

**Field Release of *Aprostocetus nitens*
Prinsloo & Kelly (Hymenoptera:
Eulophidae: Tetrastichinae) for
Biological Control of the Erythrina Gall
Wasp, *Quadrastichus erythrinae* Kim
(Hymenoptera: Eulophidae)**

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January 2023

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(HYMENOPTERA: EULOPHIDAE: TETRASTICHINAE) FOR
BIOLOGICAL CONTROL OF THE ERYTHRINA GALL WASP,
QUADRASTICHUS ERYTHRINAE KIM
(HYMENOPTERA: EULOPHIDAE)**

**DRAFT FINAL ENVIRONMENTAL ASSESSMENT
JANUARY 2023**

Prepared by

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ABSTRACT/EXECUTIVE SUMMARY

Erythrina gall wasp (*Quadrastichus erythrinae*) was first detected in Hawai‘i on the island of O‘ahu in 2005. This non-native species quickly spread to *Erythrina* species throughout the state, including wiliwili (*Erythrina sandwicensis*), a highly valued dominant species of Hawai‘i’s lowland dry forests (Figure 1). The invasion of Hawai‘i by Erythrina gall wasp has resulted in the defoliation and mortality of thousands of *Erythrina* trees throughout the state, and it was not until the approval and release in 2008 of *Eurytoma erythrinae* Gates & Delvare, 2008 (Hymenoptera: Eurytomidae), a wasp parasitoid of Erythrina gall wasp, that wiliwili populations began to show signs of recovery. Ongoing monitoring of wiliwili has shown that inflorescences and seed pods are still being heavily impacted by the Erythrina gall wasp. A potential second biocontrol agent, *Aprostocetus nitens*, has been studied as a complementary biocontrol to *E. erythrinae*, and it is hoped that this species will further reduce the gall wasp’s negative impacts.

The Hawai‘i Department Agriculture (HDOA) is proposing to release *A. nitens* to reduce the impact of the gall wasp. This environmental assessment fulfills the requirements of the National Environmental Policy Act and the Hawai‘i Environmental Policy Act by detailing the results of host specificity and biological studies of *A. nitens*. An environmental assessment is needed to acquire the necessary state and federal permits for the release of this insect.



Figure 1. Flowering wiliwili (*Erythrina sandwicensis*); Photo by Forest & Kim Starr.

CONTENTS

Abstract/Executive Summary	i
Project Summary, Background, and Purpose and Need.....	1
Background.....	1
Purpose and Need for the Proposed Action.....	4
Public Involvement and Agency Coordination	5
Proposed Action and Alternatives.....	5
Proposed Action.....	5
Locations of Rearing Facilities and Release Sites	5
Method of Release	6
No Action Alternative.....	6
Alternatives Considered but Eliminated from Detailed Analysis	6
Affected Environment	6
Biological Testing.....	6
Target Organism: Erythrina Gall Wasp	6
Organism Proposed to Be Released: <i>Aprostocetus nitens</i>	7
Host Specificity Trials	10
Multiparasitism Trials.....	13
Environmental Impacts	17
Literature Search for Other Host Records.....	17
Host Specificity in Country of Origin.....	18
Potential Impact on Threatened and Endangered Species	18
Potential of <i>Aprostocetus nitens</i> to Act as a Hyperparasite	18
Potential of <i>Aprostocetus nitens</i> to Attack Non-Targets.....	18
Impacts to Cultural Values	18
Determination.....	23
Conclusion: Finding of No Significant Impact (FONSI).....	24
Literature Cited	24

FIGURES

Figure 1. Flowering wiliwili (<i>Erythrina sandwicensis</i>).....	i
Figure 2. Percentage of young wiliwili shoots with Erythrina gall wasp damage over time.....	2
Figure 3. Canopy cover of wiliwili over time.....	3
Figure 4. Flower and seed production in wiliwili after the release of <i>E. erythrinae</i>	4
Figure 5. <i>A. nitens</i> egg	7
Figure 6: <i>A. nitens</i> larva feeding on Erythrina gall wasp pupa	8
Figure 7. <i>A. nitens</i> pupa	8
Figure 8. <i>A. nitens</i> adult	9

Figure 9. *A. nitens* ovaries..... 9
Figure 10. Average number of emerged *A. nitens* in choice tests..... 11
Figure 11. Average number of visits on *E.variegata* and non-target host plants by *A. nitens*..... 12
Figure 12. Average number of emerged *A. nitens* in no-choice tests..... 13
Figure 13. Ratio of parasitoid presence in plant tissues..... 15
Figure 14. Erythrina gall wasp suppression levels by parasitoids..... 16
Figure 15. Feeding preferences of *A. nitens* and *E. erythrinae*..... 17

TABLE

Table 1. Gall-Forming Insects Used in Host Specificity Tests against *Aprostocetus nitens* 10
Table 2. Persons that responded to request for consultation..... 19

APPENDICIES

Appendix 1. A Cultural Impact Assessment for the Proposed Statewide Release of a Wasp Parasitoid (*Aprostocetus nitens*) as Biocontrol for the Erythrina Gall Wasp (*Quadrastichus erythrinae*)

Appendix 2. Comments Received During Draft Environmental Assessment Review Period

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PROJECT SUMMARY, BACKGROUND, AND PURPOSE AND NEED

Background

The presence of the Erythrina gall wasp (*Quadrastichus erythrinae*) was first detected in Hawai'i in 2005. The wasp spread quickly to several species of *Erythrina* in the state, including the important landscape plants *Erythrina crista-galli* and *E. variegata*, and the native species wiliwili (*E. sandwicensis*). Wiliwili showed greater than 40% mortality in some affected populations (Yalemar et al. 2016). Various control methods, including injecting priority trees with systemic pesticide, were attempted in an effort to kill the Erythrina gall wasp, with ultimately unsatisfactory results (Yalemar et al. 2016).

Subsequently, the Hawai'i Department of Land and Natural Resources Division of Forestry and Wildlife (DOFAW), the Hawai'i Department of Agriculture (HDOA), the University of Hawai'i (UH), and other government entities, initiated a project to examine species that would be appropriate biocontrols against Erythrina gall wasp. Three parasitoids found to attack Erythrina gall wasp were collected during biological control exploration in Kenya, South Africa, and Tanzania from 2005 to 2006; these are two eulophid parasitoids (*Aprostocetus exertus* La Salle and *Aprostocetus nitens* Prinsloo and Kelly) and the eurytomid parasitoid, *Eurytoma erythrinae* Gates and Delvare. *E. erythrinae* and *A. nitens*, in particular, showed promise as biocontrol agents.

After extensive evaluations at the HDOA Insect Containment Facility for host-specificity indicated that *E. erythrinae* prefers to feed exclusively on Erythrina gall wasp, field releases commenced in November 2008 and continued until the parasitoid was established throughout the state. More than 8,000 individuals were released at various sites on O'ahu, Maui, Kaua'i, the Big Island, and Moloka'i. Within the span of a few months, the wiliwili trees began to show signs of recovery, with healthy, non-galled new leaves and vigorous overall growth (Yalemar et al. 2016). By the second year after the release of *E. erythrinae*, more than 60% of young shoots were found to be free of damage by Erythrina gall wasp (Figure 2), and, by 2011, 90% of the targeted sample wiliwili trees had full canopy coverage (Figure 3).

Depending on the location, recent weather, and time of year, parasitism rates by *E. erythrinae* of Erythrina gall wasp larvae inside galls range from 20% to 100% (U.S. Forest Service 2014). Flowering and fruiting have resumed, and the number of flowers has increased each year post-release (Figure 4); however, 54% of wiliwili seeds sampled were not viable (Yalemar et al. 2016). This adverse impact on flower and seed production is not only an ecological concern, but it is also a cultural issue because Native Hawaiians value the red wiliwili seeds for lei making.

This environmental assessment fulfills the requirements of the National Environmental Policy Act and the Hawai'i Environmental Policy Act by detailing the results of host specificity and biological studies of *A. nitens*. An environmental assessment is needed to acquire the necessary state and federal permits for the release of this insect.

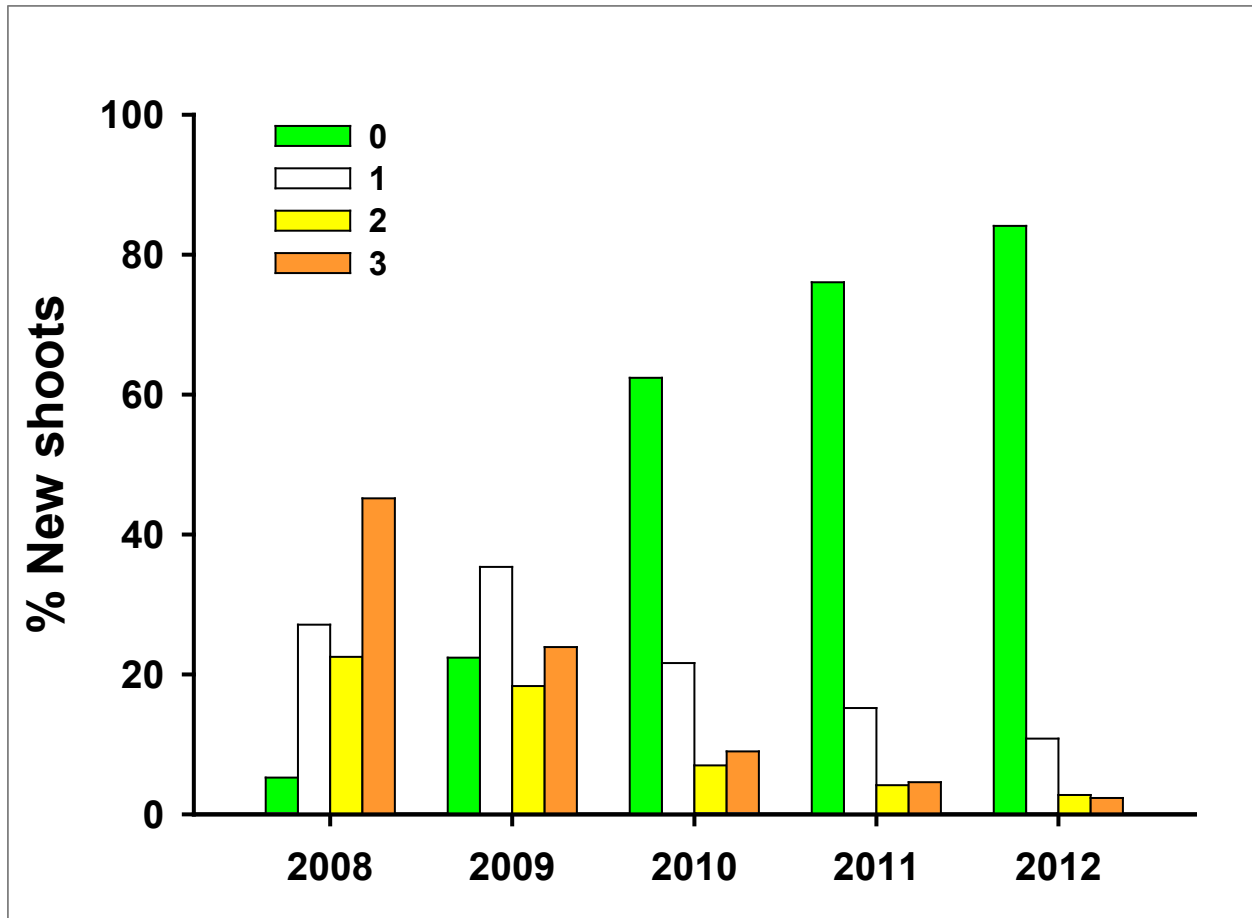


Figure 2. Percentage of young wiliwili shoots with Erythrina gall wasp damage over time where 0 = no damage, 1 ≤ 33% damage, 2 ≤ 66% damage, and 3 > 66% damage (Kaufman et al. 2014).

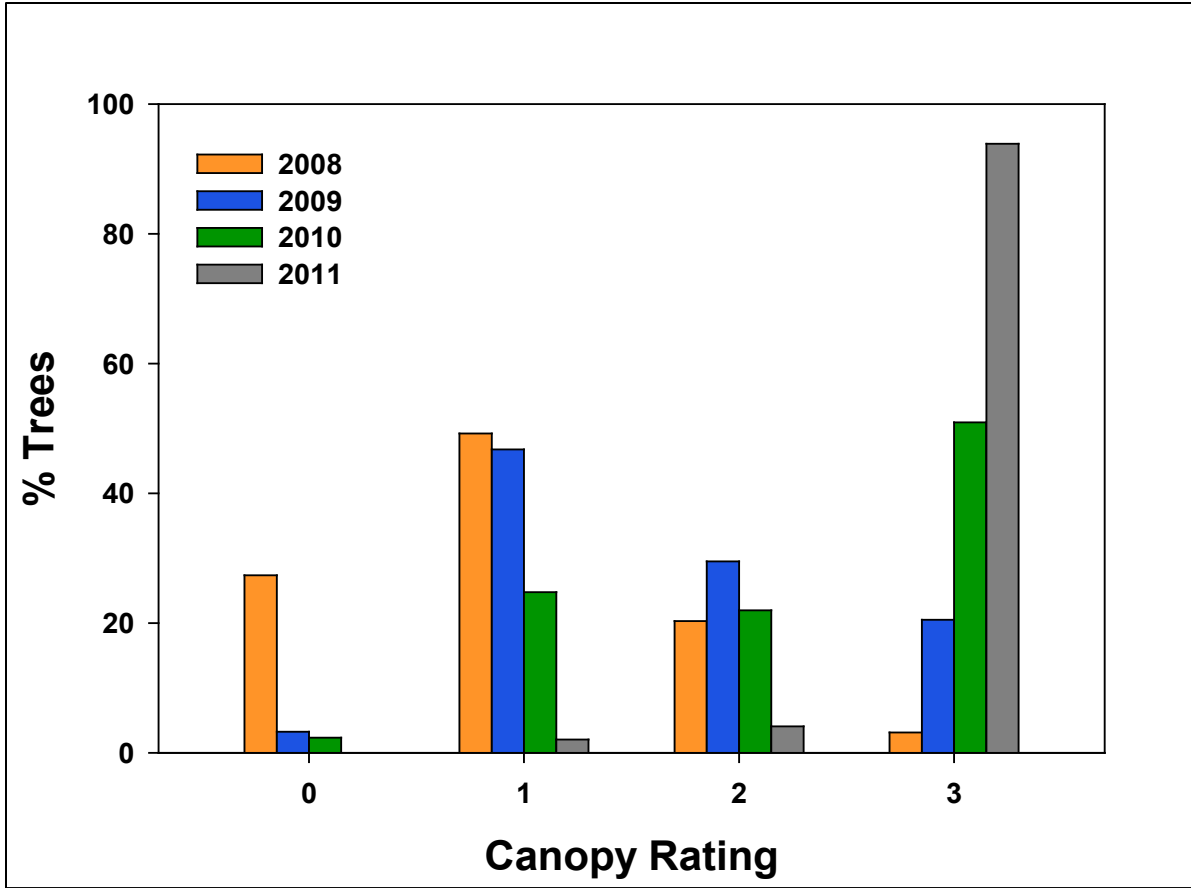


Figure 3. Canopy cover of wiliwili over time, where 0 = no canopy coverage, 1 \leq 33% canopy coverage, 2 \leq 66% canopy coverage, and 3 > 66% canopy coverage (Kaufman et al. 2014).

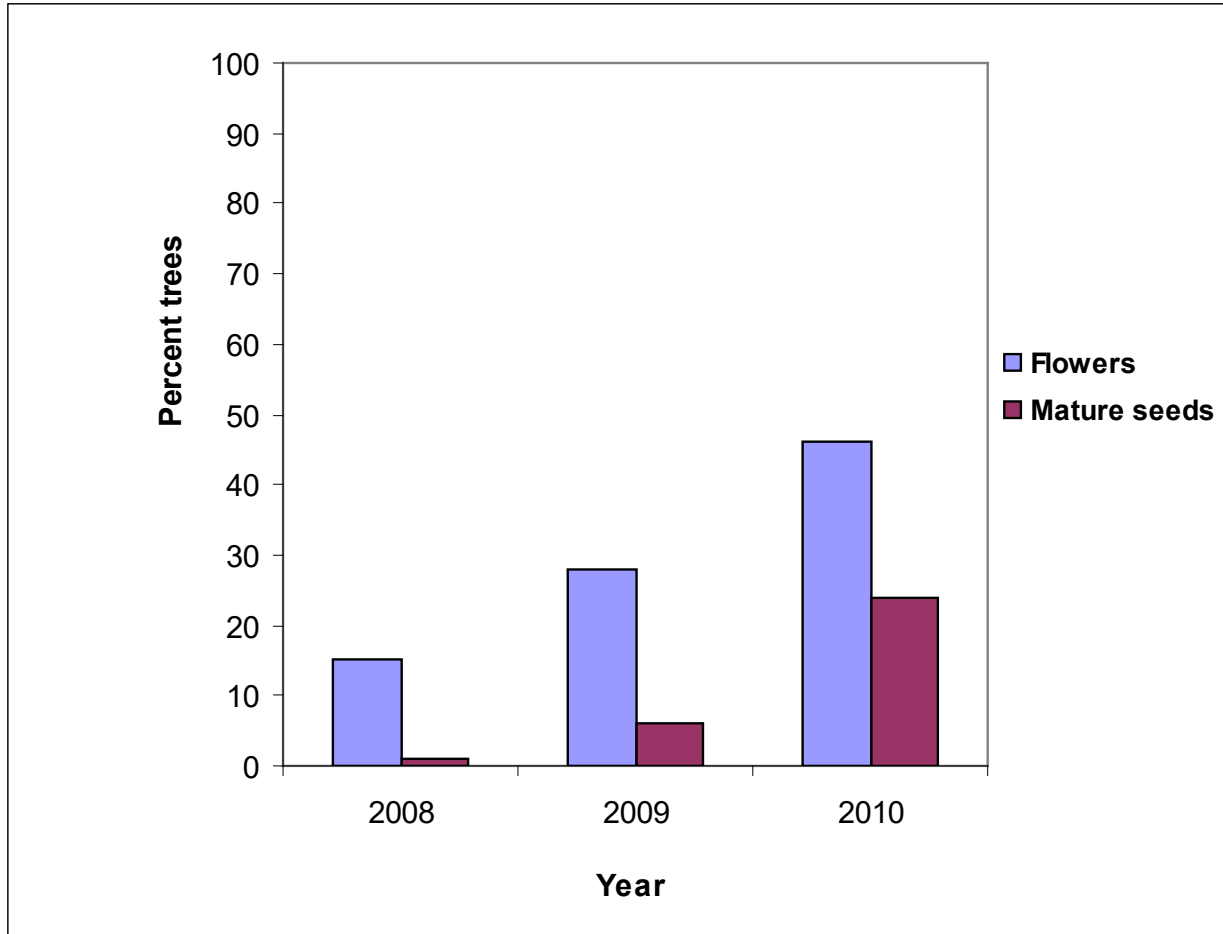


Figure 4. Flower and seed production in wiliwili after the release of *E. erythrinae* (Yalemar et al. 2016).

PURPOSE AND NEED FOR THE PROPOSED ACTION

Despite the success of the release of *Eurytoma erythrinae*, it has been known that a second species, *A. nitens*, would need to be released to enhance biocontrol efforts against Erythrina gall wasp. By releasing a second biocontrol agent, an additional non-chemical form of control will complement the suppression of Erythrina gall wasp populations (Yalemar and Bautista 2011). Because *E. erythrinae* acts as more of a predator than a parasitoid, with its larvae feeding in Erythrina gall wasp galls and tunneling to feed on additional larvae in adjacent galls, larger galls with many individual Erythrina gall wasps are preferred for oviposition. This feeding behavior leaves young *Erythrina* seedlings as well as reproductive parts (flowers and fruits)—where smaller galls tend to form—still vulnerable to attack by EGW and with little parasitism by the *Eurytoma erythrinae* parasitoid (Yalemar et al. 2016).

The Hawai‘i Department of Agriculture, with support from the Hawai‘i Department of Land and Natural Resources, proposes to release *Aprostocetus nitens* from its Insect Containment Facility [quarantine containment] into the natural environment of the state of Hawai‘i as a biological control agent. Unlike *E. erythrinae*, this parasitoid utilizes only one host individual to complete its development, and, therefore, it is able to live on much smaller galls, such as those found in flowers, seed pods, and young seedlings. This release will supplement the success of *E. erythrinae* in suppressing infestations of Erythrina gall wasp,

and will improve the survival success of wiliwili, an ecologically and culturally important native Hawaiian tree species.

Public Involvement and Agency Coordination

Comments received during Early Consultation and the 30-day public review period for the Draft Environmental Assessment (EA) for the “Field Release of *Eurytoma* sp. (Hymenoptera: Eurytomidae), for the Biological Control of the Erythrina Gall Wasp, *Quadrastichus erythrinae* Kim (Hymenoptera: Eulophidae), in Hawai‘i” were reviewed and considered during preparation of the Draft EA. Additional consultation was done (Table 2) through the Cultural Impact Assessment prepared by ASM Affiliates for the proposed action (Appendix 1).

In December 2019, a Draft Environmental Assessment was submitted to the Office of Environmental Quality Control (OEQC) [Environmental Review Program] with an Anticipated Finding of No Significant Impact. The Draft EA was published in OEQC’s Environmental Notice on December 23, 2019, for a 30-day public review period. All comments received during this period are included in Appendix 2. All comments were positive and in support of the release of *Aprostocetus nitens* for biological control of the invasive Erythrina gall wasp.

PROPOSED ACTION AND ALTERNATIVES

The actions being considered in this Final Environmental Assessment are 1) issuing a permit for release of the second parasitoid of Erythrina gall wasp, *A. nitens*. (The Proposed Action) and 2) no action (the No Action Alternative).

Proposed Action

An application has been submitted by the HDOA Plant Pest Control Branch to the HDOA Plant Quarantine Branch, 1849 Auiki Street, Honolulu, Hawai‘i, 96819, for a permit to introduce *Aprostocetus nitens* Prinsloo & Kelly (Hymenoptera: Eulophidae: Tetrastichinae) into the State of Hawai‘i under the provisions of Hawai‘i Revised Statutes, Chapter 141, Department of Agriculture, and Chapter 150A, Plant and Non-Domestic Animal Quarantine. *A. nitens* would be released to supplement efforts to control the Erythrina gall wasp, an invasive, gall-forming eulophid wasp that infests *Erythrina* trees in natural and landscaped areas in Hawai‘i.

Locations of Rearing Facilities and Release Sites

The HDOA Insect Containment Facility is located at the HDOA Main Office Complex in the city of Honolulu, Island of O‘ahu, State of Hawai‘i. The address of the property is 1428 South King Street, Honolulu, Hawai‘i, 96814-2512. If *A. nitens* is approved for release from containment (laboratory quarantine) as a biocontrol agent, mass propagation of the wasp will be done in the HDOA Insect Rearing Facility at the same location. Release sites on all islands will be selected according to the availability of *Erythrina* trees infested with Erythrina gall wasp. Initial releases will begin on the islands of O‘ahu, Maui, and Hawai‘i. Areas with endemic wiliwili trees infested with the Erythrina gall wasp will be prioritized. *A. nitens* will be hand-carried to the other Hawaiian Islands for release where needed.

Method of Release

Mature adults of *A. nitens* would be released on *Erythrina* trees infested with Erythrina gall wasp, and inoculations of this species would continue to be made statewide until *A. nitens* becomes established. HDOA expects to rear and release thousands of individuals of this wasp until the species is established. No particular timing of releases is planned.

No Action Alternative

Under the No Action Alternative, no permit would be approved and *A. nitens* would not be released. The No Action Alternative would be expected to result in the continued decline of wiliwili, due to their inability to produce viable seed. Although the release of *E. erythrinae* proved to be a success with recommencement of fruiting and flowering in *Erythrina* species, 54% of wiliwili seeds sampled after the release failed to form viable seeds as a result of gall wasp damage (Yalemar et al. 2016). This adverse impact on flower and seed production is both an ecological and cultural issue. Unlike *E. erythrinae*, *A. nitens* uses only one host individual to complete its development, so it is able to live in much smaller galls.

Alternatives Considered but Eliminated from Detailed Analysis

Because the Erythrina gall wasp feeds within plant tissues, it was thought that systemic pesticides could be used to control infestations of this species. However, widespread use of this method is cost-prohibitive, and frequent, long-term use of insecticides in natural areas is neither feasible nor advisable. Attempts in downtown Honolulu to control Erythrina gall wasp on *Erythrina variegata* using systemic pesticides were unsuccessful, and eventually resulted in the trees being cut down, after thousands of dollars were spent on chemicals (Yalemar 2016). Therefore, this alternative was not carried forward for detailed analysis in this EA.

AFFECTED ENVIRONMENT

Biological Testing

Target Organism: Erythrina Gall Wasp

The Erythrina gall wasp was first detected in 2005 when galls were observed on *Erythrina variegata* on the University of Hawai'i campus on O'ahu. Emerging adult wasps were subsequently identified as *Quadrastichus erythrinae*, a gall-forming eulophid wasp native to Africa. The current distribution of the Erythrina gall wasp as an invasive species encompasses American Samoa, Florida, Guam, India, mainland China, Puerto Rico, Singapore, and Taiwan. Like other gall-forming wasps, the Erythrina gall wasp inserts its eggs inside young leaf and stem tissue. Wasp larvae develop inside the tissue, causing a gall to form. As the infestation worsens, leaves and stems become deformed, which results in reduced levels of photosynthesis. The plant quickly loses vigor and may eventually die (Yang et al. 2004). Generation time for Erythrina gall wasp is rapid; in Hawai'i, the full life cycle from egg to adult has been observed to be approximately 20 days (HDOA Plant Pest and Control Branch 2008). Once the wasp has

established, it is dispersed via wind and through human activities such as hiking and shipping (Centre for Agricultural Bioscience International [CABI] Invasive Species Specialist Group 2015).

Organism Proposed to Be Released: Aprostocetus nitens

Aprostocetus nitens was first described to science by Prinsloo and Kelly (2009) after it was collected during exploratory surveys for natural enemies of Erythrina gall wasp in South Africa, Tanzania, and Kenya between 2005-2006. This species is quite small (1.1–1.7 mm long), and shiny black in color with a dark metallic green tinge and yellow gaster, antennae, and legs. The wings are transparent with brown venation (see Prinsloo and Kelly, 2009, for full description).

Biological studies of *A. nitens* were performed at the HDOA Insect Containment Facility. This species exhibits female parthenogenesis or thelytoky in laboratory conditions, which means that the eggs (Figure 5) do not need to be fertilized by a male to be viable and produce female offspring. The entire life cycle for this species from egg to adult (Figures 5 through 8) takes approximately 20 days, and newly hatched female offspring contain one or two mature eggs in their ovaries (Figure 9) (Yalemar et al. 2016). Females are synovigenic, which means they continue to produce mature eggs, laying an average of 139 eggs throughout their lifespan. This species can survive 4 days without food and lives for an average of 120 days (Yalemar 2016).

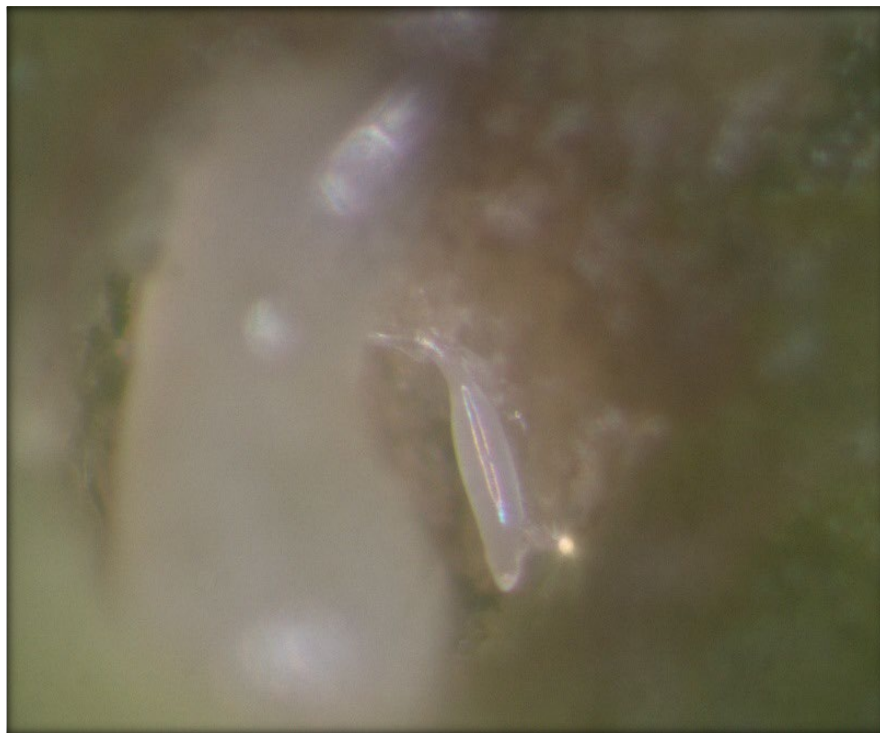


Figure 5. *A. nitens* egg; Photo by HDOA.



Figure 6. *A. nitens* larva feeding on Erythrina gall wasp pupa; Photo by HDOA.



Figure 7. *A. nitens* pupa; Photo by HDOA.



Figure 8. *A. nitens* adult; Photo by HDOA.



Figure 9. *A. nitens* ovaries; Photo by HDOA.

Host Specificity Trials

Host specificity studies were performed at the HDOA Insect Containment Facility. The non-target gall-forming insects tested were the same as those used in trials of *Eurytoma erythrinae* (Yalemar et al. 2016): banyan gall wasp (*Josephiella microcarpae*), a scale insect (*Tectococcus ovatus*) on strawberry guava (*Psidium cattleianum*), a eulophid wasp (*Ophelimus* sp.) on eucalyptus, a native psyllid, (*Pariaconus* sp.) on ‘ōhi‘a lehua (*Metrosideros polymorpha*), lantana gall fly (*Eutreta xanthochaeta*) (Diptera: Tephritidae), Hamakua pamakani gall fly (*Procecidochares alani*), and Maui pamakani gall fly (*Procecidochares utilis*) (Table 1).

Table 1. Gall-Forming Insects Used in Host Specificity Tests against *Aprostocetus nitens* (Yalemar et al 2016).

