Recommendations for Community-Based Albizia Removal and Streamside Restoration in Hawai‘i

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Abstract

Climate change is increasing the intensity and frequency of storms globally, and degraded watersheds fail to protect human infrastructure from these storms. Watershed degradation is exacerbated by non-native plant invasions, necessitating the removal of problematic species and the restoration of watersheds. Albizia (*Falcataria moluccana)* is an invasive and hazardous tree that is the fastest growing species found in Hawai‘i, growing up to 5m a year. This proposed project will provide recommendations on: (*i*) the removal of Albizia along stream sides; and (*ii*) post-removal streamside ecological restoration. The recommendations will be combined into a publicly-accessible guide that will advise community-based invasive species removal and ecological restoration, and will be applicable across the Asia-Pacific Region. The information collected by this project will be applied at a pilot site located on the island of Kaua‘i known as Kalihiwai. Recommendations will be created by synthesizing information from a literature review of available resources (e.g., peer review documents, websites, management plans) on the subject. In addition, interviews will be conducted with local non-profit groups such as the Ko‘olau Mountain Watershed Partnership, the Big Island Invasive Species Committee, and others conducting similar work. Ecological restoration recommendations will be guided by the Society of Ecological Restoration's principles which focus on practices that improve resilience of ecosystems in a changing climate. The outputs for this project are to present the literature on Albizia to the Kalihiwai community, train community members on removal methods of the species, contribute a chapter on Albizia to National Science Foundation (NSF) Ho‘omalu Halele‘a watershed management handbook, document this project through a video, write up a final capstone report, and present the project findings to the public. My outcomes for this project are to increase community connection to watersheds, improve stream characteristics, increase habitat for desired and valued species, and inform future projects and policy on Albizia removal. The timeline of this project began in January of 2022 and all physical activities will be completed by the Fall of 2022. The outputs will be completed by the Spring of 2023. Resources needed to complete this project are: an introduction to Kalihiwai community members, flights to Kaua‘i, and camera gear.

Keywords:, community-based conservation, invasive plants, climate change mitigation, Falcataria moluccana, Pacific, watershed restoration

Motivation

Climate change is resulting in an increased frequency of record-setting storms worldwide, including more frequent severe flooding events in Hawai‘i, highlighting the need for more climate-resilient ecosystems (Keener 2018). With more than 75% of ecosystems degraded globally, the desire and need for restoration has increased substantially in communities (IPBES 2019; D’Antonio 2006). Community-based restoration efforts are viewed as an important approach to ecosystem management, but there is a general lack of information and guidelines on how to successfully plan and execute them. Invasive species are one of the biggest barriers to community-led ecological restoration, and often have a large economic cost associated with their removal (D'Antonio 2006; Piemental 2011).

In Hawai‘i, watersheds were once managed and maintained by Kanaka (Native Hawaiians), but currently access to land and waterways for community management has become difficult. After the colonization of the islands and overthrow of the Kingdom, many non-native species were brought to Hawai‘i, both intentionally and unintentionally (Vitousek 1996, Keller 2011). Some of those introduced species thrive along stream banks, such as Albizia and Hau (*Hibiscus tiliaceus),* which can impede stream flow and increase flood risk. This is particularly problematic during extreme precipitation events and with an increase in annual peak flow (Vaughn 2021).

Invasive plant species are targets for restoration sites because of their ability to impact native species-area relationships (SAR) which is the abundance of native flora and fauna on a landscape (Powell 2013). They impact both terrestrial and aquatic ecosystem services, by altering watershed stream health and food webs (Atwood 2010). Where successful, however, such streamside restoration efforts provide vital watershed habitat for terrestrial and aquatic species, are more resilient to extreme weather events fueled by climate change, and improve public safety (Timpane-Padgham 2017).

