Liko Nā Pilina: Developing Hybrid Ecosystems that Enhance Carbon Storage, Native Biodiversity, & Human Mobility in Lowland Hawaiian Forests

April 2016

Problem Statement

Natural ecosystems worldwide are becoming homogenized by the introduction and establishment of non-native species. This breakdown of biogeographic barriers is unprecedented in Earth's history. In some systems, like Hawaiian Lowland Wet Forest (HLWF; Fig. 1), invasion is so pervasive that we cannot go back to all native ecosystems, either economically or practically. However, some non-native species may be playing important roles in the community in terms of providing ecosystem goods and services. We are evaluating a set of **hybrid ecosystems**, in which a mix of native and non-native species (chosen on the basis of plant functional traits) maintains valuable forest structure and ecosystems services.

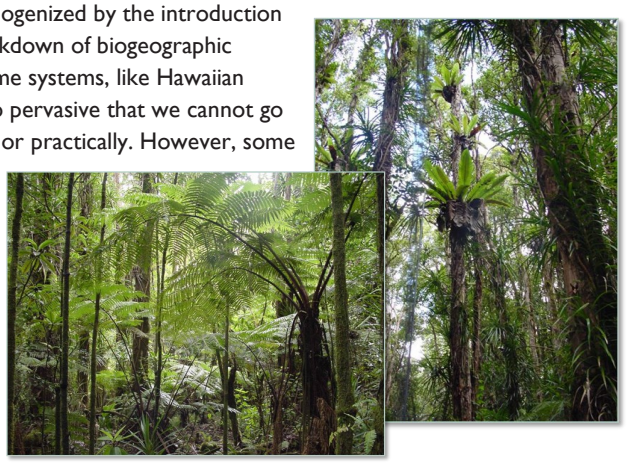

Fig. 1. *The understory (left) and canopy (right) of a Hawaiian Lowland Forest*

Research Objectives

- Measure the functional traits of HLWF species across a broad variety of HLWF environments.
- Develop a quantifiable and broadly applicable, trait-based approach for species choice in restoration.
- To restore invaded lowland forest in accordance with the land managers priorities. Specifically: carbon sequestration, invasive species management, maintaining a relatively open forest understory, and encouraging the regeneration of native species.

Liko Nā Pilina: Growing New Partnerships

Loosely translated, 'liko nā pilina' means "growing new partnerships" in the Hawaiian language. We chose this name for the project because our goal is to create novel communities to restore degraded Hawaiian lowland wet forest, using both native and non-invasive, non-native species. Developing new relationships in our community is also an important component of the Liko nā Pilina project. The project has provided volunteer and demonstration activities for local schools and youth programs including students from middle school, high school, and colleges. (Fig. 2). Our project has hosted undergraduate student interns from the University of Hawai'i at Hilo's Pacific Internship Programs for Exploring Science (PIPES), the Hawai'i Community College Forest Team, Stanford University, and the USDA Forest Service International Volunteer Program (Fig. 3). The experimental set up has offered local students a chance to participate in long term restoration, and to learn about the day-to-day realities of carrying out science and conservation in a LWF.

Fig. 2. *Project field crew and Semester at Sea class*

Fig. 3. *Undergraduate interns from Germany from the USDA Forest Service International Volunteer Program*

Research Collaborators

- University of Hawai'i at Hilo
- USDA Forest Service
- Stanford University

Funding and Support

- US Department of Defense, Strategic Environmental Research and Development Program
- Hawai'i Army National Guard Environmental Office, Keaukaha Military Reservation

Creating novel plant communities

An experimental plot with plantings of both native and non-native species.

Pacific Southwest Research Station

Designing Hybrid Ecosystems

Most of the non-native species included in our plots are 'canoe plants.' These species (like the breadfruit pictured above) were brought to Hawai'i by the first Polynesian explorers, and still have cultural importance in present-day Hawai'i.

Approach

Our goal is to relate the functional traits of species to the dynamics of the communities and ecosystems they make up, and ultimately to the ecosystem services they support. The first phase of our project involved collecting functional trait data from across 20 LWF sites across the windward side of the Island of Hawai'i, and then use this species-level information to assemble hybrid ecosystems with novel species combinations of both native and non-native species. The second phase of the project involves disassembling an existing forest community (by removing all non-native species, Fig. 4) and then building our experimental communities (Fig. 5) at the Hawai'i Army National Guard Keaukaha Military Reservation (KMR) (Fig. 6).

Fig. 4. *Disassembling a forest community - project staff removing the invasive species from the forest*

Fig. 5. *Building experimental communities - project crew planting a breadfruit tree*

Fig. 6. *The Island of Hawai'i, and the location of our experimental plots at KMR*

Unique ecosystems: Cyrtandra nanawalensis is a lowland wet forest specialist and was recently added to the endangered species list by the US Fish and Wildlife Service.

Plant Traits and Ecosystem Function

Species choice for restoration is often difficult and based on limited scientific information. Functional traits, such as leaf size (Fig. 7), are the characteristics of species which influence their growth, reproduction, and survival. It has been well established that plant traits vary among species and environments in predictable ways, so using functional trait information allows us to make species choices for restoration based on predictions of species performance. Because traits reflect species' resource-use we can use trait information to build model communities with desired ecosystem functions.

Fig. 7. *Leaf size, shape and chemistry are all easily quantifiable. These plant traits offer insights into the life-histories and ecological strategies of plant species.*

We collected data on the following functional traits for our candidate species: leaf area, leaf thickness, petiole length, photosynthetic rate, quantum efficiency, leaf nitrogen (N), carbon (C) and phosphorus (P), wood specific gravity, water use efficiency (WUE), maximum plant height, canopy structure, seed mass, altitudinal range (as a proxy for ability to withstand climate change) and potential risk of becoming invasive (using established Weed Risk Assessments for Hawai'i).

REST: Restoring Ecosystem Services Tool

We developed a web-based, functional trait decision making tool for species choice for restoring ecosystem services, REST.

What It Is:

- Computer analysis software to assist managers in selecting restoration species based on their functional traits (Fig. 8).
- Contains data for over 35,000 species while users can enter their own species and functional traits.
- Performs principal components analysis (PCA) to show users the relationships between potential species choice (Fig. 9).
- Standardizes functional trait data – allows comparison of seemingly unrelated traits related to different outcomes.
- Provides a visual for managers to use in ecosystem management decision making – REST helps you make the call.
- Regular program, trait data, and user guide updates.
- Student-developed, open-sourced, free to download.

Restoring Ecosystem Services Tool

Fig. 8. *REST workshop with Hawai'i land managers*

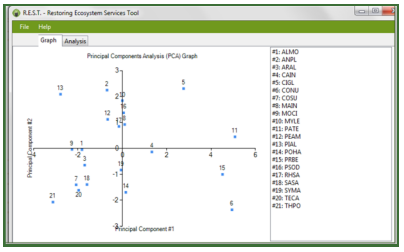

Fig. 9. *REST User interface showing visual results from the functional trait PCA analysis*

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