Family, Order	Gall-former (Scientific, common name)	Gall-former status	Gall-former source	Host plant (Scientific, common name)	Infested plant part used for testing
Pteromalidae Hymenoptera	<i>Josephiella microcarpae</i> Beardsley & Rasplus Banyan gall wasp	Immigrant	Field-collected Honolulu, O‘ahu	<i>Ficus macrocarpa</i> Chinese banyan	Cuttings
Eriococcidae Hemiptera	<i>Tectococcus ovatus</i> Hempel a Brazilian scale	Biocontrol agent	Lab-reared, USFS, HVNP Quarantine Facility and lab- reared HDOA	<i>Psidium cattleianum</i> Strawberry guava	Whole plants
Eulophidae Hymenoptera	<i>Ophelimus</i> sp. a eucalyptus gall wasp	Immigrant	Field-collected Camp Maluhia, Maui	<i>Eucalyptus</i> sp. Eucalyptus	Cuttings
Triozidae Hemiptera	<i>Pariaconus</i> sp. ‘Ōhi‘a psyllid	Endemic (native)	Field-collected, ‘Aiea and Mānoa, O‘ahu	<i>Metrosideros polymorpha</i> ‘Ōhi‘a	Cuttings
Tephritidae Diptera	<i>Eutreta xanthochaeta</i> Aldrich Lantana gall fly	Biocontrol agent	Field-collected, Hau‘ula, O‘ahu and lab-reared	<i>Lantana camara</i> Lantana	Whole plants
Tephritidae Diptera	<i>Procecidochares alani</i> steyskal Hāmākua pamakani gall fly	Biocontrol agent	Field-collected, Nu‘uanu, O‘ahu and lab-reared	<i>Ageratina riparia</i> Hāmākua pamakani	Whole plants
Tephritidae Diptera	<i>Procecidochares utilis</i> Stone Maui pamakani gall fly	Biocontrol agent	Lab-reared, UH Mānoa and lab- reared HDOA	<i>Ageratina adenophora</i> Maui pamakani	Whole plants

Host specificity assays consisted of choice tests, which approximate choices of host the parasitoid is presented with in the field, and no-choice tests to determine whether *Aprostocetus nitens* would feed on non-target hosts in the absence of its intended host. In a choice test, the parasitoid is allowed to choose plants infested by either the target (Erythrina gall wasp) or a non-target gall-forming insect for oviposition and development. In the no-choice test, the parasitoid is given only the option of using a non-target gall-former as host. At the end of each test, the mature parasitoids are removed, and the plant is held in a cage to await emergence of the parasitoid from the galls. After 1 month, galls from each test plant are dissected and examined under a microscope to determine whether parasitism has taken place (Yalemar et al. 2016) (see Figures 10 through 12).

Results of the host specificity trials indicate that *A. nitens* is host specific to *Quadrasstichus erythrinae* and has no preference for any of the seven non-target gall forming species studied. In addition, even if *A. nitens* were to parasitize these non-target species, it would be unable to produce any offspring because none of these species was shown to be suitable for supporting this species' development.

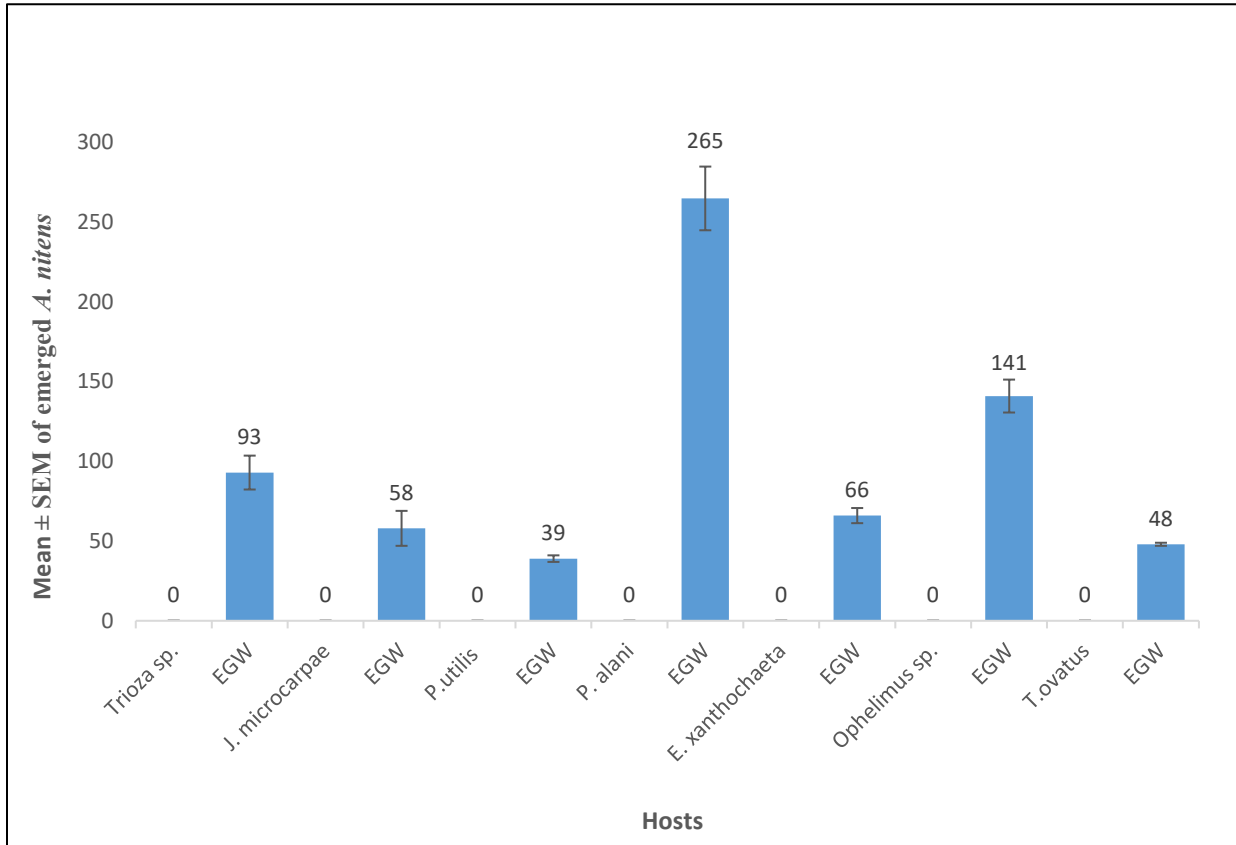


Figure 10. Average number of emerged *A. nitens* in choice tests. (EGW = Erythrina gall wasp).

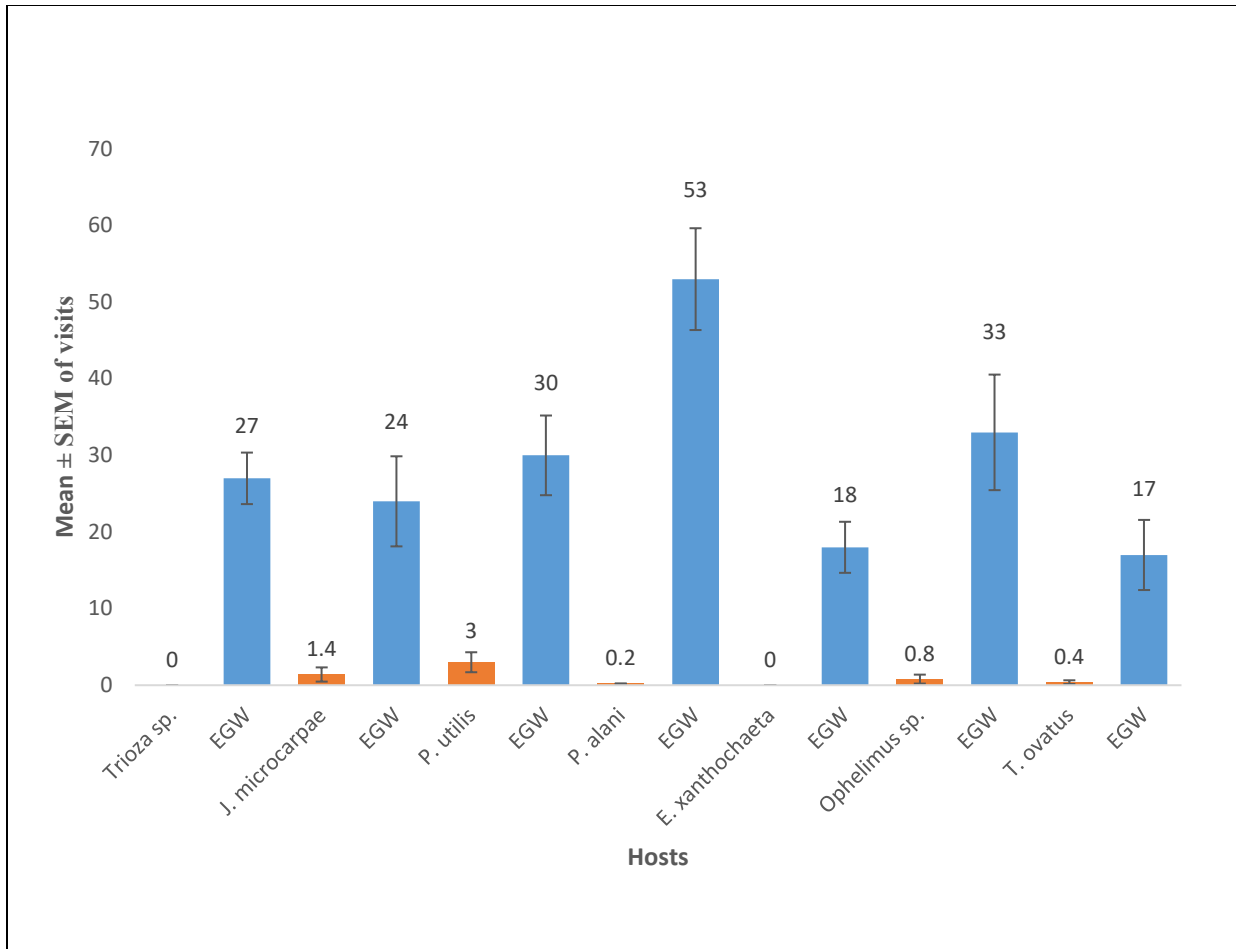


Figure 11. Average number of visits on *E. variegata* and non-target gall-forming insect hosts by *A. nitens*.

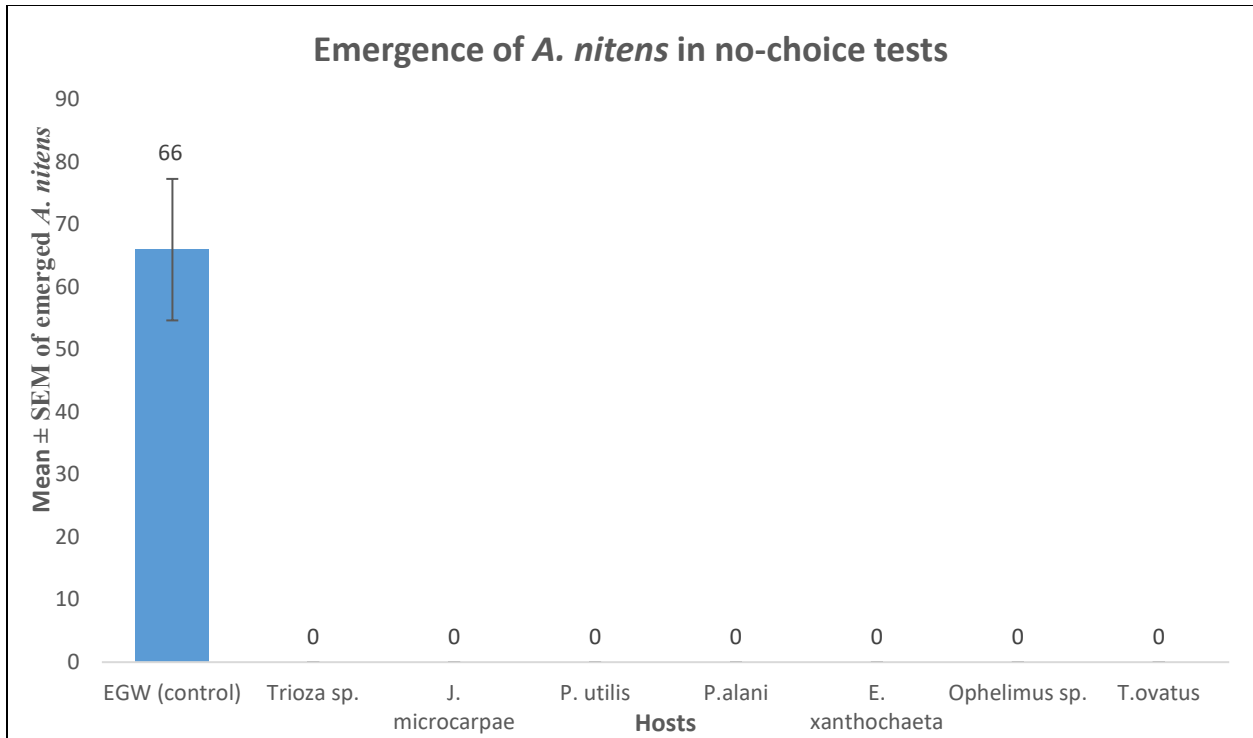


Figure 12. Average number of emerged *A. nitens* in no-choice tests.

Multiparasitism Trials

Because *A. nitens* is proposed to be released to complement the progress made by the introduction of *E. erythrinae*, multiparasitism trials were performed to determine the potential interaction between these two parasitoids. Interactions were measured as follows:

- Quantify the level and rate of Erythrina gall wasp parasitism (= predation) by the two parasitoids when either is used alone or when both are used concurrently (= multiparasitism).
- Determine if the sequence and pattern of Erythrina gall wasp exposure to the two parasitoids will have differential effects on their progeny.
- Determine if interspecific competition would make each or both parasitoids ineffective.

These trials were performed in the HDOA Insect Containment Facility. Gravid females of *E. erythrinae* (7 days old) and *A. nitens* (3 days old) were introduced to gall-infested *Erythrina variegata*. Before the introduction of the two parasitoids, the level of galling was rated to ensure that both were exposed to similar levels of galling. Galled-infested *Erythrina* were exposed to each parasitoid, alone and in combination, in cages separated by treatment type, for 72 hours.

The treatments were as follows:

- Control: Plants with Erythrina gall wasp only, no parasitoids.
- Galled *Erythrina* plants were exposed to 10 females of *E. erythrinae* alone for 72 hours. Erythrina gall wasp and *E. erythrinae* that emerge were tallied and recorded.
- Galled *Erythrina* plants were exposed to 10 *A. nitens* alone for 72 hours. Erythrina gall wasp and *A. nitens* that emerge were tallied and recorded.

- Galled *Erythrina* plants were exposed to 10 females of *E. erythrinae* and 10 females of *A. nitens* concurrently for 72 hours.
- Galled *Erythrina* plants were exposed to 10 females of *E. erythrinae* for 72 hours. Then, after 4 days, the same plants were exposed to 10 *A. nitens* for 72 hours.
- Galled *Erythrina* plants were exposed to 10 females of *A. nitens* for 72 hours. Then, after 4 days, the same plants were exposed to 10 females of *E. erythrinae* for 72 hours.

After each treatment was applied, any individuals of Erythrina gall wasp, *E. erythrinae*, and/or *A. nitens* that emerged were tallied and recorded. After this time, the plants were removed from the cages and held for 4 weeks to rear out the parasitoids. During this time, all emerging adults were captured and counted, and the sex of each was noted. Fourteen days after exposure to the parasitoids, a sample of the galls was removed from each plant and dissected to determine the number of each parasitoid developing within the galls or to determine the parasitism rate of each parasitoid. The experiment was repeated five times.

Results of the multiparasitism trials indicated that there was no significant difference in the ratio of the two parasitoids when either is released first on the host. When the two parasitoids were released concurrently, the proportion of *E. erythrinae* was found to be significantly higher than that of *A. nitens* (Figure 13). No significant difference was found in Erythrina gall wasp suppression levels when parasitoids were combined, compared to the effects of *E. erythrinae* alone (Figure 14). Most importantly, *A. nitens* and *E. erythrinae* were shown to have different feeding preferences, with *A. nitens* preferring foliage and *E. erythrinae* showing a preference for stems and petioles (Figure 15), which supports observations of these species' behavior in their native range.

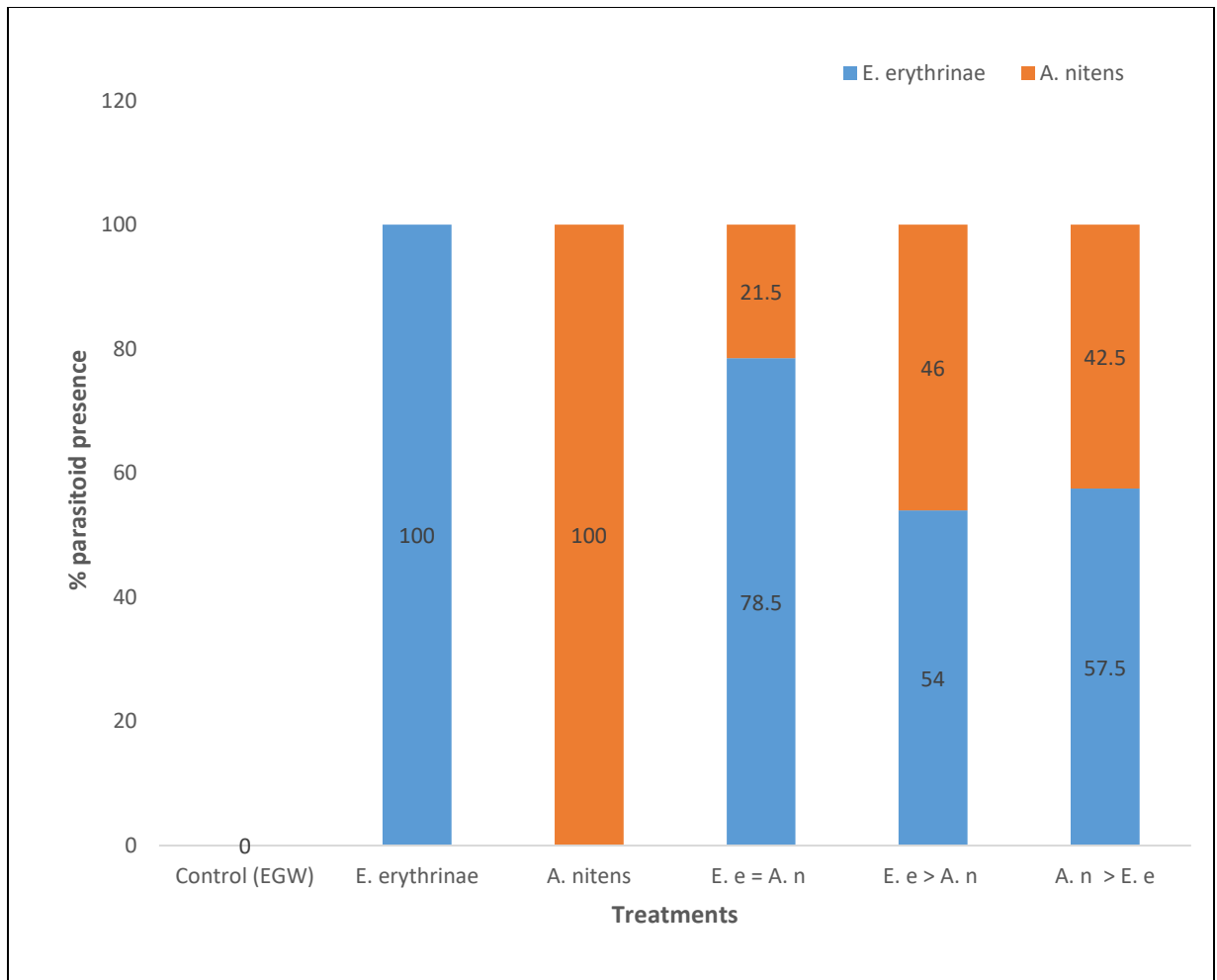


Figure 13. Ratio of parasitoid presence in plant tissues.

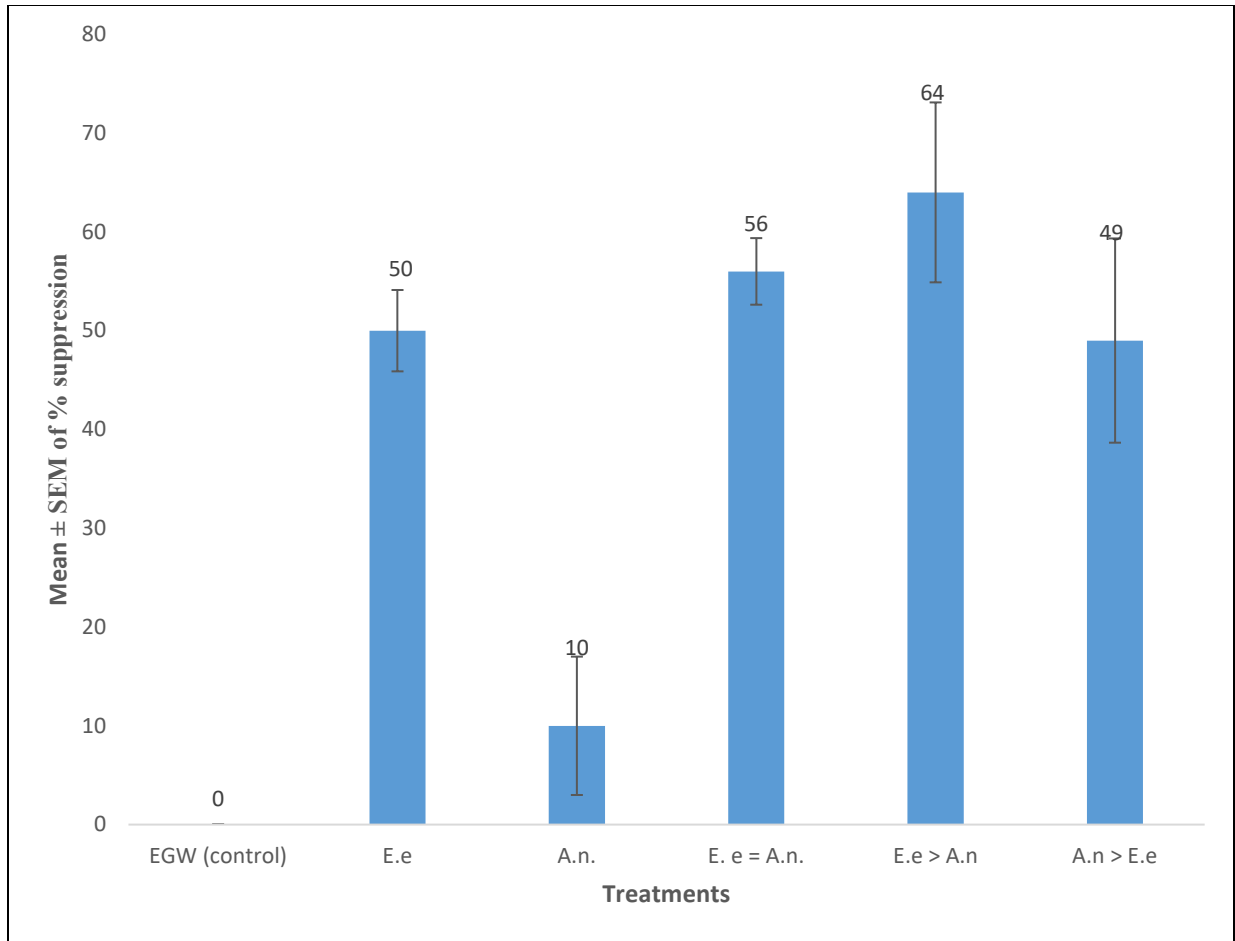


Figure 14. Erythrina gall wasp suppression levels by parasitoids.

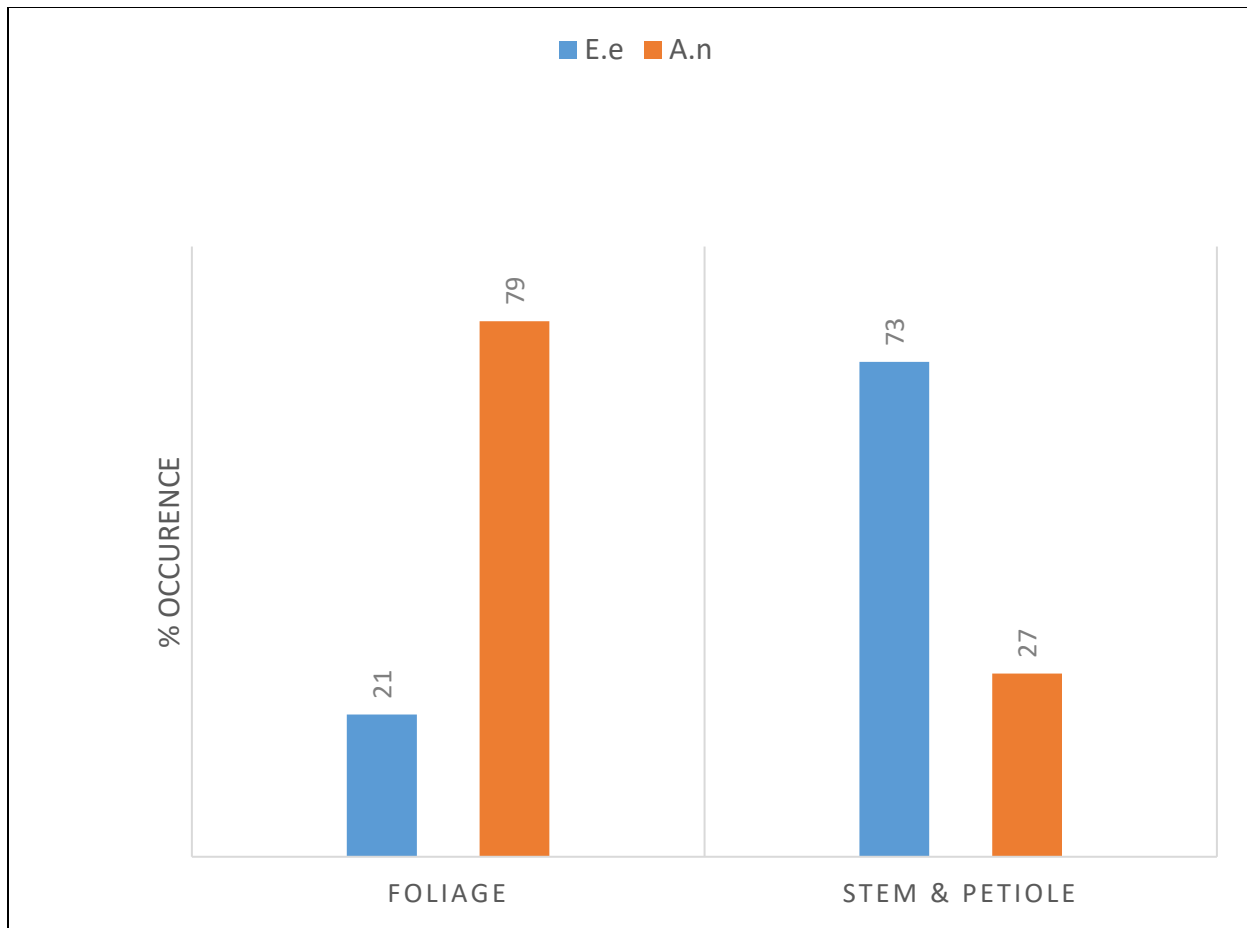


Figure 15. Feeding preferences of *A. nitens* and *E. erythrinae*.

ENVIRONMENTAL IMPACTS

Field observations of *A. nitens* in Tanzania and South Africa, and quarantine lab studies conducted in containment in Hawai‘i, strongly indicate that the proposed release of this Erythrina gall wasp biocontrol agent will not have any undesirable, negative, non-target effects on the natural environment of the Hawaiian Islands. Environmental impacts associated with the No Action Alternative of not issuing permits for release are those resulting from the continued damage to the native wiliwili tree and other species in the genus *Erythrina* caused by Erythrina gall wasp and environmental damage caused by other methods (such as systemic pesticide) employed to control Erythrina gall wasp in affected trees. The proposed release and establishment of *A. nitens* is expected to supplement the success of *E. erythrinae* in suppressing infestations of Erythrina gall wasp, effectively reducing these impacts further.

Literature Search for Other Host Records

A literature search found little to no information about *A. nitens* other than a description of the taxonomy of this species and host and plant associations with known collections used for the species description (Prinsloo & Kelly 2009). No information was found to indicate that *A. nitens* has ever been used for biological control anywhere else in the world. Therefore, the only information presently available on hosts for *A. nitens* comes from Prinsloo & Kelly (2009), field collections performed during exploration in

South Africa and Tanzania, and research performed in the HDOA Plant Pest Control Branch ICF (Yalemar et al 2016).

Host Specificity in Country of Origin

Field observations in Tanzania and South Africa indicated that *A. nitens* emerged only from galls produced on *Erythrina* species. Such galls may contain Erythrina gall wasp (*Quadrastichus erythrinae*) or other African *Quadrastichus* species. This finding of host specificity was confirmed by experiments performed at the HDOA Insect Containment Facility (Yalemar et al 2016).

Potential Impact on Threatened and Endangered Species

Because *A. nitens* feeds exclusively on gall-forming insects and because there are no gall-forming species classified as threatened or endangered in Hawai‘i, no impacts to threatened or endangered species are anticipated.

Potential of *Aprostocetus nitens* to Act as a Hyperparasite

This information is not available because scientific literature on *A. nitens* is limited to a taxonomic description of the species. Because of this lack of information, there is uncertainty regarding this species' potential to act as a hyperparasite, however field observations and host specificity studies indicate that this species only targets Erythrina gall wasps and does not develop effectively within any other host.

Potential of *Aprostocetus nitens* to Attack Non-Targets

Field observations in South Africa and Tanzania, and host specificity tests in quarantine, in Hawai‘i have confirmed that *A. nitens* will not attack non-target gall forming species (Yalemar et al 2016) and, therefore, release of *A. nitens* would not have any negative impact on the natural environment in Hawai‘i. Results of the host specificity trials indicate that *A. nitens* is host-specific and has no preference for any of the seven non-target gall-forming species studied. In addition, even if *A. nitens* were to parasitize these non-target species, it would be unable to produce any offspring, because none of these species were shown to be suitable for supporting this species' development.

IMPACTS TO CULTURAL VALUES

No negative impacts on cultural values are anticipated from the release of this parasitoid on the human environment in Hawai‘i. A positive impact would be the further reduction of Erythrina gall wasp damage to economically important cultivated *Erythrina* species and culturally important wiliwili trees.