When a large storm hit the Hawaiian Islands on April 14th 2018, 47” rain within 24 hours were recorded on the island of Kaua‘i, the new national record. Storms like these are increasing in frequency and create significant economic impacts. The 2018 storm caused $20 million in damage which included the destruction of public property, homes, roads and bridges statewide (U.S. Department 2019). A contributor to the damage was the presence of invasive plant species such as Albizia (*Falcataria moluccana)*.

The economic damage and control costs associated with invasive species is estimated at $120 billion/ year (Pimentel 2005). The Kalihiwai community, located on the northeast side of the island of Kauaʻi, was united by the hardship of the 2018 flood and have become motivated to increase the resilience of their watersheds. Removal of the invasive Albizia tree along the Kalihiwai river, has been identified as a top priority for public safety as the Kalihiwai bridge structural integrity could be undermined by another flooding event.

To accomplish their goals, the Kalihiwai community has requested guidance on streamside Albizia removal, and post-removal ecological restoration. This project aims to collect and consolidate information on removal techniques used for Albizia and streamside ecological restoration on post-removal sites. The project information gathered will be used to advise the Kalihiwai community project, and be made into a publicly available resource to broadly inform Albizia removal and post-removal restoration projects across the Asia-Pacific Region.

Background

Invasive species are defined as a species that occurs out of its native range and causes harm to humans and native species in its new habitat (Davis 2009). Invading species not only compete with native species and reduce biodiversity, but also change ecosystem processes. Successful control of these invasive species is a large challenge, economically and ecologically, and requires effort from private property owners and the motivation of their communities (Niemiec 2017). Based on Mack et al. (2000), three primary factors affect successful control of invasive species: sufficient funding, public and agency support, and a weakness of the species that can be targeted. In the case of Albizia on Kauaʻi, the National Science Foundation (NSF) Hoʻomalu Haleleʻa grant project group receives significant funding and agency support through an emergency relief fund. The NSF Hoʻomalu Haleleʻa group is made up of community members, which voice significant public support for Albizia removal and post-removal restoration in the Kalihiwai community.

Albizia, a fast-growing, shade-intolerant nitrogen fixing tree from Papua New Guinea, was introduced to Hawaiʻi in 1917 to help with the reforestation of degraded watersheds (Nelson 1965). The large canopies of these trees negatively impact cultural sites and historic views important to Kanaka (Native Hawaiians). As one of the world's fastest growing trees, Albizia can grow up to 5m a year and reach 30m in height. Albizia is structurally brittle with limbs that break

in high wind events (Watson 2018). When present along stream corridors, these broken branches have a high risk of clogging streams during flood events such as that seen on Kauaʻi in 2018 (Hawaii Sea Grant 2020, Watson 2018). On the island of Hawaiʻi, Atwood et al (2010) tested stream water from streams overrun by Albizia and concluded that nitrogen levels from this species are altering stream composition and food webs. Another problematic feature of the species is the dispersal of large numbers of seeds that germinate readily with access to sunlight, and result in many fast-growing saplings (Watson 2018).

Removal techniques currently employed on Albizia include girdling, felling the tree, and Incision Point Approach (IPA) herbicide injection, as well as various combinations of these techniques with each technique differing in cost and applicability. Once Albizia trees are removed, ecological restoration of sites with native vegetation has proven to be difficult to maintain due to the large seed bank of Albizia that can grow quickly and reduce available light for other species (Hughes 2013).

In Hawaiʻi, Albizia removal programs exist statewide, yet the most effective way to manage sites following their removal is not common knowledge. Only one published study has been done on the success of restoration sites post-Albizia removal, and that study was conducted in Samoa (Hughes et al. 2012). These authors found that restoration efforts were successful post-removal when there was an abundance of native flora already present in the restoration area. While studies like this can provide a model for eradication efforts of Albizia in Hawaiʻi, most streamsides in Hawaiʻi currently lack native vegetation seed banks, particularly at lower elevations where human communities are primarily located. As such, there is a need to provide recommendations in Hawaiʻi, to plan for the reintroduction of native or culturally significant species in the post-Albizia environment to be successful in the long-term.

