Red Mangrove Invasive Species Action Plan for the Hulēʻia

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1. Introduction

Red Mangrove (*Rhizophora mangle*), a non-native species in Hawai`i, has invaded the Hulēʻia watershed on Kaua`i. While mangroves are highly beneficial elsewhere in the world in their native habitats, because of Red Mangrove's detrimental environmental, cultural and economic impacts, Mālama Hulēʻia was formed with the mission to eradicate it from the watershed and to replace it with native vegetation.

Red mangrove is named for the red color of the wood underneath the bark. It is known for its prop roots that are derived from the trunk and drop roots from the branches. Its shiny broad leaves grow to 5 inches (12 cm) and terminate with a blunt point. It has pale yellow flowers and pencil shape propagules. It can grow to a height of over 80 feet tall (25 m).

Figure 1: Mangrove Identification Features

Propagules Drop roots Prop roots

It has invaded many wet intertidal and riverine areas in Hawaiʻi due to a lack of natural predators or competitors. It favors establishing itself in areas already disturbed by humans such as abandoned taro lo`i, fish ponds, and other areas where fresh sediment has been deposited.

Since the beginning of 2013, Mālama Hulēʻia has been working on a demonstration mangrove removal and restoration project next to Niumalu County Beach Park, utilizing with great success partner organizations and individual volunteers from the community. That project was funded by grants from NOAA and was conducted as a project of the Kaiola Canoe Club.

As the demonstration project is coming to an end, Mālama Hulēʻia has achieved independent status as a nonprofit corporation and is turning its attention to the main areas of red mangrove infestation in the Hulēʻia watershed. The organization contracted the services of the University of Hawai`i Sea Grant College Program to facilitate an action planning process to formulate a strategy to remove red mangrove from and restore these larger areas. Development of this strategy has included aerial data analysis to determine the extent and locations of red mangrove infestation, detailed research on mangrove removal options, facilitated action planning meetings with the Mālama Hulēʻia Board of Directors to establish action items and priorities. It will further include community meetings and landowner interviews to ensure that all stakeholder interests are considered.

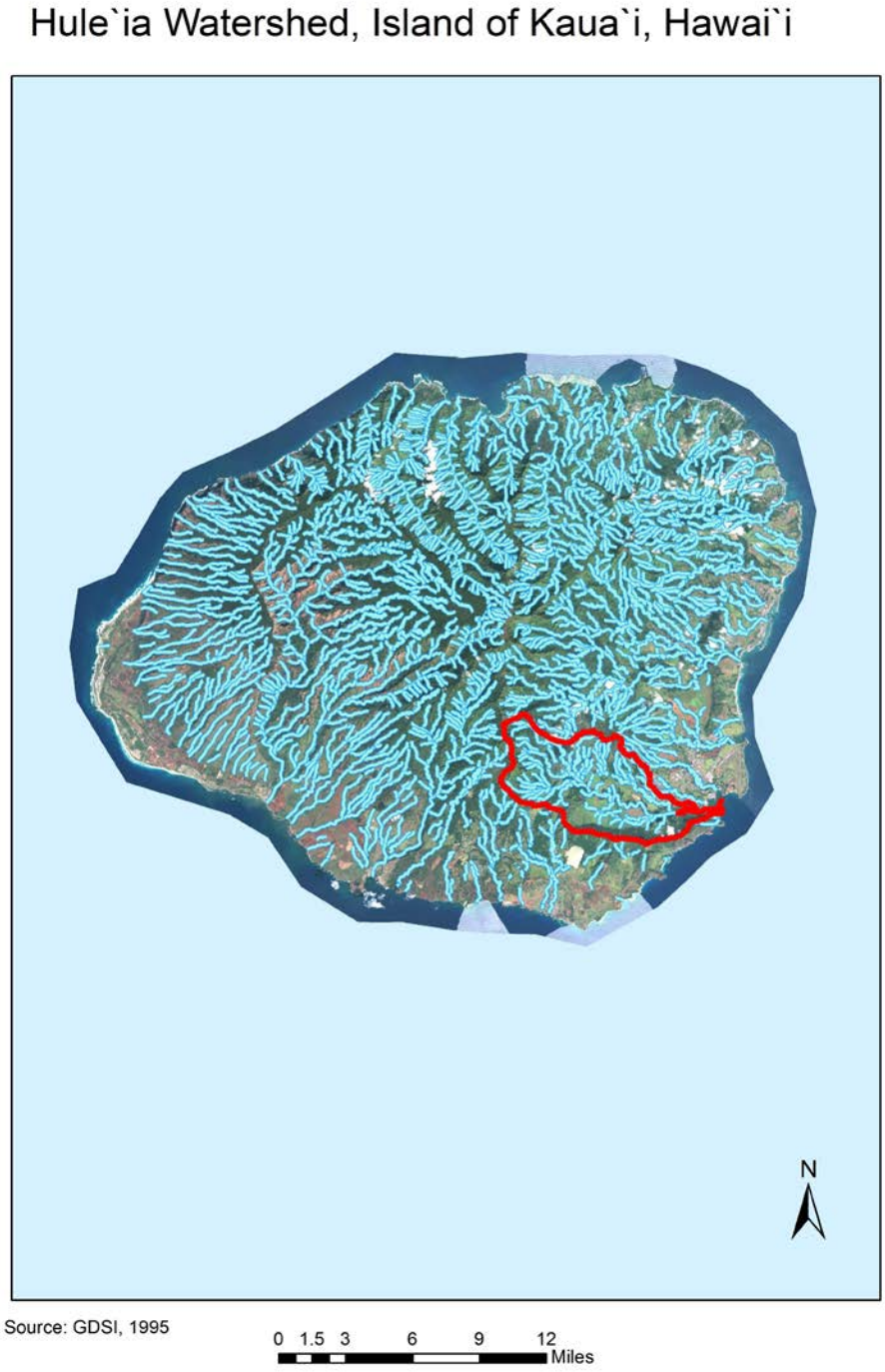

Figure 2: Approximate location of Hulēʻia watershed. This Plan covers a subset of the watershed, including Hulēʻia stream and estuary, Alakoko Fish Pond, and Pūʻali Stream, directly adjacent (see figure 6 for detail).

2. Mālama Hulēʻia's Mission

Mission Statement: ***Within ʻĀinakumuwai Hulēʻia and Pūʻali, we will eradicate invasive red mangrove and replant with native vegetation.***

a. Key Priorities

i. Prioritize mangrove eradication at the Alakoko Fish Pond, utilizing a hand cut/hand removal technique.

ii. Concurrent with (a), pursue partnerships and willing landowners in the rest of the watershed where mangrove removal can take place, taking an adaptive management approach. The technique to be utilized in the rest of the watershed may be a combination of hand cut cutting with hand removal and equipment removal.

b. Why Red Mangrove must be eradicated

While mangroves are highly beneficial elsewhere in the world in their native habitats, Red mangrove in Hawai`i is invasive and presents negative environmental, cultural and economic impacts.

i. Environmental impacts

- <u>Wildlife Habitat:</u>

In Hawaii, the establishment of mangrove has dramatically altered ecosystem processes in the areas it has invaded. It changes macrofaunal species and food-web structure, facilitating greater dominance by sub-surface deposit feeders, and creating new niches for other exotic species in mangrove sediments (Demopoulos, 2004; Demopoulos et al., 2007; Demopoulos and Smith, 2010).

The introduction of red mangrove in Hawaiʻi represents an entirely new lifeform in the Hawaiian wetland ecosystem. There is little wildlife found in Hawaiian mangrove forests except that they can provide shelter for predators that prey on waterbird chicks, such as cattle egrets, rats and mongoose. This means less habitat for Hawaiʻi's fish and endemic water birds, such as the Hawaiian Stilts, Hawaiian Coots, Hawaiian Ducks and Hawaiian Moorhens.

Red mangroves have been shown to displace nesting habitats of the endangered Hawaiian duck (*Anas wyvilliana*), stilt (*Himantopus knudseni*), coot (*Fulica americana*) and moorhen (*Gallinula chloropus*) (Rauzon and Drigot 2002, Chimner, et al. 2006).

In addition, Mangroves may be having a negative impact on fish community structure in Hawai`i. The most extensive studies on mangrove impacts to fish have been done on Moloka‘i (Demopoulos et al. 2007, Nakahara 2007) and show similar results to studies on the island of Hawai‘i, that mangroves appear to be providing habitat for invasive fish species, such as poeciliids, snapper, and tilapia (Van der Veur 2006, MacKenzie et al. unpublished data). These are all species that have adverse effects on habitat value for native fish communities as well as on native fish community structure.