ASM Affiliates Hawai‘i, a Heritage and Cultural Resource Management firm, prepared a Cultural Impact Assessment (CIA) for the proposed action, which is attached as Appendix A and summarized below. The CIA report was prepared in adherence with the Office of Environmental Quality Control (OEQC) *Guidelines for Assessing Cultural Impacts*, adopted by the Environmental Council, State of Hawai‘i, on November 19, 1997, and pursuant to Act 50, approved by the Governor on April 26, 2000.

In general, CIA studies are intended to inform environmental studies that are conducted in compliance with HRS Chapter 343. The purpose of a CIA is to gather information about the practices and beliefs of a particular cultural or ethnic group or groups that may be affected by the actions subject to HRS Chapter 343.

The primary focus of the CIA is on understanding the cultural and historical context of the Erythrina gall wasp and the endemic wiliwili with respect to Hawai‘i’s host culture. It includes a cultural-historical context of the settlement of the Hawaiian Islands by early Polynesian settlers and the transformation of their beliefs and practices associated with the land following western contact, an overview of the history of biocontrol in Hawai‘i, and a discussion of the introduction of *E. erythrinae* to the Hawaiian Islands. It also includes a discussion of potential impacts as well as appropriate actions and strategies to mitigate such impacts.

Location

Conventional CIAs assess the potential impacts on cultural practices and features within a geographically defined “project area,” which are often defined by an established Tax Map Key number or numbers. However, CIAs conducted for biocontrol projects differ in that the assessment must consider statewide impacts with emphasis on areas where the target species can be found in abundance. In Hawai‘i, *E. erythrinae* is found on the island of O‘ahu, Hawai‘i, Kaua‘i, Maui, Moloka‘i, Kaho‘olawe, and Lāna‘i.

Consultation

As stated in the OEQC Guidelines for Assessing Cultural Impacts, the goal of the oral interview process is to identify potential cultural resources, practices, and beliefs associated with the Erythrina gall wasp and wiliwili and its habitat. Gathering input from community members with genealogical ties and long-standing residency or relationships to the anticipated area of impact or to the target species is vital to the process of assessing potential cultural impacts on resources, practices, and beliefs.

In an effort to identify individuals knowledgeable about traditional cultural practices and/or uses associated with the subject-affected environment, a public notice was submitted by ASM Affiliates to the Office of Hawaiian Affairs (OHA) for publication in the May 2019 issue of their monthly newspaper, *Ka Wai Ola*. While no responses were received from the public notice, 45 individuals were contacted via email and/or phone regarding the preparation of the CIA report. A list of those individuals is available upon request. Of the 45 individuals contacted, 20 responded to the request with either brief comments, referrals, or acceptance of the interview request (see Table 2). ASM Affiliates conducted a total of eight interviews, the summaries of which can be found in the CIA.

The interviewees were asked a series of questions regarding their background, and their experience and knowledge of wiliwili. Additional questions focused on any known cultural uses, traditions, or beliefs associated with wiliwili. The interviewees were then asked about their thoughts on the cultural appropriateness of using biocontrol agents and whether they were aware of any potential cultural impacts that could result from the use of biocontrol and whether they had any recommendations to mitigate any identified cultural impacts or any other thoughts about the proposed action.

Table 2. Persons that responded to request for consultation.

<i>Name</i>	<i>Affiliation, Island</i>	<i>Initial Contact Date</i>	<i>Comments</i>
Shalan Crysdale	The Nature Conservancy, Ka‘ū Preserve, Hawai‘i	3/6/2019	See summary in CIA

Field Release of *Aprostocetus nitens* for Biological Control of the Erythrina Gall Wasp, *Quadrastichus erythrinae*

John Repogle	Retired from The Nature Conservancy, Ka'ū Preserve, Hawai'i	3/6/2019	See summary in CIA
Nohealani Ka'awa	The Nature Conservancy, Ka'ū Preserve, Hawai'i	3/6/2019	See summary in CIA
Arthur Medeiros	Auwahi Forest Restoration Project, Maui	3/7/2019	Responded via email on March 11, 2019, stating "Thank you for your valuable work supporting this essential action to attempt to slow the loss of Hawaiian biota."
Jen Lawson	Waikōloa Dry Forest Initiative, Hawai'i	4/3/2019	See summary in CIA
Robert Yagi	Waikōloa Dry Forest Initiative, Hawai'i	4/3/2019	See summary in CIA
Wilds Brawner	Ho'ola Ka Manaka'ā at Ka'ūpūlehu, Hawai'i	4/9/2019	See summary in CIA
Sam 'Ohu Gon III	The Nature Conservancy, O'ahu	4/22/2019	Responded to interview request but was unable to provide input on this project.
Mike DeMotta	National Tropical Botanical Gardens, Kaua'i	4/22/2019	See summary in CIA
Wili Garnett	Cultural practitioner, Moloka'i	5/7/2019	Responded via email stating "I have mostly been involved with Erythrina gall wasp parasite release and monitoring, but experience watching <i>Tibouchina</i> and <i>Schinus</i> degrade watershed on many islands, including Molokai and even cultural resources at Kalaupapa."
Emily Grave	Laukahi Network, O'ahu	5/7/2019	Responded via email stating that she was not aware of cultural uses of this plant.
Kim Starr	Starr Environmental, Maui	5/9/2019	See summary in CIA
Forest Starr	Starr Environmental, Maui	5/9/2019	See summary in CIA
Manaiakalani Kalua	Cultural practitioner, Hawai'i	5/30/2019	See summary in CIA
Talia Porter	Honolulu Botanical Gardens, O'ahu	6/3/2019	Responded to interview request but was unable to secure an interview.
Robert Keano Ka'upu		6/16/2019	

	Cultural practitioner, O'ahu		Responded via phone that he has been interested in learning about the cultural uses of <i>wiliwili</i> but was not aware of any uses or of anyone else who used this wood for cultural purposes.
Hinaleimoana Wong-Kalu		7/16/2019	
	Cultural practitioner, O'ahu		Responded to interview request but was unable to secure an interview.
Pelehonuamea Harman		7/31/2019	
	Cultural practitioner, Hawai'i		Referred ASM staff to Dennis Kana'e Keawe.
Dennis Kana'e Keawe		8/12/2019	
	Cultural practitioner, Hawai'i		See summary in CIA
Iliahi Anthony		8/30/2019	
	Cultural practitioner, Hawai'i		See summary in CIA

End of Table 2

Summary of Culture-Historical Background, Consultation, and Significance Assessment

A review of the cultural-historical background in addition to the consultation efforts has yielded no reported cultural use for Erythrina gall wasp nor is there any evidence to suggest that Erythrina gall wasp is crucial to any particular ethnic groups' cultural history, identity, practices, or beliefs, nor does it meet any of the significance criteria outlined by the CIA. Although Erythrina gall wasp does not meet any of the significance criteria, the use of wiliwili in Hawaiian culture and its appearance in traditional legendary accounts are both extensive and well-documented.

The use of wiliwili in Hawaiian culture and its appearance in traditional legendary accounts are both extensive and well-documented in mo'olelo, 'ōlelo no'ēau, and Kumulipo. Wiliwili clearly played a vital role in enhancing and maintaining the traditional lifestyle of the Hawaiian people. Its availability to those who settled in the leeward parts of the islands proved most useful as the lightweight and highly buoyant wood was carved into small fishing canoes but more commonly fashioned into 'iako (outrigger booms) and ama (outrigger floats) for larger canoes. Wood of wiliwili has also been used for fishing and aquatic gear, carved into wooden images in traditional hula ki'i and pendants, shaped into water troughs and used as firewood. Flowers and seeds have been used in traditional lei making and bark and flowers were employed in traditional healing practices. The brightly colored flowers are known to indicate increasing presence of sharks in nearshore waters.

Reference to an extensive wiliwili forest in the Kohala District of Hawai'i Island is found in the account of Kapunohu, a hero, who, in a test of strength, is said to have forced his spear with a single thrust through some eight hundred trees. Wilds Brawner described observing many kupuna wiliwili (ancient wiliwili) trees in the North Kona District of Hawai'i Island. Consultation with Wilds Brawner and Mike DeMotta also indicates that an extensive wiliwili forest was also present in the Kahikinui and Kaupō areas of Maui Island—an area that has been severely devastated by the EGW in more recent years.

It is evident from culture-historical background research and from the consultation efforts that wiliwili was widely used in various traditional Hawaiian cultural practices. While historical accounts describing its abundance are somewhat conflicting, it is evident that wiliwili populations were in decline by the late 19th-century as a result of the changing political economy of the islands, particularly the shift to large scale ranching and commercial agriculture which severely impacted Hawai'i's dryland forest habitat. The

overall decline in dryland forest habitat coupled with the impacts of private property rights are likely the key factors that have contributed to the decline in the cultural uses of this plant. Although the cultural uses of wiliwili may have waned during the 20th century, as evident in the consultation efforts, knowledge of the cultural and ecological significance of this plant have remained deeply embedded in the hearts and minds of Hawai‘i’s people. Though the arrival of the EGW has decimated thousands of wiliwili trees, it has also generated more public awareness about this plant’s importance to Hawai‘i’s dryland forest ecosystem and to Hawaiian culture.

Identification of Cultural Impacts and Recommendations

Based on a synthesis of cultural uses summarized above and described in depth in the CIA, it is clear that wiliwili is a culturally significant floral species and the primary habitat (dryland forest) in which it is found could be considered a transitional cultural property that is significant under Criterion E – because it has an important value to the native Hawaiian people. For these reasons protecting the remaining populations of *Erythrina* is imperative as this will help to ensure that its environmental and cultural significance are not diminished. It is likely that increasing populations of wiliwili may help in the revitalization of certain Hawaiian cultural practices.

Based on the information derived from the cultural-historical background and from the insight shared by the consulted parties, it is the assessment of this study that the release of the proposed biocontrol agent, *Aprostocetus nitens*, will not result in impacts to any valued cultural, historical, or natural resources. Conversely, if no action is taken to further reduce remaining populations of *Quadrastichus erythrinae* from claiming more of Hawai‘i’s native *Erythrina*, impacts to this valued resource would be anticipated.

While no specific cultural impacts were identified through the CIA, the consulted parties shared valuable insight, concerns, and recommendations that could reduce the potential for any future impacts and improve public transparency regarding the effectiveness of biocontrol as a conservation management strategy. Several key themes emerged from the consultation efforts, all of which are further described in the CIA:

- 1) maintain stringent pre and post-release testing and monitoring;
- 2) improved community transparency and input;
- 3) active and ongoing public outreach and education;
- 4) improve efforts to limit the introduction of potentially harmful invasive species.

While the consulted parties did not explicitly oppose the use of biocontrol, especially to aid in the recovery of Hawai‘i’s native forest habitat, they all shared a sense of concern and spoke about the risks inherent in biocontrol activities.

The CIA recommends that conducting background research, consulting with community members, and taking steps toward mitigating any potential cultural impacts is done in the spirit of Aloha ‘Āina, a contemporary movement founded on traditional practices and beliefs that emphasize the intimate relationship that exists between Native Hawaiians and the ‘āina (land).

DETERMINATION

Section 11-200-12 of the HAR sets forth the criteria by which the significance of environmental impacts shall be evaluated. The following discussion restates these criteria individually and evaluates the project's relation to each.

1. The project will not involve an irrevocable commitment or loss or destruction of any natural or cultural resources.

The proposed action deals with specific interactions between the biological control agent and the target pest insect and is not expected to involve irrevocable commitment or loss or destruction of any natural or cultural resources.

2. The project will not curtail the range of beneficial uses of the environment.

The proposed action involves specific interactions between the biological control agent and the target pest insect and is not expected to curtail any beneficial uses of the environment.

3. The project will not conflict with the State's long-term environmental policies.

The proposed action is expected to benefit the environment by reducing the negative impact caused by the invasive pest wasp on native wiliwili and therefore the State's natural environment. This is in line with the State's long-term environmental policies.

4. The project will not substantially affect the economic or social welfare of the community or State.

The proposed action involves specific interactions between the biological control agent and the targeted pest species and is not expected to affect the economic or social welfare of the community or State.

5. The project does not substantially affect public health in any detrimental way.

The proposed action involves specific interactions between the biological control agent and the target invasive erythrina gall wasp. The biological control agent is a stingless wasp and will not impact public health.

6. The project will not involve substantial secondary impacts, such as population changes or effects on public facilities.

The proposed action involves specific interactions between the biological control agent and the target pest and is not expected to cause substantial secondary impacts.

7. The project will not involve a substantial degradation of environmental quality.

The proposed action deals with specific interactions between the biological control agent and the target invasive wasp and is expected to improve environmental quality by reducing the negative impacts caused by the wasp to the environment.

8. The project will not substantially affect any rare, threatened, or endangered species of flora or fauna or habitat.

The proposed action is expected to benefit native wiliwili by reducing the direct attack and negative impact caused by the target pest.

9. The project is not one which is individually limited but cumulatively may have considerable effect upon the environment or involves a commitment for larger actions.

The proposed action does not involve a commitment for larger actions, and the cumulative effect is expected to be beneficial by reducing the direct impact of this invasive species on native wiliwili trees, protecting the tree from extinction in the wild, and thus beneficial to the environment.

10. The project will not detrimentally affect air or water quality or ambient noise levels.

The proposed action involves specific interactions between the biological control agent and the target species and is not expected to affect air or ambient noise levels.

11. The project will not affect or will not likely be damaged by being located within an environmentally sensitive area such as floodplains, tsunami zones, erosion-prone areas, geologically hazardous lands, estuaries, fresh waters or coastal waters.

The proposed action involves specific interactions between the biological control agent and the target pest and is not subject to damage by being located within an environmentally sensitive area.

12. The project will not substantially affect scenic vistas or viewplanes identified in county or state plans or studies.

The proposed action will not substantially affect scenic vistas or viewplanes identified in county or state plans or studies. The biocontrol agent will have a positive impact on scenic vistas by preserving the native wiliwili tree.

13. The project will not require substantial energy consumption.

The proposed action involves specific interactions between the biological control agent and the target pest species and will not require substantial energy consumption.

Conclusion

For the reasons above, and in consideration of comments received during early consultation, the HDOA, with support from the DLNR-DOFAW, has concluded that the proposed project will not have a significant impact in the context of HRS Chapter 343 and Section 11-200-12 of the HAR, and has determined a Finding of No Significant Impact (FONSI) with the FEA.

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**APPENDIX 1: CULTURAL IMPACT ASSESSMENT FOR THE PROPOSED STATEWIDE
RELEASE OF A WASP PARASITOID (*APROSTOCETUS NITENS*) AS A BIOCONTROL FOR
THE ERYTHRINA GALL WASP (*QUADRASTICHUS ERYTHRINAE*)**

A Cultural Impact Assessment for the Proposed Statewide Release of a Wasp Parasitoid (*Aprostocetus nitens*) as Biocontrol for the Erythrina Gall Wasp (*Quadrastichus erythrinae*)

State of Hawai‘i

FINAL



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CHAPTERS

	Page
1. INTRODUCTION	1
PROPOSED ACTION	2
ERYTHRINA GALL WASP AND THE PROPOSED BIOLOGICAL CONTROL AGENT	2
2. BACKGROUND.....	5
GEOGRAPHICAL AND CULTURAL CONTEXT OF HAWAI‘I.....	5
Evolution of Hawaiian Land Stewardship Practices and the Impacts to Hawai‘i’s Native Forests.....	8
The Arrival of Foreign Plants and Animals and the Transformation of the <i>Kapu</i> System	9
Private Property and Its Effects on Traditional Concepts of Land and Land Use Practices.....	10
HISTORY OF BIOCONTROL IN THE HAWAIIAN ISLANDS	11
Regulated Efforts to Control Unwanted Pest in Hawai‘i	13
NATURAL AND CULTURAL HISTORY OF <i>WILIWILI</i>	16
Cultural Value of Hawai‘i’s Dryland Forests.....	18
Physical Description of <i>Wiliwili</i>	18
Traditional Legendary Accounts Concerning <i>Wiliwili</i>	25
Birth of the <i>Wiliwili</i> in the Hawaiian Cosmogony Chant, <i>Kumulipo</i>	25
<i>Nā Wiliwili O Pā‘ūla</i> (The <i>Wiliwili</i> Trees of Pā‘ūla).....	26
Māui Snares the Sun by Tethering Its Legs to a <i>Wiliwili</i> Tree in Kaupō, Maui.....	27
<i>Wiliwili</i> Mentioned in the Legend of Kawelo	28
<i>Wiliwili</i> of Kohala Pierced by the Spear of Kapunohu.....	29
<i>Wiliwili</i> Wood Carved into an Image in <i>Ka‘ao no Pupuuluena</i>	29
Grove of <i>Wiliwili</i> in Mānoa Valley, O‘ahu as Noted in the Legend of Kahalaopuna	30
<i>Wiliwili</i> Referenced in <i>Ka Mo‘olelo No Hi‘iakaikapoliopole</i>	30
Traditional Uses of <i>Wiliwili</i>	33
<i>Wiliwili</i> Used In the Construction of <i>Wa‘a</i> (Canoes).....	33
<i>Wiliwili</i> ’s Association with <i>Manō</i> (Sharks)	34
<i>Papa He‘enalu</i> (Surf Board)	34
<i>Wiliwili</i> Woods Used in the <i>Kōheoheo</i> Style of Fishing	35
<i>Lei Wiliwili</i>	35
<i>Hula Ki‘i</i>	36
Medicinal Uses of <i>Wiliwili</i>	38
<i>Wiliwili</i> Used in the Construction of Water Troughs	38
Descriptions of <i>Wiliwili</i> in the Hawaiian Language Newspapers	38
<i>Ke Kalaiwaa Ana A Me Kona Ano</i> (The Nature of Canoe Carving).....	40
Changing Uses of <i>Wiliwili</i>	41

3. CONSULTATION.....	41
INTERVIEW METHODOLOGY.....	41
SHALAN CRYSDALE, JOHN REPLOGLE, AND NOHEALANI KA‘AWA.....	43
WILDS PIHANUI BRAWNER.....	44
MIKE DEMOTTA.....	45
JEN LAWSON AND ROBERT YAGI.....	46
FOREST AND KIM STARR.....	47
MANAIAKALANI KALUA.....	48
DENNIS KANA‘E KEAWE.....	49
ILIAHI ANTHONY.....	52
4. IDENTIFICATION AND MITIGATION OF POTENTIAL CULTURAL IMPACTS	53
Summary of Culture-Historical Background, Consultation, and Significance Assessment.....	54
Identification of Cultural Impacts and Recommendations.....	56
REFERENCES CITED.....	58

FIGURES

	Page
1. Pair of EGW, male (left) and female (right) (Plant Pest Control Branch 2013).	3
2. Close up of galling to <i>wiliwili</i> , showing gall wasp emergence holes (Plant Pest Control Branch 2013).....	3
3. <i>Wiliwili</i> gall wasp parasitoid, <i>Eurytoma erythrinae</i> (Plant Pest Control Branch 2013).	4
4. Shalan Crysdale of The Nature Conservancy Ka‘ū Preserve points to formerly infected areas on a <i>wiliwili</i> tree in Ka‘ū.	4
5. Map of the Hawaiian archipelago.	6
6. Map of the main Hawaiian Islands.	6
7. Estimated extent of Hawai‘i’s dryland forest habitat.....	17
8. Historical photo showing two <i>wiliwili</i> trees growing on Kaho‘olawe Island, date and photographer unknown. Hawai‘i State Archives, PP-46-10-002.....	17
9. Tall <i>wiliwili</i> tree in Ka‘ū, Hawai‘i Island.	19
10. <i>Wiliwili</i> growing in the uplands of Kau Ahupua‘a, North Kona, Hawai‘i Island.	19
11. The bark of a <i>wiliwili</i> tree, Ka‘ū, Hawai‘i Island.....	20
12. Close up of the thin and porous outer bark from a dried <i>wiliwili</i> tree.....	20
13. Short spines on a young <i>wiliwili</i> tree.	21
14. Low-lying <i>wiliwili</i> tree twisting over the rugged lava landscape in Waikōloa Ahupua‘a, South Kohala, Hawai‘i Island.	21
15. Leaves of the <i>wiliwili</i> tree, Ka‘ū, Hawai‘i Island.....	22
16. Close-up of <i>wiliwili</i> flowers, Waikōloa, Hawai‘i.....	22

17. <i>Wiliwili</i> blossoms in Kaū Ahupua‘a, North Kona, Hawai‘i Island.	23
18. Close-up of a <i>wiliwili</i> seed pod, Ka‘ū, Hawai‘i Island.	23
19. Reddish-orange seeds of a <i>wiliwili</i> tree, Ka‘ū, Hawai‘i Island.	24
20. Dried <i>wiliwili</i> trunk at Waikōloa Ahupua‘a, Kohala, Hawai‘i.....	24
21. Close up of dried <i>wiliwili</i> wood, Ka‘ū, Hawai‘i Island.....	25
22. Drawing of the marionettes, Maile Pakaha (left) and Nihi-Au-Moe (right). From Emerson (1909:91).....	37
23. Emerson’s sketch of the marionette Maka-Kū.From Emerson (1909:93)	37
24. Top—Emerson’s (1909:90) drawing of two marionettes named Maile Pakaha (left) and Nihi-Au-Moe (right). Bottom—Original marionettes of the above drawing at the Smithsonian Museum,photos by Dennis Kana‘e Keawe.....	50
25. Close up of seams near the hand of Emerson’s marionette collection at the Smithsonian Museum. Photo by Dennis Kana‘e Keawe.	50
26. Left—Emerson’s (1902:92) drawing of the marionette named Maka-Kū. Right—Original Maka-Kū marionette at the Smithsonian Museum, photo by Dennis Kana‘e Keawe.	51
27. Original marionette from Emerson’s collection at the Smithsonian Museum. Photo by Dennis Kana‘e Keawe.....	51

TABLE

1. Persons contacted for consultation.....	42
--------------------------------------------	----

APPENDIX

<i>Ka Wai Ola</i> Public Notice.....	Page 67
--------------------------------------	-------------------

1. INTRODUCTION

At the request of the Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW) and Hawai‘i Department of Agriculture (HDOA), referred to hereafter as the State of Hawai‘i, ASM Affiliates (ASM) has prepared this Cultural Impact Assessment (CIA) for the proposed statewide release of a wasp parasitoid (*Aprostocetus nitens*) to further combat the erythrina gall wasp (EGW) (*Quadrastichus erythrinae*), a destructive pest that has adversely affected the endemic *wiliwili* tree (*Erythrina sandwicensis*) and other non-native *Erythrina* species found in Hawai‘i (Heu et al. 2008; Suszkiw 2010). EGW was first described in 2004 as a new species originating from specimens in Singapore, Mauritius, and Reunion (Kim et al. 2004). On April 19, 2005, damage from the EGW was discovered on coral trees (*Erythrina varigata*) at Mānoa on O‘ahu and by August of that year, the EGW had reportedly spread to the islands of Hawai‘i, Kaua‘i, Maui, and Moloka‘i (Bell et al. 2013; Li et al. 2006). By October of 2005, the EGW was reported on the islands of Kaho‘olawe and Lāna‘i (Heu et al. 2008). In 2008, following the completion of extensive studies to identify a natural predator, the *Eurytoma erythrinae* was identified and subsequently released as a biocontrol agent targeting EGW at various locations across the State of Hawai‘i. The introduction of *E. erythrinae* has significantly reduced the EGW populations resulting in the recovery of many *wiliwili* trees. Despite the overall decrease in the EGW, continued statewide monitoring of the surviving populations of *wiliwili* by the State of Hawai‘i has shown that the inflorescences and seed pods are still being adversely impacted by the EGW. The proposed biocontrol agent *Aprostocetus nitens*, is expected to enhance control against the EGW by complimenting the previously introduced biocontrol agent *E. erythrinae*. In the State of Hawai‘i, the EGW is formally recognized as one of numerous “invasive species.” In the State of Hawai‘i the term “invasive species” is any “alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health”(Invasive Species Advisory Committee 2006:1). To further combat the remaining populations of EGW, the State of Hawai‘i is proposing to release another natural enemy (*A. nitens*, a wasp parasitoid) by the year 2021 to lower the population of EGW in inflorescence and seed pods.

The current CIA is intended to supplement an Environmental Assessment (EA) conducted in compliance with Hawai‘i Revised Statutes (HRS) Chapter 343. This CIA was prepared in adherence with the Office of Environmental Quality Control (OEQC) *Guidelines for Assessing Cultural Impact*, adopted by the Environmental Council, State of Hawai‘i, on November 19, 1997. As stated in Act 50, which was proposed and passed as Hawai‘i State House of Representatives Bill No. 2895 and signed into law by the Governor on April 26, 2000, “environmental assessments . . . should identify and address effects on Hawaii’s culture, and traditional and customary rights . . . native Hawaiian culture plays a vital role in preserving and advancing the unique quality of life and the ‘aloha spirit’ in Hawai‘i. Articles IX and XII of the state constitution, other state laws, and the courts of the State impose on governmental agencies a duty to promote and protect cultural beliefs, practices, and resources of native Hawaiians as well as other ethnic groups.”

The primary focus of this report is on understanding the cultural and historical context of the endemic *wiliwili* with respect to Hawai‘i’s host culture. This CIA is divided into four main sections, beginning with an introduction of the proposed action followed by a description of the EGW’s impacts on the *Erythrina spp.* and the proposed biocontrol agent, *Aprostocetus nitens*. Part two of this report provides a cultural-historical context of the settlement of the Hawaiian Islands by early Polynesian settlers and the transformation of their beliefs and practices associated with the land following western contact. An overview of the history of biocontrol in Hawai‘i is also provided, and this section concludes with a detailed presentation of the natural and cultural history of *wiliwili*; all of which combine to provide a geographical and cultural context in which to assess the proposed action. The results from the consultation process are then presented, along with a discussion of potential impacts as well as appropriate actions and strategies to mitigate any such impacts.

PROPOSED ACTION

DOFAW has been working cooperatively with HDOA and the United States Forest Service (USFS) to control the harmful impacts of certain widespread invasive plant or pest species through the use of biological control (also referred to as biocontrol). Biocontrol is the strategy of using an invasive species' natural enemies from its native range to reduce the impacts of the invasive species. Biocontrol projects typically require years of research and survey work to find potential candidates that are subjected to a host of tests. Only those candidates that are host-specific, meaning they can only complete their life cycle on their intended invasive species host and shown to only negatively impact the growth and abundance of the target invasive species are considered for release. Once testing has been successfully completed, agencies must comply with national and state regulatory requirements for the release of the biocontrol agent. As such, the proposed action involves the use of state lands and funds, which necessitates compliance with Hawai'i Revised Statutes (HRS) Chapter 343, also known as the Hawai'i Environmental Policy Act (HEPA). The proposing agencies are conducting an Environmental Assessment (EA) of the proposed action to evaluate potential environmental impacts and this CIA is an essential component of the EA to ensure compliance with HRS Chapter 343.

ERYTHRINA GALL WASP AND THE PROPOSED BIOLOGICAL CONTROL AGENT

The erythrina gall wasp (EGW), scientifically termed *Quadrastichus erythrinae* (Figure 1) is a non-native gall-forming eulophid wasp that deposits its eggs into the leaf and stem tissue of the host plant (Bell et al. 2013; Heu et al. 2008). As the wasp larvae develop, they induce the formation of galls on the leaflets and petioles (Figure 2). If the infestation progresses, it results in the loss of growth and vigor, and sometimes defoliation and death of the tree (ibid.). Of all the species of *Erythrina* in Hawai'i that have been impacted by the EGW, the endemic *wiliwili* tree—a keystone species of Hawai'i's dryland forest—prompted officials to make serious efforts to respond to this rapidly destructive infestation. Bell et al. (2013:216) reports that a variety of treatments, including insecticide application and infected tissue removal, were tested but proved to be “insufficient to address the large spatial scale of the *Q. erythrinae*.” Bell et al. (ibid.:216) goes on to report that the Hawai'i Department of Agriculture and the University of Hawai'i at Mānoa College of Tropical Agriculture and Human Resources began identifying and assessing “the biological life history and host specificity of three potential biocontrol agents with origins in Africa”. Of the three agents studied, *Eurytoma erythrinae* (Figure 3), a predator of the erythrina gall wasp was the selected candidate and on November 28, 2008, some 500 specimens reared in captivity were released at a gall-infested *wiliwili* stand in the Lili'uokalani Botanical Garden in Honolulu (Suszkiw 2010). Specimens of *E. erythrinae* were subsequently released at sites on the islands of Hawai'i, Maui, O'ahu, and Kaua'i (Bell et al. 2013). The introduction of *E. erythrinae* has significantly reduced the EGW populations resulting in the recovery of many *wiliwili* trees (Figure 4). Despite the overall decrease in the EGW, continued statewide monitoring of the surviving populations of *wiliwili* has shown that the inflorescences and seed pods are still being adversely impacted by the EGW. The proposed biocontrol agent *Aprostocetus nitens* is expected to enhance control against the EGW since it targets infested inflorescences and seed pods which are still vulnerable to the EGW. Host specificity tests conducted at the State of Hawai'i Department of Agriculture (HDOA) indicated that *A. nitens* is host specific and has different feeding preferences than *E. erythrinae*.



Figure 1. Pair of EGW, male (left) and female (right) (Plant Pest Control Branch 2013).



Figure 2. Close up of galling to *wiliwili*, showing gall wasp emergence holes (Plant Pest Control Branch 2013)



Figure 3. *Wiliwili* gall wasp parasitoid, *Eurytoma erythrinae* (Plant Pest Control Branch 2013).



Figure 4. Shalan Crysdale of The Nature Conservancy Ka‘ū Preserve points to formerly infected areas on a *wiliwili* tree in Ka‘ū.

2. BACKGROUND

To generate an understanding of the Hawaiian cultural significance and value of *wiliwili* and to establish a cultural context in which to assess any potential impacts that may result from the use of biocontrol to save existing populations of *wiliwili* trees across the Hawaiian Islands, a general culture-historical context is provided that includes information on traditional legendary accounts, documented traditional uses, and excerpts from 19th and 20th century Hawaiian language newspapers.

GEOGRAPHICAL AND CULTURAL CONTEXT OF HAWAI‘I

The Hawaiian Islands are located within the vast and remote Pacific Ocean, situated more than 3,200 kilometers (2,000 miles) from the nearest continent (Juvik and Juvik 1998). The 16,640 square kilometers (6,425 square miles) of land consists of eight main large volcanic islands, Hawai‘i, Maui, Kaho‘olawe, Lāna‘i, Moloka‘i, O‘ahu, Kaua‘i, and Ni‘ihau and 124 smaller islands, reefs, and shoals (ibid.) (Figures 5 and 6). Due to its geographical placement in the middle of the vast Pacific Ocean, coupled with its diverse climatic conditions, the Hawaiian Islands boasts the highest levels of endemism in both native plants and animals, with over 10,000 species found nowhere else in the world (Cannarella 2010).

