Final Project Report

Pacific Islands Climate Science Adaptation Center

Determining effectiveness of high-elevation habitat restoration efforts for Palila, an endangered honeycreeper: increasing resilience to climate change impacts

Project Team:

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Project summary:

The Palila (*Loxioides bailleui*) is a federally endangered Hawaiian honeycreeper currently restricted to subalpine forests dominated by māmane (*Sophora chrysophylla*) and Naio (*Myoporum sandwicense*) on Maunakea, Hawaii. Around 1,000 individuals were estimated in the last population survey in 2018 (Genz et al. 2018). The species is threatened by habitat modification from feral ungulates, invasive predators, impacts of drought on native forest cover and food availability, and avian diseases spread by mosquitoes (Banko et al 2013). Climate change is predicted to exacerbate drought impacts on Palila habitat, increase fire risk, and increase the threat of mosquito-borne disease due to rising temperatures allow mosquitoes to persist at higher elevations.

Habitat restoration for Palila has occurred at the Ka’ohe and Pu’u Mali Restoration Areas on the western and northern slopes of Maunakea respectively, for the past few decades. In the mid 1980s, outplanting was also carried out at high-elevation (~10,000 feet) sites on the western slope of Maunakea. More recently, these high-elevation sites have been targeted for additional outplanting in anticipation of climate change impacts on the survival of the population at lower elevations. This project measures and evaluate the growth rates and survival of māmane outplantings at these high elevation sites so that this information may be used to better inform current restoration efforts. This includes 1) estimating the amount of time necessary for the establishment of a viable māmane population that provides resources for Palila in the project area and 2) determining the mortality rate of māmane that have been outplanted in the past in order to provide information on the number of seedlings needed per acre for continued restoration efforts.

Project goals, methods and summary of empirical findings

The goals of this project are to provide critical information on the growth and survival rates of māmane that were out planted in the mid-1980’s and 2015-2018 in high elevation habitat on Maunakea. This information will be used to produce guidelines to optimize current planting techniques, and to provide information on the effectiveness of plantings in providing native bird habitat. We hypothesized that there would be an effect of planting location (plot) on the growth rate and mortality of outplanted māmane individuals. In addition, we began an experimental evaluation of the use of “frost guards” to reduce mortality of newly planted seedlings with the goal of optimizing out-planting efforts.

The method of data collection were relatively straightforward and included a Garmin GPS, measuring sticks that were marked off every 10 centimeters with blue tape and every meter with red for measuring height, DBH tape, blue flagging tape, and aluminum tags with numbers corresponding to GPS points. These tags were secured to trees with 1 inch nails and a claw hammer. A sickle was often needed to cut away overgrown grass/weeds.

Outplanted māmane plots were located above approximately 2700m elevation on the west side of Maunakea with GIS and Google Earth imagery (Fig. 1). The corners of each plot were located on the ground with the GPS and tagged with flagging. These corners and perimeter were used to find the total area of each plot, then combined to determine the total area of all plots. Transects were created through each plot and trees were measured at stations separated by either 20 or 50 meters along each transect, depending on tree density within the plot. Each tree was then measured for diameter at breast height (DBH) of each trunk (these trees often have multiple trunks extending from the base).

In order to calculate the DBH of trees with multiple trunks, we calculated the basal area (BA) of each branch using the equation BA = □(r^2), summed the BA's for all branches, then computed a single DBH from the sum of BA's using the formula DBH = 2(√(BA/□)). Based on the best available information, we assumed that all plots were planted from 1985-1987 by the Sierra Club and other volunteer organizations under the direction of DOFAW. In order to calculate annual growth rates we made the conservative assumption that trees were planted in 1985 and had a diameter of 1cm when planted. Growth rate of each individual tree was calculated as current (DBH-1)/34 years. Percent mortality of māmane outplantings was estimated

from only two plots (Plots 4 and 5) in which the trees were planted uniformly. We used Google Earth Pro to count the number of live trees vs. missing trees in each of these plots.

Plot boundary location points were uploaded to ArcGIS and polygons were made corresponding to each plot. Plot area was determined through GIS and then recorded along with tree measurements in Microsoft Excel. Plot slope, elevation, and substrate type were recorded as a "plot profile" (Table 1). Data was collected and saved to the MKFRP desktop and also uploaded to Google Drive so that multiple copies exist and documents saved to Google Drive will be shareable to other Google accounts. ArcGIS data is saved to the program and in the GPS.