- Water Quality:

Red mangroves in Hawai’i have been found to grow to higher densities than in their native range (Cox and Allen, 1999), probably because Hawai’i lacks the species that attack the flowers and propagules. Litterfall from mangrove stands at Nu‘upia Pond, Oahu has been measured at 2.52 kg ha-1, which exceeds net primary productivity in its native range in Florida (Cox and Jokiel 1996, Odum McIvor and Smith 1982). These added organic inputs have led to detrital accumulations and algal blooms. Other influential ecosystem processes include water stagnation, soil sedimentation, anoxia and hypersalinization (Cordona and Botera 1998, McKee 1996).

The dense stands of trees and roots crowd out native plant species, causes water stagnation, and the sheer amount of decomposing plant matter leaves the water devoid of oxygen, which is inhospitable for native species. In the Hulē‘ia River the sewage smell among the mangrove roots from these anoxic conditions is often apparent and alien fish species like tilapia are observed to be on the rise. A section of the river bordering the Hulē‘ia National Wildlife Refuge is particularly affected. Due to heavy erosion of nearby hills during rainstorms, this part of the river remains brown with silt long after the rain stops. The river cannot quickly flush out the sediment due to the mangrove, and the stagnant water between the mangrove roots smells like sewage due to anoxic conditions.

According to the Hawai‘i Department of Health’s Total Maximum Daily Load (TMDL) for the Nāwiliwili Watershed, Nāwiliwili Bay, the marine receiving waters for all the streams in the watershed is listed under Section 303(d) of the Clean Water Act as impaired for excessive nutrients and turbidity, and certain stations within the Bay are elevated for bacterial indicators (enterrococus). Hulē‘ia, Pū‘ali, Papokolea, and Nāwiliwili Streams are impaired by elevated turbidity, nutrients, and bacteria levels. The TMDL specifically states that the invasion of red mangrove in the Hulē‘ia may contribute a significant amount of organic material and increase turbidity and nutrient concentrations (HI DOH 2008; citing Furness et al 2002).

The TMDL references the Watershed Plan for Nāwiliwili, which identifies four overarching goals, to (1) improving water quality and de-listing impaired

segments of the watershed; (2) enhancing current in-stream flows; (3) enhancing biological integrity of waterways; and (4) enhancing sustainability of the watershed. Among other things, the Plan proposes certain restoration activities such as controlling non-native, invasive species such as mangroves (HI DOH 2008; citing El-Kadi et al 2004).

ii. Cultural impacts

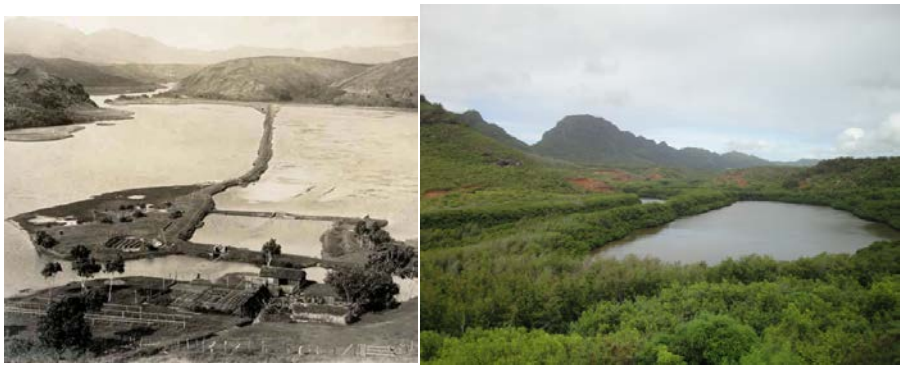

Figure 3: Alakoko Fish Pond before and after the red mangrove invasion

- Loko I`a (Native Hawaiian Fish Ponds): The Alakoko fishpond complex once consisted of ponds on both sides of the Hulēʻia Stream. Due to the red mangrove invasion, it is now reduced to one main pond that is entirely surrounded by the red mangrove. The main fishpond stone walls are completely buried under the mangrove roots, and it is likely individual rocks have broken off into the pond. Since the pond is relatively shallow, the red mangrove easily spreads inward toward the center of the pond. With continuous inward spreading of the mangrove, the area of open water becomes smaller and smaller. If left unchecked, the red mangrove will eventually fill the whole fishpond, making its destruction complete. This destruction will amount to a tremendous cultural loss, because the Alakoko Fishpond is a site highly valued both for its unique history as a productive loko Iʻa and as the subject of many Native Hawaiian moʻolelo (legends).

- Other Historic Sites: It is possible that other historic sites lay hidden by the red mangrove.

- Native Hawaiian Cultural Practices: The rich history of the Hulēʻia Valley for traditional Hawaiian methods of sustenance as already been negated by other factors of modern life. However, the red mangrove invasion makes returning to many of those methods of sustenance more difficult. Use of the fishpond for managing and harvesting fish populations is not possible as long as the pond is overgrown by red mangrove. Use of wetlands for kalo loʻi is problematic if the wetland is already invaded by red mangrove. Even simple activities like fishing or swimming from the river banks are not possible because of the thick tangle of red mangrove along the banks.

iii. Economic impacts

- Recreation/Navigation: The Hulēʻia is used for recreation by paddlers of all forms, including canoes, kayaks, and stand up paddle (SUP). The Hulēʻia is a frequent waterway for training for the Kaiola and Niumalu canoe clubs. In addition, kayak tours are run for tourists up the stream. The steady expansion of red mangrove and poor water quality conditions pose navigational hazards for these activities, threatening traditional and economic livelihoods.

- Food Production: The red mangrove invasion negatively impacts several forms of food production, including wetland taro farming, raising fish in fishponds, harvesting other aquatic animals besides fish (crabs, opae, hihiwai, etc.) which are now rare because of the destruction of their habitats.

- Cost of Restoration: Eradication of the red mangrove and restoration of natural areas and historic sites will be very complicated and expensive. Restoration of the Alakoko Fishpond walls will be especially problematic and costly.

- Loss of Opportunities: If nothing is done to stop the growth and spreading of red mangrove, it is unlikely that the Hulēʻia River and Alakoko Fishpond will continue to be the iconic tourist attractions that they have been. Moreover, the possibility of enhancing their attractiveness to all people by restoration of wildlife habitats and cultural enrichment of historic sites will be lost.

c. Why red mangrove should be replaced with native and Polynesian-introduced plants

Red mangrove must be replaced with native and Polynesian-introduced plants in order to control erosion, restore native wildlife habitats, and conserve the environment as earlier Native Hawaiians experienced it.

i. Erosion control

Replanting of areas cleared of red mangrove should occur soon after the mangrove has been removed. If the mangrove roots are cut at or slightly above ground or water level, as done in our demonstration project, they will hold the soil until they die and rot. This allows sufficient time to replant with vegetation appropriate for the site. By experimenting with various trees, sedges, ground covers and grasses at our demonstration project site, we have learned which ones are most tolerant of the partially saline conditions that will be encountered around the Hulēʻia River. In open riparian areas of the river, it is likely that various sedges and ferns can be used.

Currently, along most of the Hulēʻia River, red mangrove trees front the river and extend into the water. Behind the mangrove is usually hau, and on the higher ground, other invasives such as Java plum, Haole Koa, buffalo, guinea, and California grasses, and Indian fleabane bush. Where the red mangrove is backed by or mixed with hau, removing the mangrove and leaving the hau could be a way to maintain erosion control, since the primary plant holding the soil will be the hau growing on the land, not the red mangrove growing mostly in the water. Removing the red mangrove should allow the river water to flow more freely. We can minimize the problem of suddenly releasing silt and debris accumulated by the mangrove by cutting off the mangrove roots and leaving them in the water to gradually rot.

ii. Restoration of native wildlife habitats

At the Niumalu/Pūʻali demonstration project site, it is possible to already see the positive effects of removing red mangrove and replacing it with native ground covers and sedges. Native Kōloa (ducks), ʻAlaeʻula (moorhen), ʻUlili (wandering tattler), ʻAukuʼu (night heron), `Akekeke (ruddy turnstone), Kolpa (Pacific Golden Plover), and Hunakai (Sanderling) have been observed enjoying the water and open space there. Similar results are expected when the red mangrove is eradicated from the rest of the Hulēʻia watershed.

It is not just the native birds that should benefit from mangrove eradication. Aquatic wildlife should also benefit as the river water flows more freely, becomes cleaner, and is bordered by plans more familiar to native fishes and crustaceans.

iii. Cultural Preservation

Replanting with native and canoe plants to create a natural environment will be more consistent with traditional Hawaiian practices that once were common in the Hulēʻia watershed.