While the question of the timing of the first settlement of Hawai‘i by Polynesians remains unanswered, several theories have been offered that derive from various sources of information (i.e., archaeological, genealogical, mythological, oral-historical, radiometric). However, none of these theories are today universally accepted. What is more widely accepted is the answer to the question of where Hawaiian populations came from and the transformations they went through on their way to establish a uniquely Hawaiian culture. More recently, with advances in palynology and radiocarbon dating techniques, Kirch (2011) and others (Athens et al. 2014; Wilmshurst et al. 2011) have convincingly argued that Polynesians arrived in the Hawaiian Islands, sometime between A.D. 1000 and A.D. 1200 and expanded rapidly thereafter (c.f., Kirch 2011). The initial migration to Hawai‘i is believed to have occurred from Kahiki (the ancestral homelands of Hawaiian gods and people) with long distance voyages occurring fairly regularly through at least the 13th century. It has been generally reported that the sources of the early Hawaiian populations originated from the southern Marquesas Islands (Emory in Tatar 1982). In these early times, Hawai‘i’s inhabitants were primarily engaged in subsistence-level agriculture and fishing (Handy and Handy 1991). This was a period of great exploitation and environmental modification when early Hawaiian farmers developed new subsistence strategies by adapting their familiar patterns and traditional tools to their new environment (Kirch 1985; Pogue 1978). According to Fornander (1969), the Hawaiians brought from their homeland certain Polynesian customs and belief: the major gods Kāne, Kū, Lono, and Kanaloa; the *kapu* system of law and order; the *pu‘uhonua* (places of refuge), the *‘aumakua* concept, and the concept of *mana*.

For generations following initial settlement, communities were clustered along the watered, windward (*Ko‘olau*) shores of the Hawaiian Islands. Along the *ko‘olau* shores, streams flowed and rainfall was abundant, and agricultural production became established. The *ko‘olau* region also offered sheltered bays from which deep-sea fisheries could be easily accessed, and nearshore fisheries, enriched by nutrients carried in the fresh water, could be maintained in fishponds and coastal waters. It was around these bays that clusters of houses where families lived could be found (McEldowney 1979). In these early times, Hawai‘i’s inhabitants were primarily engaged in subsistence-level agriculture and fishing (Handy and Handy 1972). Following the initial settlement period, areas with the richest natural resources became populated and perhaps crowded, and by about A.D. 1200, the population began expanding to the *Kona* (leeward side) and more remote regions of the island (Cordy 2000).

As the population continued to expand so did social stratification, which was accompanied by major socioeconomic changes and intensive land modification. Most of the ecologically favorable zones of the windward and coastal regions of all major islands were settled and the more marginal leeward areas were being developed. During this expansion period, additional migrations to Hawai‘i occurred from Tahiti in the Society Islands. Rosendahl (1972) has proposed that settlement at this time was related to the seasonal, recurrent occupation in which coastal sites were occupied in the summer to exploit marine resources, and upland sites were occupied during the winter months, with a focus on agriculture. An increasing reliance on agricultural products may have caused a shift in social networks as well; as Hommon (1976) argues, kinship links between coastal settlements disintegrated as those links within the *mauka-makai* settlements expanded to accommodate the exchange of agricultural products for marine resources. This shift is believed to have resulted in the establishment of the *ahupua‘a* system sometime during the A.D. 1400s (Kirch 1985), which added another component to an already well-stratified society. The implications of this model include a shift in residential patterns from seasonal, temporary occupation, to the permanent dispersed occupation of both coastal and upland areas.

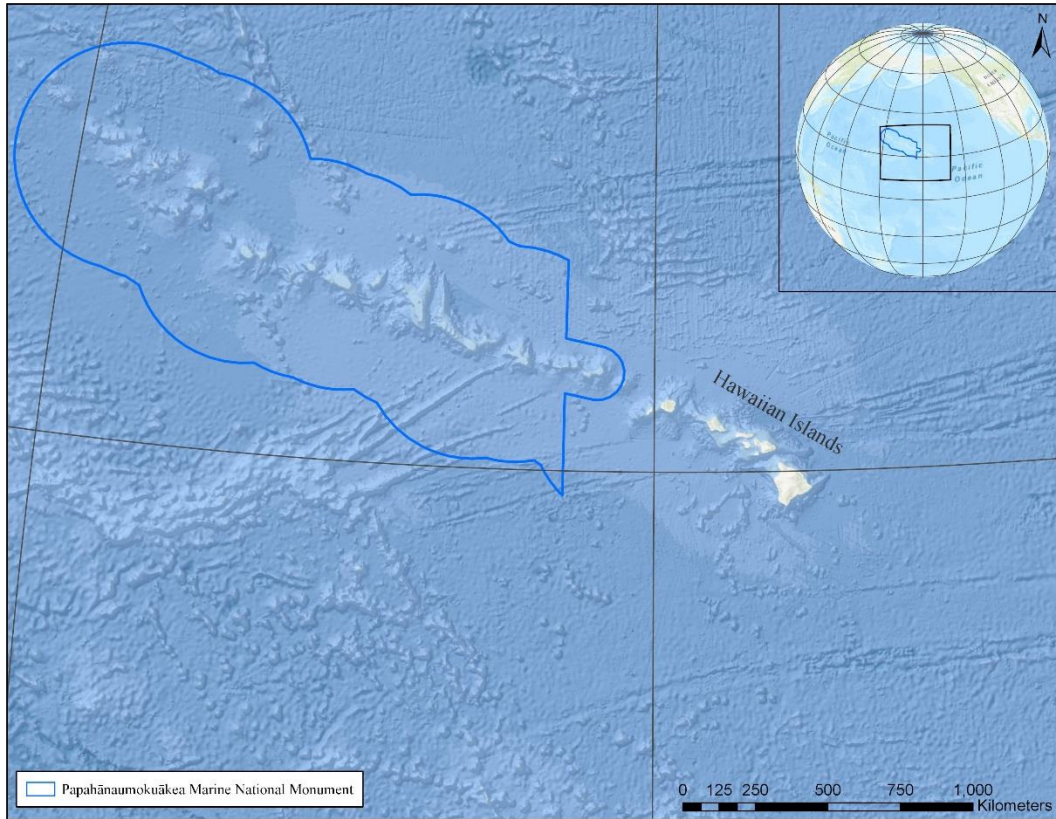


Figure 5. Map of the Hawaiian archipelago.

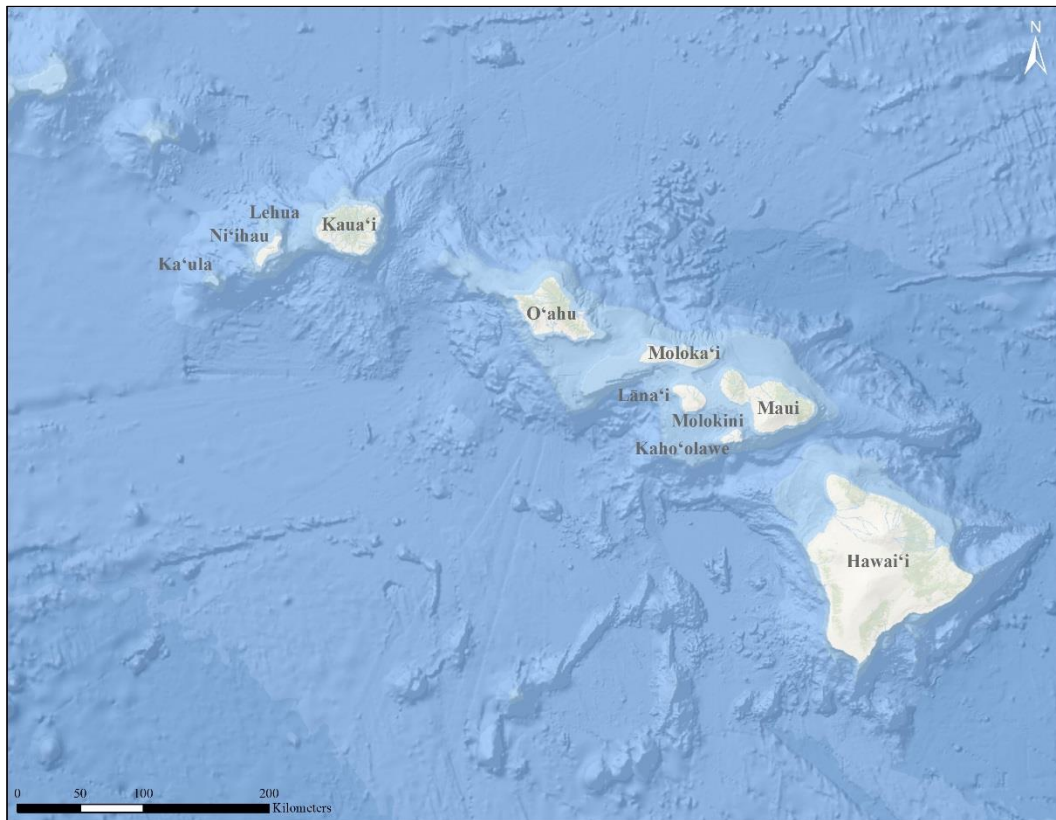


Figure 6. Map of the main Hawaiian Islands.

Adding to an already highly-complex society was the development of the traditional land division system, which included the *ahupua'a*—the principle land division that functioned for both taxation purposes and furnished its residents with nearly all of the fundamental necessities. *Ahupua'a* are land divisions that typically incorporated all of the eco-zones from the mountains to the sea and for several hundred yards beyond the shore, assuring a diverse subsistence resource base (Hommon 1986). Although the *ahupua'a* land division typically incorporated all of the eco-zones, their size and shape varied greatly (Cannelora 1974). In summarizing the types of ecozones that could be found in a given *ahupua'a*, Hawaiian scholar and historian, Samuel Kamakau writes:

Here are some names for [the zones of] the mountains—the *mauna* or *kuahiwi*. A mountain is called a *kuahiwi*, but *mauna* is the overall term for the whole mountain, and there are many names applied to one, according to its delineations ('*ano*). The part directly in back and in front of the summit proper is called the *kuamauna*, mountaintop; below the *kuamauna* is the *kuahea*, and makai of the *kuahea* is the *kuahiwi* proper. This is where small trees begin to grow; it is the *wao nahele*. Makai of this region the trees are tall, and this is the *wao lipo*. Makai of the *wao lipo* is the *wao 'eiwa*, and makai of that the *wao ma'ukele*. Makai of the *wao ma'ukele* is the *wao akua*, and makai of there is the *wao kanaka*, the area that people cultivate. Makai of the *wao kanaka* is the '*ama'u*, fern belt, and makai of the '*ama'u* the '*apa'a*, grasslands.

A solitary group of trees is a *moku la'au* (a “stand” of trees) or an *ulu la'au*, grove. Thickets that extend to the *kuahiwi* are *ulunahale*, wild growth. An area where *koa* trees suitable for canoes (*koa wa'a*) grow is a *wao koa* and mauka of there is a *wao la'au*, timber land. These are dry forest growths from the '*apa'a* up to the *kuahiwi*. The places that are “spongy” (*naele*) are found in the *wao ma'ukele*, the wet forest.

Makai of the '*apa'a* are the *pahe'e* [*pili* grass] and '*ilima* growths and makai of them the *kula*, open country, and the '*apoho* hollows near to the habitations of men. Then comes the *kahakai*, coast, the *kahaone*, sandy beach, and the *kalawa*, the curve of the seashore—right down to the '*ae kai*, the water's edge.

That is the way *ka po'e kahiko* [the ancient people] named the land from mountain peak to sea. (Kamakau 1976:8–9)

The *hoa'āina* (native tenants) and '*ohana* (families) who lived on the land had rights to the gather resources for subsistence and for tribute (Jokiel et al. 2011). As part of these rights, the *ahupua'a* residents were also required to supply resources and labor that supported the royal communities of regional and/or island kingdoms. The *ahupua'a* became the equivalent of a local community, with its own social, economic, and political significance and served as the taxable land division during the annual *Makahiki* procession (Kelly 1956). During this annual procession, the highest chief of the land sent select members of his retinue to collect *ho'okupu* (tribute and offerings) in the form of goods from each *ahupua'a*. The *hoa'āina* (native tenants) who resided in the *ahupua'a* brought their share of *ho'okupu* to an *ahu* (altar) that was symbolically marked with the image of a *pua'a* (pig). *Ahupua'a* were ruled by *ali'i 'ai ahupua'a* or chiefs who controlled the *ahupua'a* resources; who, for the most part, had complete autonomy over this generally economically self-supporting piece of land (Malo 1951). *Ahupua'a* residents were not bound to the land nor were they considered the property of the *ali'i*. If the living conditions under a particular *ahupua'a* chief were deemed unsuitable, the residents could move freely in pursuit of more favorable conditions (Lam 1985). This structure safeguarded the well-being of the people and the overall productivity of the land, lest the chief loses the principle support and loyalty of his or her supporters. *Ahupua'a* lands were in turn, managed by an appointed *konohiki* or lesser chief-landlord, who oversaw and coordinated stewardship of an area's natural resources (ibid.). In some places, the *po'o lawai'a* (head fisherman) held the same responsibilities as the *konohiki* (Jokiel et al. 2011). When necessary, the *konohiki* took the liberty of implementing *kapu* (restrictions and prohibitions) to protect the *mana* of the area's resources from physical and spiritual depletion.

Many *ahupua'a* were further divided into smaller land units termed '*ili* and '*ili kūpono* (often shortened to '*ili kū*). '*Ili* were created for the convenience of the *ahupua'a* chief and served as the basic land unit, which *hoa'āina* often retained for long periods of time (Jokiel et al. 2011; MacKenzie 2015). As the '*ili* themselves were typically passed down in families, so too were the *kuleana* (responsibilities, privileges) that were associated with it. The right to use and cultivate '*ili* was maintained within the '*ohana*, regardless of any change in title of the *ahupua'a* chief (Handy and Handy 1991). Malo (1951), recorded several types of '*ili*: the '*ili pa'a*, a single intact parcel and the '*ili lele*, a discontinuous parcel dispersed across an area. Whether dispersed or wholly intact, the '*ili* land division required a cross section of available resources, and for the *hoa'āina*, this generally included access to agriculturally fertile lands and coastal fisheries. While much of the same resource principles applied to the '*ili kūpono*, these land units were

politically independent of the *ahupua'a* chief. This designation was applied to specific areas containing resources that were highly valued by the ruling chiefs, such as fishponds (Handy and Handy 1991).

The *ali'i* who presided over the *ahupua'a* (*ali'i-ai-ahupua'a*), in turn, answered to an *ali'i ai moku* (chief who claimed the abundance of the entire *moku* or district) (Malo 1951). Although *moku* (districts) were comprised of multiple *ahupua'a*, they were considered geographical subdivisions with no explicit reference to rights in the land (Cannelora 1974). This form of district subdividing was integral to Hawaiian life and was the product of resource management planning that was strictly adhered to. As knowledge of place developed over the centuries and passed down intergenerationally by direct teaching and experience, detailed information of an area's natural cycles and resources were retained and well-understood. Decisions were based on generations worth of highly informed knowledge and sustainably adapted to meet the needs of a growing population. This highly-complex land management system mirrors the unique Hawaiian culture that coevolved with these islands.

Evolution of Hawaiian Land Stewardship Practices and the Impacts to Hawai'i's Native Forests

Their ancient and ingrained philosophy of life tied Hawaiians to their environment and helped to maintain both natural, spiritual, and social order. In describing the intimate relationship that exists between Hawaiians and *'āina* (land), Hawaiian historian and cultural specialist, Kepā Maly writes:

In the Hawaiian context, these values—the “sense of place”—have developed over hundreds of generations of evolving “cultural attachment” to the natural, physical, and spiritual environments. In any culturally sensitive discussion on land use in Hawai'i, one must understand that Hawaiian culture evolved in close partnership with its' natural environment. Thus, Hawaiian culture does not have a clear dividing line of where culture and nature begins.

In a traditional Hawaiian context, nature and culture are one in the same, there is no division between the two. The wealth and limitations of the land and ocean resources gave birth to, and shaped the Hawaiian world view. The *'āina* (land), *wai* (water), *kai* (ocean), and *lewa* (sky) were the foundation of life and the source of the spiritual relationship between people and their environs. (Maly 2001)

The Hawaiian *'ōlelo no'eau* (proverbial saying) “*Hānau ka 'āina, hānau ke ali'i, hānau ke kanaka*” (Born was the land, born were the chiefs, born were the commoners), conveys the belief that all things of the land including *kanaka* (humans) were literally born (*hānau*), and are thus connected through kinship links that extend beyond the immediate family (Pukui 1983:57). *'Āina* or land, was perhaps most revered, as another *'ōlelo no'eau* notes, “*He ali'i ka 'āina; he kauwā ke kanaka,*” which has been translated by Pukui (1983:62) as “[t]he land is a chief; man is its servant.” The lifeways of early Hawaiians, which were derived entirely from the finite natural resources of these islands, necessitated the development of sustainable resource management practices. Over time, what developed was an adaptable management system that integrated the watershed, freshwater, nearshore fisheries, all of which are connected through the many unique ecosystems that extend from the mountains to the sea (Jokiel et al. 2011).

Kilo or astute observation of the natural world became one of the most fundamental stewardship tools used by the ancient Hawaiians. The vast knowledge acquired through the practice of *kilo* enabled them to observe and record the subtlest changes, distinctions, and correlations in their natural world. Examples of their keen observations are evident in Hawaiian nomenclature, where numerous types of rains, clouds, winds, stones, environments, flora, and fauna, many of which are geographically unique, have been named and recorded in centuries-old traditions such as *oli* (chants), *mele* (songs), *pule* (prayers), *inoa 'āina* (place names), *'ōlelo no'eau* (proverbial sayings), all of which were transmitted orally through the ages. Other traditional Hawaiian arts and practices including, (but not limited to) *hula* (traditional dance), *lapa'au* (traditional healing), *lawai'a* (fishing), *mahi'ai* (farming) further reinforced knowledge of the natural environment.

Their exclusive dependency on a thriving natural environment led Hawaiians to develop a sophisticated and comprehensive system of land stewardship that was reinforced through the strict adherence to practices that maintained and enhanced the *kapu* and *mana* of all things in the Hawaiian world. In Hawaiian belief, all things natural, places, and even people, especially those of high rank, possesses a certain degree of *mana* or “divine power” (Pukui et al. 1972; Pukui and Elbert 1986:235). *Mana* is believed to be derived from the plethora of Hawaiian gods (*kini akua*) who were embodied in elemental forces, land, natural resources, and certain material objects and persons (Crabbe et al. 2017). Buck (1993) expanded on this concept noting that *mana* was associated with “the well-being of a community, in human knowledge and skills (canoe building, harvesting) and in nature (crop fertility, weather etc.)” (in Else 2004:244).

To ensure the *mana* of the resources, certain places, and people remained protected from over-exploitation and defilement, *kapu* of various kinds were implemented and strictly enforced. Elbert and Pukui (1986:132), defined *kapu*

as “taboo, prohibitions; special privilege or exemption...” Kepelino (1932) notes that *kapu* associated with the gods applied to all social classes, while the *kapu* associated with the chiefs were applied to the people. As the laws of *kapu* dictated social relationships, it also provided “environmental rules and controls that were essential for a subsistence economy” (Else 2004:246). Juxtaposed to the concept of *kapu* was *noa*, translated as “freed of taboo, released from restrictions, profane, freedom” (Pukui and Elbert 1986:268). Some *kapu*, particularly those associated with maintaining social hierarchy and gender differentiation were unremitting, while those *kapu* placed on natural resources were applied and enforced according to seasonal changes. The application of *kapu* to natural resources ensured that such were resources remained unspoiled and available for future use. When the *ali‘i* or the lesser chiefs (including *konohiki* and *po‘o lawai‘a*) determined that a particular resource was to be made available to the people, a decree was proclaimed indicating that *kapu* had been lifted, thereby making it *noa*. Although transitioning a resource from a state of *kapu* to *noa* allowed for its use, people were still expected to practice sustainable harvesting methods and pay tribute to the ruling chief and the gods and goddesses associated with that resource. *Kapu* were strictly enforced and violators faced serious consequences including death (Jokiell et al. 2011). Violators who managed to escape death sought refuge at a *pu‘uhonua*, a designated place of refuge or sometimes were freed by the word of certain chiefs (Kamakau 1992). After completing the proper rituals, the violator was absolved of his or her crime and allowed to reintegrate back into society.

This ancient and ingrained way of life underwent serious transformations following the arrival of Captain James Cook in 1778. This year marks the end of what is often referred to as Hawai‘i’s Precontact Period and the beginning of the Historic Period. While this time mark signifies an important date in Hawaiian history, it is vital to note that throughout the Early Historic Period, even with Western influences, the Hawaiian chiefs still held outright rule over the land and its resources and maintained strict adherence to the *kapu* system—the very system from which their power was derived. For many Hawaiian historians, the abrogation of the *kapu* system in 1819, also marked significant socio-religious changes. Some researchers have argued that the abolishment of the *kapu* system undermined the very foundation upon which traditional Hawaiian society was built, ultimately altering the relationship between the chiefs and the people as well as their relationship to the land (Else 2004; Kame‘eleihiwa 1992). At the outset of the Historic Period, there was a continued trend toward craft and status specialization, intensification of agriculture, *ali‘i* controlled aquaculture, the establishment of upland residential sites, and the enhancement of traditional oral history. The veneration of traditional gods and the strict observation of the *kapu* system were at their peaks (Kent 1983; Kirch 1985). With the influx of foreigners, many of whom were quick to introduce the idea of trade for profit, Hawai‘i’s traditional culture, and the sociopolitical economy began to shift to meet the growing demands of the foreign populations.

The Arrival of Foreign Plants and Animals and the Transformation of the *Kapu* System

By the time Kamehameha had conquered O‘ahu, Maui, and Moloka‘i, in 1795, Hawai‘i saw the beginnings of a market system economy and the work of the native tenants shifted from subsistence agriculture to the production of foods and goods that could be traded with early explorers and whalers (Kent 1983). Introduced fruit trees and garden vegetables, often grown for trade with Westerners included yams, coffee, melons, Irish potatoes, Indian corn, beans, figs, oranges, guavas, and grapes (Wilkes 1845). Animals such as goats, sheep, pigs, cattle, horses, and turkeys that were left by Cook and other early visitors between 1778 and 1803 were allowed to roam freely (Kuykendall 1938). Of all the foreign introductions, cattle had the most profound impact. Setting the foundations of Hawai‘i’s livestock industry, in 1793, Captain George Vancouver, who had visited the islands during Cook’s 1778 voyages, gifted the first cattle to Kamehameha. The lack of quality cattle feed proved to be detrimental to the animals. To combat this, Kamehameha, at the demand of Captain George Vancouver, enforced a *kapu*, which lasted until the 1830s that prohibited the killing of the animals (Bergin 2004; Kuykendall 1938). The first head of steer and sheep that were gifted by Vancouver were driven into the upland plains of Waimea on Hawai‘i Island and allowed to roam and multiply (Barrera 1983). The unrestrained populations of cattle had increased significantly and by the 1830s had become a nuisance to native farmers. Additionally, the environmental degradation of the native forests had become apparent to Kamehameha’s sons and heirs who began to take steps to control the ravenous cattle population. In an effort to protect their crops, and to reduce the risk of encountering the large and often dangerous animals, native farmers began constructing taller enclosures to prevent the animals from plundering their gardens and destroying their homes. On Hawai‘i Island, where cattle populations are said to have numbered in the tens of thousands, tall rock walls that stretched for miles were built around the more densely populated areas (Bergin 2004). While the introduced plants and animals contributed to the development of Hawai‘i’s early market economy, the exportation of native hardwoods, particularly *‘iliahi* or sandalwood compounded the preexisting environmental degradation and wreaked havoc on the native lifeways.

The *'iliahi* or sandalwood (*Santalum ellipticum*) trade established by Euro-Americans in 1790 quickly turned into a viable commercial enterprise (Oliver 1961). By 1810, and with the backing of Kamehameha and other chiefs, this industry flourished, as farmers and fishermen were ordered into the mountains of their district to cut sandalwood and carry it to the coast. Although the laborers were compensated with *kapu* (material), food and fish (Kamakau 1992), the neglect of their personal subsistent duties lead to food shortages and famine. The harsh working conditions coupled with lack of nutrition severely degraded the health and *mana* of the native people, ultimately contributing to a population decline. This industry also began to erode the relationship between the *ali'i* and the common people (Else 2004). Kamakau (ibid.:204) described the collapse of a traditional subsistence system and the industry's detrimental effects on the people: "...this rush of labor to the mountains brought about a scarcity of cultivated food . . . The people were forced to eat herbs and tree ferns, thus the famine [was] called Hi-laulele, Haha-pilau, Laulele, Pualele, 'Ama'u, or Hapu'u, from the wild plants resorted to." Once Kamehameha realized the dire effects this industry on his people, he "declared all the sandalwood the property of the government and ordered the people to devote only part of their time to its cutting and return to the cultivation of the land" (ibid.: 1992:204).

On May 8th, 1819, Kamehameha, who had seen the impacts brought about by foreign introductions, died at his royal residence at Kamakahonu in Kailua-Kona and named his son 'Iolani Liholiho heir to his kingdom (Kamakau 1992). By May 21st 'Iolani Liholiho (Kamehameha II) at the age of twenty-one began his rule. As traditional custom dictated and to allow for all people to rightfully mourn the loss of their chief, all *kapu* were relaxed following the death of a chief (ibid.). It was the responsibility of the new ruler to conduct the proper rituals and ceremonies to reinstate all *kapu*. However, Liholiho's attempts to reinstate the long-standing *kapu* system was futile and the future of the *kapu* system stood in a state of uncertainty. *Kuhina Nui* (Premier), Ka'ahumanu (the wife of Kamehameha and the *hānai* (adopted) mother of Liholiho) and his biological mother Keōpūolani lured the young chief back to Kona and the *kapu* system was symbolically abolished when Liholiho ate in the presence of his mothers. While Liholiho, his mothers and other chiefs favored the complete abolishment of the *kapu* system, others including Kekuaokalani and his followers prepared to wage war, determined to have the ancient laws reinstated. After several failed attempts at negotiation, Liholiho's army led by Kalaimoku went head-to-head against the forces of Kekuaokalani in the Battle of Kuamo'o (Fornander 1918–1919). Western weaponry had already permeated traditional Hawaiian warfare and Kekuaokalani, who stood behind the ancient laws of the land was killed by gunfire on the battlefield alongside his wife Manono, thereby extinguishing the last public display of resistance. The abolishment of the *kapu* system in 1819, began to undermine the very foundations upon which traditional Hawaiian culture was formed. Adding to an already socially and politically fractured society was the arrival of Protestant missionaries who sought to fill the spiritual void of the Hawaiian people.

In October of 1819, just five months after the death of Kamehameha, the first American Protestant missionaries aboard the Brig. *Thaddeus* left Boston, Massachusetts and by March 30th, 1820, sailed to Kawaihae on the northwest coast of Hawai'i Island (Hawaiian Mission Children's Society 1901). Having heard of the overturning of the ancient *kapu* system, these early missionaries formed close alliances with some of Hawai'i's royalty, including Ka'ahumanu who held a tremendous amount of political power. Starting in 1823, these early missionaries, one of which included William Ellis (1917) set out into the remote parts of the islands in search of suitable locations for future mission stations and within a few short years, mission stations were being constructed outside of the main town centers. Christian beliefs quickly spread and soon established a firm foothold in the islands. The missionaries quickly discovered that many Hawaiians were selective about what aspects of Christianity they were willing to adopt. In striving for complete conversion, the missionaries with the help of the *ali'i* implemented laws that enforced Euro-American beliefs on the Hawaiian people. To an extent, this furthered the efforts of the missionaries. Despite these massive cultural changes, many Hawaiians continued to hold to their ancient beliefs, especially those associated with their relationship to the land. Throughout the remainder of the 19th century, introduced diseases and global economic forces continued to degrade the traditional life-ways of the Hawaiian people.

Private Property and Its Effects on Traditional Concepts of Land and Land Use Practices

By the mid-19th century, the ever-growing population of Westerners in the Hawaiian Islands forced socioeconomic and demographic changes that promoted the establishment of a Euro-American style of land ownership. By 1840 the first Hawaiian constitution had been drafted and the Hawaiian Kingdom shifted from an absolute monarchy into a constitutional government. Convinced that the feudal system of land tenure previously practiced was not compatible with a constitutional government, the *Mō'ī* Kamehameha III and his high-ranking chiefs decided to separate and define the ownership of all lands in the Kingdom (King n.d.). The change in land tenure was further endorsed by missionaries and Western businessmen in the islands who were generally hesitant to enter business deals on leasehold lands that

could be revoked from them at any time. The push for exclusive private property rights culminated in the *Māhele ʻĀina* of 1848 and the subsequent *Kuleana Act* or Enabling Act of 1850.

While the formalization of private property rights was a success for many Westerners, this ultimately led to the displacement of many Hawaiians from their ancestral lands—lands that they had come to know so intimately. In general, although many Hawaiians were awarded lands during this period, it was realized that the parcels they were awarded were insufficient to sustain their traditional subsistence lifestyles. Additionally, access to resources that were once a part of the now fragmented *ahupuaʻa* system further curtailed traditional subsistence activities. As many Hawaiian continued to migrate to the populated centers around the islands and even elsewhere, large tracts of land that were once dotted with small communities and extensive traditional agricultural fields were being prospected for large scale commercial agriculture and ranching. Although these industries added to the cultural tapestry of the islands, such operations required vast amounts of land and water. The mass acquisition of land and the diversion of water from their natural courses during the 19th and 20th centuries resulted in numerous court battles between Western businessmen competing to increase their operations and native Hawaiians who willfully held to their traditional lifeways. Such issues continue to be vetted in Hawaiʻi courtrooms.

Formerly forested lands were being grazed down and, in some places, planted with introduced species of grass and various shrubs to form natural fencing and to be used as livestock feed (Henke 1929). In the drier leeward area of Hawaiʻi, the planting of *kiawe* or algaroba (*Prosopis pallida*) proved to be useful for the cattle and apiary industry (ibid.). By the mid-19th century, the apparent destruction of native forest habitat had severely diminished the water supply of islands, ultimately prompting action by the Hawaiian Kingdom government. In 1876, the Kingdom legislature under the administration of King David Kalākaua passed “An Act for the Protection and Preservation of Woods and Forests” (Planters’ Labor and Supply Company 1887:438).” Between 1876-1910, uncoordinated efforts between the government and various agricultural sectors were undertaken to remedy the loss of native forests and to increase water supply (Cannarella 2010). Wild ungulates were removed from some native forests habitats—an effort that began in the 1830s—and efforts to fence off sections of intact forests set the foundation for Hawaiʻi’s forest reserves. To replenish severely degraded forests, a large number of non-native species were experimentally planted, including, *paina* or ironwood (*Casuarina equisetifolia*), silver oak (*Grevillea robusta*), wind acacia, sour plum, and a number of other species (Henke 1929). Efforts to diversify the Kingdom’s economy and the long-standing trend of introducing exotic plant and animal species to the islands continued to mount.