Table 1. Characteristics of the nine plots used in the current study

Plot Number	**Plot Slope**	**Plot Elevation (m)**	**Substrate Type**
1	1.2%	3,083	Rock/Cinder
2	1.2%	3,071	Rock/Cinder
3	8.1%	2,959	Rock/Cinder
4	10.1%	3,083	Rock/Cinder
5	16.6%	2,953	Rock/Cinder
6	28.8%	3,041	Rock/Cinder
7	36.4%	3,067	Rock/Cinder

8	22%	3,110	Rock/Cinder
11	36.1%	3,122	Cinder/Rock

Summary of Findings

A total of 1095 trees were measured in nine plots. The mean DBH for all trees combined was 20.48cm but this varied by plot as shown below:

	Mean ± SD
Plot1	30.09 ± 15.6
Plot2	25.28 ± 16.9
Plot3	10.68 ± 2.42
Plot4	16.55 ± 11.15
Plot5	21.69 ± 13.5
Plot6	26.02 ± 19.6
Plot7	21.80 ± 9.87
Plot8	14.19 ± 8.44
Plot11	18.05 ± 11.6

A One-Way Anova demonstrated there is a significant difference in DBH between plots ($F=4.6$, $df = 8,220$, $P<0.001$). A Tukey's post-hoc test showed that Plot 1 is significantly different than plots 3,4,8, 11 and Plot 2 is significantly different than plot 3 and 8 (Fig. 2). The mean annual growth rate for all trees combined was 0.58cm/year (range = 0.40-0.85 per plot). The overall mortality for trees in Plots 4 and 5 was 17/144 and 15/120 (11.8% and 12.5% respectively).