3. The Niumalu/Pūʻali Demonstration Project

Figure 4: Niumalu/ Pūʻali Demonstration Project

Mālama Hulēʻia is a young organization, but in its short history, it has achieved great success. As mentioned in the introduction, it has been working on a grant-funded mangrove removal demonstration project in an area bordered by the Niumalu Beach Park and Pūʻali Stream. The lessons learned in that demonstration project figure strongly in the shaping of plans for the future:

- Strong community support is essential for overcoming the challenges of Mālama Hulēʻia's mission.
- Active cultural and educational programs need to be integrated with the effort to eradicate red mangrove.
- Techniques for effectively and efficiently eradicating red mangrove were learned and firsthand experience was gained with hand cut, hand removal and equipment removal methods.
- Native plants grow best in wet, semi-saline environments.

It may go without saying that the Mālama Hulēʻia corporation moving forward with this Action Plan is essentially the same organization that worked on the Niumalu/Pūʻali demonstration project. But continuity and follow-through are important, so the organization has taken credit for and acknowledges the on-going responsibility for the demonstration project site. Partnerships will be sought to help with its further development as a cultural learning center.

4. Long Term Goals and the Purpose of this Plan

Looking forward, in order to accomplish our mission, we recognize that we must achieve the following goals:

- Formation of partnerships with landowners and other stakeholders
- Acquisition of funding for eradication work and restoration work
- Eradication of mangrove and restoration of the Alakoko Fishpond

- Eradication of mangrove and replanting along the entire Hulēʻia River
- Establishment of a perpetual Hulēʻia /Alakoko stewardship organization to maintain a red mangrove-free Hulēʻia watershed.

The purpose of this plan is to provide relevant information and to initiate a process for achieving the first goal. We aim to engage the community and landowners in working out agreements that can serve as a legal basis for continuing on to the next steps in the pursuit of our mission.

5. Extent of the Red Mangrove Invasion

Red mangrove was introduced to Hawaii from Florida by sugar plantations on Molokai in 1902 to stabilize the soil and provide forage for bees. Since then, the plant has spread across the Hawaiian Islands and invaded its preferred habitats. It has invaded many wet intertidal and riverine areas due to a lack of natural predators or competitors. It favors establishing itself in areas already disturbed by humans such as abandoned taro lo`i, fish ponds, and other areas where fresh sediment has been deposited. The Hulēʻia watershed is classic case of this, including the marshes of the Hulēʻia National Wildlife Refuge, the walls and mudflats around the Alakoko Fishpond, up Pūʻali stream and the rock walls surrounding the Nāwiliwili Small Boat Harbor. In addition to the Hulēʻia watershed, mangrove is established along waterways in Anahola, Kapa`a, Wailua, and Hanapepe on Kauai.

Figure 5: Hulēʻia Stream

Anecdotal information indicates that red mangrove began establishing itself in the Hulēʻia around 1930. Currently, approximately 62 total acres are affected. Mature trees reach approximately 30 – 40 feet in height. Based on high resolution aerial photography and Geographical Information Systems (GIS) techniques used by Marcela Brimhall for Mālama Hulēʻia, we have relatively accurate estimates of acreage and volumes of mangrove on the lower part of the Hulēʻia. (See following picture in which the mangrove is outlined in red.) Digital imagery of the mauka section of the river has been obtained, but GIS analysis is yet to be completed. We expect that it will yield an amount consistent with the 62 total acreage stated above.

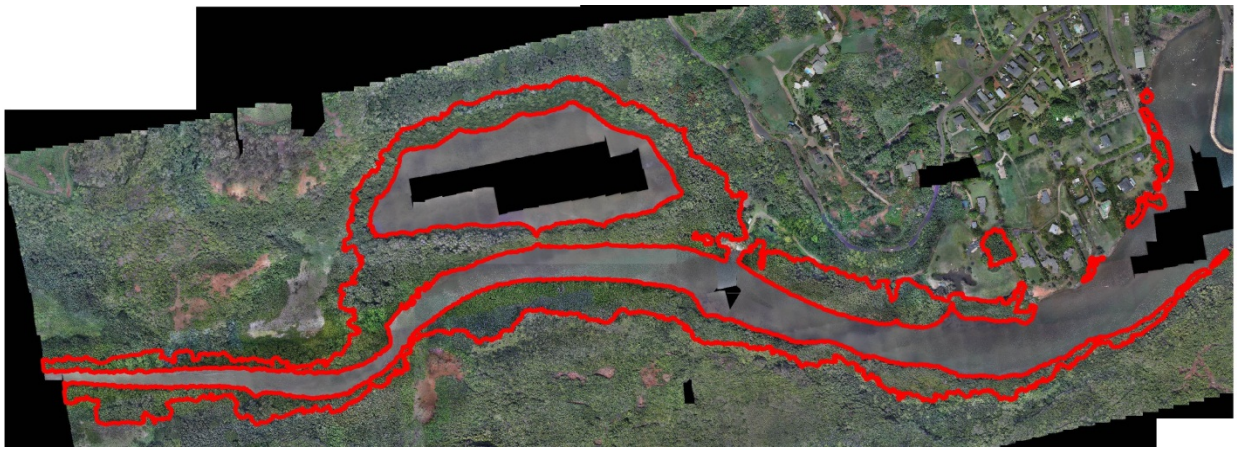

Figure 6: Lower Hulēʻia mangrove infestation boundary

The data on mangrove amounts was broken down into acres and cubic feet of mangrove trees per TMK. This can serve as a basis for discussion with landowners for the eradication effort. The data cover 49 separate lots of record. 46 of these are private parcels.

Red Mangrove spreads either through its propagules, which germinate while still hanging from the parental branches, or by horizontal expansion of the tree's branch and aerial root system. When released, the propagules fall into or are washed into the water and float with the currents in a vertical position until they reach a suitable habitat to set their roots and spread their branches. Subsequent growth is rapid. Branches and roots work together to anchor the plants and enable them to spread horizontally as well as to grow vertically. Prop roots descend from branches high above the water. These roots stabilize the trees in soft and submerged ground, and allow the trees to breathe well even when they are situated in stagnant water or rotting vegetation lacking in oxygen.

If nothing is done to stop it, red mangrove will continue to expand into the wetlands adjoining the Hulēʻia River and into the shallow water of the Alakoko Fishpond. It will also expand, eventually, into the deeper water of the river. Its range is limited primarily by the by availability of brackish water. So although propagules have taken hold of the rocks on the Nāwiliwili Harbor Breakwater, they are not growing well there because the water is too saline. On the other end of the Hulēʻia River, about 2 miles upstream where the water is less saline and there is no tidal influence to wash propagules upstream, the mangrove infestation gradually tapers, and hau is the dominant riparian tree.

Because red mangrove spreads so easily by propagules over water, eradication requires continuing maintenance to kill newly arrived propagules. Eventually, all the red mangrove plants along a waterway must be killed to prevent further spreading and repopulation. The rock walls surrounding the Nāwiliwili Small Boat Harbor are an example of a location that was once cleared of the red mangrove but has become re-infested.

6. Red Mangrove Eradication and Management Methods in the Hulēʻia Watershed

a. Alternative Methods of Eradication

Mālama Hulēʻia considered several alternatives for mangrove eradication in the Hulēʻia watershed, based on research conducted by the University of Hawaiʻi Sea Grant College Program.

1. Herbicide Drill/Paint	Herbicide applied to trunk	$3,000/acre
2. Hand Cut/Hand Remove	Cut with saw below the high tide line	$25–$100,000/acre
3. Hand Cut/Equipment Remove	Cut with hand saw, remove with excavator or crane	$25-$100,000/acre
4. Grind and Vacuum Removal	Excavator with a grinding head below high tide and a vacuum attachment to disperse chips	$50-$100,000/acre
5. Equipment Removal	Excavator pulls trees out	$100,000/acre

Figure 7: Mangrove Eradication Methods Considered

Due to costs, permitting requirements, feasibility, and community concerns, alternatives 2 and 3 - utilizing hand cut techniques and removal by hand or with equipment - were selected for this plan. A full description of the alternatives can be found in Appendix A. It was also decided to prioritize mangrove eradication at the Alakoko Fish Pond, utilizing a hand cut/hand removal technique. Concurrently, partnerships will be pursued with willing landowners in the rest of the watershed.

i. Alakoko Fish Pond

Due to the sensitivity of the historic fish pond stone walls and its cultural significance, it is important to use a non-invasive method of mangrove removal. The hand cut/hand remove technique will be used for the Alakoko Fish Pond banks. With this method, trunk and aerial stems are cut with hand saw, chain saw, or rotary blade below the high tide line. The approximate cost for this technique is between $25,000 and $100,000 per acre.

ii. Remainder of Hulēʻia and Pūʻali

For the remainder of the watershed, mangrove will be hand cut and removed either by hand or with equipment, such as an excavator or crane (see Appendix A for details).