Objective

The overarching objective of this capstone project is to collate available information for the public in Hawaiʻi on removal strategies of Albizia trees and post-Albizia removal streamside restoration techniques. The specific objectives of this proposed project are to: (1) document and contribute the success and failures of Albizia removal and ecosystem restoration post removal in Hawaiʻi into a synthesized document; (2) use these findings to provide recommendations to a pilot site community on Albizia removal and post-removal of streamside restoration. Ultimately,

this project will not only provide suggestions and recommendations specific to the pilot site community on both Albizia removal and post-removal streamside restoration, but will also provide an accessible resource for other projects to reference throughout Hawai‘i and the Asia-Pacific Region where Albizia is invasive and problematic.

Approach

The approach for this project will focus on sourcing literature on Albizia removal and post-removal streamside restoration. These methods are intended to be repeatable for other researchers and made broadly applicable to other sites and communities in Hawai‘i, and across the Asia-Pacific Region. The streamside ecological restoration in this project will focus on adaptive management as the effects of climate change show that historical systems are not feasible goals for a healthy ecosystem.

Study Site

The proposed project work will be broadly applicable but the culmination of my findings will be piloted to assess if it is feasible for communities. The pilot site is proposed for the Kalihiwai river in the moku (district) of Halele‘a on the north side of the Island of Kaua‘i. The combination of changes in climate and invasive species proliferation create challenges for ecological restoration of these watersheds. Kaua‘i is known for having some of the highest recorded rainfall in the world (WRCC). To better know the site, and people living there, I will attend NSF Ho‘omalu Halele‘a project grant meetings that community members are a part of. Once a stronger relationship is formed an in-person visit of Kalihiwai will occur and give visual information for removal and restoration planning.

Literature Review

Scientific literature and online information will be synthesized into a final report to share with the Hawaiian Archipelago communities on: (*i*) Albizia removal, and (*ii*) streamside ecological restoration following removal. The Onesearch database, available via the University of Hawai‘i at Mānoa library, will be used to search and review relevant scientific literature. The topic words searched will include: Albizia, management, watershed, Hawai‘i, ecological restoration, *Falcataria moluccana*, and streamside.

Additional first-hand information will be gathered through phone and zoom interviews with local nonprofits and community groups conducting similar work across Hawai‘i as well as local botanists and stream ecologists (see Appendix A for draft interview questions). These groups will be identified through a Google search on Albizia in Hawai‘i and through snowball sampling starting in the university network. Through the interviews, a list of biocultural and biodiverse plant species used or seen at previous restoration sites will be documented noting the climate of the restoration site, and where the plants have been successfully outplanted. To conduct these interviews, the questions will be added to the NSF groups current project proposal filed with the Institutional Research Board (IRB) office at UH Mānoa.

Albizia Removal

I will attend training sessions with the Ko‘olau Mountains Watershed Partnership (KMWP) on the use of the IPA herbicide method, bark stripping and sapling removal techniques. Once trained, I will hold sessions with the pilot site, the Kalihiwai community, to train them on these techniques. Arborists among the community, or present on Kaua‘i, will be identified and recruited through online searches and community recommendations for large tree removal, as the community has already identified some trees for removal. Aside from those identified, additional trees will be located by paddling up the river. The stream banks will be surveyed with the permission of the landowners to identify and assess the removal of other major problematic trees within 15m from the river.

Before the trees are removed, the costs of tree removal (i.e., labor and supplies associated with felling, sectioning, and movement off site) will be estimated based on interviews (see above). The total distance of streambank restoration on the Kalihiwai river will be determined based on available funding from the NSF Ho‘omalu Halele‘a grant and the ability to move trees off the sites, or turn them into other products.