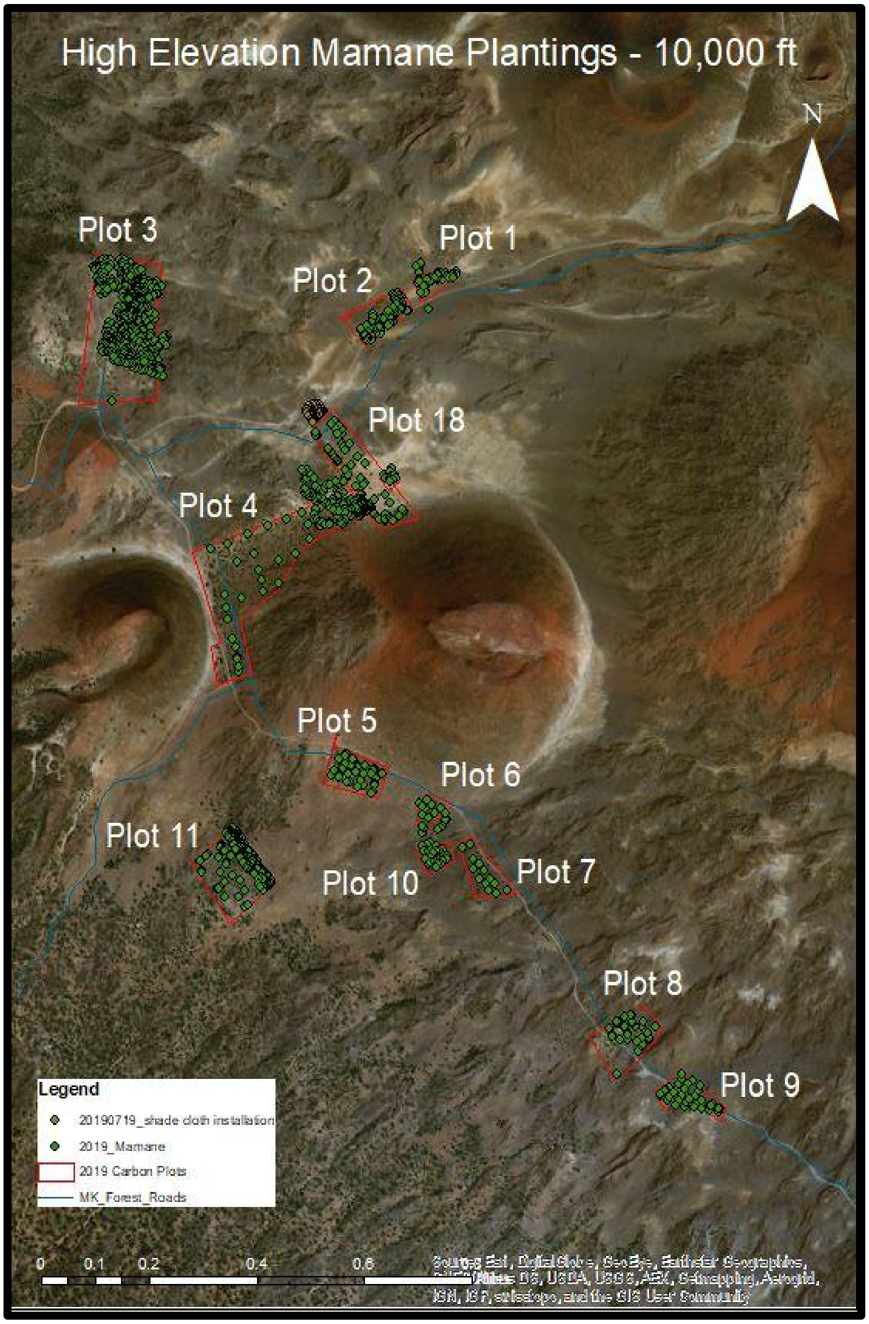


Figure 1. Location of plots on west side of Maunakea

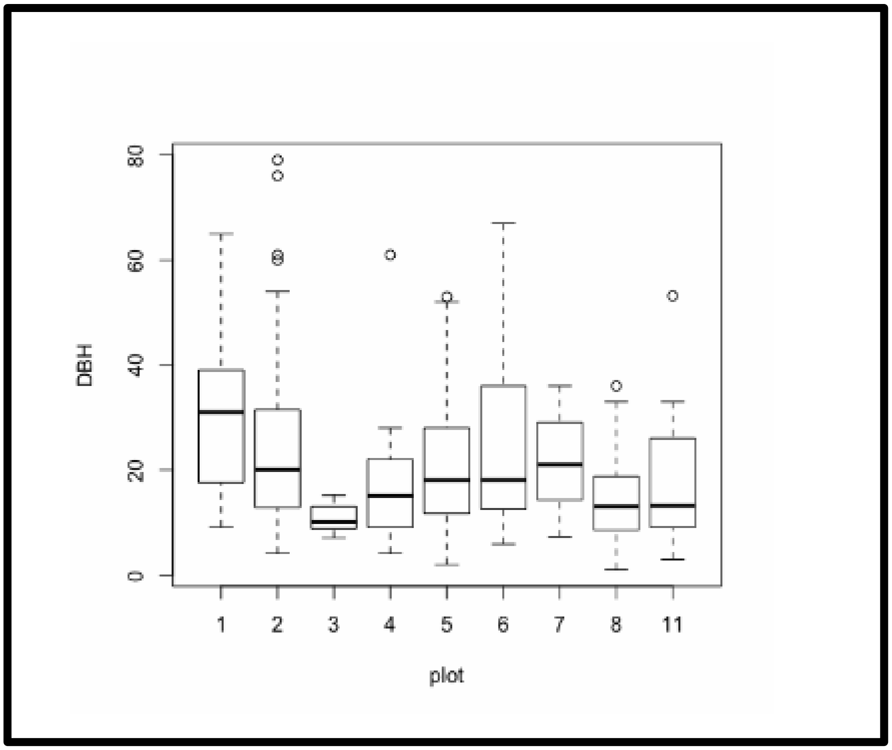


Figure 2. Median, Q1, and Q3 growth rate for each of the plots measured.

Collaborative elements.

Collaboration in this project was very important in this every stage of this project, between working with the Maunakea Forest Restoration team, Kalā Asing, Joe Kern, Jeremy Uowolo, Emily Long, the PIPES interns, Nahi Pilago and Amberly Pigao, researchers from UH Hilo, Patrick Hart, Scott Laursen, Sharon Ziegler-Chong, and Jim Juvik who has historically worked in the area. Working with the field team and PIPES allowed for larger portions of sampling to have been done, which greatly reduced the amount of time spent in each plot. Being able to work with UH Hilo researchers was key in gathering historical information about past works in the area, communication with past researchers and managing data. Providing this information will lay a foundation to other high elevation plantings, carbon sequestration efforts, native bird habitat and other possibilities through data collection, and creation of native species habitat.

Overall project conclusions.