Hand cut and hand remove techniques will be employed in cases where sensitive cultural resources are present to avoid damage. Determination of hand removal vs. equipment removal will also depend on accessibility, cost, and permit requirements. In all cases best management

practices (BMPs) will be employed to control erosion and runoff, including careful selection of native plant species for replanting.

b. Re-vegetation

A nursery will be contracted to propagate and grow for out-planting ground covers, sedges, ferns shrubs and trees. A separate contract and extensive community involvement will be needed for the actual out-planting once the mangrove has been removed and debris cleared from the area. Mālama Hulēʻia has had already involved 4 local schools in the growing and out-planting of plants at the demonstration site. The schools have asked that this program be expanded to involve more students throughout the year.

A rough cost estimate of replanting for the entire project is $310,000 (planting material) + $103,000 (labor) = $413,000 for 62 acres. The greatest determinant of cost is the planting density, the plant species.

Note that this estimate is based upon replanting the 62 acres covered by mangrove. Much of this coverage is over open water, which would not be replanted. Thus the actually acreage required to replant would likely be much less than 62 acres.

c. Green Waste Management

Removal of red mangrove trees will generate a considerable amount of green waste. The following options have been identified for further study.

Chipping and spreading: This option involves chipping the mangrove trees and spreading the chips over a wide area as mulch. This technique would potentially be more efficient than trucking the chips to a disposal facility. Once accurate volume estimates are available, spreading areas can be identified. This was done at the Niumalu demonstrations site.

Chipping and trucking to the waste to energy plant: Green Energy Kaua‘i has a biomass-to-energy plant on Kauai, burning Albezia trees to produce electricity. Red mangrove can be used as a supplement as long as it meets their requirements. The company has agreed to collaborate on this project where possible.

Community uses. Other options for waste disposal include doing promotions to give chips or logs away to community organizations, farmers and individuals, and exploring the feasibility of producing products, such as particle board. Partnerships with community leaders, organizations, and Kaua‘i Community College may be pursued in this regard. This was done at the Niumalu demonstration site.

d. Maintenance and Monitoring

A monitoring and maintenance plan will be developed that involves follow up hand removal of keiki after the mangrove eradication and replanting efforts, as propagules may wash in to the lower reaches of the estuary from other sites around Kauai or from other islands. Therefore, a necessary component of this plan is ongoing monitoring and follow up removal events. This can be achieved through community, landowner, and government partnerships. We have successfully engaged local schools of pre-school through grade 12 in maintenance removal of the propagules at the demonstration site.

7. Cost Estimates

The cost for implementing this plan, including eradicating and removing all the mangrove in the entire watershed (~62 acres) and replanting with natives is between $1,963,000 and $6,799,000 using hand cut/hand removal methods. The approximate cost for hand cut/hand removal technique is between $25,000 and $100,000 per acre. All cost estimates based on paid labor, equipment, materials, and mobilization. Cost estimates do not include planning/permitting costs.

Low end: ~62 acres x $25,000 = $1,550,000 + $413,000 (native planting) = **$1,963,000**
High end: ~62 acres x $100,000 = $6,200,000 + $413,000 (native planting) = **$6,613,000**

Lower costs are associated with shorter drag and chip distances and non-Federal lands. Federal lands are always more expensive due to contracting rules. In terms of drag and chip distances, for this project it could be at the lower end of the range if you start at the river mouth and move back

eliminating the need to cut multiple access ways and drag long distances. Costs would also be lessened by disposing of chips onsite (if permitted).

The native planting estimate is based upon replanting the 62 acres covered by mangrove. Much of this coverage is over open water, which would not be replanted. Thus the actually acreage required to replant would likely be much less than 62 acres.

It should also be noted that the cost of removing the red mangrove will increase over time. The acreage will increase as the mangrove expands further into wetlands, the shallow waters of the fishpond and the river sections where silt and debris are trapped. Moreover, as the mangrove trees mature, growing taller and developing more tangled root systems, the work to cut them will be more difficult and time-consuming, and the volume of material to be removed will be greater and more costly to remove.

8. Forming Partnerships

To cover these costs, substantial funding will be necessary. However such funding is usually available only after some kind of partnership between stakeholders has been agreed upon. The partnership can take alternative forms, and these will need to be further explored. The only thing that is definite at this point is that no party alone can successfully eradicate the red mangrove and restore the Hulēʻia watershed.

The required partnerships for successful implementation include:

- Individual landowners, including large landowners such as the Okada Family, Rice Family and the US Fish and Wildlife Service and the others on the opposite side of river.
- County of Kauai
- Hawaii State Division of Land and Natural Resources

Other important potential partners include:

- US Environmental Protection Agency (primarily for grant funds)
- Ducks Unlimited (successful recipient and manager of a large NAWCA grant)
- Pacific Birds Habitat Joint Venture– a key partner for the NAWCA grant program
- Pono Pacific (experienced service provider for mangrove removal in Hawaii)
- US Coast Guard
- State Division of Boating and Waterways (DOBOR)
- University of Hawaiʻi Sea Grant College Program
- Kauaʻi Invasive Species Council (KISC)
- Kauaʻi County Public Access, Open Space and Natural Resources Preservation Fund (possible land purchase for conservation)
- Hawaiian Islands Land Trust (possible land purchase for conservation)
- Trust for Public Land (possible land purchase for conservation)
- The Nature Conservancy (possible land purchase for conservation)
- Kauai Community College
- State Legacy Land Conservation Commission (provides Funding for the acquisition and protection of threatened resources
- Political representatives at the Federal, State, and Local level

9. Funding

Given the magnitude of work to be done and its cost, substantial funding will be necessary. Even more funds will be required if any land is to be purchased as part of forming a partnership. Small grants (less than $100,000) could be helpful only if the red mangrove eradication work could be subdivided into discrete sub-projects. However this approach will probably entail much more management overhead. Ideally, funding would be obtained in the form of one or more multi-year

multi-million dollar sources of revenue. The following are some of the possibilities for funding a project of the magnitude being considered. Other smaller grant opportunities are listed in Appendix B.

a. The following sources may be used to fund mangrove eradication efforts:

U.S. Fish and Wildlife Service National North American Wetlands Conservation Act

The U.S. Fish and Wildlife Service National North American Wetlands Conservation Act (http://www.fws.gov/birdhabitat/Grants/NAWCA/index.shtm) provides large grants to partners to restore wetland habitat. In 2014, $46,985,124 in funds were awarded to 47 projects. At least a 1:1 match is required for these funds, so partnership are essential. USFWS strongly recommend that you contact the coordinator of the joint venture region in which your project is located early in the process for guidance on developing your project and proposal. Joint venture coordinators' prioritization of NAWCA proposals from their geographic region is a key element in the selection process. This grant was received by Ducks Unlimited in Hawaii and was used for mangrove removal on Oahu.

EPA Wetland Program Development Grants

EPA assists states, tribes, and local governments to protect and improve wetlands within their jurisdictions by awarding monetary grants under section 104(b)(3) of the Clean Water Act. WPDGs assist state, tribal, local government agencies and interstate/intertribal entities in building state/tribal/local programs which protect, manage, and restore wetlands. The primary focus of these grants is to build state and tribal wetland programs. A secondary focus is to build local (e.g. county or municipal) programs**.** Implementation of wetland protection programs is not an eligible project under this announcement. An implementation project is one that is accomplished through the performance of routine, traditional, or established practices, or a project that is simply intended to carry out a task rather than transfer information or advance the state of knowledge. All monitoring and mapping projects should transfer information or advance the state of knowledge and therefore are eligible under this grant. Awards range from $50,000 - $500,000.

Hawai‘i State Legislature Grant-in-Aid

HRS Chapter 42F states that grant applications can be submitted to standing committees at the beginning of each legislative session. There is no maximum amount of funding that can be applied for. The application can be found on: http://capitol.hawaii.gov/GIA/2014GIA.aspx. Strong relationships with legislative representatives help in this process.

Hawai‘i Department of Health 319 Funds

The Polluted Runoff Control Program administers grant money it receives from the EPA through Section 319(h) of the Federal Clean Water Act to address Hawai`i's polluted runoff. Proposed projects should include implementation of a component of an existing watershed management plan, total maximum daily load (TMDL), or other work/action plan to address water quality

issues. The Nāwiliwili watershed plan does address mangrove removal. Current maximum amount to request for funding is $700,000.