The introduction of large-scale planting of sugarcane during the mid- to late-19th century resulted in massive land clearing efforts around the islands. The success and growth of the sugar industry within the more arid parts of the islands was highly dependent upon an ample supply of irrigation water (Wilcox 1996). Occasional wildfires and pests such as the leafhopper threatened the burgeoning sugar industry (Campbell and Ogburn 1990). To ensure economic prosperity, these sugar companies invested in experimental agriculture. New varieties of cane collected from various parts of the world were introduced without restraint and tested to meet the climatic challenges of growing cane in Hawaiʻi. By the 1890s, under the administration of King David Kalākaua, efforts to regulate plant and animal imports, many of which carried pests that were unknown to the islands, had become a priority for the Hawaiian Kingdom government.

HISTORY OF BIOCONTROL IN THE HAWAIIAN ISLANDS

The use of classical biocontrol, “the suppression of pest populations by introduction and liberation of natural enemies,” has been actively undertaken in the Hawaiian Islands for roughly 130 years with varying degrees of success (Funasaki et al. 1988:105; Lai 1988). The history of classical biocontrol in the Hawaiian Islands has certainly evolved, from unregulated and often poorly thoughtout introductions to one requiring government oversight and a stringent range of pre-release testing protocols that screens agents for host specificity and potential adverse impacts to other species (Reimer 2002). The origins of biocontrol in the Hawaiian Islands emerged during latter half of the 19th century, as the islands became an agricultural hotspot for sugarcane and many new plant species, some of which carried insect pests, that were introduced without restraint. In 1890, the Hawaiian Kingdom Government, under the administration of King David Kalākaua established the Commissioners of Agriculture to prevent unwanted immigrant pests from entering the islands, and to control those that had already been introduced. The duties of the Commissioners were detailed in Chapter II of *Session Laws of 1890*. Chapter II titled “An Act Relating to the Suppression of Plant Disease, Blight, and Insect Pests” reads:

SECTION 2. It shall be the duty of such Commissioners to seek to prevent the introduction into this Kingdom of any plant disease, blight, or insect pests injurious to any tree or trees, plant or plants, or vegetation; and to seek to exterminate any such diseases, blight or insect pests now existing or hereafter introduced.

They shall have the power to enter upon any premises where they have reason to believe there is any tree, plant, or vegetation affected with any disease, blight, or insect pest; and to take all reasonable and proper steps to prevent the spread of any such disease, blight or insect pest, and if after due trial (such trial to be not longer than ten days) it is found by said Commissioners, or one of them, that the trees, plants or vegetation cannot be cured, or the blight destroyed, that then an in such case he or they may order the same destroyed. (Kalakaua 1890:4–5)

The initiation of the 1890 laws was in response to unregulated efforts to control pests—an act that prior to 1890 was being initiated at the whim of private citizens. The earliest accounts of the unregulated use of biocontrol can be traced back to 1865, when Dr. William Hillebrand, a physician and naturalist, brought the mynah bird (*Acridotheres tristis*) from India to Hawai‘i to control army worms that were infesting Hawai‘i’s pastures (Funasaki et al. 1988). Because of the mynah bird’s appetite for rotting and decomposed things, and for its use of garbage as nesting material, the bird was given the Hawaiians name of “*manu-‘ai-pilau*,” which can be translated as the bird that consumes rotten things (Pukui and Elbert 1986:486). The mynah bird is also known in Hawaiian as “*piha‘ekelo*”, literally translated as “full of ‘ekelo sound,” a name given because of its raucous nature (ibid.:326). The debate over whether the introduction of the mynah bird was successful in controlling army worms spilled over into local newspapers. Proponents of the mynah bird emphasized its success, however, others alleged that such comments poorly represented the birds’ impacts to agriculture and to the people. An article published in *The Pacific Commercial Advertiser* in 1876 challenged some of the alleged successes:

THOSE CATERPILLARS.—The *Gazette* says that owing to the large increase of *mynah birds*, “not a caterpillar is to be seen in this regions,” (Honolulu) while at points outside of this favored range of the birds the grass has been destroyed. This would be a very pretty and pleasing statement in favor of the usefulness of the *mynahs*, if it were true, as unfortunately it is not. Right here and now, in the immediate neighborhood of the city, on the plains and elsewhere the birds abound, caterpillars do much more abound,—in such immense quantities that it would be simply impossible for the former to make any perceptible impressions on the mass. No doubt the *mynah* would not refuse a fat caterpillar now and again; but we don’t believe they prefer them as a regular diet, for the bird is something of an epicure and delights to range from stolen beefsteak to a nest of pigeon’s or dove’s eggs. Chickens are very good at destroying the vermin, so far as their capacities go; and turkeys are better. But the plague is usually of but brief duration. (*The Pacific Commercial Advertiser* 1876:3)

Complaints of the mynah bird attacking people and livestock filled the local newspapers throughout the late 19th century. The noisy mynah bird had become such a nuisance to the residents of Honolulu that some people took to the city with guns to exterminate the birds. The mynah bird proponents fired back and proposed a law that would prevent the killing of the birds. An article written in the November 9th, 1894, issue of *The Hawaiian Star* blamed the mynah bird and the dove for aiding in the spread of another noxious introduction, *Lantana camara*, which was brought to the islands from “tropical America in the year 1858” (*The Hawaiian Star* 1894:3).

During Hawai‘i’s sugar plantation era, rats had become a serious pestilence to sugar plantation owners and considerable attempts to bring Hawai‘i’s rat population under control were being actualized. An article published in the March 31, 1883, edition of *The Pacific Commercial Advertiser* details the proposed introduction of the infamous mongoose (*Herpestes javanicus*), a native of India to Hawai‘i’s cane fields:

THE Planters’ Monthly has lately been proposing the introduction of a little animal from India called the mongoose, as a destroyer of rats. He is a famous ratter, surpassing the cat or the ferret. He is described as a lively little urchin, about the size of a weasel, as having a snaky body, vicious looking claws, a sharp nose, a villainous eye and looks like “murder incarnate.” In speaking of his action in capturing rats, it is said that he crawls sinuously up to his victim until within easy distance for a rush, and then strikes with unerring aim, snapping rats just at the base of the brain. The rat has not time even to squeak, so sudden and deadly is the onslaught. Wherever the rat can enter the mongoose can follow. Thus as a ratter this lively little Indian is incomparable, but the trouble is he will not confine his operations to what is deemed his legitimate business. Some writers have endeavored to save his credit as a poultry destroyer, but a naturalist, who has carefully observed his characteristics, says that he is a general destroyer, not only of everything under, but of many creatures over his size. When in a cage the sight of a small living creature made him frantic and whenever he escaped, as he sometimes did, he made a sensation in the poultry house. The mongoose is not content with marauding forays in the yard, but he seems to pervade the house when domesticated... The rat is unquestionably a great pest of the cane and rice planter and grain cultivator in all parts of the world. The rat pest was deemed so serious here some fifty years ago that an enlightened and enterprising

Commissioner of the Hawaiian Government, sent inquest of Chinese... to procure a species of snake famed as a destroyer of rats; but the Hawaiian people, whose sacred soil had been kept free from snakes and toads by some patron saint equal in influence to St. Patrick, conceived a holy terror of the snake, notwithstanding his possible utilities, and passed a decree that Hawaii would have no snake in her plantations. The destruction of rats in the cane-fields was hardly deemed a sufficient compensation to the Hawaiian mind for the probable presence every now and then of his snakeship in the thatch of the Hawaiian *hale pili*... (The Pacific Commercial Advertiser 1883:2)

By September of 1883, Mr. William H. Purvis, a plant collector and investor in the Pacific Sugar Mill at Kukuihaele on Hawai'i Island, imported seven mongooses, fowls, and exotic plants from Australian colonies (Daily Honolulu Press 1883). The imported mongooses were "...intended for the damp lands of the Kukuihaele plantation at Hamakua..." (ibid.:4). A number of *'iole manakuke* or mongooses, were liberated in the cane fields of both Hilo and Hāmākua (Funasaki et al. 1988; Pukui and Elbert 1986). Subsequently, in 1885, mongooses were released on Maui, Moloka'i, O'ahu, and Kaua'i. While mongoose populations had quickly established themselves on Maui, Moloka'i, and O'ahu, to date, the mongoose has not established itself on Kaua'i. Both introductions rapidly multiplied and spread beyond their intended target species. While the introduction of the mongoose appears to have some success in combatting the rodents, their impacts were highlighted in newspaper editorials as early as 1886, from writers complaining that the mongooses were becoming a pest in their own. One such article read:

The mongoose is a useful little creature for the destruction of rats. He was brought here for that purpose, and, we believe, had done his work thoroughly well on several plantations. But the mongoose does not confine himself to rats, and complaints come from some quarters that ducks and chickens are being destroyed by wholesale. The mongoose may ultimately prove to be a greater nuisance than a benefit. (The Daily Bulletin 1886:2)

By the late 19th-century, the mongoose had become a sort of cultural symbol. A review of newspaper articles published in Hawai'i during this period reveals that the mongoose was often used metaphorically to refer to people or things that exhibited wild behavior and for people who came to the islands without having any intent to leave. However useful these introductions were in controlling its intended target, over time, their unintended impacts had become obvious. In its wake, the mongoose destroyed livestock, the eggs of native bird species, and the noisy mynah bird, is associated with aiding in the proliferation of the noxious weed, *Lantana camara* (Funasaki et al. 1988). These early and poorly thought out introductions are what Funasaki et al. (1988:106) described as a classic example of "biological control gone astray." Funasaki et al. (ibid.) emphasize that:

However, it must be realized that prior to 1890, planning and evaluation before the introduction of any organism were nonexistent simply because they were not required. There were no laws or regulations restricting or prohibiting the importation of any plant or animal from other geographical areas into Hawaii.

While these early introductions appear to have been a practical solution to a growing problem, ultimately, the lack of regulation, adequate pre-release testing protocols, and post-release monitoring created even more problems for Hawai'i's environment and people. In response to these ill-fated early and unregulated releases, Hawai'i's government leaders began to formalize a plan that would limit the introduction of unwanted pest species and control those that had already been introduced.

Regulated Efforts to Control Unwanted Pest in Hawai'i

By the late 19th century, efforts to study the natural enemies of unwanted pests that were impacting Hawai'i's agricultural industry were being formalized. In 1893, the year of the unlawful overthrow of Queen Lydia Lili'uokalani, the provisional government of the Republic of Hawai'i appointed Albert Koebele as the entomologist to biologically control the many species of immigrant pests (Funasaki et al. 1988). Koebele is credited with being "one of the first, if not the very first entomologist, to engage in the introduction of natural enemies as a method of combating insect pests" (Giffard et al. 1925:340). Between 1893 and 1910, Koebele spent much of his time traveling to places like Australia, Fiji, Japan, China, Ceylon (modern-day Sri Lanka), Mexico, and California where he studied various insects that he thought would be beneficial to combat pests that were introduced to the islands. In 1893, Koebele successfully used biocontrol to combat the cottony cushion scale (*Icerya purchasi*). In summarizing Koebele's biological introductions to the Hawaiian Islands, Giffard et al. (1925:342) remarked:

He made the beginning in this line of work, and much of the time was working alone, yet seventeen species of lady beetles were successfully introduced by him and have become valuable factors in keeping reduced such pests as scale insects, mealybugs, plant lice and leaf mites. At least six other

lady beetles were introduced and became established, but after a few years disappeared. The eight lantana insects were introduced by him, and about the same number of miscellaneous parasites of Diptera and Lepidoptera, etc. Following Mr. Koebele in this line of work, the other entomologists have introduced a larger number of beneficial insects, and some of them have produced more spectacular and valuable results, but this should not in any way lessen the credit to be given to him who was the pioneer in Hawaii in this important branch of entomological work.

Encouraged by Koebele's successes, in 1903, the Territorial Government (formalized in 1898), enacted laws to create the Board of Commissioners of Agriculture and Forestry (the precursor to the Hawaii Department of Agriculture (HDOA)). These early laws provided for facilities and materials "to obtain, propagate, study, and distribute beneficial species of insects to control pest species of insects and weeds" (Funasaki et al. 1988:107). Additionally, a quarantine system to prevent new immigrant pests from entering the islands was also created. Another early organization responsible for the release of a number of biological control agents was the Hawaiian Sugar Planters' Association (HSPA), founded in 1895. In 1904, HSPA instituted an Entomology branch and from its founding to about 1942, this branch aided in combatting a variety of pests that were plaguing Hawai'i's cane fields and threatening the economic promise of the sugar industry (ibid.). Throughout the early to mid-20th century, as Hawai'i's agricultural interest grew to include pineapple and other tropical fruit, additional institutions were organized to study and combat its share of pests. Such organizations included the United States Bureau of Entomology and Plant Quarantine's Fruit Fly Laboratory (now U.S. Department of Agriculture's Tropical Fruit and Vegetable Research Laboratory), Experiment Station of the Pineapple Producers Cooperative Associations, HSPA's Experiment Station, Hawaii Agricultural Experiment Station of the University of Hawaii's College of Tropical Agriculture, the California Agricultural Experiment Station of the University of California, and the Hawaii Department of Health (ibid.). By the 1940s and 1950s, the creation and introduction of chemical pest control had become the favored alternative (Howarth 1983). While chemical pest control still maintains its place in managing unwanted pests, the environmental and health risks associated with its use has led to the adoption of stricter regulations and a push towards finding more natural and low-cost alternatives (ibid.).

Collectively, the laws passed in 1890 to regulate unwanted immigrant pests set the foundation for what is known today as Hawai'i Revised Statutes (HRS) Chapter 141, which governs the State of Hawai'i, Department of Agriculture (HDOA)—the state agency responsible for protecting and diversifying Hawai'i's agricultural industry. HDOA's Plant Industry Division maintains three branches: Pesticides Branch, Plant Pest Control Branch, and the Plant Quarantine Branch that collectively work "to protect Hawaii's agricultural industries, environment, and [the] general public by preventing the introduction and establishment of harmful insects, diseases, illegal non-domestic animals, and other pests..." (Department of Agriculture 2016). In 2003, under Hawai'i Revised Statutes (HRS), Chapter 194, the State of Hawai'i legislature authorized the creation of the Hawai'i Invasive Species Council (HISC), the agency responsible for coordinating efforts between various local, state, federal, and international agencies and organizations to stop the introduction and spread of invasive species in the islands (State of Hawai'i 2005). Since the creation of the HISC, millions of dollars have been allocated to various local councils and government departments and programs to combat invasive species. Efforts have been directed at prevention, response and control, research and technology, and outreach (ibid.). There are four invasive species committees that represent each of the four counties (Kaua'i, O'ahu, Maui, and Hawai'i Island) in addition to an aquatic invasive species team (ibid.).

Historically, Hawai'i's biological control programs were aimed at controlling weeds and pests that were adversely impacting the agricultural industry. During the 1970s and 1980s, the heightened interest in native and endemic taxa, fueled by the passing of federal legislation to protect endangered plants coupled with the growth of native-plant organizations has led to greater consideration of the potential risk of introduced biological control agents on endemic taxa (Pemberton 2004). Hawai'i as a "hub for tourism, trade, and military transport" and the state's continued reliance on globally imported goods perpetuates the ongoing assault of introduced foreign species (Messing and Wright 2006). Funasaki et al. (1988:108) report that "more biological control projects against immigrant species of insect pests have been conducted in Hawaii than anywhere else in the world" and nearly a third of the introduced species (roughly 200 pest species) are known to be established. Reimer (2002:86) reports that "many of these introductions appear to have been successful in that the pest populations eventually did drop to acceptable levels, although scientific evaluations of the effectiveness of these introductions have been virtually non-existent." The lack of natural enemies to combat such pests has propelled state agencies, namely HDOA to continue to identify the pests' natural enemies and to develop stringent host-range testing protocols for the study and release of such agents. Although the application of classical biocontrol in Hawai'i has, at times proven to be economically successful, it is recognized that environmental risks are inherent in biological control programs (Holland et al. 2008; Howarth 1983; Pemberton 2004).

Historically, several individuals and agencies have participated in the study and release of biocontrol agents in the Hawaiian Islands. Today, the U.S. Department of Agriculture-Animal Plant Health Inspection Service-Plant Pest Quarantine (USDA-APHIS-PPQ) and the HDOA regulates the importation of biocontrol agents (Reimer 2002). While these agencies have distinct mandates and jurisdictions, there is some overlap with respect to the regulated use of biocontrol. Efforts to improve pre-release testing has resulted in a federal and state permitting process which includes an environmental review. In summarizing this process, Reimer (ibid.:87) writes:

All biocontrol agents imported for weed control attack plants and are by definition plant pests. They are, therefore, regulated by USDA.

The USDA requires separate permits for

- 1) Importation of a plant pest into the U.S.;
- 2) Movement of a plant pest between States; and
- 3) Release of a plant pest into the environment.

The federal permitting process requires the submission of PPQ Form 526 (Application for Release) that is forwarded to the HDOA for review and recommendations. All applications to date, for which HDOA has recommended rejection, have also been denied by the USDA. If approval is recommended by HDOA, USDA then reviews the application. This process usually involves review by the Technical Advisory Group; however, Hawai'i applications are exempt from TAG review due to the thoroughness of the HDOA review process. A draft environmental assessment (EA) is requested from the applicant for any requests for the release of weed biocontrol agents. The USDA prepares the final EA. If endangered or threatened species potentially are affected by the release of a biocontrol agent then the application is sent to the U.S. Fish and Wildlife Service for review. A release permit is issued if the evaluation of the EA produces a finding of no significant impact (FONSI).

While there are some similarities between the federal and state process, Chapter 150A of the Hawai'i Revised Statutes (HRS) regulates the importation of any plant or animal into the State of Hawai'i whether or not it is a plant pest (Reimer 2002). HRS 150A strictly prohibits the importation of all non-domestic animals and microorganisms unless approval is obtained by the Board of Agriculture. The review process for a state importation permit application involves six steps. Reimer (ibid.:88-89) provides a synthesis of the six-step process:

First, the application is submitted to the HDOA with all of the required and pertinent information, including information on host specificity, distribution, preferred habitat, temperature requirements, etc. Host specificity studies may be carried out either in the country of origin or in one of the three approved containment facilities in Hawai'i. The Advisory Subcommittee then reviews the application. The recommendations from this subcommittee are passed on to the Plants and Animals Committee for their recommendations to the BOA. The BOA either approves or disapproves the application. If approved, the application is submitted to a public hearing process. Comments from the public are brought back to the BOA for discussion, followed by final approval or disapproval of the application. If approved, a State permit is issued. The organism may be imported and released if both State and Federal permits have been issued and permit conditions are met by the importers.

The HDOA review process for the introduction of biocontrol agents has evolved into an effective system that screens agents for host specificity and potential negative impacts on other species. None of the agents introduced since the review process was initiated in 1975 have attacked any native or beneficial plant or animal species. This was not the case before 1975.

Additionally, efforts to improve public transparency following the decision rendered by the Hawai'i Intermediate Court of Appeals (*Ohana Pale Ke Ao v. Board of Agriculture, State of Hawaii*, 118 Hawaii 247, 249-50, 188 P.3d 761, 763-64 [Hawaii Ct. App. 2008]) has made the HDOA recognize that such biocontrol activities are subject to Chapter 343, Hawai'i Revised Statutes (Hawai'i Environmental Policy Act, HEPA) (Holland et al. 2008). Between 1890 and 1999, a total of 708 natural enemies have been released in Hawai'i, of which 286 have become established and the majority (237) of the introduced agents have contributed to the control of the target pest species (Reimer 2002). Prior to 1944 (before the formalization of the BOA), only 54% of the introduced agents were host-specific. This percentage has increased over the years with 77% host specificity being reported between the years 1944-1975. Since 1975, host specificity for all released biocontrol agents increased to 100% (ibid.). While stricter regulations have been adopted and modified over the years to reduce the environmental risk associated with the use of biological

control agents, continued field research and open dialogue remains as a critical component to improving our understanding and mitigating the environmental, economic, and cultural risks associated with such actions.

NATURAL AND CULTURAL HISTORY OF *WILIWILI*

The endemic *wiliwili* (*Erythrina sandwicensis*) grows primarily in Hawai‘i’s tropical dryland forest (Figure 7) below the 600-meter (1,968 feet) elevation and on volcanic substrates characterized by its high viscosity that tends to form loose, rough blocks of basaltic lava (Bell et al. 2013). Because of the preferred environmental conditions, *wiliwili* are more likely to be non-uniformly distributed across a particular lava flow. Although *wiliwili* have been found growing in Hawai‘i’s dry coral plains, its preferred habitat is within the biologically diverse and critically threatened tropical dryland forests ecosystem—an ecosystem that is sustained with as little as 30-120 centimeters (10-55 inches) of annual rainfall (Krauss 1993). Hawai‘i’s dryland forests host 25% of all endangered Hawaiian flora and studies have estimated that only 5-10% of Hawai‘i’s dryland forest ecosystem remains (Bell et al. 2013; Bruegmann 1996).

The dramatic decline in Hawai‘i’s dryland forest has been “attributed to deforestation, land development, invasive plant species, changes in fire regime, and introduced ungulate grazing” (Bell et al. 2013:215). In the 1930s, American Ecologist, Frank E. Egler (1942) wrote about the changes to Hawai‘i’s dryland forest areas following Western contact. In identifying some of the main causes, Egler wrote:

With the arrival of Europeans came the introduction and semi-naturalization of cattle, sheep, and goats—the greatest single blunder that could have been unwittingly perpetrated upon a scientifically and economically valuable vegetation cover. Some of these animals had taboos placed upon them; they multiplied rapidly and became naturalized in the hills and mountains. The animals completed the destruction of the original foothill vegetation, permitting the soil cover to be stripped from the lava rock, and causing the dry summer to be vastly more unfavorable for plant life. (ibid.:18)

Within a relatively short period following European colonization, there was created a large area practically devoid of closed vegetation, an unsaturated region ready to absorb any of dozens of pioneer species, be they introduced or native. The lowlands, being the site of the ports, towns, gardens, and experimental stations, did receive a tremendous influx of foreign plants, some of which found favorable the barren unoccupied overgrazed lowlands. They are said to have spread over the island like uncontrolled fire. Thus lantana, opuntia, and klu (*Acacia farnesiana* (L.) Willd.) came to dominate the lower slopes while kiawe (*Prosopis chilensis* (Molina) Stuntz.) covered the dusty coastal plain with an evergreen verdure that transformed the face of the land. (ibid.:18)

The transformation of the native vegetation in the dryland forest is shown in a historic photo found at the Hawai‘i State Archives that shows two *wiliwili* growing in the dry desolate conditions of Kaho‘olawe Island (Figure 8). In spite of these sweeping changes, some pockets of dryland forests across Hawai‘i managed to escape this devastating onslaught. Egler’s (1942:20) note about *wiliwili* as “apparently unpalatable to cattle” may explain why these trees managed to survive, even in pasture lands. In the North Kona District on the Island of Hawai‘i stands some of the largest remaining pockets of dryland forest. On the island of Maui, along the leeward slopes of Haleakalā in Auwahi Ahupua‘a, stands another pocket of dryland forest surrounded by the grazing lands of ‘Ulupalakua Ranch. These patches of dryland forest, however, continue to be adversely impacted by introduced plants including fountain grass (*Pennisetum setaceum*); ungulates, mainly cattle, and feral goats and sheep; and pests such as rats (Bruegmann 1996).

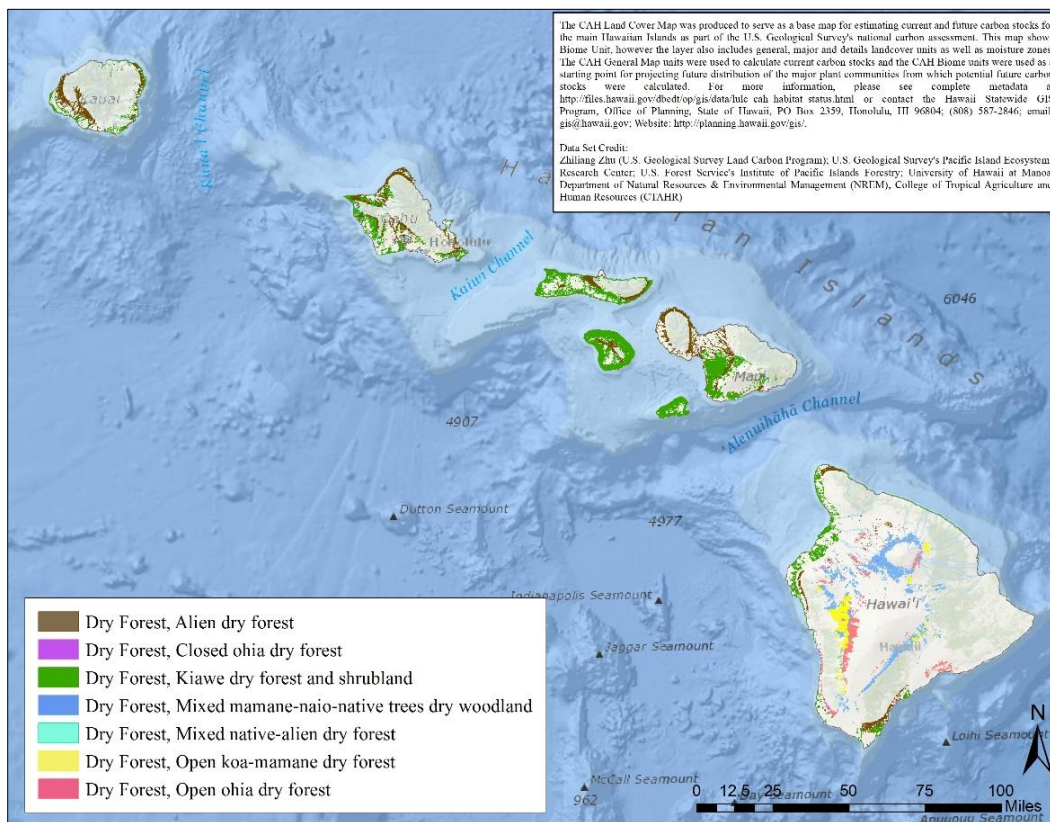


Figure 7. Estimated extent of Hawai‘i’s dryland forest habitat



Figure 8. Historical photo showing two *wiliwili* trees growing on Kaho‘olawe Island, date and photographer unknown. Hawai‘i State Archives, PP-46-10-002.

Cultural Value of Hawai‘i’s Dryland Forests

The diversity of flora and fauna found in Hawai‘i’s dryland forests provided an array of natural resources that were extensively utilized by Hawaiians for utilitarian, ceremonial, and medicinal purposes. In an ethnobotanical study conducted for Auwahi on the island of Maui, Program Manager of the Auwahi Forests Restoration Project, Arthur C. Medeiros, writes:

From a utilitarian point of view, nearly everything that could be obtained from the rain forests could be found in the dryland forests, as well as probably a much greater seasonal productivity of birds and spring flushing of vegetation. Dryland forests were also the source of a wide variety of tree species that provided wood to early Hawaiians. To human cultures without metal, sources of abundant and diverse hardwoods are one of the most important of ethnobotanical resources. (Medeiros et al. 1998:7)

The array of unique natural materials found in Hawai‘i dryland forests, particularly hardwoods, likely played a vital role in the expansion of Hawaiian society into the leeward regions of the islands. Such resources were traditionally utilized for medicine, tool-making, canoe and house construction, weapons, fishing, dyes, and for ceremonial purposes (ibid.). Medeiros et al. (ibid.:1) also notes other miscellaneous uses of dryland forests including the collection of “edible fruits or seeds, bird lime, cordage, a fish narcotizing agent, firewood... scenting agents, *poi* boards, and *hōlua* sled construction.” Historical accounts have identified multiple areas across Hawai‘i where dryland forests were located and where *wiliwili* could be obtained. The *‘ōlelo no‘eau* (proverbial saying) “Ka *wiliwili* o Kaupē‘a,” (The *wiliwili* grove of Kaupē‘a) makes reference to a *wiliwili* grove that grew in Kaupē‘a, ‘Ewa, O‘ahu (Pukui 1983:180). In summarizing known *wiliwili* habitat, Tommy Holmes, in his book *The Hawaiian Canoe*, (1981:23) writes:

Wiliwili, by some accounts, was never very plentiful. Kalokuokamaile notes that “in the olden days...there were very few places in which this tree grew.” This is somewhat at odds with botanists W. E. Hillebrand, who wrote that *wiliwili* was “much more common formerly than now.” It was said by some that Ka‘ū was the best place for *wiliwili*. Today *wiliwili* can be found flourishing in certain areas. The author had visited a grove of *wiliwili* above the Mākena area on Maui that comprises several hundred acres. Many of the trees are 3 to 4 feet in diameter with trunks often rising 15 to 20 feet high before branching. Other sizeable stands of *wiliwili* dating from precontact times can still be found in the Pu‘uanahulu, Pu‘uwa‘awa‘a and Kalapana areas of Hawai‘i. Smaller populations are also found on Kaua‘i behind Kekaha, in west O‘ahu, south and west Moloka‘i, Kaupō on Maui, Ka‘ū on Hawai‘i and on Kaho‘olawe.

