staff met to discuss how the HETF is an integral part of the Kupu-Forest Service relationship. Participants took part in an onsite service project as well as an offsite excursion to the HIPPNET plot within the Laupāhoehoe Unit of the HETF.

- *Mauna Kea Watershed Alliance (MKWA)* along with other signed watershed partners together, including the Institute of Pacific Islands Forestry, spent a week at the Kahikina Learning Center with the American Fencing Association providing technical information and training to partners (fence installation) to restore, conserve, and sustain tropical forests including the Laupāhoehoe Forest. The Mauna Kea Watershed Alliance partners include land management agencies who use fencing to protect native forests, this training adds to the technical abilities of on-the-ground management agencies.

- *Kanu O Ka ʻĀina* students visited Kupuaʻe, the ʻŌhiʻa Common Garden to learn about the place, the work the USFS does there studying ʻōhiʻa, learning about Rapid ʻŌhiʻa Death (where it is and what it is), Ulu Lehulehu (the Million Tree Initiative) and Halau ʻŌhiʻa (a unique professional development opportunity for stewards of the Hawaiʻi landscape). Students also learned about ʻōhiʻa phenology and seed collection methods, and helped to mālama the garden.

- *Salish Group* the USFS hosted the Salish Group at Kupuaʻe (the ʻŌhiʻa Common Garden) where they spent the day learning about the research being done that helps to support the protection and conservation of Hawaiʻi's natural landscapes and resources.

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 (HIPPNET), http://www.hippnet.hawaii.edu/.

Laupāhoehoe

Mean annual rainfall, temperature, and relative humidity at Laupāhoehoe, 2014 – 2018 (standard errors in parenthesis).

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

YEAR	Rainfall (mm)	Rainfall (inches)	Temperature (C°)	Relative Humidity (%)
2018	5226	206	15.5 (±0.6)	90.9 (±1.3)
2017	4261	168	16.5 (±0.4)	88.1 (±1.6)
2016	4613	182	16.1 (±0.3)	90.3 (±1.2)
2015	5067	199	16.7 (±0.5)	89.2 (±1.0)
2014	4533	178	16.6 (±0.4)	88.3 (±1.0)
Mean	4740 (±178)	186 (±7)	16.3 (±0.2)	89.4 (±0.5)

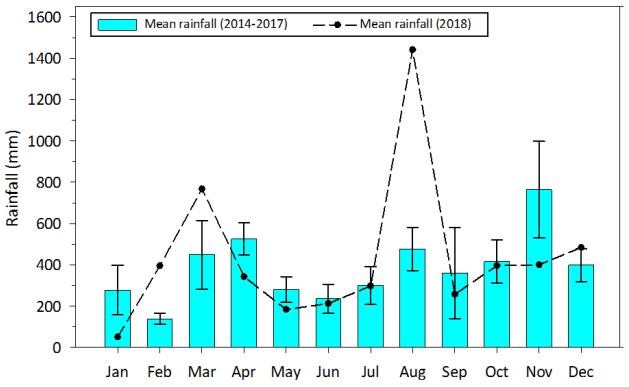


Figure 5: Mean rainfall for 2014-2017 compared to 2018 in Laupāhoehoe.

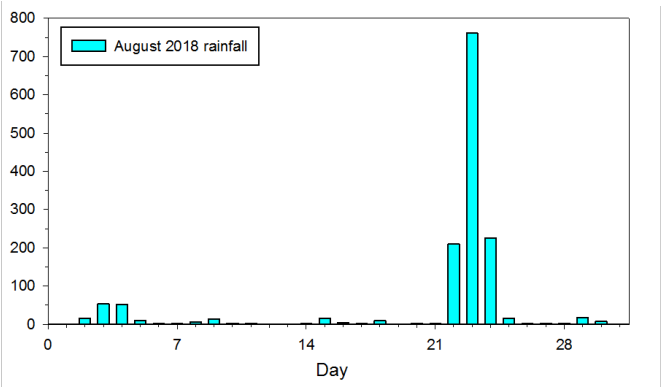


Figure 6: Storm event - August 2018 rainfall during Hurricane Lane. The 761 mm that fell on Aug 23 is the largest single day amount that we have recorded since 2011.

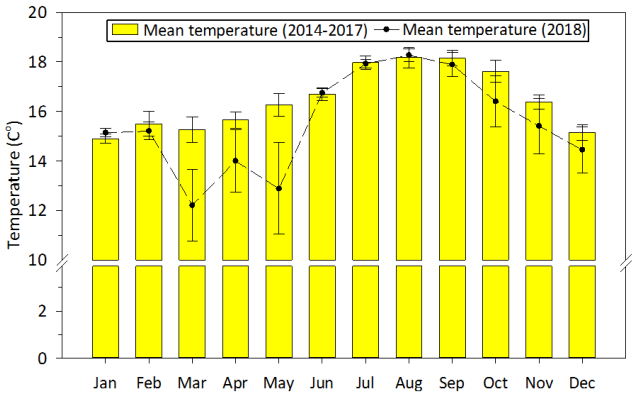


Figure 7: Mean temperature for 2014-2017 compared to 2018 in Laupāhoehoe.