Ecological Restoration

The recommendations will aim to restore a mixed system for biodiverse and non-invasive managed species which create beneficial ecosystem services. These systems include native, polynesian introduced, and agroforestry species. The goal of the mixed system is to restore

functions of the ecosystem for a future state and not a past one as the effects of climate change and the extinction of keystone species will not support the restoration.

Planning for this system will take time, funding, and site-specific knowledge. The restoration site recommendations I will propose for streamside areas containing Albizia trees will be informed by local community input, the ecology and history of the area (including current and desired plant species presence), the existing scientific literature on Albizia, and methods focused on resilience in a changing climate. The Society for Ecological Restoration (SER) ecological restoration standards will be used to adapt the recommendations for restoration for a mixed streamside system. These standards provide a model for creating a healthy relationship between nature and culture while increasing biodiversity and climate change resilience.

The SER's framework will be utilized to inform removal techniques, native plant species selection, site maintenance, and continued monitoring. In using the SER framework, this project will be made more adaptable to other streamside sites with varying degrees of degradation, size, funding and complexity (Gann 2019). To achieve this, the SER eight principles for restoration will be utilized which are listed in the first column of Table 1. Implementation of these principles into the project are briefly addressed in the second column of Table 1. An example of how the project addresses the principles is as follows; The first principle states that success of ecological restoration comes from the engagement of stakeholders. This project will focus on the engagement of local community stakeholders involvement in streamside restoration and the connection that is created through their engagement to maintain and monitor a place they are invested in.

Table 1. A summary of the Society of Ecological Restoration's eight principles and their application to this project.

Society of Ecological Restoration Principles		
	Eight Principles for Restoration	Project Implementation
1	Engages stakeholders	Driven by community members interests and engagement in participatory monitoring and maintenance
2	Draw on many types of knowledge	Guided by Local Ecological Knowledge (LEK),

		Traditional Ecological Knowledge (TEK), practitioners in this field of work, and our scientific discoveries along the way
3	Informed by native reference ecosystems, while considering environmental change	Restoring towards a future state of the ecosystem that includes a mixed system of biodiverse and non invasive system
4	Support ecosystem recovery processes	The support to recover the streamsides with long-term goals in mind informed by the history of the stream
5	Assess recovery against clear goals and objectives, using measurable indicators	The community's goals and indicators will be identified with them while applying adaptive management
6	Seek the highest level of recovery attainable	The project will also implement slow and long term recovery of the sites with the creation of a maintenance plan
7	Gain cumulative value when applied at large scales	The ability of recommendations to be conducted at a full watershed scale
8	Part of a continuum of restorative activities	Finding the most appropriate treatment to the area based on the communities ecological, social, and financial conditions will be determined with the NSF Hoʻomalu Haleleʻa group community meetings

At each restoration site the current state of degradation will be assessed in an area that extends 15m from the stream banks (Protection of Waters). Native plant presence on these sites will be identified, and protected wherever possible. The study in American Samoa attributes successful restoration following removal to the presence of early successional native species that could quickly outcompete Albizia saplings for sunlight (Hughes 2012). If native species are not present during the ground survey, nursery grown cultural importance and native plants will be chosen based on landowners input. Using information from the literature review, a list will be compiled of native and cultural plants appropriate for use in Hawaiʻi streamside restoration that could be planted post Albizia-removal to reduce erosion and enhance bank stability. In particular, recommendations will be made for three restoration scenarios: native species, cultural and food

species, and native and cultural/food species mixtures. Each scenario will provide information on the benefits of species, how to plant each species, and maintenance required.

A part of the SER's standard practices that land managers often overlook is the monitoring and maintenance of a site post-restoration (Gann 2019). As such, a long-term maintenance program will be developed in conjunction with community groups and landowners. SER suggests a pre-monitoring plan to collect baseline inventory on species presence, current abiotic conditions, and drivers of degradation. This data will be collected by the NSF Hoʻomalu Haleleʻa group. Once restoration begins, the maintenance plan will include weeding invasive species such as the young Albizia by hand along the streambanks. The recommended native, canoe (polynesian introduced), and food plants selected for restoration sites will be plants of cultural importance that the community will be motivated to monitor and maintain, improving the chances of a successful restoration and monitoring program.