Physical Description of *Wiliwili*

Wiliwili is a large, Hawaiian endemic, dryland forest tree that can reach heights between eighteen to forty-five feet tall (Figures 9 and 10). This slow-growing tree has a thin yellowish-orange bark with shallow fissures with a sparsely armed trunk and branches (Figures 11 and 12) (Lilleeng-Rosenberger 2005). The branches and bark of the *wiliwili* have short spines (Figure 13) and the tree often has a gnarled appearance (Krauss 1993). As the tree matures, the spines become less noticeable (ibid.). Its gnarled and twisted (*wili*) appearance is a striking and distinguishing feature of this dryland tree (Figure 14), which Hawaiians duly named *wiliwili*, meaning “to wind, twist, writhe, crank, turn, screw” (Pukui and Elbert 1986:385). *Wiliwili* have developed highly specialized adaptations suitable for the arid conditions of Hawai‘i’s leeward regions. The thin outer bark and stems are photosynthetically active (Doccola et al. 2009). *Wiliwili* is one of few deciduous native trees found in Hawai‘i. It loses its leaves during the dry summer months as well as during periods of prolonged droughts to conserve water loss (Lilleeng-Rosenberger 2005). Leaves are most present from November through April but correlate more with rainfall (Doccola et al. 2009). Each leaf has three round to triangular-shaped leaflets (Figure 15). The leaves of a healthy *wiliwili* tree measure about six centimeters long by seven centimeters wide with a smooth upper surface and a hairy underside ((Lilleeng-Rosenberger 2005). The flowers of the *wiliwili* are bilaterally symmetrical and clustered at the end of the branches (Figures 16 and 17). The corolla, or petals, ranges in color from orange, yellow, white, to light green (see Figures 16 and 17). The flowers are bilaterally symmetrical and occur in terminal inflorescences (Lilleeng-Rosenberger 2005). When the tree is in full bloom it is strikingly beautiful and vibrant and can be quite easily observed.

The *wili* (twisting or winding) characteristic is also evident in the brown woody pods that become twisted when they mature (Figure 18). These hanging pods are slightly woody and can contain anywhere from one to three seeds per pod. *Wiliwili* seeds range in color from bright red-orange (Figure 19) to purplish in color and are bean-shaped measuring approximately 1.5 centimeters long by 1 centimeter wide. Each seed is capsuled in a hard outer coating

that softens when exposed to water. *Wiliwili* seeds have been incorporated into the Hawaiian tradition of *lei* making (Shimizu Ide 2000). These seeds, so highly prized by *lei* makers are also a food source for rodents and beetles. The soft, whitish wood was also utilized by Hawaiian. The buoyant nature of the dried wood (Figures 20 and 21) was the choice material for surfboards, net floats, and the outriggers (*ama*) on canoes (Lilleeng-Rosenberger 2005).



Figure 9. Tall *wiliwili* tree in Ka‘ū, Hawai‘i Island.



Figure 10. *Wiliwili* growing in the uplands of Kau Ahupua‘a, North Kona, Hawai‘i Island.



Figure 11. The bark of a *wiliwili* tree, Ka‘ū, Hawai‘i Island.



Figure 12. Close up of the thin and porous outer bark from a dried *wiliwili* tree.



Figure 13. Short spines on a young *wiliwili* tree.



Figure 14. Low-lying *wiliwili* tree twisting over the rugged lava landscape in Waikōloa Ahupua‘a, South Kohala, Hawai‘i Island.



Figure 15. Leaves of the *wiliwili* tree, Ka'ū, Hawai'i Island.



Figure 16. Close-up of *wiliwili* flowers, Waikōloa, Hawai'i.



Figure 17. *Wiliwili* blossoms in Kaū Ahupua‘a, North Kona, Hawai‘i Island.



Figure 18. Close-up of a *wiliwili* seed pod, Ka‘ū, Hawai‘i Island.



Figure 19. Reddish-orange seeds of a *wiliwili* tree, Ka‘ū, Hawai‘i Island.



Figure 20. Dried *wiliwili* trunk at Waikōloa Ahupua‘a, Kohala, Hawai‘i.



Figure 21. Close up of dried *wiliwili* wood, Ka‘ū, Hawai‘i Island.

Traditional Legendary Accounts Concerning *Wiliwili*

Several traditional legendary accounts concerning the *wiliwili* have been recorded, one of which includes the famed Kumulipo, a Hawaiian cosmogony chant that describes the birth of this tree. The second account titled *Nā Wiliwili O Pā‘ūla*, originally told in Hawaiian by Mrs. Wiggins and recited by Mary Kawena Pukui tells of how three distinct features of the *wiliwili* came to be. The third account concerns the adept and youthful demigod Māui and his use of *wiliwili* during the battle to entangle and slow the speeding sun, and the following five legendary accounts contains brief mentions of *wiliwili* trees at specific location on the islands of Kaua‘i, O‘ahu, and Hawai‘i.

Birth of the Wiliwili in the Hawaiian Cosmogony Chant, Kumulipo

The Kumulipo is a *mele ko‘i honua* (Hawaiian cosmogonic chant) that describes the birth of various life forms found in the Hawaiian Islands. Containing over 2,000 lines, this chant was uttered by the high priest Puou in Kealahou, Kona upon the birth of the 18th-century high chief Ka‘i‘imamao as a way to recognize and fortify the depth of his royal family’s divine origin (Liliuokalani 1978). This chant, nonetheless, anchors the Hawaiian world and its people to the ocean by way of the primal substance known to Hawaiians as *walewale* (slime). According to the *Kumulipo*, all animate and inanimate objects were literally born or *hānau ‘ia*, with the *‘uku ko ‘ako ‘a* or coral polyp being identified as the very first organism born in the ocean. This lengthy chant is broken up into sixteen *wā* or eras with the first four *wā* centered around the reoccurring theme of duality where each aquatic life form is paired with a land counterpart. Throughout the third and fourth *wā*, the birth of various dryland forest plants are described, one of which includes the *wiliwili*. In this chant, the *wiliwili* is paired with its aquatic counterpart, *wili*, the name given to a boring type of fish (Andrews 1865). That portion of the chant describing the *wiliwili* reads:

O kane ia Wai‘ololi, o ka wahine ia Wai‘olola	Man by Waiololi, woman by Waiolola
Hanau ka Wili noho i kai	The Wili was born and lived in the sea;
Kia‘i ia e ka Wiliwili noho i uka	Guarded by the Wiliwili that grew on land (tiger’s claw tree)
He po uhe‘e i ka wawa	A night of flight by noises
He nuku, he la‘i ka ‘ai a kolo	Through a channel; la-i is food, and creeps
O ke Akua ke komo, ‘a‘oe komo kanaka	So the gods may enter, but not man.
(Beckwith 1951:198)	

Nā Wiliwili O Pā‘ula (The Wiliwili Trees of Pā‘ula)

In the book, *Folktales of Hawai‘i*, Mary Kawena Pukui retells a *mo‘olelo* (story), that describes the varied and unique characteristics of the branches and leaves of the *wiliwili*. In this story, three sisters were transformed into *wiliwili*, with characteristics similar to their physical human traits. The story begins with the birth of four daughters to a mother, who is unnamed in the story. The eldest and most beautiful daughter was Moholani. Born after Moholani was Wiliwili‘ohe‘ohe, Wiliwilipe‘ape‘a, and the youngest daughter was Wiliwilikuapu‘u all of whom did not match the beauty of Moholani. In describing the features of the three younger sisters, Pukui and Green write:

Wiliwili‘ohe‘ohe was marred by baldness, and Wiliwilipe‘ape‘a had a mass of tangled hair which was tossed here and there when the wind blew. As for Wiliwilikuapu‘u, the hunchbacked one, we can see from her name that she lacked beauty altogether. (Pukui and Green 1995)

To Moholani was born one son, named Kauilamākēhāokalani meaning “Lightning flashing from the heavens” who was “given into the care of the gods” and raised in Kuaihelani, “the land hidden in the clouds” (ibid.:13). Moholani’s husband, who was a fine man, frequented a point at the seashore where he was admired by two *wāhine kupua* (supernatural women) named ‘Ahikananā and ‘Ahikāhuli. These *wāhine kupua* “seized every opportunity to tempt him by chanting the songs of the sea and relating tales of the deep blue ocean” (ibid.:13). Bewitched by the wiles of the *wāhine kupua*, Moholani’s husband plunged into the depth of the sea and accompanied the women to their cavern at the ocean floor.

After waiting for his return home, Moholani set out in search of her husband, but her efforts were in vain. Distressed by her husband’s disappearance, Moholani called out to her sister Wiliwili‘ohe‘ohe:

“O Wiliwili‘ohe‘ohe, listen! Come to my aid! O Wiliwili‘ohe‘ohe come to my aid! Do you know if my husband has been carried away by ‘Ahikananā and ‘Ahikāhuli to the place where the little stones rattle.”

But Wiliwili‘ohe‘ohe looked at her crossly and answered, “Ugh! He is a big, worthless man! I do not know where your husband is!”

Moholani walked on, weeping, to the second sister and called, “O Wiliwilipe‘ape‘a, listen! Come forth! O Wiliwilipe‘ape‘a, come forth! Do you know if my husband has been carried away by ‘Ahikananā and ‘Ahikāhuli to the place where the little stones rattle?”

But Wiliwilipe‘ape‘a answered like her older sister, “Ugh! He is a big, worthless man! I do not know where your husband is!” (ibid.:13)

Moholani proceeded on to the home of her younger sister, Wiliwilikuapu‘u and cried out in the same manner only to be met with the same dreadful response. Having received no sympathy or assistance from her sisters, Moholani sought her one and only son, Kauilamākēhāokalani and requested that the gods, who were his guardians release him from Kuaihelani to aid in the search of his father. Kauilamākēhāokalani eventually located his father at the bottom of the ocean floor and when:

‘Ahikananā and ‘Ahikāhuli refused to relinquish their lover, the boy’s wrath flashed forth; because of their obstinacy, he changed his body into a lightning flame, and at the glancing of his lightning on the ocean floor, the women were cut into pieces and transformed so that from them come all that kind of fish called mackerel. Gone were their powers to tempt other women’s husbands, for they were not nothing but fishes! (ibid.:14)

Because of the sisters’ unkindly response to Moholani, they were each transformed into *wiliwili* trees:

Because Wiliwili‘ohe‘ohe was bald, she became a tree which is almost leafless; Wiliwilipe‘ape‘a became a tree whose leaves flutter in the whispering breeze; and Wiliwilikuapu‘u was a hunchback, her trunk became crooked. (ibid.:14)

It is noted that the appearance of a *wiliwili* varies according to its environment and the weather. It has, says Miss Green, “all the characteristics borne by the sisters.”

While the account provided by Pukui describes the physical features of the *wiliwili* tree, another account written by W. D. Westervelt, tells of a large *wiliwili* tree in Kaupō, Maui, where the young and agile *kūpua* (demi-god) Māui hid and tethered the sun in his attempt to slow the heedless sun across the sky.

Māui Snares the Sun by Tethering Its Legs to a Wiliwili Tree in Kaupō, Maui

The swift and strong-willed *kupua* Māui is noted in Hawaiian lore for accomplishing many epic feats. While the accounts of Māui often involve grueling battles and trickery, his brave acts ultimately lead to an improved life for humankind. One such account recorded by W. D. Westervelt (1910) in his book *Legends of Ma-ui—A Demi God of Polynesia and of his Mother Hina*, tells of Māui’s heroic adventure to slow the fast-moving sun that raced across the heavens. This tale begins with Māui’s mother Hina, who took to her wooden mallets daily, tirelessly pounding bark and felting them into sheets of bark cloth known as *kapa*, which would be fashioned into sleeping mats and clothing. These *kapa* cloths, however, had to be thoroughly dried, but the days were so short that by the time Hina had laid out her *kapa*, the sun would race across the sky and descend into the underworld, leaving Hina in the dark and forcing her to gather up her *kapa*. The reckless moving sun also created other troubles “[t]he food could not be prepared and cooked in one day. Even an incantation to the gods could not be chanted through ere they were overtaken by darkness” (Westervelt 1910:43).

Māui pitied his mother and set out with determination to alter the pace of the sun. Māui traveled to the northwest of the island to the summit of ‘Iao to study the course of the sun. Māui saw that the sun rose on the eastern side of Haleakalā and passed directly over its summit. After studying the sun’s path, Māui returned to his mother’s home and informed her that he would “...cut off the legs of the sun so that he could not run so fast” (ibid.:43). After talking with her son, Hina handed Māui “...fifteen strands of well-twisted fiber and told him to go to his grandmother, who lived in the great crater of Haleakala...” (ibid.:44). Hina continued:

You must climb the mountain to the place where a large **wiliwili** tree is standing. There you will find the place where the sun stops to eat cooked bananas prepared by your grandmother. Stay there until a rooster crows three times; then watch your grandmother go out to make a fire and put on food. You had better take her bananas. She will look for them and find you and ask who you are. Tell her you belong to Hina. (ibid.:45)

When she had taught him all these things, he went up the mountain to Kaupo to the place Hina had directed. There was a large **wiliwili** tree. Here he waited for the rooster to crow. The name of that rooster was Kalauhele-moa. When the rooster had crowed three times, the grandmother came out with a bunch of bananas to cook for the sun. She took off the upper part of the bunch and laid it down. Maui immediately snatched it away. In a moment she turned to pick it up, but could not find it. She was angry and cried out: “Where are the bananas of the sun?” Then she took off another part of the bunch, and Maui stole that. Thus he did until all the bunch had been taken away. She was almost blind and could not detect him by sight, so she sniffed all around her until she detected the smell of a man. She asked: “Who are you? To whom do you belong?” Maui replied: “I belong to Hina.” “Why have you come?” Maui told her, “I have come to kill the sun. He goes so fast that he never dries the tapa Hina has beaten out.” (ibid.:45-46)

Māui’s grandmother then handed him a magical stone ax and another rope and taught him how to catch the sun. She explained:

“Make a place to hide here by this large **wiliwili** tree. When the first leg of the sun comes up, catch it with your first rope, and so on until you have used all your ropes. Fasten them to the [*wiliwili*] tree, then take the stone axe to strike the body of the sun.” (ibid.:47)

Māui then dug a hole and concealed himself among the roots of the *wiliwili* and watched closely for the sun. Soon the first leg—the first ray of the sun—came up over the mountain and Māui threw his rope and ensnared the first leg then fastened it to the *wiliwili*. One-by-one, Māui continued to entangle the legs of the sun as they came over the crater of Haleakalā, tethering each rope to the *wiliwili* until all that remained was the longest leg. Using the rope given to him by his grandmother, Māui caught the last leg of the sun.

When the sun saw that his sixteen long legs were held fast in the ropes, he began to go back down the mountain side into the sea. Then Maui tied the ropes fast to the tree and pulled until the body of the sun came up again. Brave Maui caught his magic stone club or axe, and began to strike and wound the sun, until he cried: “Give me my life.” Maui said: “If you live, you may be a traitor. Perhaps I had better kill you.” But the sun begged for life. After they had conversed a while, they agreed that there should be a regular motion in the journey of the sun. There should be longer days, and yet half the time he might go quickly as in the winter time, but the other half he must move slowly as in summer. Thus men dwelling on the earth should be blessed. (ibid.:46-47)

The sun assented to Māui's request and an agreement was made. Māui released the sun back onto its course and from that day the sun agreed to move slower through the heavens.

Wiliwili Mentioned in the Legend of Kawelo

Wiliwili is briefly mentioned in a chant featured in the legend of Kawelo, a famous ruler of Kaua'i. The chant describes the lands of Kalehuawehe in Waikīkī, O'ahu, which was known for its blooms of *lama* (*Diospyros sandwicensis*) and *wiliwili*. Kaweloleimakua (Kawelo) was one of five children born to Malaiaikalani, the mother and Maihuna, the father. Kaweloleimakua's maternal grandparents were skilled at foretelling the future of a child through palpating the child's limbs and examining all aspects of the body. The grandparents performed this act on all their grandchildren and found nothing spectacular about them, however, when examining Kawelo, the grandparents were thrilled at what they found.

After the examination the old people called the parents of Kawelo and said to them: "Where are you two? This child of yours is going to be a soldier; he is going to be a very powerful man and shall some day rule as king." (Fornander 1918–1919:2)

Kawelo was taken from Hanamā'ulu to Wailua on Kaua'i and raised by his grandparents. While Kawelo was being raised, 'Aikanaka, the son of the king of Kaua'i was born as was Kauahoa of Hanalei, two characters that would later play a key role in Kawelo's rise to *ali'i*. These three chiefly children were raised together but Kawelo showed all the signs of a powerful future chief, one of which was his profound appetite for food, strength, and skill. His grandparents grew tired of the boy's insatiable appetite and thought that giving him a canoe would entice him away from his continual eating. A canoe was made for Kawelo, which he paddled up and down Wailua River. Kawelo's new canoe caught the eye of his childhood friend, Kauahoa, who in a display of character made himself a kite which caught the eye of Kawelo. In response, Kawelo's grandparents made him a kite and one day as the two boys were playing, their kites had become entangled. Kawelo's kite snapped Kauahoa's string, sending his kite floating over the mountains and landed at Kaho'oleināpe'a, Kōloa, a place named after this particular event. Kawelo thought that Kauahoa would surely attack him since he was bigger than Kawelo, but he didn't. Kawelo thought to himself "Kauahoa will never overcome me if we should ever meet in any future battle" (ibid.:4). In any competition against the other boys, Kawelo always displayed greater strength and skill. After some time, Kawelo's grandparents in their longing to see their other grandchildren who had moved to O'ahu, packed up and sailed to Waikīkī, O'ahu, taking Kawelo with them.

While on O'ahu, Kawelo took up farming and married Kanewahineikiaoha. Kawelo went on to master both fishing and the art of war and had become renowned for his feats of strength. He eventually returned to Kaua'i to defend his family against 'Aikanaka, who had stolen Kawelo's parents land and resources. Kawelo, in his attempt to recapture his parent's land, made preparation to return to Kaua'i to battle with 'Aikanaka. While adrift off the coast of Wailua, some of 'Aikanaka's people who were at the top of Nounou Hill roused 'Aikanaka and told him of the coming of large canoes. 'Aikanaka dispatched his runners, chief officers, and warriors and had his men set up blockades on the shore hoping to stop the approaching canoe from landing. A large crowd had gathered on the shores of Wailua at which time Kaehuikiawakea, 'Aikanaka's messenger was sent out to sea to investigate the canoe and found only Kamalama, who was not perceived as a threat to the warriors of Kaua'i. Kawelo, however, hid on the canoe and was not spotted by Kaehuikiawakea. Assuming that only Kamalama was on the canoe, Kaehuikiawakea permitted the canoes to land. When they reached the beach, 'Aikanaka's men anxiously waited to attack, but Kaehuikiawakea stopped them saying:

Don't fight them now. Let us carry the canoes to the dry sand and let these people go and have a bath, and when they return, let them partake in some food; when they are satisfied they can then gird on their loin cloths, then after that we can fight them. (ibid.: 34)

The warriors of Kaua'i proceeded to lift the canoes out of the water and as they carried the canoes ashore, Kamalama had loosened the sack that held Kawelo at which time, Kawelo jumped out and announced his presence in a loud voice. This created a great scurry and cause them to drop the canoe crushing many people. Kawelo then looked towards Wailua and saw a great disorder amongst 'Aikanaka's people. A great battle ensued between Kawelo and the people of Kaua'i. After slaying some of 'Aikanaka's top warriors, Kawelo found himself in a head-to-head battle with his childhood foe, Kauahoa, who was the most noted warrior in 'Aikanaka's army. Kauahoa's large stature and skillful fighting maneuvers greatly intimidated Kawelo. Instead of hastily rushing into battle, Kawelo carefully studied his childhood opponent and began to recall the memories of their youth. Taking pity on his opponent, Kawelo chanted to Kauahoa, hoping to put the matter of combat in the hands of Kauahoa. After Kawelo ended his chant, Kauahoa replied:

This club will never spare you in the day of battle. You have slain our men so that there are none left; how can you then expect this club to spare you? As it has been your deal, you can see the results; and when it will be my deal, I will see the result. (ibid.:54)

Kauahoa's response continued to fill Kawelo with fear, however, the daring Kawelo reminisced on his childhood and recalled "how his kite got tangled up with Kauahoa's kite and how Kauahoa's kite broke ways, and how Kauahoa was afraid to fight him" (ibid.:55-56). Knowing that Kauahoa's bravery did not match his own, Kawelo in his final impromptu, chanted to Kauahoa:

<p><i>O Hanalei aina ua, Aina anuanu, aina koekoe, Aina a ka pea i noho ai, Noho ana e liu ana e, Maewa ana ka ukiuki o Honokoa I ka pali o Kalehuawehe; Pua ka lama me ka wiliwili O ka ua lele ma waho o Mamalahoa, O Kauahoa o ka meeui o Hanalei, O ke kanaka a Kamalama i hopo ai o Kauahoa, He mea e ka nui—e—a! Eia ka hoi ua kanaka nui O Kauai, o Kauahoa</i></p>	<p>Hanalei, the land of rain, The cold land, the wet land, The land where the end is. Sitting there, delaying there, For the anger of Honokoa is reviling. At the cliff of Kalehuawehe Where the <i>lama</i> and <i>wiliwili</i> bloom, Where the rain sweeps on the outside of Mamalahoa. Kauahoa, the stalwart youth of Hanalei, The person of whom Kamalama is afraid, Kauahoa, For he is indeed large. He is the largest man Of Kaua'i, Kauahoa</p>
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Wiliwili of Kohala Pierced by the Spear of Kapunohu

The legend of Kapunohu, as told by Fornander (Fornander 1918–1919) is set in the Kohala District of Hawai'i Island which was ruled by the *ali'i* Kukuipahu. This story briefly mentions a great grove of *wiliwili* in Kohala. While out enjoying the game of "glancing spear" Kapunohu saw the spear of a man named Kanika'a (ibid.:214). Kapunohu came along and picked it up and quickly ran off with it. Having seen Kapunohu's actions, Kanika'a gave chase and the two men became entangled in a battle which they peaceably resolved. Having befriended each other, Kapunohu adopted Kanika'a as his god and kept Kanika'a's spear which was named Kanikawī. After an insulting situation arose between Kapunohu and the king of Kohala, Kapunohu wandered into the uplands. Fornander continues:

From this place Kapunohu went on up towards the uplands until he came to a row of *wiliwili* trees. These trees were of large size, resembling the kukui trees, but very light and not as hard as the wood of the kukui. Kapunohu then, with an idea of testing his strength, threw his spear at the first tree and the spear went through them all. It is said there were eight hundred of the trees which stood in a straight row. He made a clean hole in each tree, all in one thrust. (ibid.:216)

The story continues with Kapunohu traveling into the interior parts of Kohala where he eventually joined the forces of the chief Niuli'i. In an act of retaliation, Kapunohu exacted death to the Kukuipahu.

Wiliwili Wood Carved into an Image in Ka'ao no Pupuhuluena

The account describing the carving of *wiliwili* wood into an image used to appease the gods appears in *Ka'ao no Pupuhuluena*, written by Fornander (1916–1917). This story provides thought-provoking details regarding the introduction of edible food plants to the lands of east Kohala by way of Ka Lae, Ka'ū on account of the legendary hero Pupuhuluena. Upon arriving and settling along the steep cliffs of east Kohala, Pupuhuluena learned that no food plants were being grown, "no taro, no potatoes, no yams, nor anything else in the shape of food" (ibid.:570). Pupuhuluena learned that all of the food plants were taken and hidden by the gods in Ka Lae in the Ka'ū District. Having no luck with procuring food, Pupuhuluena took to the sea, setting out in his canoe. While fishing off the coast of Maka'ūkiu, Pupuhuluena observed that fishes of various kinds, including the *uhu*, *nenue*, *ulua*, *kāhala*, *ōpakapaka*, *he'e*, *manini*, *ōpelu*, and *aku* had congregated under this canoe. When the fish began to move away, he followed suit. Pupuhuluena continued in his canoe, following the fish past the lands of Kohala. When they arrived at Manini'ōwali, the *manini* fish remained behind, but Pupuhuluena continued. From the Kekaha lands until Ka'elehuluhulu the *aku* and *ōpakapaka* stayed behind. When arriving at Kapukaulua just before Ka Lae, the *ulua* fish stayed behind. While at Kapukaulua he saw a canoe "with a large-mouth net let down on the coral bed" (ibid.). Pupuhuluena placed a *kukui* nut in his mouth and chewed it and blew the oily substance on the surface of the sea, allowing him to see a great school of fish entering the net of the two fishermen, Ieiea and Poopalu. Pupuhuluena called out to the two fishermen informing them to haul up their net. The two fishermen were not aware that their net was full of fish because they were using the *mohihi* bean instead of the *kukui* to look underwater. Looking at Pupuhuluena strangely, the two fishermen heeded his

words of the stranger and hauled up their net and to their surprise, it was filled with fish. The two fishermen asked Pupuhuluena for some *kukui* nuts and he handed them a few. The fishermen used some nuts for fishing and a few were kept to be planted and it is said that this is how the *kukui* was introduced to the districts of Kona and Ka‘ū. In exchange, Poopalu and Ieiea gave some cooked *kalo* and ‘*uala*, to which Pupuhuluena placed in his calabash. Poopalu asked, “why do you put them in the calabash?” to which Pupuhuluena replied, “[t]o save them for planting” (ibid.). Po‘opalu remarked:

They will not grow as they are already cooked. The gods have charge of the food and all else, and we can only get it after it is cooked. If you wish to get some for the purpose of planting then obey this instruction: You must first hew out an image from a **wiliwili** tree and then braid a basket of ie [‘ie‘ie]. (ibid.:572)

Pupuhuluena consented and followed out the instruction of Po‘opalu. After the items were made, Po‘opalu said to Pupuhuluena, “[p]lace the image behind you on the canoe while I will get into the basket and then we will sail to the land of the gods” (ibid.). The two men loaded into the canoe and sailed for Ka Lae, where the gods were living. As they were approaching Ka Lae, they began calling out to the gods, who responded with instruction to land at a particular spot. From within the basket, Po‘opalu told Pupuhuluena not to land there because that place was a refuse pile and that the proper landed spot was elsewhere. Using their power, the gods had caused the water at the refuse place to become calm and the proper landing place to be rough. Pupuhuluena called out once more to the gods, telling them “[t]hat is a refuse heap; here is the landing place where the surf is breaking, for I am a native son of this place.” Upon hearing the words of Pupuhuluena, the gods calmed the waters of the proper landing place and Pupuhuluena paddled his canoe ashore. The gods came down to the shore to help lift the canoe out of the water. At this Pupuhuluena said to the gods, “[t]he stern of my canoe is kapued. I will lift that part myself while you can lift the forward part.” The canoe was carried onshore and the gods brought all different kinds of tubers to Pupuhuluena.

The first tuber was brought down and shown to Pupuhuluena. Po‘opalu, still hidden in the basket spoke quietly, informing Pupuhuluena that the tuber was *hoi* and was poisonous. Pupuhuluena conveyed this information to the gods and another tuber was brought down and the gods asked Pupuhuluena of its nature. Again, from within the basket, Po‘opalu whispered, “[i]t is a yam [uhi], it is a life-giving food,” which Pupuhuluena conveyed to the gods. The gods continued showing Pupuhuluena all types of tubers and after, the gods invited him to join them in some of their games. While playing a certain game, Pupuhuluena managed to shame the gods by standing them up on their heads. So ashamed they were, that they gave each of the different tubers to Pupuhuluena. Having acquired an assortment of tubers, Pupuhuluena returned to his lands in east Kohala and planted the *uhi* at the bottom of the cliffs, where they can still be seen growing.

Grove of Wiliwili in Mānoa Valley, O‘ahu as Noted in the Legend of Kahalaopuna

Set in Mānoa Valley on O‘ahu, the legend of Kahalaopuna tells of a beautiful and sacred maiden who lived with her attendants at Kahaiamano on the path that led to the pool known as Waiakeakua. She was betrothed at a young age to Kauhi, the young chief of Kailua in Ko‘olau, who up until their purported marriage, provided her with fresh *poi* and fish from his district. Having heard rumors from two disfigured men that Kahalaopuna was madly in love with them, Kauhi, filled with rage set out to kill Kahalaopuna. In describing that portion of the story that references a grove of *wiliwili*, Thrum writes:

He started for Manoa at dawn, and proceeded as far as Mahinauli, in mid-valley, where he rested under a hala (*Pandanus odoratissimus*) tree that grew in a grove of **wiliwili** (*Erythrina monosperma*). He sat there some time, brooding over the fancied injury to himself, and nursing his wrath. Upon resuming his walk he broke off and carried along with him a bunch of hala nuts. It was quite noon when he reached Kahaiamano and presented himself before the house of Kahalaopuna. The latter had just awakened from a sleep, and was lying on a pile of mats facing the door, thinking of going to the spring, her usual bathing-place, when she perceived a stranger at the door. (Thrum 1907:121)

Wiliwili Referenced in Ka Mo‘olelo No Hi‘iakaikapoliopole

A tale of perseverance, bravery, and spite is recounted in *Ka Mo‘olelo O Hi‘iakaikapoliopole*, initially published in the Hawaiian language newspaper *Ka Na‘i Aupuni* between the years 1905-1906 by Ho‘oulumāhie. Throughout the early 21st century, Hawaiian language scholar, Puakea Nogelmeier compiled the chapters written by Ho‘oulumāhie, translated each page of text, and published it in a double volume (one in Hawaiian and the other in the English). Nogelmeier notes that Ho‘oulumāhie’s version is one of twelve known published accounts of *Ka Mo‘olelo O Hi‘iakaikapoliopole*.

This tale describes the challenge-filled journey undertaken by Hi‘iakaikapoliopole, the youngest sibling of the Pele clan, while in search of her sister’s dream lover, Lohi‘au. Her journey begins in Puna on Hawai‘i Island and while passing through the various parts of the islands, Hi‘iaka encountered a number of characters and obstacles, which are described in both text and in chant form. Through these challenges, Hi‘iaka ultimately learns about her family and her personal powers as a rising goddess. References to the *wiliwili* are noted when Hi‘iaka is constructing a canoe as well as when traveling through the arid plains of ‘Ewa, O‘ahu. The use of *wiliwili* in the many chants presented throughout this account is also riddled with *kaona* or “hidden meanings” (Pukui and Elbert 1986:130), that hint at the *wili* or torturous feelings of love felt by Hi‘iaka (Andrews 1865). Those portions of the story that mention *wiliwili* are briefly contextualized and transcribed below.

While preparing to depart Ka Lae O Ka‘ena on O‘ahu’s northwesternmost point, Hi‘iaka solicits the help of her brothers in preparing a canoe which she and her companions were to use to travel to Kaua‘i. The brothers provided her with all the parts needed to make their canoe, including a *paukū wiliwili* (section of *wiliwili*) which they used for their *ama*.