U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Regional Conservation Partnership Program

NRCS is the Department of Agriculture's (USDA) conservation agency working with farmers, ranchers, and private forest landowners nationwide to identify and address natural resource objectives in balance with operational goals in order to benefit soil, water, wildlife, and related natural resources locally, regionally, and nationally. NRCS works in partnership with other entities to accelerate getting conservation on the ground. Through the Regional Conservation Partnership Program (RCPP), NRCS seeks to co-invest with partners in innovative, workable and cost-effective approaches to benefit farming, ranching, and forest operations, local economies, and the communities and resources in a watershed or other geographic area. RCPP partners develop project applications, as described in this notice, to address specific natural resource objectives in a proposed area or region. Partnering organizations design, promote, implement, and evaluate the project outcomes.
http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/farmbill/rcpp/

b. The following programs may be used to fund possible land purchases for conservation and restoration, thereby facilitating mangrove eradication efforts:

Kaua‘i County Public Access, Open Space and Natural Resources Preservation Commission

The Kaua‘i Public Access, Open Space, and Natural Resources Preservation Fund uses funds generated from real property taxes to acquire lands or property entitlements for the following purposes:

1. Outdoor recreation and education, including access to beaches and mountains
2. Preserving of cultural and historic sites
3. Protecting habitats or ecosystems
4. Preserving forests, beaches, coastal areas, and agricultural lands; and
5. Protecting watershed lands
6. Conserving land to reduce erosion and runoff
7. Improving access to public land and open space
8. Acquiring access to public land and open space
9. Conserving land for open space and scenic values

http://www.kauai.gov/default.aspx?tabid=294

State Legacy Land Conservation Program
The Legacy Land Conservation Program (LLCP) provides funding from the Land Conservation Fund for the acquisition of lands, including easements, for:

1. Watersheds protection
2. Parks

3. Coastal areas, beaches, and ocean access
4. Natural areas
5. Habitat protection
6. Agricultural production
7. Cultural and historical sites
8. Open spaces and scenic resources
9. Recreational and public hunting area

Grants from the Land Conservation Fund are available through Legacy Land Conservation Program to State agencies, counties, and non-profit land conservation organizations seeking funding to acquire property that has value as a resource to Hawai‘i. County agency or nonprofit land conservation organization grant recipients must provide matching funds of at least 25% of the total project costs.
http://dlnr.hawaii.gov/ecosystems/llcp/

Hawaiian Islands Land Trust (HILT)

HILT is a non-profit organization that works with landowners, community groups, and government partners to protect lands. Using a variety of tools, including conservation easements, fee ownership, or brokering land transfers to other land protection agencies, HILT helps landowners integrate conservation into their land use plans in perpetuity. HILT is a nationally accredited organization that assumes responsibility of protected lands in their care and future acquisitions forever. Kaua‘i has its own advisory council made up of community leaders.
http://www.hilt.org/

The Trust for Public Land (TPL)

The Trust for Public Land’s mission is to create parks and protect land for people, ensuring healthy, livable communities for generations to come. TPL offers a range of services for land conservation. It helps communities raise funds, conduct research and planning, acquire and protect land, and design and renovate parks, playgrounds, trails, and gardens.
https://www.tpl.org/

The Nature Conservancy

From mauka to makai**,** The Nature Conservancy (TNC) works with local communities**,** businesses and people protect Hawaii's best natural lands and waters. Since 1980, it has established a statewide system of Conservancy preserves, helped create new wildlife refuges and expand national parks, forged partnerships to protect the most important watershed forests and coral reefs, and led efforts to stem the tide of invasive species entering the state. www.nature.org.

10. Recommended Actions and Timetables

Figure 8: Action, responsibility, timeframe

Number	Action	Responsibility	Timeframe
1.	Approach landowners for collaboration	UH Sea Grant and Mālama Hulēʻia	May 2015 - ongoing
2.	Community Meetings	UH Sea Grant, Mālama Hulēʻia, and Community Members	June 2015 August 2015
3.	Finalize Red Mangrove Invasive Species Action Plan for the Hulēʻia	Mālama Hulēʻia and UH Sea Grant	October 2015
4.	Pursue partnerships to implement the Plan	Mālama Hulēʻia	June 2015 - ongoing
5.	Identify Permit Requirements & Timelines	UH Sea Grant	December 2014 (complete)
6.	Apply for Permits		
7.	Apply for Funding		
8.	Initiate Work		

11. Community Input

Community and landowner input on this Plan was solicited through multiple avenues. Letters and drafts were mailed directly to all landowners along the Hule`ia river. Newspaper articles were published highlighting the Plan and the request for input, and the draft was available online for review. A community meeting and dinner was held on June 16, 2015. Approximately twenty-five community members learned about the project and provided input on the Plan. Most of the comments did not warrant major changes to the Plan, but provided good questions to include in frequently asked questions (FAQ) section, which has been added to this document as Appendix D.

Appendix A. Huleʻia Mangrove Removal Options (total acreage ~62)

Sea Grant proposal work items 1, 2, and 5 state that alternative removal, maintenance, and replanting techniques will be identified for each habitat type within Hulēʻia, with associated costs, permit requirements, and timeline for each so that comparisons and decisions can be made by the steering committee on a path forward. The results of this research are detailed below.

1. Herbicide Drill – Paint

Description	Herbicide (Garlon or Habitat) is applied to the main trunk. Herbicide can be applied either by drilling and syringe injection, or painting on bark with a brush.
Cost	$3,000 / acre; $186,000 total[1]
Cost per Habitat Type	no cost differential
Permit Requirements	County Minor Special Management Area Permit
Timeline	20 acres / year removal rate Project timeline = 3 years
Project Staging Location Options	Easiest option to stage as workers could probably access most areas by boat
Funding/Partnership Options	U.S. Fish and Wildlife Service has funded this technique on Big Island
Maintenance Requirements	Would require follow up over all areas at least 1 year post treatment to confirm kill and retreat if needed. It would also require 1-2 years of hand removal of keiki
Replanting with Natives	See Section 6 below; same for all methods
Pros	Least expensive, least regulation, safe and fast, ease of access
Cons	Use of herbicide around water, skeleton trees,

[1] All cost estimates based on paid labor, equipment, materials, and mobilization. Does not include planning/permitting costs.

	difficult maintenance, no replanting
Comments	This technique is certainly the most cost effective and least regulated method of stopping the growth and spread of mangrove in Hule`ia. However, it leaves a skeletal forest of mangrove that may be a flood hazard and would certainly be considered a visual impact by some.

Examples of the Use of this Technique

Mālama O Puna

Contact = Ann Kobsa at Mālama o Puna (965-2000). They have conducted several site eradication efforts for mangrove on the Big Island. They use a drill hole-herbicide (Habitat) technique that is very effective. They have eradicated over 50 acres of mangrove over several sites, with the single largest contiguous area being 20 acres. They leave the dead mangrove standing, thus avoiding any trigger for 404 or 401 permit requirements. Even though they were conducting work directly in coastal waters, in one case in a Marine Life Conservation Area. They were required to obtain a County SMA permit only. They had funding and support from USFWS. They used 3-5 paid people to eradicate 20 acres in 1 year at a cost of about $2500 per acre.

State of Hawaii DLNR-DOFAW

Contact = Dave Smith in DOFAW (225-5614). He believes that the most effective method is to paint the trunk with Garlon 4. After the trees die they can be pulled out by hand or equipment virtually without sediment disturbance because the roots are gone. He suggests some group should test the 404 trigger with this technique as it might pass, even with removing the dead trees because there is so little sediment disturbance.

2. Hand Cut and Hand Remove

Description	Trunk and aerial stems are cut with hand saw, chain saw, or rotary blade below the high tide line.
Cost	$25,000 - $100,000 / acre; $1,550,000 – 6,200,000 total[1] Lower costs are associated with shorter drag and chip distances and non-Federal lands. Federal lands are always more expensive due to contracting rules. In terms of drag and chip distances, for this project it could be at the lower end of the range if you start at the river mouth and move back eliminating the need to cut multiple accessways and drag long distances. Costs would also be lessened by disposing of chips onsite (if permitted)
Cost per Habitat Type	No differential
Permit Requirements	County Minor Special Management Area Permit for cost less than $500k. SMA Use Permit for costs greater than $500k.[2] DLNR Division of Land and Natural Resources Office of Coastal Lands Conservation District Site Plan Approval Department approval of plan (> 1 acre) State EA unless OCCL determines it to be exempt NEPA compliance on Refuge lands
Timeline	0.25 acres - 2 acres/person/year Project timeline = 3 years with a work crew of 15 people
Project Staging Location Options	1. Single linear access parallel to the river and move back systematically (simplest, assuming landowner approval) 2. Multiple access sites perpendicular to river. May have to do this to get around drainage ditches or streams; or if no landowner approval. This would bring expense to higher end of range.
Funding/Partnership Options	Standard technique currently funded and used in Hawaii

[2] County SMA may be exempt if they consider it to be maintenance work. A permit determination form can be submitted to Planning to get the final answer once plans are more firm.