This project provides critical information on the growth and mortality of māmane trees at high elevations on Maunakea that will be highly useful to ongoing restoration efforts. Data taken from the diameters of the trees shows that the growth rates are similar, but with minor differences among plots. For example, trees in Plots 1 and 2 had slightly higher growth rates than trees from most other plots. Interestingly, while all plots are on similar rocky-cinder substrate, the slope of these plots is noticeably less than other plots (Table 1). This indicates that managers may want to consider the slope of a plot when searching for future areas to plant trees. Although the trees in varying plots may have similar heights and diameters, there were a few trees that were significantly larger in both height and diameter, which may be due to differences at the microhabitat scale. Finally, the mortality for the trees in Plots 4 and 5 was unexpectedly low for outplantings in such a harsh environment. It is possible that this low mortality is an underestimate for the area as a whole, as the trees in the other plots were not planted as uniformly, so estimates were not produced for those plots. Overall, our finding of relatively high growth rates and low mortality for previously outplanted māmane trees demonstrates great potential for ongoing outplanting efforts to successfully provide habitat for Palila in the future. The higher elevation plantings will also provide habitat and resources for other native birds, as global warming continues and disease carrying mosquitoes increase in elevation.

Manager deliverables.

Now that the project has been completed, next steps include:

- Determine how future planting areas differ and what kind of impact these differences have on the tree survival growth rates
- how do trees planted at lower elevations grow compared to the high elevation plantings?
- how can more high elevation plantings help to sequester carbon?
- how can future plantings be made to be more efficient and successful.

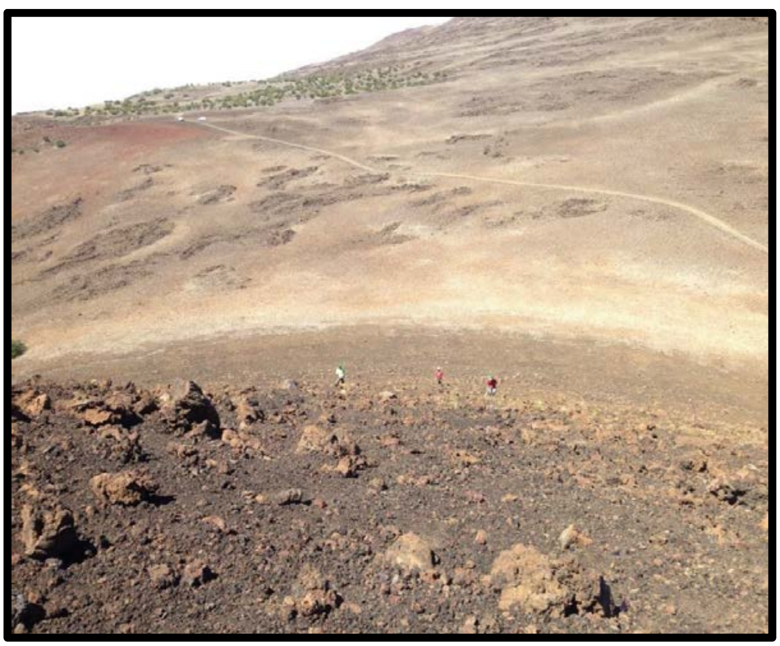
All data compiled will be used in future plantings and kept as a record to track growth in the future, possibly for use as Palila forage and seed stock since so many of the trees have done well in the high elevation plots.

Another part of the project included the installation of frost guards on newly planted māmane, in a block of 100 trees, 50 frost guards were installed at every other tree to see how it may or may not affect the growth of the seedlings. These trees will be monitored at the same rate as current outplanting monitoring occurs: 6 months, 1 year, 3 years and 5 years.

Presentations.

-W. Julian Jr., High Elevation Māmane Monitoring. Hawaii Ecosystems Vitousek Talks, Hilo, HI (July 2019)

-N. Pilago, PIPES Summer Internship Symposium, Hilo, HI (August 2019)



Above photos- views of high elevation plots where the current study took place

<u>Final list of collaborators</u>.

-Dr. Patrick Hart, Department of Biology, UH-Hilo

-Chauncey Asing, Mauna Kea Forest Restoration Project Coordinator, Pacific Cooperative

Studies Unit

-Dr. Lainie Berry, Forest Bird Recovery Coordinator, Hawaii Division of Forestry and Wildlife

Literature cited

Banko, P.C., R.J. Camp, C. Farmer, K.W. Brinck, D.L. Leonard, and R.M. Stephens. 2013. Response of palila and other subalpine Hawaiian forest bird species to prolonged drought and habitat degradation by feral ungulates. Biological Conservation 157:70-77.

Genz, A.S., K.W. Brinck, and R.J. Camp. 2018. 2017-2018 Palila abundance estimates and trend. Technical Report HCSU-086. University of Hawaii at Hilo.