Ki‘i akula nō kēia a ka paukū **wiliwili**, lālau ke ko‘i kālai a nā kaikunāne, ‘o ko ia nei kālai ihola nō ia a lo‘a ka iama o ka wa‘a. Kāhea akula kēia i ke ‘aikāne, “E Wahine‘ōma‘o ē! Ma kēlā po‘o mai ho‘i ‘oe o ka iama o ka wa‘a o kāua, ho‘opili nō ho‘i ‘oe i kāua ‘ao‘ao i kāu ‘iako, hauhoa nō ho‘i a pa‘a i ka ‘aha, a pēlā nō ho‘i ka‘u ‘ao‘ao. E hana wahine a‘e nō ho‘i kāua i ko kāua wa‘a! (Ho‘oulumāhie 2006a:177)

She fetched a piece of *wiliwili* wood, seized the brothers’ adze, and carved until the canoe had an outrigger float. She called to her friend, “Hey Wahine‘ōma‘o! You take up that end of the canoe float, connect your end to the boom on your side, lash it firmly with the cordage, and I will do the same with my side. We women will make our canoe.” (Ho‘oulumāhie 2006b:166)

In a latter part of this saga, while passing through the heights of Pōhākea in the Wai‘anae mountains and down to the plains of Keahumoa, Hi‘iaka observed some women stringing *lei* of *ma‘o* flowers, which Hi‘iaka greatly adored. After an exchange with the women, Hi‘iaka proceeded to the coast of ‘Ewa to the shore near the calm lochs of Pu‘uloa. Hi‘iaka watched as the canoe carrying her dear friend, Wahine‘ōma‘o and their husband Lohi‘au sail along the coast. Overcome by emotions for her companion and for the destined fate of Lohi‘au, Hi‘iaka called out in chant to them:

Ku‘u kāne i ke awa lau i Pu‘uloa	My dear man of Pu‘uloa’s branching lochs
Mai ke kula o Kānehili ke noho ē	From the plans of Kānehili to reside
E noho kāua i ke kaha	Let us dwell in the strand, you and I
I ka ‘ōhai, i ka wiliwili	Amid the ‘ōhai shrubs and the wiliwili trees
I ka pua o ka lau noni	With the blossoms of the noni trees
‘O ka ihona i Kānehili lā	On the descent to Kānehili
Ua hili au ē.	I have gone astray, ah.
(Ho‘oulumāhie 2006a:288)	(Ho‘oulumāhie 2006b:269)

Carrying along in her journey, Hi‘iaka arrived at the plains of Honouliuli and observed two women, Pu‘ukapōlei and Nāwāhineokama‘ōma‘o resting under some ‘ōhai shrubs. Hi‘iaka acknowledged them and offered up a chant. The women encouraged Hi‘iaka to carry along in her journey because the heat of the sun would soon overwhelm her. The kind women informed Hi‘iaka that the land had become so parched that there were but very few plants and no water from which they could sustain themselves. After her encounter, Hi‘iaka moved once again towards the sea, searching for the canoe of her dear companion and Lohi‘au. Filled once again with emotion, Hi‘iaka chanted out:

Ku‘u kāne i ke awa lau o Pu‘uloa	My dear man of the branching lochs of Pu‘uloa
Mai ka kula o Pe‘ekāua ke noho	From the plans of Pe‘ekāua to dwell
E noho kāua i ke kaha o ka ‘ōhai	Let us stay where the ‘ōhai grows
I ka wiliwili , i ka pua o ka lau noni	Amid the wiliwili trees and the blossoms of abundant noni
‘O ka ihona i Kānehili lā	On the descent to Kānehili
Ua hili au ho‘i ē.	I have strayed, ah.
(Ho‘oulumāhie 2006a: 290)	(Ho‘oulumāhie 2006b:271)

Continuing to search for her companion and Lohi‘au, Hi‘iaka crossed the stretch of Pu‘uloa. After recalling the edict, put forth by Wahine‘ōma‘ō that forbid Lohi‘au from talking to her Hi‘iaka chanted once more. The young goddess continued on over the expanse of Kaupe‘a, and seeing that it was only her and the blazing heat of the sun, Hi‘iaka put forth the following chant:

<p>‘A‘ole au e hele i ke kaha o Kaupe‘a Kēlā kaha kūpā koili a ka lā i ke kula Ua kūpono a‘ela ka lā i ka piko o Wākea Ola i ke ahe a ka makani Māunuunu I ka hapahapai mai a ka makani ‘Ao‘aoa Ke koi lā i kea o o ka Nāulu e hanini i ka wai Ola ihola nā kupa kama‘āina i ka wai a ka ‘ōpua Ke halihali a‘ela nā ‘ōpua i ke awa lau E koi mai ana iā Hi‘iaka e kūo‘e hele i ke kula I kuleana i lāhui ai ka moe i laila I laila au lohe i ke kani leo le‘a a ka ‘ō‘ō i ke kula Ho‘āikane ana lāua me ke kai o Wāwaemoku Mokumokuāhua loko, kupākupā koili i ka ‘ino I ‘ino ho‘i au i kēia kanaka i ka hiki ‘ana mai I kāhela a‘ela ka ‘ai a ka manu I ka pua o ka wiliwili Wili a‘ela nā ‘ōpua i luna No luna wau Wili a‘ela ka ‘ōpua i lalo Lalo ē! Lilo i lalo ka hele ‘ana a ke kanaka Kalakala kea o no Hawai‘i I ka pā ‘ia mai e kēia makani ‘A‘ole au makana i ka lā o ka hilahila E hili hewa paha auane‘i au Wilia i na‘e, wiliala i lalo Wilia i kai, wiliala i uka ‘O kauhale a ka ‘ōlelo Ho‘ohiki ihola i kānāwai Kau ihola i kānāwai He kānāwai ‘okia ‘Ālina ihola kā o Pu‘uloa He ‘āina kauā. (Ho‘oulumāhiehie 2006a:294–295)</p>	<p>I shall not tread Kaupe‘a’s expanse That stretch where the sun beats down on the plain The sun is right overhead, at the naval of Wākea I am spared by the Māunuunu wind By the uplifting ‘Ao‘aoa breeze Urging the Nāulu storm clouds to pour down their waters The native here survive on water from the clouds Which billowing clouds carry along to the branching lochs Compelling Hi‘iaka to trudge that open stretch Duty making rest forbidden there There I head the happy trill of the ‘ō‘ō bird on the plain Befriending the sea of Wāwaemoku By heart grieves, thrashed by harm I may be harmed by this person upon arrival Leaving the birds to feed expansively On the blossoms of the wiliwili trees The clouds spin above I am from above The clouds spin below Below indeed! The movement of mankind is cast down Craggy are the clouds from Hawai‘i Blown here by this wind I have no gift to offer on this day of shame I shall perhaps end up astray Spiraling windward, or to the lee Spinning towards the sea, toward the highlands O house made of words Utter as an edict Place as a law An order of separation Thus Pu‘uloa is branded by epithet A land of outcast and slaves. (Ho‘oulumāhiehie 2006b:275–276)</p>
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While at ‘Ewa, Hi‘iaka had learned from some of the area residents that the ruling chiefess Pele‘ula was hosting a large celebration at Kou (the ancient name of present-day Honolulu). Delighted by the invitation, Hi‘iaka desired to attend the festivities. After reuniting with her beloved companion, Wahine‘ōma‘o and Lohi‘au, they set out in their canoe towards the coast of Kalihi. Here Hi‘iaka saw Pele‘ula surfing the waves of Kapu‘uiki and called out to the chiefess. The chiefess declined to board their canoe, so Hi‘iaka put a spell on the chiefess, which caused her to enter into a deep sleep. Laid out on her surfboard, Hi‘iaka’s canoe floated near the sleeping chiefess and at Hi‘iaka’s command, Lohi‘au picked up the chiefess and her board and placed them on the canoe. They continued sailing down the coast until they reached Waikīkī, where Hi‘iaka raised her voice in chant:

<p>Ku‘u kāne i ke kaha o Pu‘uloa Mai ke kula o Pe‘ekāua ke noho E noho kāua i ke kaha, i ka ‘ōhai, i ka wiliwili Ka pua o ka lau noni o Kaiona i Kānehili Ua hili ho‘i au ē. (Ho‘oulumāhiehie 2006a:300)</p>	<p>My husband of the strands of Pu‘uloa From the plains of Pe‘ekāua, there to abide Let us dwell on that stretch amid the ‘ōhai and wiliwili And the blossoms of Kaiona’s noni grove at Kānehili I have strayed (Ho‘oulumāhiehie 2006b:280)</p>
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After playing an exciting game of *kilu*, Hi‘iaka’s desire for Lohi‘au continued to grow, despite the rules Pele had proclaimed to her sister. Unable to hide their feelings towards each other, and in an act to propose a private courtship, Hi‘iaka and Lohi‘au continued to chant to each other. While the two lovers were hidden in a *milo* tree in Honolulu, Kauakahiapaoa, the companion of Lohi‘au called out in chant likening the two lovers to the various places they had journeyed through. A portion of this eleven stanza chant again makes references to the *wiliwili*, which reads:

...Ke kuhi maila ke kai o Kuhia
 E pae ko‘u wahi wa‘a i Kapua
 ‘O ku‘u pua i mālama pono ai nāu
 Ho‘omaoe ka **wiliwili** hele lā
 Ka lupalupa o ka pua ‘ōhai...
 (Ho‘oulumāhie 2006a:442)

...Assuming it to be the sea of Kuhia
 My little canoe shall land at Kapua
 That dear blossom that I watched over for you
 The **wiliwili** trees gnarl in the sun
 Where the ‘ōhai flourishes...
 (Ho‘oulumāhie 2006b:413)

Traditional Uses of *Wiliwili*

As Hawai‘i’s early inhabitants transported their most important food, medicinal, and utilitarian crops over the vast Pacific Ocean, their ability to adapt and grow their culture was dependent upon the available natural resources of each island. Over time, Hawaiians had become well-versed in the different ecological niches and productive in foraging and experimenting with a plethora of plants that had established themselves prior to human contact. Continued adaption allowed them to discern which plants were most suitable to meet life’s basic needs and pleasures, and which ones aided in enhancing the complexity of their society. These highly evolved plant practices were observed and recognized by many early Western explorers (Abbott 1992).

The use of native plants was woven within every aspect of their lives, from subsistence, *hula*, ceremonies, attire, wayfaring, and ocean activities. The knowledge to utilize these plants became an integral part of maintaining a sophisticated lifestyle. The extent to which plants permeated daily life and gave rise to a uniquely Hawaiian culture cannot be understated. These factors helped to shape a thriving and unique collection of traditions exclusive to Hawaiian society and to these islands. In the face of great change to both their culture and environment, many Hawaiian today strive to reclaim their ancient traditions and live according to the principles of their ancestors. The preservation and perpetuation of Hawaiian culture is contingent upon the restoration and preservation of native plant habitats. This sentiment is echoed in the words of the respected Hawaiian educator and ethnobotanist, Isabella Aiona Abbott, who in 1992 wrote, “[t]here is no time to lose in protecting these plants, upon which the authentic revival of many Hawaiian cultural elements depends” (Abbott 1992:xii).

One of the many plants that maintained that quality of sophistication, even though contemporary times, is *wiliwili*. According to early missionary, William Ellis, the ancient people also referred to this plant as “*oviriviri*, or *viriviri*” (Ellis 1917:166). Endemic to the Hawaiian Islands, *wiliwili* is a soft-whitish wood and is considered one of the lightest of the Hawaiian woods (Kent 1986; Lilleeng-Rosenberger 2005). Its lightness and buoyancy made it a favored wood for the construction of surfboards, net and fishing floats, and canoes. Additionally, this plant maintained a highly valued quality due to its rareness. As noted in the book, *The Hawaiian Canoe* (Holmes 1981), *wiliwili* was not abundant and grew in very few places, thus suggesting that objects built or made of *wiliwili* were unique and exclusive, as proof of its use and favor by certain royal families.

Wiliwili Used In the Construction of Wa‘a (Canoes)

Wa‘a or canoes played an important part in the settling and political expansion of Hawai‘i’s chiefs during the Precontact and early Historic Periods. *Wa‘a* were vital to accessing near-shore and deep-sea fisheries and reduced long-distance travel time. These practices relied heavily on vessels that could sustain this way of life and because of its significance, was cherished and cared for like a person would their home (Holmes 1981). Commonly referred to as *wa‘a*, these boats were of various sizes and constructed from different plant materials depending on its intended purpose. The *kahuna kālai wa‘a* (master canoe carver) oversaw the entire process, which was inclusive of harvesting the appropriate plant material, the physical construction of the canoe as well as the spiritual and ceremonial aspects that accompanied such an undertaking. *Wa‘a* were generally designed as a single or double-hull and sometimes contained a mast and sail. To build a vessel designed to fit one’s needs, careful consideration and customs were undertaken in the selection of a tree. Although *koa* (*Acacia koa*) was the preferred wood for canoe building, *wiliwili* was also known to be highly favored by many, including the *ali‘i* (Holmes 1981). Other woods including *kukui* (candlenut) and *‘ulu* (breadfruit) were also used in canoe construction (Fornander 1918–1919). One of the earliest documented account describing the use of *wiliwili* as a make-shift canoe appears in the legend of ‘Ai‘ai, Son of Ku‘ulu, which was published in Thrum’s *Hawaiian Folk Tales A Collection of Native Legends* (Thrum 1907). In relating that portion of the story describing the use of *wiliwili*, Thrum writes:

The first time that Ai ai tested this station and caught a fish with his noted hook, he saw a fisherman in his canoe drifting idly, without success. When he saw Ai ai, this fisherman, called Kanemakua, paddled till he came close to where Ai ai was floating on an improvised canoe, a wiliwili log, without and outrigger,—which much surprised him. Before the fisherman reached him, Ai ai felt a tug at his line and knew that he had caught a fish and began pulling it in. When Kanemakua came within

speaking distance Ai'ai greeted him and gave him the fish, putting it into his canoe. Kanemakua was made happy and thanked Ai'ai for his generosity. (Thrum 1907:236)

Wa'a made from the *wiliwili* wood was built as a single-man canoe and rarely exceeded twenty feet in length but were typically between ten to fifteen feet long. Canoes constructed from a single *wiliwili* trunk were deemed rare, provided that a tree was large enough to make the vessel and the wood was seasoned (not green in color) before being carved. In 1937 Kenneth Emory, a Pacific anthropologist, documented the cultivation of the *wiliwili* for the purpose of canoe making and gathered that in order for the *wiliwili* to grow tall and straight, the side branches were pruned consistently before the tree began to crown (Emory in Holmes 1981).

Around 1794, during Kamehameha I preparations to invade Kaua'i a certain *kaukauali'i* (lesser chief) by the name of Waipa constructed both canoes and a ship for the king. According to Kamakau (Kamakau 1992:187), this was the first ship "...put together by a native builder..." and that "the ribs were *koa* and *hau* wood, the flooring *wiliwili* wood, the nails of *kauila* wood from Napu'u [near Pu'uwa'awa'a]. This ship was amongst Kamehameha's famed fleet of *peleleu* war canoes which were said to have numbered around eight hundred (ibid.).

Canoe's made of *wiliwili* were lightweight, thus were preferred for near-shore, play, or training, particularly for young aspiring canoeists (Holmes 1981). In the book *Fragments of Hawaiian History*, John Papa 'Ī'ī, a 19th-century Hawaiian historian, noted that as a young boy he had learned how to paddle a canoe made of *wiliwili* which was gifted to him by his parents ('Ī'ī 1959). The wood of the *wiliwili* was, however, the preferred material used for the construction of the *ama*, or outrigger float. Holmes (1981:48) notes that "when a man found the *wiliwili* for his floater, he cared for it as he would his own child." The lightweight of the *wiliwili* allowed the *ama* to be effectively buoyant and incapable of sinking.

Wiliwili served various other purposes in the construction of a canoe, and as described in *Lā'au Hawai'i, Traditional Hawaiian Uses of Plants*, the king's canoes were often painted in red but the use of black paint was most common for other vessels, with tests showing that "the best paint was made by blending juices from the inner bark of *kukui* roots with charcoal from the base of *lauhala* or from *wiliwili* branches" (Abbott 1992:81). While passing through the Ka'ū District on Hawai'i Island in 1823, early missionary, William Ellis (1917) noted that *wiliwili* branches were used as fencing and sections of *wiliwili* were carved into stools that were placed under the canoe when they were drawn on the beach or stored in the canoe shed. Although *wiliwili* wood lacked in durability, it was favored because of its moldability and buoyancy. Yet, many did not prefer this type of wood because of the concern for "greater vulnerability of the light wood canoes to occasional shark attacks" (ibid.).

Wiliwili's Association with Manō (Sharks)

Traditionally and even today, many adhered to a famous proverb, "*pua ka wiliwili nanahu ka manō*," whose literal translation means "when the *wiliwili* tree blooms, the sharks bite" (Pukui 1983:295). While this saying has been applied metaphorically to "a beautiful woman [who] attracts young men—sharks—who become fierce rivals over her with," this saying also speaks truth to the astute observation and seasonal correlations made by Hawaiian. Having such a keen understanding of their environment and as a people who moved according to seasonal changes, Hawaiians identified a correlation between the blooming *wiliwili* and increased shark activity in nearshore waters. In recent years, historical shark attack data collected by the Department of Land and Natural Resources, Division of Aquatic Resources (DAR) has been compared to the *wiliwili* blooming season which occurs during the dry summer months (Department of Land and Natural Resources 2016). The data compiled from 1980 through 2015 showed that there were 122 unprovoked shark attacks with 26 of those, or 21% occurring during the month of October (ibid.). Some researchers have proposed that the increase in shark activity correlates to shark pupping season, combined with the female sharks need to feed to replenish lost energy (Papastamatiou et al. 2013). Today, this proverb has been adopted by some Hawai'i government agencies to warn of the increase in shark activity during the dry summer months.

Papa He'enalu (Surf Board)

Surfing or *he'e nalu* is indisputably the best known of all the Hawaiian recreational activities and one of the most esteemed pastimes. The use of a board was widely popular and was commonly referred to as a *papa he'e nalu* (surfboard). There were several types of traditional *papa he'e nalu*, but the two most popular is the short, thin board, usually made of wood from *koa* or '*ulu* (breadfruit) trees, called *alaia*, which measured about two meters long and forty centimeters wide with a convex on both sides of the fore-end (Abbott 1992). A larger board, measuring an average of six meters in length, and cigar-shaped, was called *olo*. Due to its large size, the *olo* boards were preferably made with *wiliwili* weighing about 44 to 132 pounds (Abbott 1992; Fornander 1919–1920). In 1823, Ellis (1917:166) commented that "[t]he best kinds of surf-boards are also made of this wood [*wiliwili*], which is lighter than any other the natives possess." Due to the difficulty in finding *wiliwili* trees of sufficient size such boards were made and

reserved for Hawaiian royalty (ibid.). However, the larger boards were most commonly made from *koa*, as *wiliwili* of sufficient diameter were scarce (Abbott 1992).

Wiliwili Woods Used in the Kōheoheo Style of Fishing

Fornander briefly describes a traditional fishing style known as *kōheoheo*, which was carried out in canoes and for the purposes of catching *mahimahi* (*Coryphaena hippurus*). In this fishing style, the *wiliwili* served as a floater that was attached to a line and baited with a live *malolo* fish. Fornander writes:

10. Koheoheo. He laau *wiliwili* ke koheoheo, a he malolo ola no hoi. E lima anana ka loa o keia aho. O keia hana he hoowalewale i ka mahimahi, a hae ka mahimahi, alaila kuu kea ho me ka makau. A ai ka ia, alaila pau ka hoe ana o ka waa. He ia hae ka mahimahi ke pa ai ka makau, he ia ahai, a he ia puoho e lele ai i luna. He anana a puehu ka ia nui, a he muku ka ia liilii. He lapalapa ka ia nui, a he ao kekahi, he Iwilei ka palahalapa mai ka lae a ka waha. Eia na inoa o ka mahimahi: He lapalapa, he ao, papahe. O ka ai a keia ia o ka mahimahi, o ka malolo, o ka lelepo, o ke puhukii. (Fornander 1919–1920:185)

[Translation]

10. The *koheoheo*. *Koheoheo* is a piece of *wiliwili* wood with a live flying-fish attached. The line is five fathoms long, the object is to allure the dolphin, and when it becomes ferocious the line and hook is thrown. When the fish bites the paddling of the canoe ceases. The dolphin is a very game fish when caught with a hook, it is a great struggler and snorts when leaping up. A large fish is a fathom and over, long, a small fish is *muku* (four and a half feet). A large fish is called a *lapalapa*, also *ao*, having a breath of a yard from the forehead to the mouth. Here are the different names of the dolphin: *Lapalapa*, *oa* and *papahe*. The principal food of this fish, the dolphin, are flying-fish, *lelepo* and *puhukii*. (ibid.:184)

Lei Wiliwili

The purpose and use of the *lei* (garland, necklace) in contemporary times has changed significantly from the Precontact era. Nonetheless, *lei* are still an adornment worn frequently by many. Strict customs were observed when a *lei* was made and worn because of the belief that personal items contained a person's *mana* (power). Additionally, since *lei* are typically made by one person and gifted to another, the belief that the crafter imparted their *mana* into the *lei* which was to be worn by another warranted extra spiritual precaution. These beliefs coupled with the unique materials that were carefully selected to match the appropriateness of the occasion make wearing and crafting a *lei* highly significant. A *lei* was either made with materials that were highly perishable such as flowers and foliage or were made with long-lasting and durable material. The method that was employed was dependent on the purpose and intent of its creation. One such adornment is the infamous *lei niho palaoa* (ivory pendant necklace), made of braided black human hair for the necklace, and a curved tongue-shaped pendant made of ivory both of which were held together by cordage made of *olonā* (*Touchardia latifolia*). According to Malo (1951), this style of *lei* was one of the most prized possessions of an *ali'i*. Although the *niho palaoa* (ivory tooth of a sperm whale) was considered the choice material for such a necklace, historical accounts indicated that wood from the *wiliwili* was also used for the tongue-shaped pendant with all other attributes remaining the same. In *Fornander's Collection of Hawaiian Antiquities and Folklore* (1916), the use of *lei wiliwili* (*lei* made of *wiliwili*) is described in the *mo'olelo* (story) of 'Umi-a-Liloa during his provocative visit to Hilo. Fornander writes:

When Umi was living with the daughter of Kulukulua he noticed that she had on a royal necklace, an imitation ivory necklace made of *wiliwili*, bridged with jet-black hair securely tied together. One night there was a grand entertainment for all the chiefs of Hilo at Kanukuokamanu, in Waiakea; there was dancing and games of papuhene, kilu and loku. Umi noticed that the daughter of Kulukulua was adorned with bird feathers on her body and on her head, and on her neck was a *wiliwili* ornament necklace. At the close of the chief's entertainment, after they had gone home, Umi asked his wife, the daughter of Kulukulua, for the necklace, which she let him have. Umi asked her: "Is this your necklace of royalty?" "Yes," answered the woman; "yes, that is our royal necklace, which is not commonly used by the people." "Those things are plentiful and common with the children of our place, and owned by many, from young people to old women. The necklace of our chief is of ivory, made of whale's teeth: that is the royal necklace and securely tied with cords of hair." And, saying this, Umi then broke the *wiliwili* necklace of the daughter of Kulukulua. (Fornander 1916–1917:220, 221)

Fornander's account implies that *lei wiliwili* was a commonly worn adornment for the chiefs of Hilo, however, this was not true for the chiefs of his homeland in Hāmākua, who favored the ivory pendant. This narrative also suggests that *lei wiliwili* was used by the *maka āinana* of Hāmākua. Ultimately, 'Umi's disrespectful act led to a revolt against 'Umi-a-Liloa, and his men, which resulted in Kulukulua's daughter gaining possession of 'Umi's *lei niho palaoa*, a gift that he received from his high-ranking father and chief, Līloa.

Abbott (1992), describes the *lei wiliwili* which was fashioned into a *lei hua*, or seed *lei*. The origin of this style of *lei* is uncertain but may have been influenced by adornments made of beads introduced by European visitors (ibid.). The bright red seeds sourced from the *wiliwili* tree had a unique gathering process. The seeds needed to be gathered and immediately pierced using a thorn, fishbone or fine twig, as soon as the pods opened, lest the seeds harden making them very difficult to penetrate (ibid.). Once all the perforations were made, the seeds were gathered and strung into a *lei*.

Hula Ki'i

Hula, a traditional art form is intrinsically tied to Hawaiian storytelling, beliefs, and genealogy and can be performed in various ways and styles. *Hula* is most commonly perceived as dance, however, there are other less common forms of *hula*, one of which included the use of *ki'i*, or doll-like images that were carved from the softwood of either *kukui* (*Aleurites moluccanus*) or *wiliwili* and dressed to resemble humans (Figures 22 and 23). In Emerson's (1909:92) published work, *Unwritten Literature of Hawaii 'i*, he explains that the performer "stood behind a screen, by insinuating his hands under the clothing of the marionette" while simultaneously chanting. Emerson (ibid.) goes on to add that "its usual instrument of musical accompaniment was the ipu..." which "...was handled by that division of the performers called the *ho'opa'a* [*ho'opa'a*], who sat in full view of the audience manipulating the ipu in a quiet, sentimental manner..." In describing the physical characteristics of these *ki'i* Emerson writes:

The makeup and style of these *ki'i* are so similar that a description of one will serve for all six. This marionette represents the figure of a man, and was named *Maka-kū*. The head was carved out of some soft wood—either *kukui* or *wiliwili*—which is covered, as to the hairy scalp, with a dark woven fabric much like broadcloth. It is encircled at the level of the forehead with a broad band of gilt braid, as if to ape the style of a soldier. The median line from the forehead over the vertex to the back-head is crested with the *mahi-ole* ridge. This, taken in connection with the encircling gilt band, gives to the head a warline appearance, somewhat as if it were armed with the classical helmet, the Hawaiian name for which is *mahi-ole*. The crest of the ridge and its points of junction with the forehead and back-head are decodated with fillets of wool dyed of a reddish color, in apparent imitation of the *mamo* or *o'o*, the birds whose feathers were used in decorating helmets, cloaks, and other regalia. The features are carved with some attempt at difelity. The eyes are set with mother of pearl. (Emerson 1909:91–92)

Emerson (ibid.:91) initially hypothesized that the *hula ki'i* was an adaption of Euro-American puppet shows, however, additional research yielded no evidence "other than what might be inferred from general resemblance..." Emerson went on to explain that "...the words used as an accompaniment to the play agree with report and tradition, and bear convincing evidence in form and matter to a Hawaiian antiquity.



Figure 22. Drawing of the marionettes, Maile Pakaha (left) and Nihi-Au-Moe (right). From Emerson (1909:91).



Figure 23. Emerson's sketch of the marionette Maka-Kū. From Emerson (1909:93)

Medicinal Uses of Wiliwili

Wiliwili was also known for its medicinal properties and a review of historical *lā'au lapa'au* (healing using plants) literature indicate that the flowers were used to treat venereal diseases, and the bark was used to reduce swelling. During Hawai'i's Territorial years (1898-1959), Reverend David Kaluna Kaaikamanu, who was considered a "qualified expert", joined the Territorial Board of Health to study native herbs and medicines (Chun 2016:187). Many of Kaaikamanu's articles were later translated by Reverend Akaiko Akana, a pastor of Kawaiaha'o Church (ibid.). One such article, written by Kaaikamanu describes the herbal mixture made with *wiliwili* flowers:

This tree grows in dry places and in stony or rocky ground. When dried, the wood becomes very light. The flowers are effective for venereal diseases. The tea from it is very helpful for diseases of the sexual organs. The bark is pounded and mixed with spring water and taken as a drink. When mixed with the chili pepper and with the *Pelea cinerea* and then taken with the *Piper methsticum*, it becomes a very strong dose. It is taken every evening. The *Impomea dissecta* should be taken every morning. (Kaaikamanu and Akina 1922)

In describing one of the herbal concoctions used to treat swelling, one such reference notes the use of *hoi* leaves (*Dioscorea bulbifera*), that were pounded and mixed with other plant parts including *wiliwili* bark:

Pound leaves with twisted bark of kukui, 5 'ama'u shoots, 4 hau shoots, & *wiliwili* bark; bathe in the sea, then apply, allow to dry before smearing again, 5x/day. Patient can only eat kalo until skin is "loose" and given koali to eat. (Edith Kanaka'ole Foundation 2003:XII.4a)

Wiliwili Used in the Construction of Water Troughs

In the more arid regions of Hawai'i, particularly in the lava-ridden landscapes of North Kona, Hawai'i Island, procuring the scarcely available freshwater was a difficult task and because of this, knowledge of these water collection areas was closely guarded. In 1886, during the founding of Hu'ehu'e Ranch, Eliza Maguire (daughter of John A. McGuire the founder of Hu'ehu'e Ranch) reported that many old *kama'āina* shared stories and legends associated with specific places (Maguire 1926). One such account concerns Mākālei, the name give to a water cave. The more complete story of Mākālei has been published in the May 29th, 1924 edition of the Hawaiian language newspaper *Ka Hōkū O Hawai'i* (Kihe 1924) as well as by Eliza Maguire (Maguire 1926). Handy (1940) on account of Mrs. Pukui provides a succinct version of this story, which describes the use of *wiliwili* wood for water troughs. Handy writes:

On the southern side of the hill of Akahipuu in Kona, Hawaii, lived Koamokumokuohueia. He came from Koolau and lived at Akahipuu with his wife, two daughters, and his son, Makalei. He was a farmer and raised sugar cane, taro, sweet potatoes, bananas, and awa. He was told by the natives that this was a waterless land and if any one dared to steal water from any of the natives who had a little, that persons would be killed by them. He dug a hole in the rock and when the rains fell the hole was filled with water.

One day Makalei went behind their house to answer the call of nature; he felt a sharp gust of wind under him, and when he looked he saw that it came out of a small hole. He told his father, who removed some of the stones around the hole. They thus found a big cave with water dripping from the top, and were glad to have a water supply. None of the natives knew of the existence of this cave, and these two did not mention it to the rest of the family. Later they went down into the cave and saw that it was very large, enabling them to walk upright. Koamokumokuohueia took some *ohia* and *wiliwili* logs into the cave at night and there he made boat-shaped troughs to hold the water that dripped from the roof, until he had covered the floor with troughs. The natives wondered at the way his plants thrived, but he never told them that he watered them at night from his secret cave. The water of this cave is very cold and the cave itself has been named Makalei's cave.

When Mr. McGuire went to Huehue to live he built a tank in the cave and laid pipes from the cave to the house. (Handy 1940:35–36)

Descriptions of *Wiliwili* in the Hawaiian Language Newspapers

The following section features articles with explicit reference to *wiliwili* trees that were published in the Hawaiian language newspapers in 1922 and 1930. While many other articles exist that references the famed proverb, *pua ka wiliwili, nanahu ka manō*, only two articles were identified that described traditional uses of *wiliwili*. These articles have been transcribed and translated by the lead author and all mentions of *wiliwili* have been bolded for emphasis. The first article was written by W. J. Kahopukahi on August 24th, 1872, and published in the September 4th, 1930

edition of *Ke Alaka'i O Hawai'i*, and details various traditional uses of *wiliwili*. The second is an excerpt from an article that was part of a series published by Z. P. K. Kawaikaumaiikamakaokaopua concerning the various stages of canoe building.