Maintenance Requirements	Would require follow up over all areas 1-2 years post treatment to confirm kill and hand removal of keiki.
Pros	Minimum regulation, current standard technique, cost effective, can be used in Alakoko
Cons	Access development, dangerous to workers
Comments	The cost range of this technique is influenced by the access clearing and chip moving requirements.

Examples of the Use of this Technique

Kaloko Honokohau National Park:

Contact = Tyler Campbell (329-6881, tyler_paikuli_campbell@nps.gov). The National Park began removing mangrove from the fishponds in the 1990's. They also avoided any 404-401 permit by hand cutting and putting cut vegetation on a boat or sling from a helicopter to upland sites. They removed about 5 acres in total at a cost of about $150K/acre including 10,000 worker hours/acre.

Navy - Pearl Harbor:

Contact = Luke at Pono Pacific. They have the contract with the Navy to remove mangrove at sites around Pearl Harbor. They have done several smaller areas with the Navy before. They are currently working on a 25 acre project. They have 15-25 people on the project and expect to be completed in 1 year. They are cutting with chainsaws, dragging to upland, chipping into a truck, then trucking to a disposal site on Navy land. Cost estimate is $50K per acre. No permits were required accept for SHPO at a fishpond site.

Bellows Air Force Base

Contact = Craig Gorsuch = 259-4213, 927-1867, craig.gorsuch.ctr@us.95.mil

They use hand removal only. They have removed about 4 acres in total, including an 800' strip along a stream. Costs are $100K/acre for hand cutting, chipping, and hauling. It required 2 years of intensive follow up on keiki removal but now they have virtually no recruitment. No permits were required.

Ka`elepulu – Oceanit

Contact = Bob Bourke at Oceanit. They obtained a 319 grant from the EPA to do restoration work on the wetland at Ka'elepulu. They removed 1 acre of mangrove (estimated at 60 tons) by hand at a cost of $25K / acre. No permits were required.

3. Hand Cut with Equipment Removal

Description	Trunk and aerial stems are cut with hand saw, chain saw, or rotary blade below the high tide line. Cut material is lifted/dragged out of wetland with an excavator or crane.
Cost	$25,000 - $100,000 / acre; $1,550,000 - $6,200,000 total[1]
Cost per Habitat Type	Lower costs are associated with shorter drag and chip distances. Federal lands are always more expensive due to contracting rules. In terms of drag and chip distances, for this project it could be at the lower end of the range if you start at the river mouth and move back eliminating the need to cut multiple accessways and drag long distances. Costs would also be lessened by disposing of chips onsite (if permitted)
Permit Requirements	County Minor Special Management Area Permit for cost less than $500k. SMA Use Permit for costs greater than $500k.[3] Division of Land and Natural Resources Office of Coastal Lands Conservation District Site Plan Approval (> 1 acre) State Environmental Assessment unless determined to be exempt National Environmental Protection Act (NEPA) compliance on Refuge lands
Timeline	0.25 acres - 2 acres/person/year Project timeline = 3 years with a work crew of 15 people
Project Staging Location Options	If chipping is required (likely), then linear access along river must be created. This will increase cost to the higher end of the range.
Funding/Partnership Options	This is a novel variant on the standard technique currently funded and used in Hawaii. Should be equally likely to acquire funding.

[3] County SMA may be exempt if they consider it to be maintenance work. A permit determination form can be submitted to Planning to get the final answer once plans are more firm.

Maintenance Requirements	Would require follow up over all areas 1-2 years post treatment to confirm kill and hand removal of keiki.
Pros	Minimum regulation, within range of current standard technique, cost effective
Cons	Access development, dangerous to workers, cannot be used in Alakoko on wall (see below)
Comments	The cost range of this technique is influenced by the access clearing and chip moving requirements. Because this technique is not well documented, the expected cost reduction from standard hand work is not available. At the least it would increase the rate of work and safety of workers.

4. Grind and Vacuum Removal

Description	An excavator with a grinding head would grind all parts to below high tide level. At the same time a vacuum attachment would pull all chip and dust material away from water and blow it onto adjacent upland.
Cost	$50,000 - 100,000 / acre; $3,100,000 – $6,200,000 total[1] Cost includes access development
Cost per habitat type	No differential
Permit Requirements	County Minor Special Management Area Permit for cost less than $500k. SMA Use Permit for costs greater than $500k.[4] DLNR Division of Land and Natural Resources Office of Coastal Lands Conservation District Site Plan Approval (> 1 acre) State Environmental Assessment unless determined to be exempt National Environmental Protection Act (NEPA) compliance on Refuge lands
Timeline	1 year permitting, 2-3 years' work Project timeline = 3-4 years
Project Staging Location Options	Linear access along river must be created, but included as part of cost estimate
Funding/Partnership Options	No one has funded this novel technique in Hawaii. Might require initial demonstration grant first.
Maintenance Requirements	Would require follow up over all areas 1-2 years post treatment to confirm kill and hand removal of keiki.
Pros	Minimum regulation (but untested), within range of current standard technique, safest because no blades, less hard labor

[4] County SMA may be exempt if they consider it to be maintenance work. A permit determination form can be submitted to Planning to get the final answer once plans are more firm.

Cons	Access development novel technique, cannot be used in Alakoko on wall
Comments	This technique is not readily available but should be able to be found or easily developed. This technique could not be used on Alakoko wall and possibly other area of loko I'a (see below)

5. Equipment Removal

Description	An excavator would pull all woody material out of water and either pile or chip and deposit onto adjacent upland.
Cost	$100,000 / acre; $500,000 total[1]
Cost per Habitat Type	Cost includes access development
Permit Requirements	County SMA Minor Permit for cost less than $500k. SMA Use Permit for costs greater than $500k.[5] Army Corp 404 individual permit, United States Fish and Wildlife Service (USFWS) review, Department of Health (DOH) 401 and National Pollution Discharge Elimination System (NPDES) permits, Section 103 –Section 106 consultation, State Environmental Impact Statement (EIS), State Conservation District Site Plan Approval or Conservation District Use Permit, County Grading and Grubbing Permit, National Environmental Policy Act (NEPA) compliance on federal lands
Timeline	1-2 years permitting, 2-3 years' work Project timeline = 3-5 years
Project Staging Location Options	Linear access along river must be created, but included as part of cost estimate
Funding/Partnership Options	This technique would require partnership and funding with/from State and Federal agencies. Ducks Unlimited and North American Wetland Conservation Act NAWCA grant used this technique on Oahu Wildlife Refuges and some State lands.
Maintenance Requirements	Would require follow up over all areas 1-2 years post treatment to confirm kill and hand removal of keiki.
Pros	Least dangerous, familiar technique
Cons	Access development, maximum regulation and permits, lengthy permit time, high cost, cannot be used in Alakoko
Comments	This technique could not be used on Alakoko wall and possibly other area of loko I'a

[5] County SMA may be exempt if they consider it to be maintenance work. A permit determination form can be submitted to Planning to get the final answer once plans are more firm.

6. Replanting with Native Hawaiian Vegetation

The permitting, effort and cost of replanting is the same for all removal techniques, thus does not need to be compared among them.

We have a very good range of cost estimates from ongoing restoration projects here on Kauai. The costs used here are largely derived from the contractor, Pono Pacific, who is doing replanting work at Kilauea Point NWR. Plants are purchased from NTBG in Lawai.

Plants themselves cost between $5-$25 dollars. Trees costing more than ground cover. The total number of plants required will depend upon species selection and planting density. For discussion purposes, let's use $10/plant with a plant density of 500/acre (planting distance of 10 feet). This is a cost of $5,000 per acre and $310,000 for the entire project.

With a crew of 4 people working 40 hours/week at $5,000/week (for the crew), they can plant about 1500 plants/week. This is about 3 acres/week. The entire project would require about 20 weeks with a labor cost of $103,000.

So a good rough cost estimate of replanting for the entire project is $310,000 (planting material) + $103,000 (labor) = $413,000 for 62 acres. The greatest determinant of cost is the planting density, the plant species.

Note that this estimate is based upon replanting the 62 acres covered by mangrove. Much of this coverage is over open water, which would not be replanted. Thus the actually acreage required to replant would likely be much less than 62 acres.

7. Suggested Plan for Staging the Project: Start with Alakoko Fish Pond

Work Item #1 of the Sea Grant proposal states that work will involve a suggested plan for how to best stage the project over the target areas, given the type of equipment available, permit requirements, debris removal requirements, land ownership, etc.
It is prudent to consider mangrove removal efforts in Alakoko fishpond as a separate or potentially separate sub-project for the following reasons.

