

HOW USEFUL IS LiDAR IN ESTABLISHING A STREAM GAUGING NETWORK IN A TROPICAL EXPERIMENTAL FOREST

Boris Poff,¹ Daniel G. Neary,¹ and Gregory P. Asner²

In the late summer of 2007 the Institute for Pacific Islands Forestry (IPIF), which is part of the US Forest Service Pacific Southwestern Research Station, asked the USFS Rocky Mountain Research Station's (RMRS) Air, Water and Aquatic Program's (AWA) Southwest Watershed Science Team for assistance in the establishing baseline data in the initial phase of a long term research project in the newly established Hawaiian Experimental Forest. RMRS and its predecessors have a history of the long standing watershed related research in the southwestern United States which was established experimental watersheds on volcanic rock over 50 years ago. Both systems, in Hawaii and Arizona, have mostly washes that have flashy precipitation events driven flows. Funding availability, personnel shortages and other ongoing collaborative projects between experimental forests of the research branches of the U.S. Forest Service facilitated the joint effort in this project.

STUDY SITE

The 12,343-acre Laupahoehoe Unit of the Hawaii Experimental Tropical Forest (HETF) is located in North Hilo on the Isle of Hawaii and was formally established on state land on March 23, 2007. It is one of two experimental forests in the HETF network (Figure 1).

Located upslope of former sugarcane lands, the site also contains timber plantations, degraded pastures and numerous streams. Its location and size make it an ideal global location for global climate change research studies of native forest restoration, invasive species control, and watershed management. The Laupahoehoe unit contains five streams, of which only two are perennial and contain aquatic organisms.

Three streams have cut their stream beds through 65,000 year old rock formations, while the other channels exist on newer bedrock, which formed between 4,000 and 65,000 years ago. All channels are located in Akaka soils generic class, with the exception of the Kaawalii stream, which is located on Honokaa soils.

RESEARCH NEEDS

None of the stream channels in the HETF had previously been surveyed. Since its recent designation as an experimental forest, it became prudent to properly inventory, classify and survey the streams channels in the HETF. These activities are also necessary to select possible locations for stream gauging stations along those channels. While certain criteria for a stream gauge location can be evaluated using a GIS, such as proximity to roads, forest boundaries etc. other criteria, such as channel morphology still needs to be evaluated in the field. The first stream selected to be surveyed was the Kaawalii Stream in the Wet Forest vegetation zone of the HETF. This is one of five streams on Laupahoehoe Unit and is the number one priority for future research efforts, mostly due to its accessibility and proximity to one of the few roads in the HETF.

The first 2 km reach of the Kaawalii Stream fall within the Experimental Forest. The objective of this study is to complete a Kaawalii Stream baseline geomorphic survey and add one experimental gauged watershed to the EF. Gathered data will be used for future studies of the effects of climate change on hydrology channel substrates, aquatic organisms, and coarse woody debris. Required work consists of the establishment of cross-section, GPS monumenting, photo documentation, channel classification, geologic substrate, and pebble counts. This includes running level surveys of the cross-sections to provide a baseline of channel conditions, and ground-truth data for the LiDAR survey, establishing of coarse woody debris status in the streams and conducting baseline aquatic organism surveys. Location of the Laupahoehoe

¹Rocky Mountain Research Station, US Forest Service, Flagstaff, Arizona

²Carnegie Institution, Stanford University, Palo Alto, California

Experimental Forest in the Hawaii Experimental Tropical Forest as shown in figure 1.