Outputs

The proposed outputs for this project are intended to provide a comprehensive and accessible resource on Albizia removal and post-removal ecological restoration scenarios that are transferable to other streamsides in Hawaiʻi. I propose to: (*i*) present the results of my research on Albizia removal methods and post-removal restoration to the Kalihiwai community; (*ii*) train community members of Kalihiwai on those methods at in-person training sessions; (*iii*) contribute a chapter to the NSF Hoʻomalu Haleleʻa project's community watershed management handbook, informed by a collection of case studies including the Kalihiwai community; (*iv*) document the Kalihiwai project with a video as a visual representation for this community and other communities to utilize; *(v)* create a final capstone report of the project for UH Mānoa NREM department; and *(vi)* present the project findings to the public once completed.

Outcomes

This project aims to promote long-term positive economic, cultural and ecological outcomes. The improvement in stream characteristics helps protect roads, bridges, and homes from damage during flooding and extreme weather events caused by climate change. Protecting critical infrastructure is essential to mitigate the negative economic impacts of a changing climate, as disruptions to transportation can have broad-reaching impacts. A cultural outcome is

to create an increased connection between community members and their ahupua‘a through streamside maintenance, and restore culturally significant views blocked by the canopies of Albizia. The increased connection to their local ecology helps enable and promote land stewardship. Ecological outcomes will include an increase in habitat for native fauna and flora, as well as space for other desired and valued plant species by the community members. The recommendation documents will also contribute to the broader efforts of invasive species removal and restoration, providing information for future Albizia removal projects. These outcomes will directly benefit the community and the surrounding communities by improving the resilience of their watershed. However, this project may have broader impacts if the knowledge can be applied to future Albizia removal projects throughout Hawai‘i and the Asia-Pacific Region.

Timeline

Figure 1. Proposed Project Timeline

Literature review began in November of 2021 and will conclude in March 2022 to inform proposed community meetings about the background of Albizia before removal occurs. Phone calls with nonprofits and other agencies focused on Albizia will also be finished during this timeframe. The accumulated research will then be presented to the Kalihiwai community in March, while in-person meetings and site visits with the Kalihiwai community will begin in April for tree selection. Trees will be removed by June and extraction of the felled trees will

follow. Checking in with the community and the monitoring teams will continue into 2023. Beyond the given timeline, personal check-ins with the community will continue long term for the continued monitoring and restoration of the site.

Resources Needed

Resources needed for the online literature component of the project are available through the University of Hawai‘i at Mānoa scientific journal database. Other information needed will be provided through phone calls which may need introductions and support from natural resource managers across Hawai‘i. To support my time and effort dedicated to the project, I have applied for scholarships to fund my travel costs for the project and procurement of plants for the restoration site. Dr. Mehana Vaughan will support travel to Kaua‘i from O‘ahu with funding from the NSF Ho‘omalu Halele‘a project grant, and she will also provide an introduction to the community leaders. All landowners on the Kalihiwai river have given permission to access their land for the Ho‘omalu Halele‘a project. Participation by landowners to determine goals of their Albizia removal sites is needed to lead the direction of post removal goals. This will be attained by participating in community meetings and building relationships. Funding for the removal tools and restoration of the trees will also be provided by the Ho‘omalu Halele‘a project. In order to document the project visually, I will use my personal camera, video editing software, and experience in cinematography.

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Appendix

Appendix A -Draft Interview Questions

- What techniques are used by your group to remove Albizia?
- What restoration techniques have been successful in riparian areas for Albizia removal?
- What techniques have not?
- What are best practices for tree disposal?
- Do you notice any native or canoe plants that can compete with Albizia saplings after a tree is removed?
- Do you recommend any plants for post-removal restoration sites?