Because of the built-structure of the fishpond wall and the fact that the mangrove has attached itself around rocks/boulders, it is unlikely that any heavy equipment could be used, thus limiting removal options to herbicide or hand cut.

The State has approved a streamlined permitting process for fishpond work that is limited to activities such as mangrove removal by hand. While the Army Corp has yet to promulgate a General Permit that supports this, they have also said that if the hand cutting technique is used then no permit is required from them.

There are only 2 land owners in or around the fishpond. Work on the USWFS Refuge portion would require consultation with SHPO and Advisory Council on Historic Preservation.

We believe that mangrove removal in the fishpond would be the most regulatory and logistically streamlined portion of the project, as it would allow much more area to be worked without triggering a State EA and accompanying permits.

It would also be one the easiest areas to access and provide the largest return on effort with regard to visual impact and public and agency support.

We suggest that this would be a large but chewable bite that could be implemented while the larger project planning and funding effort is addressed.

Appendix B: Additional Grant Sources

Five Star Restoration Program
National Fish and Wildlife Foundation supports community stewardship projects are supported by the Five Star Restoration Program (http://www.nfwf.org/fivestar/Pages/home.aspx#.VQeHBtLF_To), a partnership with the U.S. Environmental Protection Agency that supports locally based wetland, riparian and coastal habitat projects. They have funded several projects in Hawaii. Awards range from $20,000* to $50,000 with an average size of $30,000 and 40-50 grants awarded per year.

Community Restoration Partnership
The Hawaii Community Foundation (HCF) and its partners--the Harold K. L. Castle Foundation, The Weissman Family Foundation, The Hawaii Tourism Authority, the National Oceanic and Atmospheric Administration (NOAA), and the Marisla Foundation—fund the Community Restoration Partnership (CRP). This funding opportunity provides support for on-the-ground lower watershed and coastal restoration projects in Hawai‘i that are led by local community groups and focus on durable and sustainable positive impacts on the environment. Requests for up to $50,000 are currently considered.
http://www.hawaiicommunityfoundation.org/nonprofits/open-grants/community-restoration-partnership-grant

National Fish Habitat Partnership Funds
The Hawaii Fish Habitat Partnership seeks to cooperatively develop and implement conservation projects to benefit native aquatic life and sustainable uses of streams, estuaries, and nearshore marine habitats through the support and participation of government agencies, non-governmental organizations, and communities. The Partnerships issues fish habitat funding opportunities through national fish habitat partnership funds (http://www.fishhabitat.org/). Awards range from $25,000 - $50,000. Contact Gordon Smith, Coordinator, (808) 792-9400 300; gordon_smith@fws.gov.

USFWS Partners for Fish and Wildlife Program

http://www.fws.gov/pacificislands/partners.html

The Partners for Fish and Wildlife Program was established to offer technical and financial assistance to landowners who wish to restore wildlife habitat (native ecosystems) on their property.

Projects can include, but are not limited to, construction of fences to exclude feral ungulates; control of alien plants, mammalian predators, and feral ungulates; out-planting of native plants; and restoration of native ecosystem elements, such as hydrology and micro-habitat conditions.

The assistance provided by the U.S. Fish and Wildlife Service (Service) can range from informal advice on the design and location of potential restoration projects to cost-share funding of project

implementation under a formal cooperative agreement with the landowner. The Service can also provide participating property owners with technical assistance to develop Safe Harbor Agreements that cover habitat managed for endangered or threatened species, and provide assurances that additional land, water, and/or natural resource use restrictions will not be imposed as a result of their voluntary conservation actions to benefit covered species.

Funding is limited. Projects given highest priority are those that re-establish natural biological communities and provide long-term benefits to declining migratory bird and fish species, species that are endangered, threatened, candidates or proposed for listing, and those projects on private lands that satisfy the needs of wildlife populations on National Wildlife Refuges.

USFWS Coastal Program

The Pacific Islands Coastal Program is one of the regional programs under the USFWS Coastal Program. The Pacific Islands program provides a crucial link between private landowners, Federal agencies, State and local governments, and communities to facilitate significant coastal conservation efforts. Protection and restoration actions restore near-shore marine environments and benefit trust resources such as federally listed sea turtles, waterbirds, and endangered species, as well as migratory seabirds, shorebirds, wetlands, and coral reefs.

Selected projects are funded from annual appropriations to the Coastal Program, although there are always more proposals than available funding. Project pre-proposals can be submitted at any time. See http://www.fws.gov/pacificislands/coastal.html for more information.

Appendix C: Frequently Asked Questions (FAQ)

Q. Mangroves provide important benefits to the environment worldwide, including erosion and water quality benefits, wildlife habitat, and coastal protection. Why then, are you trying to eradicate them in Hawai`i?

A. Even though beneficial elsewhere, in Hawai'i mangroves are invasive and studies show they are destructive to the environment. Below is some factual information about erosion, water quality, wildlife habitat and coastal protection:

Erosion and Water Quality

Both in its native habitat and here in Hawaii, studies show that red mangrove traps sediment and accretes soil in coastal and riparian brackish water systems. In some areas this improves the water quality of adjacent coral reefs, as the mangroves capture sediment, keeping it off the reef. This certainly occurs in Hawaii also and is one of the reasons that red mangrove was introduced to Hawaii in the first place.

However, it is not necessarily true that the sediment and water quality in a mangrove system in Hawaii is an improved state. What is true is that it is not a natural state of that particular area that has been overrun with mangrove, nor is it the natural state of the water in that area as it interfaces with downstream and adjacent systems like coral reefs.

We want to emphasize that the goal of this effort is not just to remove mangrove, but to replant the banks and riparian area with native plants which will restore sediment transport, storage and other water quality parameters to more natural states.

But there is also documentation of specific water quality impacts of mangrove in Hawaii. Red mangroves in Hawai'i have been found to grow to higher densities than in their native range (Cox and Allen, 1999), probably because Hawai'i lacks the species that attack the flowers and propagules. Litterfall from mangrove stands at Nu'upia Pond, Oahu has been measured at 2.52 kg ha-1, which exceeds net primary productivity in its native range in Florida (Cox and Jokiel 1996, Odum McIvor and Smith 1982). These added organic inputs have led to detrital accumulations and algal blooms. Other influential ecosystem processes include water stagnation, soil sedimentation, anoxia and hypersalinization (Cordona and Botera 1998, McKee 1996).

Wildlife Habitat

In Hawaii, the establishment of mangrove has dramatically altered ecosystem processes in the areas it has invaded. It changes macrofaunal species and food-web structure, facilitating greater dominance by sub-surface deposit feeders, and creating new niches for other exotic species in mangrove sediments (Demopoulos, 2004; Demopoulos et al., 2007; Demopoulos and Smith, 2010).

The positive fish habitat value of mangroves has been well documented in ecosystems where these trees are native (i.e., Caribbean, Australia, and Florida). In Hawai'i,

however, it appears that mangroves may be having a negative impact on fish community structure. The most extensive studies on mangrove impacts to fish have been done on Molokaʻi (Demopoulos et al. 2007, Nakahara 2007) and show similar results to studies on the island of Hawaiʻi; mangroves seem to be providing habitat for invasive fish species (e.g., poeciliids, snapper, tilapia) (Van der Veur 2006, MacKenzie et al. unpublished data); species that have adverse effects on habitat value for native fish communities as well as on native fish community structure.

It is true that some native birds, such as the Black-crowned Night Heron, will utilize mangrove stands, particularly for roosting. However, most native birds that would naturally occur in mangrove areas, such as shore birds and endangered waterfowl (see below) have been displaced by the mangrove. The detrimental impact of red mangrove on native bird habitat in Hawaii is recognized by the State of Hawaii Department of Land and Natural Resources, U.S. Fish and Wildlife Service, National Park Service, and Ducks Unlimited (personal communication).

Coastal Protection

Mangroves were introduced in the early 20th century to stabilize the soil. Due to their capabilities in reducing wave energy, trapping sediments, and reducing erosion, mangroves do provide shoreline protection from coastal hazards such as flooding, erosion, and high wave events – as well as protection during extreme storm events, such as storm surge from hurricanes (Spalding et al 2014).

Mangroves are native to the Western Pacific (American Sāmoa marks the easternmost range of mangroves indigenous to the Pacific) and provide an important ecosystem function role there, including hazard protection. They are particularly helpful in “low” atoll islands that do not benefit from the hazard relief that high elevation volcanic islands, like Hawaiʻi, do. “High” islands like Hawaiʻi generally have more natural resources, such as land and freshwater, which provide more sea climate change adaptation options, such as sea level rise (Keener et al 2012).