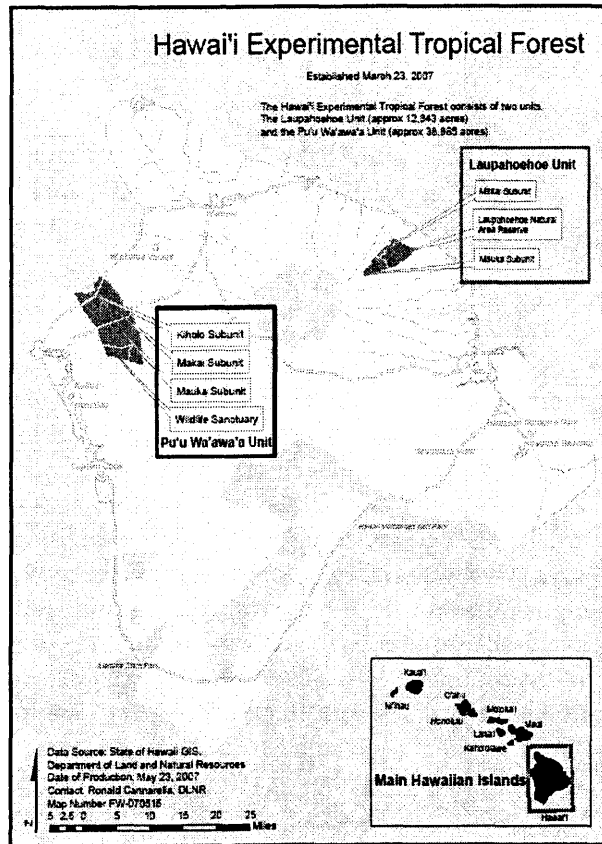


Figure 1. The Laupahoehoe Experimental Forest in the Hawaii Experimental Tropical Forest.

METHODS

The methods used in this study consist of a LiDAR mission flown over the HETF and field work conducted by a survey crew in the Kaawalii stream channel. Both projects were carried out in 2007.

LiDAR

In the summer of 2007, the Carnegie Airborne Observatory (CAO) LiDAR was flown at 2000 m a.g.l., at 50 khz pulse repetition rate, which resulted in 1.0 m spacing between laser spot centers. The resolution of each laser spot was 1.2 m. Maximum scan angle was limited to 18 degrees off-nadir.

Field Methods

The lower 900 m of the 2 km reach of the Kaawalii Stream within the HETF were surveyed during the last week of September 2007. Cross-sections were established at randomly pre-selected locations on successive 100 m segments of the stream. The cross-sections were permanently monumented, photo-documented, located with GPS coordinates, channel-typed using the Rosgen method, and measured for substrate composition using the pebble-count method. These cross-sections constitute ground-truth data for a LiDAR database being constructed for the HETF.

DISCUSSION OF METHOD

While the CAO LiDAR was intended to specialize in vegetation, it can also identify hidden geomorphologic features in the landscape. The CAO scan indicates a series of depressions-water catchments and channels on the forest floor. These features have not been documented to this extent and detail as a whole. The CAO covers a large area and provides levels of detail beyond what can be achieved on foot, but the question is: Can it be used in establishing a stream gauging network and determining other channel characteristics? The simple answer is no. The LiDAR output is helpful in identifying the main stream channels on the map and displaying major geomorphic features such as waterfalls and channel junctions. However, field work is still necessary to identify geomorphic features that are required to establish a stream gauge.

These include classifying the substrate, channel classification, substrate size range, slope, and degree of entrenchment. Some stream characteristics, such as sinuosity can be determined by LiDAR. The CAO data can be helpful in planning the field work, determining access points, channel paths, major channel alterations etc., but it can not serve as a replacement for the actual field work. Aside from its use in planning for stream gauging activities, the LiDAR could be more useful if collected at higher spatial resolution (e.g. < 1 m), which can easily be accomplished by flying the system at lower altitude. For the current data set, the LiDAR was flown at high altitude (12,000 ' m.s.l.) to cover the entire 4,995 hectare reserve in a few hours.

Future work is proposed for the 2008 Fiscal Year to complete the Kaawalii stream survey (including level surveys, cross-section establishment, GPS monumenting, photo documentation, channel classification, geologic substrates, pebble counts, coarse woody debris status) and complete one additional stream survey within the HETF, which also includes a baseline aquatic organism survey for the perennial stream.

ACKNOWLEDGMENTS

The Carnegie Airborne Observatory (CAO) is funded by the W.M. Keck Foundation, William Hearst III, and the endowment of the Carnegie Institution for Science.