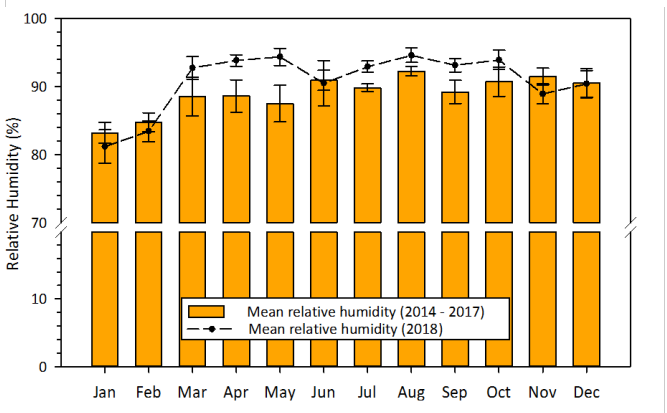


Figure 8: Mean relative humidity for 2014-2017 compared to 2018 in Laupāhoehoe.

Pu‘uwa‘awa‘a

Mean annual rainfall, temperature, and relative humidity at PWW (standard errors in parenthesis). Rainfall mean is for 2014-2018, excluding 2016*.

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 (%)
2018	1365	53.7	14.2 (±0.7)	80.6 (±2.5)
2017	900	34.5	14.5 (±0.3)	81.5 (±2.4)
2016	699*	27.5	14.5 (±0.4)	84.6 (±2.0)
2015	1531	60.3	14.9 (±0.5)	83.8 (±2.9)
2014	815	32	14.4 (±0.3)	83.9 (±2.0)
Mean	1153 (±175)	45.4 (±6.9)	14.5 (±0.1)	82.9 (±0.8)

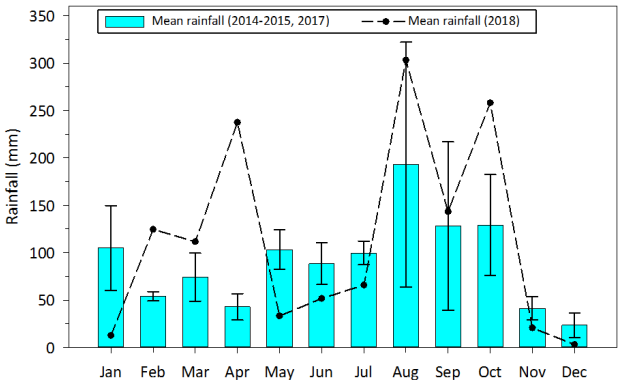


Figure 9: Mean rainfall for 2014-2017 (excluding 2016) compared with 2018 in Pu‘uwa‘awa‘a.

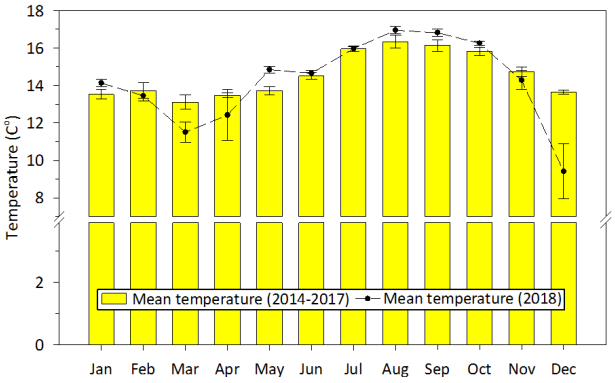


Figure 10: Mean temperature for 2014-2017 compared to 2018 in Pu‘uwa‘awa‘a.

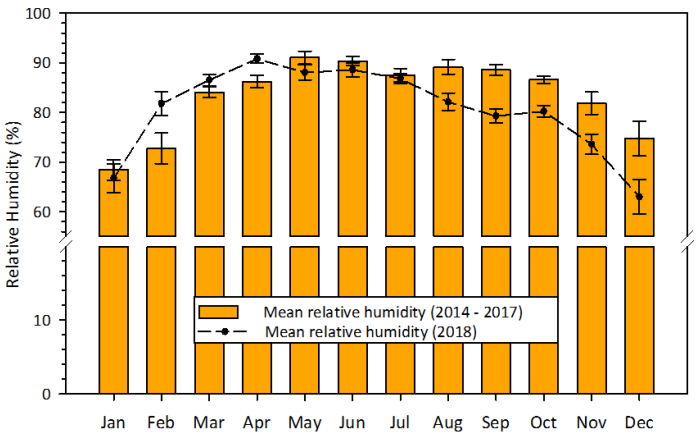


Figure 11: Mean relative humidity for 2014-2017 compared to 2018 in Pu‘uwa‘awa‘a.

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Submitted with 2018 annual reports:

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