Despite these coastal protection capabilities, sea level rise induced erosion and inundation is a threat to mangroves, especially if it is sudden or if there is no path for them to migrate landward in their natural habitat. Also, the increased intensity and frequency of storms from climate change has the potential to increase damage to mangroves through defoliation and tree mortality and can also alter sediment elevation that the mangroves grow on, causing reduced or eliminated function. Tsunamis can cause severe damage to mangroves (Keener et al 2012; Ellison 2000; Gilman et al 2008).

In Hawaiʻi, mangroves are considered invasive, and despite their hazard protection utility, it is clear that the impacts to the native coastal wetland ecosystem far outweigh the benefits. Instead, maintaining and restoring native coastal ecosystems and habitats, including intertidal wetlands, beaches, dunes, and reefs are the essential components to hazards resilience (UH Sea Grant and Hawaiʻi DLNR 2004; Spalding et al 2014; Hwang 2005). This, coupled with proper planning, siting and design for coastal

structures/communities, appropriate shoreline and riparian setbacks for structures, and allowing the shoreline to retreat and accrete naturally (dubbed “accommodation” in adaptation planning) are the least impactful methods for hazards resilience from an environmental standpoint.

Q. How do mangroves in the Hule`ia watershed affect endangered species?

A. Red mangroves have been shown to displace nesting habitats of the endangered Hawaiian duck (*Anas wyvilliana*), stilt (*Himantopus knudseni*), coot (*Fulica americana*) and moorhen (*Gallinula chloropus*) (Rauzon and Drigot 2002, Chimner, et al. 2006).

Q. Will eradication of Red Mangrove in the Hule`ia watershed affect the endangered Hawaiian Hoary Bat?

A. Observations of the endangered Hawaiian Hoary Bat confirm that they occur in the lower Hule`ia watershed where mangrove become established is consistent with other observations of the Hoary bat foraging over riparian and coastal areas at dusk (USFWS Recovery Plan 1998). However, there is no evidence that the bats are using, or benefiting from, the mangrove in these areas. While undocumented, bats may roost in mature mangrove, and consultation with State and Federal biologists will occur, but this concern has not impeded the removal of mangrove from State and Federal properties. In addition, routine removal of trees by State agencies and contractors along highway corridors is usually scheduled from July to October, outside the pupping season of the bat. Removing mangrove seasonally would be consistent with the recommendations of U.S. Fish and Wildlife Service.

Q. Has Malama Hule`ia fully considered the use of herbicide for mangrove eradication?

A. The use of herbicide (Garlon and Imazapyr) was fully researched and considered. Due to concerns about aesthetics, environmental impacts, cultural sensitivity, and potential community concerns it has been ruled out for the time being. While the technique by itself is relatively cheap, $3k/acre, it would involve injecting mangrove trunks with herbicide and allowing them to die in place. This would leave a skeleton forest in its place, which would be visually unappealing. Therefore, efforts would then need to be undertaken to remove the dead wood, which would be additional labor and cost ($25k to $100k per acre). This same labor and cost for removal without the herbicide is already planned, therefore the group felt there was little value added with using the herbicide.

The following were the pros and cons discussed by Malama Hule`ia:

- Pros: prevents spread, erosion control (leaves trees in place), Renovate 3 approved for aquatic use, low cost by itself (3k/acre), KISC already uses, easier to chip, lighter wood, on rock wall prevent regrowth, immediately stops seed production and spread of seedlings

- Cons: harder to remove dead wood, double work, aesthetics of leaving in place necessitates removal anyway, community concerns, leaf droppings – water quality issue.

Q. Will mangrove removal on the Alakako Fish Pond walls destabilize the rocks on the walls?

A. Due to the sensitivity of the historic fish pond stone walls and its cultural significance, it is important to use a non-invasive method of mangrove removal. The hand cut/hand remove technique will be used for the Alakoko Fish Pond banks. With this method, trunk and aerial stems are cut with hand saw, chain saw, or rotary blade below the high tide line. It is probable that some of the rocks will become destabilized during this process because the mangrove roots have entangled themselves in the rocks. This will need to be further investigated as the project gets closer to fruition.

Appendix D: References

Publications

Allen, J. A. 1998. Mangroves as alien species: The case of Hawaii. Glob. Ecol. Biogeogr. Lett.7:61–71.

Cormier, Nicole., Fry, Brian. Chemical Ecology of Red Mangroves Rhizophora mangle, in the Hawaiian Islands. Pacific Science 65(2):219-234. 2011

Demopoulos, Amanda W.J. and Smith, Craig R. 2010. "Invasive Mangroves Alter Macrofaunal Community Structure and Facilitate Opportunistic Exotics." Marine Ecology Progress Series. Vol. 404: 51 – 67, doi: 10.3354/meps08483

El- Kadi AI, Fujioka RS, Liu CCK, Yoshida K, Vithanage G, Pan Y, Farmer J. 2003. Assessment and protection plan for the Nāwiliwili watershed: phase 2--assessment of contaminant levels. Honolulu (HI): Water Resources Research Center, University of Hawaii at Manoa. WRRC-2003-02.

El-Kadi, A.I., M. Mira, S. Dhal, and J.E.T. Moncur. 2004. Assessment and Protection Plan for the Nāwiliwili Watershed: Phase 3 – Restoration and Protection Plan. University of Hawaii Water Resources Research Center WRRC 2004-05.
hawaii.gov/health/environmental/water/cleanwater/pubntcs/prc/pdf/WatershedBasedPlanNāwiliwili.pdf

Ellison, J. C. (2000). "How South Pacific mangroves may respond to predicted climate change and sea level rise." In A. Gillespie & W. C. G. Burns (Eds.), Climate change in the South Pacific: Impacts and responses in Australia, New Zealand, and Small Island States, Advances in Global Change Research (Vol. 2, pp. 289–301). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Fronda, R., M. Lane-Kamahele and B. Harry. 2008. Removal of alien red mangrove from Kaloko- Honokohau National Historical Park. Pacific Cooperative Studies Unit Technical Report 162, University of Hawai`i at Manoa, Department of Botany, Honolulu, HI.

Furness, M., A.I. El-Kadi, R.S. Fujioka, and P.S. Moravcik. 2002. Assessment and Protection Plan for the Nāwiliwili Watershed: Phase 1 - Validation and Documentation of Existing Environmental Data. University of Hawaii Water Resources Research Center

Gilman, E. L., Ellison, J., Duke, N. C., & Field, C. (2008). Threats to mangroves from climate change and adaptation options: A review. Aquatic Botany, 89(2), 237–250. doi:10.1016/j.aquabot.2007.12.009

Hawai‘i State Department of Health, Tetra Tech Inc., and AECOS, Inc. 2008. Total Maximum Daily Loads (TMDLs) for Nutrients, Sediment, and Bacterial Indicator in Major Streams of the Nāwiliwili Bay Watershed, Kauai, Hawai‘i.

Hwang, Dennis J. 2005. Hawai‘i Coastal Hazard Mitigation Guidebook. Prepared for Office of Conservation and Coastal Lands Department of Land and Natural Resources State of Hawai‘i, and the Coastal Zone Management Program Office of Planning, the University of Hawai‘i Sea Grant College Program, and the National Oceanic and Atmospheric Administration Pacific Services Center.

Keener, V. W., Marra, J. J., Finucane, M. L., Spooner, D., & Smith, M. H. (Eds.). (2012). “Climate Change and Pacific Islands: Indicators and Impacts.” Report for the 2012 Pacific Islands Regional Climate Assessment. Washington, DC: Island Press.

Spalding, Mark D.; Ruffo, Susan; Lacambra, Carmen; Imen, Meliane; Hale, Lynne Zeitlin; Shepard, Christine C.; Beck, Michael W. 2014. “The Role of Ecosystems in Coastal Protection: Adapting to Climate Change and Coastal Hazards.” Ocean and Coastal Management 90 University of Hawai‘i Sea Grant Extension Service; State of Hawai‘i Department of Land and Natural Resources Office of Conservation and Coastal Lands (2004). Draft Erosion Management Alternatives for Hawai‘i.

Websites

Mālama Hulē‘ia: http://MālamaHulē‘ia .org/

Canoe Plants of Ancient Hawaii: http://www.canoeplants.com/

Cockett, PM et al. 2001 ‘Ainakumuwai: Ahupua'a of Nāwiliwili Bay. http://www.hawaii.edu/environment/ainakumuwai/index.htm

Native Plants of Hawaii**:** http://nativeplants.hawaii.edu/index/

Hawaiian Plants and Tropical Flowers: http://wildlifeofhawaii.com/flowers/