He Wahi Moolelo No Ka Wiliwili

O ka wiliwili oia kekahi o na laau maikai o Hawaii nei, aole nae i like kona ano me na laau e ae, a eia na me ai loa mai ia 'u ma o ko 'u ninau ana aku i na hoa. Ua ha 'i mai lakou no Hawaii nei no keia laau, aka, aole i hoikeia mai kahi i hoomaka ai o keia laau e ulu. O ke ano o keia laau he ooi.

O KA HANA A KA WILIWILI

O ka wiliwili, he laau hana nui ia keia ma Hawaii nei i mea e kuai aku ai me kekahi poe, a i mea ama waa no hoi kekahi. Aole oia wale no, i mea wahie no hoi kekahi i mea e mo 'a ai o ka ai.

O kahi ulu nui o keia laau ma na kualono a ma na kula hauliuli e waiho mai nei. Ua kiiia i mea hooholo moku e na kamalii a me na kanakamakua no hoi, ua kiiia i mea hana aniani no kahi poe, aia a naha ke aniani, alaila, hookomo iho.

Aole oia wale no, he hanaia no i waa, i na he wiliwili nui e kupono ana i na kanaka elua a ekolu o piholo i ke kai, aole nae i ka manawa e kalai ai, aia a waiho aku a maloo alaila, lawe mai, ua like no ka hana ana o kea ma me ka waa koa, a hiki mai i ka manawa e ike ia ai o ka i 'a, o ka inoa oia ano i 'a he auau, holo aku la kahi waa wiliwili holo pu me ka nui o na waa koa, a loa mai la kai 'a, alaila, hoi mai kanaka haawi ia iho la kahi i 'a na kahi kanaka nona ka waa wiliwili, no ka mea, he laka loa keia ano i 'a i keia ano waa wiliwili me he laau makalei ala ka muimui a ka i 'a.

Aole oia wale no, he hanaia e kekahi poe i pulupulu i mea pulupulu-ahi i mea e hoomau ai i ka a i mea puhi paka no kekahi poe.

Oia iho la na me ai loa mai ia 'u ma o ko 'u hele ana aku e ninau i na hoa, a ua hai mai no lakou e like me ka me ka mea i loa ia lakou a wili iho la me kahi me ai loa ia 'u a mahuahua iki he nui wale aku no paha na mea i koe, aole nae i loa aku ia 'u.

A no keia ano laau no ka oleloia, Pua ka wiliwili, nahu ka mano (Kahopukahi 1930).

[Translation]

A STORY ABOUT THE WILIWILI

Wiliwili is one of the best plants of Hawai'i, but it does not look like other plants, and here are some of the things that I have collected by asking my friends. They have told me that this plant is from Hawai'i, but it was not revealed to me where this plant first grew. This tree is prickly.

USES OF THE WILIWILI

The **wiliwili** is a wood which was prepared here in Hawai'i for sale to others and used as *ama* [outrigger float] for canoes. That is not all, it was used by some as firewood to cook food.

This tree was most commonly found near the mountain ridges and on the forested plains. It was collected by children and adults to make toy boats and it was collected by some people to make glass/mirror, and when it shattered, then **wiliwili** was inserted.

That is not all, it was also made into canoes, only if the **wiliwili** was sizeable and suitable for two or three people, lest it sinks in the ocean. A canoe made of **wiliwili** was never craved when it was freshly cut, only after it had been dried, then it was brought and carved in the same manner as that of a *koa* canoe. And when the fish was observed, the fish called *a 'ua 'u* [young marlin], the **wiliwili** canoe sailed with a large number of *koa* canoes, and located the fish, and then, when the men returned, fish was given to the owner of the **wiliwili** canoe, because, this kind of fish was attracted to the **wiliwili** canoe in the same manner as the wood of the *makalei* tree attracted fish.

That is not all, some people used it as kindling to keep the fire for the tobacco burning.

That is what I have obtained from asking my friends, and they have told me what they knew and I have combined that with what I know. There are probably many other uses, which I have not obtained.

And it is from this plant that this saying is derived, *pua ka wiliwili, nahu ka mano* (when the **wiliwili** blooms, the shark bites). (Kahopukahi 1930)

Ke Kalaiwaa Ana A Me Kona Ano (The Nature of Canoe Carving)

A series of articles written by Z. P. K. Kawaikaumaiikamakaokaopua described the various stages of canoe carving. These articles were published in *Ka Nūpepa Kū'oko'a* between October 26th, 1922, and February 15th, 1923. In the article appearing in the February 1st, 1923 edition, the author described the use of *wiliwili* during the finishing stages of canoe construction, particularly the painting and construction of the ama or outrigger float of the canoe. In relating knowledge of the preferred paint color, the author described the use of black paint, which was said to better conceal the shadow of the fisher. Those portions of the article describing the use of *wiliwili* are transcribed and translated below.

...Aole o ka **wiliwili** wale no ke pena e hanaia ai, i hanaia no paha ka **wiliwili** ma na Kona nei, no ka mea, o ka laau nui ia manawa ma Kona nei. O ke akaakai o na lo'i, o ia ka mea oi loa aku o ka maikai, ame ka na-ku, no ka mea, he hikiwawe ko laua pau i ka a ia e ke ahi...

Apau keia mau mea i ka makaukau, o ke ama aku ia mea hana nui i ka huli; no ka mea, o ke ama makemake loa ia, o ia no na ama **wiliwili** no ka hoe ana, aole e komo iloko o ke kai ke hoe a pupu hoi, no ka mea he lana loa iluna, a he oi loa aku hoi ma ke kukulu pe'a ana, o ia mau ia. (Kawaikaumaiikamakaokaopua 1923a)

[Translation]

Wiliwili was not the only type of paint made, **wiliwili** was likely used here in Kona, because there are many trees here in Kona. The *akaakai* (bulrush) found in the *lo'i*, is, however, far more superior as well as the *naku* (bulrush), because they burned rapidly in the fire...

And when these things were prepared, great effort was made to find an *ama* [outrigger float], because the most preferred wood is an *ama* made of **wiliwili**, to paddle with; when in the water it does not move slowly because it floats high on the water, and far more superior when sailing, and so forth.

In the February 8th edition of the article, the Kawaikaumaiikamakaokaopua further described the places in Kona that were known to for its *wiliwili*, which the canoe carvers of that time used to make their *ama* and *'iako*.

No ke ama o ka waa; aole i makemakeia na laau e ae i ka wa kahiko i ama no ka waa. O ka laau **wiliwili** wale no; a he kakaikahi wale no na aina i uluia e keia laau. Ua olelo ia mai ka poe kahiko ma ka apana o Kona Hema, ma Kapua e loa ai na ama **wiliwili** maikai, a ma Kona Akau hoi, mai ke a aku o Kahilina'i ahiki i Napuu.

Oia hoi o Puuwaawaa ame Puuanahulu. Ia mau ama e hele ai ka poe huli ama. Aia ma na kula a-a e ulu ai keia ano laau. He kakaikahi loa ka ulu ma na aina lepo. A ua hele aku kekahi poe i Kau, a ua olelo mai kekahi poe kahiko i hele i Kau, he oi aku ia o ka aina wiliwili i ka wa kahiko, a i keia wa, ke nalowale loa aku nei keia laau; mamua he ike aku oe i ka laau **wiliwili**.

O ka loa ana o ke ama **wiliwili** i kekahi kanaka, like ia me he keiki hanau maoli ana nana. E malama loa ana oe i ke kaikai ana; elike no me ke kaikai ana o ka waa, no ka mea, he minamina loa lakou o uluulu a manumanu. I makemake loa ka poe kahiko no ka holo ana i kahi loihi no ke kukulu pea ana... (Kawaikaumaiikamakaokaopua 1923b)

[Translation]

For the *ama* of the canoe, no other wood was preferred in the ancient times for the *ama* of the canoe. Only the wood of the **wiliwili**; and there were only a few places where this tree grew. According to the old people, in South Kona, at Kapu'a was the best place for an *ama wiliwili* and in North Kona, from the north of Kahilina'i all the way to Napu'u.

That is, Pu'uwa'awa'a and Pu'u'uanahulu. These *ama* were sought after by the *ama* seekers. These trees could be found growing on the 'a'ā plains. It grew very sparsely in well-soiled lands. And some people have traveled to Ka'u and these old people that traveled to Ka'u reported that there were far more **wiliwili** lands in the old times, but now, this tree is disappearing; before **wiliwili** was commonly seen.

According to some people, procuring an *ama wiliwili* for them was like giving birth. Great care is given, just as was done for a canoe because they grew irregularly. The people of old greatly preferred *wiliwili* for long distance sailing.

Changing Uses of *Wiliwili*

In summary, the abundance of literature describing the traditional cultural uses of *wiliwili* as well as the locales that were famed for this tree highlights its usefulness and significance in Hawaiian culture. Many of the traditional legendary accounts describe extensive groves of *wiliwili* in the arid regions of both Hawai‘i, Maui, Moloka‘i, O‘ahu, and Kaua‘i islands. While historical accounts describing its abundance are somewhat conflicting, it is evident that the *wiliwili* populations were in decline by the late 19th-century as a result of the changing political economy of the islands, particularly the shift into large scale ranching and commercial agriculture which severely impacted Hawai‘i’s dryland forest habitat. The reduction in Hawai‘i’s dryland forest habitat and the privatization of land have undoubtedly affected access to and therefore, use of this plant in its traditional manners. Additionally, the introduction and adoption of modern technologies such as western medicine, contemporary fishing equipment, fiberglass, and resin technology provided an alternative from which many of these traditional items could be made. While some of the traditional uses of *wiliwili* appear to have ceased with the changing lifeways of the people, many of the more popular items that were once crafted from *wiliwili* such as canoes and surfboards continue to be an important part of maintaining aspects of traditional Hawaiian culture.

Although many of the canoes and surfboards used in Hawai‘i continue to be manufactured from wood and mostly of fiberglass technology, practitioners today continue to seek ways in which traditional woods such as *wiliwili* can once again be utilized (Bornhorst 2010). Since at least the early 2000s, concerted efforts to reconstruct the traditional Hawaiian surfboards using both native woods such as *wiliwili* and non-native woods has gained worldwide attention. However, some practitioners in Hawai‘i continue to maintain the traditional customs and ceremonies associated with felling, hewing, and carving traditional surfboards (Stevens 2011). Some people today favor a more environmentally friendly approach to making these timeless cultural objects, coupled with the move to revitalize dormant traditions, the need for suitable native woods continues to be realized. Conservation and stewardship of critically endangered dryland forest habitats have also gained momentum and many of today’s conservation groups have an in-depth understanding of both the ecological and cultural value of Hawai‘i’s dryland forest ecosystems. Traditionally, as a people who relied exclusively on healthy and thriving resources of the land and ocean, many Hawaiians and other Hawai‘i residents alike understand the interconnectedness of Hawai‘i’s host culture to the environment. The cultural and ecological significance of *wiliwili* is further discussed in the following section of this study.

3. CONSULTATION

Gathering input from community members with genealogical ties and long-standing residency or relationships to the affected areas and with cultural experience with the target species is vital to the process of assessing potential cultural impacts to resources, practices, and beliefs. It is precisely these individuals that ascribe meaning and value to traditional resources and practices. Community members often possess traditional knowledge and in-depth understanding that are unavailable elsewhere in the historical or cultural record of a place. As stated in the OEQC Guidelines for Assessing Cultural Impacts, the goal of the oral interview process is to identify potential cultural resources, practices, and beliefs associated with the affected project area. It is the present authors’ further contention that oral interviews should also be used to augment the process of assessing the significance of any identified traditional cultural properties. Thus, it is the researcher’s responsibility to use the gathered information to identify and describe potential cultural impacts and propose appropriate mitigation as necessary.

INTERVIEW METHODOLOGY

In an effort to identify individuals knowledgeable about traditional cultural practices and/or uses associated with *wiliwili* or the habitat in which this plant is found, a public notice was submitted to the Office of Hawaiian Affairs (OHA) for publication in their monthly newspaper, *Ka Wai Ola*. The notice was submitted via email on April 9th and was subsequently published in the May 2019 issue of *Ka Wai Ola* (2019:21) (Appendix A). As of the date of the current report, no responses have been received from the public notice. Although no responses were received as a result of the *Ka Wai Ola* publication, ASM staff contacted forty-five individuals via email and/or telephone regarding the preparation of the current CIA. These individuals were selected because they were either recognized cultural practitioners, plant experts, or Native Hawaiian organizations who utilize Hawai‘i’s forest resources for cultural purposes or were believed to have cultural knowledge about the target species or other plants found within the target species habitat. Of the forty-five individuals contacted, twenty individuals responded to our request with either brief comments, referrals, or accepted the interview request. The names and affiliation of these twenty individuals are listed in Table 1 below. Of the twenty respondents, ASM staff successfully conducted interviews with nine individuals (see summaries below). A complete list of all persons contacted for consultation is available upon request.

3. Consultation

The interviewees were asked a series of questions regarding their background, and their experience and knowledge of the target species. Additional questions focused on any known cultural uses, traditions, or beliefs associated with any of the target species. The interviewees were then asked about their thoughts on the cultural appropriateness of using biocontrol control agents and whether they were aware of any potential cultural impacts that could result from the use of biocontrol control. The interviewees were then asked whether they had any recommendations to mitigate any identified cultural impacts as well as share any additional thoughts about the proposed action.

As part of the interview process and with the consent of the interviewees, some of the interviews were audio-recorded for note-taking purposes only (audio files not available). Where audio recordings were not permitted, ASM staff recorded notes throughout the interview process. Upon completion of the interview, ASM staff prepared an interview summary, which was emailed to the interviewees for review. The interviewees were given the opportunity to review the summary for accuracy and allowed to make any necessary edits. With the approval of the interviewees, the finalized version of the summaries is presented below.

Table 1. Persons contacted for consultation.

<i>Name</i>	<i>Affiliation, Island</i>	<i>Initial Contact Date</i>	<i>Comments</i>
Shalan Crysdale	The Nature Conservancy, Ka‘ū Preserve, Hawai‘i	3/6/2019	See summary below
John Repogle	Retired from The Nature Conservancy, Ka‘ū Preserve, Hawai‘i	3/6/2019	See summary below
Nohealani Ka‘awa	The Nature Conservancy, Ka‘ū Preserve, Hawai‘i	3/6/2019	See summary below
Arthur Medeiros	Auwahi Forest Restoration Project, Maui	3/7/2019	Responded via email on March 11, 2019, stating “Thank you for your valuable work supporting this essential action to attempt to slow the loss of Hawaiian biota.”
Jen Lawson	Waikōloa Dry Forest Initiative, Hawai‘i	4/3/2019	See summary below
Robert Yagi	Waikōloa Dry Forest Initiative, Hawai‘i	4/3/2019	See summary below
Wilds Brawner	Ho‘ola Ka Manaka‘ā at Ka‘ūpūlehu, Hawai‘i	4/9/2019	See summary below
Sam ‘Ohu Gon III	The Nature Conservancy, O‘ahu	4/22/2019	Responded to interview request but was unable to provide input on this project.
Mike DeMotta	National Tropical Botanical Gardens, Kaua‘i	4/22/2019	See summary below
Wili Garnett	Cultural practitioner, Moloka‘i	5/7/2019	Responded via email stating “I have mostly been involved with <i>Erythrina</i> gall wasp parasite release and monitoring, but experience watching <i>Tibouchina</i> and <i>Schinus</i> degrade watershed on many islands, including Molokai and even cultural resources at Kalaupapa.”

Table 1 continues on next page

Table 2. continued.

<i>Name</i>	<i>Affiliation, Island</i>	<i>Initial Contact Date</i>	<i>Comments</i>
Emily Grave	Laukahi Network, O'ahu	5/7/2019	Responded via email stating that she was not aware of cultural uses of this plant.
Kim Starr	Starr Environmental, Maui	5/9/2019	See summary below
Forest Starr	Starr Environmental, Maui	5/9/2019	See summary below
Manaiakalani Kalua	Cultural practitioner, Hawai'i	5/30/2019	See summary below
Talia Porter	Honolulu Botanical Gardens, O'ahu	6/3/2019	Responded to interview request but was unable to secure an interview.
Robert Keano Ka'upu	Cultural practitioner, O'ahu	6/16/2019	Responded via phone that he has been interested in learning about the cultural uses of <i>wiliwili</i> but was not aware of any uses or of anyone else who used this wood for cultural purposes.
Hinaleimoana Wong-Kalu	Cultural practitioner, O'ahu	7/16/2019	Responded to interview request but was unable to secure an interview.
Pelehonuamea Harman	Cultural practitioner, Hawai'i	7/31/2019	Referred ASM staff to Dennis Kana'e Keawe
Dennis Kana'e Keawe	Cultural practitioner, Hawai'i	8/12/2019	See summary below
Iliahi Anthony	Cultural practitioner, Hawai'i	8/30/2019	See summary below

End of Table 1

SHALAN CRYSDALE, JOHN REPLOGLE, AND NOHEALANI KA'AWA

On March 6th, 2019, Lokelani Brandt and Matt Clark interviewed Shalan Crysdale, John Replogle (retired from the Nature Conservancy), and Nohea Ka'awa of The Nature Conservancy (TNC) Ka'u Preserve regarding DOFAW's proposed action and to gather any known cultural knowledge of *wiliwili*. When asked about any known cultural uses of *wiliwili*, Shalan spoke about some of the known past uses which included its use in the traditional construction of surfboards and other traditional aquatic equipment as well as *lei* made from the seeds. Shalan emphasized that although there are many known traditional uses of this plant, he was not familiar with anyone who continues to use the plant in any traditional manner but emphasized that there may be practitioners that continue to work with *wiliwili*. They explained that *wiliwili* is common in the district of Ka'u and that intact groves are still found throughout the drier parts of the district. Shalan also described its preference for growing on the rocky 'a'ā lava. Shalan and John spoke specifically about the grove of *wiliwili* in Kawela Ahupua'a, which they recalled being the site of the 2006 release of the wasp parasitoid *Eurytoma*. Shalan stated that when news of the EGW was made public, some people from the Ka'u community responded and set out to personally collect as many seeds from various *wiliwili* trees. He believes that this public outcry demonstrates its value and significance to these communities.

The crew from the Nature Conservancy then took ASM staff on a tour to visit a stand of *wiliwili* trees that were impacted by the EGW. As evidenced by the field visit and emphasized by TNC staff, many of the *wiliwili* trees in Ka'u are being encroached upon by Christmas Berry (*S. terebinthifolia*) and other invasive species including unguates. Shalan noted that because many of these invasive species grow at a much quicker rate, they rapidly spread over an area and compete with the *wiliwili* for habitat. Shalan also described the episodic wildfires that burn rapidly through the drier portion of the district that further threatens the remaining populations of *wiliwili*.

Shalan noted that after the 2006 release of the wasp parasitoid (*Eurytoma erythrinae*), he has observed the recovery of many *wiliwili* trees, which Shalan stated, is not to overshadow the demise of many other *wiliwili* in Ka'u. While Shalan and John were not entirely against the use of biological control agents, they did share some of their concerns. Shalan, John, and Nohea stressed the importance of trial testing to ensure that the release of any proposed

biological control agent does not adversely impact other native species as well as other valued crops. They spoke about the limitations of laboratory trial testing that may not account for all the variables that are present in the tree's natural habitat. They strongly recommended that extensive trial testing be conducted prior to any proposed field release and they hope to see more post-release field monitoring to safeguard against the spread beyond the intended target species.

WILDS PIHANUI BRAWNER

Wilds Brawner, Site Manager of the non-profit organization, Ho'ōla Ka Makana'a at Ka'ūpūlehu Dryland Forest, was interviewed by Lokelani Brandt on April 18th, 2019. Since 2008, Wilds has worked at the 70-acre Ka'ūpūlehu Dryland Forest preserve performing a variety of duties including management and education.

When asked if he knew of any traditional practices, uses, or beliefs associated with the *wiliwili*, Wilds stated that the wood was used for floaters, surfboards, *wa'a*, and *ama*, and that the seeds and flower are used for *lei*. He has also seen other traditional implements made of *wiliwili*, such as a *hohoa* (*kapa* beater), but alluded that due to wood's lightness, this type of *hohoa* may have been used in the final stages of *kapa* making. Wilds also spoke about the famed '*ōlelo no 'eau*, "*pua ka wiliwili, nanahu ka manō*." He explained that one interpretation of this '*ōlelo no 'eau* describes male behavior when vying for a female, which is likened to a fierce shark. He further explained that the literal translation is in reference to increased shark activity, which coincides with the tree's flowering season. He stated that this traditional observation is backed by scientific evidence shared with him from marine-based project partners.

He also spoke of the *mo'olelo, Nā Wiliwili O Pā'ula* (The *Wiliwili* Trees of Pā'ula), that was shared with him by Auntie Ku'ulei Keakealani, a storyteller and cultural practitioner from the North Kona and Waimea area. Wilds explained that this *mo'olelo* describes the physical attributes that are unique to the *wiliwili*, such as "weird nodules" and "crooked branches." He also described the *wiliwili* to be one of the very few truly deciduous trees in Hawai'i. He also illuminated that when the tree is in full bloom it is a magnificent sight. He has learned that the Kohala Mountains, as well as areas on Maui, had extensive *wiliwili* forests and that during the flowering season created a stunningly beautiful sight. He recalled that those fortunate observers often described this flowery scene as a "fire on the mountainside" due to the flowers vibrant orange color.

When asked of his knowledge and experience with *wiliwili*, he noted that Ka'ūpūlehu Dryland Forest does not contain any wild mature *wiliwili* trees but has a small thriving population of *wiliwili* trees that were planted prior to his employment. Wilds has, however, seen *kupuna wiliwili* (ancient *wiliwili*) trees in the area of Pu'ukawaiwai, Palamanui, Makalei, and 'O'oma. He added that *wiliwili* in a thriving forest is considered a keystone species, which is evidenced through research for areas near Ka'ūpūlehu, Pu'uwa'awa'a, Kūki'o, Awake'e, Makalawena, and Mahai'ula. Although *kupuna wiliwili* are present in these areas, their preferred habitat is now occupied by exotic grasses, silk oak, Christmas berry, and Jacaranda. Wilds noted that other keystone native plants species are also found in these areas including *lama*, '*ohi'a*, and *alahe'e* but emphasized that like the *wiliwili* these are becoming increasingly uncommon. He described the *wiliwili* as a "famed lowland dry forest species" and has observed and seen remnants of these forests in nearby areas such as Pu'uwa'awa'a and the leeward side of Kohala mountain. He remarked that the color of the *pua wiliwili* (*wiliwili* flowers) is regionally based, with gradations of white, green, and orange. Wilds shared that traditionally, enormous forests of *wiliwili* served as a major food source for pollinators such as birds, and insects, as *wiliwili* flowers contain a "pouch of nectar." He suspects that larger mature *wiliwili* produced a multitude of flowers and that these formerly forested areas, would have provided the necessary support for a thriving habitat. Additionally, these former *wiliwili* forests would have provided an abundant food source for wildlife as well as a windbreak or physical buffer for the forest, shade for new growth, and healthy ground soil.

Wilds deduced that the introduction of feral ungulates, wildfire, exotic grasses, habitat loss due to human development, powdery mildew fungus and exotic pests (including EGW, red spider mites, and non-native seed weevils), has heavily impacted many of the older trees and severely inhibited the growth of new *wiliwili*. He added that although *wiliwili* is extremely easy to grow, these threats, particularly the EGW, are affecting its ability to thrive. Wilds described the EGW to be very host specific and observed the distinct damage it causes to the *wiliwili*, which is auspiciously not seen on other native trees. To manage these threats, the Ka'ūpūlehu Dryland Forest staff has utilized a combination of manual clearing, chemical treatment, and biological control practices. Wilds shared that conducting chemical control practices has proven to have adverse effects as it kills, not only the EGW but other naturally occurring potential biocontrol species as well. He added that the sole use of insecticides is not a viable method because the manpower needed to administer the insecticide is costly and it does not make sense to treat entire forests or patches of forest. He recommended that in order to prevent "killing our beloved *wiliwili* tree" the habitat must be ideal for successful regeneration and management methods. Wilds suggested the concept of integrated pest management, particularly for native plants, where natural and cultural management practices are employed concurrently. Examples

of this include, timing weed removal and planting companion plants to attract active pollinators or insects that may combat other invasive insects.

When asked about any potential cultural impacts that could result from the use of biocontrol, Wilds emphasized that utilizing biocontrol has “great potential” and that it may be a solution to help manage unwanted pests under the condition that there has been extensive research, lab and field testing, and controlled releases. He emphasized that extensive research should consider every possible factor that could potentially result in negative impacts, especially to other endemic taxa. He also stressed that public education should be a key component in this process, as it will create opportunities for the public to learn and provide input. He believes that public input can help assess the possible risks and identify steps to manage those risks. Wilds strongly recommended that all future biological control efforts integrate public input and that it should move towards a community-based resource management structure. Wilds suggested that ways to promote biocontrol are through responsible action, extensive and evidence-based testing and research, and if these pre-release efforts are successful, biocontrol “can be the silver bullet” to managing pests. He concluded that although the process has potential to control invasive species, the idea and use of the word “control,” as opposed to “management,” is very loaded and attaches unrealistic expectations to the effort. As with any forest, Wilds believes that with proper “management”, the results will net a positive cultural impact. New forest growth produces more flowers and seed and ultimately creates more opportunities for people to interact with these forests through place-based learning. He emphasized that when people interact and participate in caring for our “beloved” resources and when the *mo’olelo* of these resources are shared, it can then become a living cultural resource for the people.

MIKE DEMOTTA

On April 24th, 2019, Lokelani Brandt conducted an interview with Mike DeMotta, the Head Curator of the living collections for the National Tropical Botanical Gardens (NTBG) on Kaua‘i. Mike manages the center’s plant inventory database, which includes a large collection of native plants. Through his work, Mike has been heavily involved with native plant restoration from the coastal dry areas on Lehua Island to the pristine native forests in Limahuli Valley on Kaua‘i’s north shore.

When asked about any traditional cultural uses of the *wiliwili* on Kaua‘i, Mike stated that there are people who continue to utilize the flowers and seeds for *lei*. Mike also noted that he has seen *wiliwili* floats on outrigger canoes but expressed that he has not observed the actual making of the float. He did share that *wiliwili* still grows on Ni‘ihau and was traditionally used for *lei* making, oftentimes strung together with the infamous *pūpū o Ni‘ihau* (Ni‘ihau shells). Mike added that the people of Ni‘ihau greatly valued the *wiliwili* tree and were able to distinguish a native *erythrina* from non-native varieties based on its distinctive colors. He also shared that with the decline of *wiliwili* populations, due to ranching, the people of Ni‘ihau have had to adapt their traditional and cultural practices to their changing environment, such as replacing native plants with “weedy non-native” species for medicinal purposes.

Mike described that at the NTBG, they had a large collection of *Erythrina* species that were collected from all over the world and that with the arrival of the EGW, they had lost half of their collection. He noted that the native *wiliwili* have been severely impacted by the EGW and specifically referenced the area of Kahikinui and Kaupō on Maui, where thousands of *wiliwili* were affected. When the EGW began its assault on the native *wiliwili*, Mike was a part of a statewide effort to collect as many *wiliwili* seeds as possible. As a result, he was able to see many *wiliwili* populations on Kaua‘i and discovered that many of the remote populations, in the areas of Waimea Canyon, Kalalau, and Polihale, had no presence of EGW and were never affected. Mike stated that the first release of the wasp parasitoid played a critical role in helping to get the EGW populations under control.

When asked about any potential cultural impacts that could result from the use of biocontrol, Mike believes that with proper research, biocontrol could preserve or rescue native forests. With his strong involvement with restoration, Mike strongly believes biocontrol will assist in opening up spaces for the regeneration of native forests and proposed that drastic measures are imperative to control or eradicate the aggressive nature of invasive species. Although he is genuinely concerned about the possibility of a collateral loss of one or two native species, Mike reasoned that the overwhelming threat to native forests from invasive species had lent to his advocacy for biocontrol. He argued that the manpower needed to control these threats are not feasible and are unrealistic. Therefore, he is pleased to learn that the Department of Agriculture and DOFAW are considering more releases as it has been over a decade since the release of the *Eurytoma* parasitoid wasp. He is particularly impressed that the focus has shifted to conservation and that there is a growing awareness that we are losing pristine forests to these invasive species.

JEN LAWSON AND ROBERT YAGI

On April 26th, 2019, Lokelani Brandt and Aoloa Santos met with Executive Director, Jen Lawson and Preserve Manager, Robert Yagi, of the Waikōloa Dry Forest Initiative. The Waikōloa Dry Forest Initiative manages 275 acres of dryland forest located near the Waikōloa community. The 275-acre preserve is home to sixty-two *wiliwili* trees plus over a thousand planted and *keiki* (young) trees, which Jen described as a fraction of the *wiliwili* trees that once grew in the area.

When asked if they were familiar with any traditional customary practices or beliefs associated with the *wiliwili*, Jen mentioned that people have visited the forest for traditional or customary practices, such as gathering seeds or for wood. She noted that community members, including practitioners, have asked and collected fallen branches for *ama* as well as surfboards. Jen also added that people continue to collect seeds but do so without permission. She further explained that the forest is underutilized probably because people are unaware or *kama'āina* have other areas they source from. Due to the fragile state and with a small population of *wiliwili* in the preserve, they highly discourage the collection of the seeds until the threat of the EGW can be controlled. Although the seeds are vital to their reforestation efforts, the organization's long-term goal is to reduce and eventually eradicate the threats to increase tree population so that the forest can continue to be used for traditional and customary practices.

Jen and Robert both shared their experience with working with the wasp parasitoid, *Eurytoma erythrinae*. Jen shared that in 2008, the State of Hawai'i, Department of Agriculture conducted preliminary research and informed communities of their intent to release a biocontrol agent to control the EGW. Following the release of the wasp parasitoid, the Waikōloa Dry Forest staff saw a significant decrease in the EGW population which lent to the recovery of many *wiliwili* trees. Despite this success, Jen noted that they did lose a number of *wiliwili* trees. However, in a continued effort to be good stewards of the biocontrol and to better manage the trees within the preserve they developed in-house strategies and practices to further combat the remaining EGW populations. Robert explained that he has experimented with raising, breeding, and releasing the *Eurytoma* during the flowering season when EGW populations peak. Jen shared that a healthy population of *Eurytoma* is needed to combat EGW but their observations have shown that as *Eurytoma* eliminates the EGW it also eliminates their food source resulting in a population decline. Subsequently, an influx of EGW returns during the flowering season and outnumbers the *Eurytoma*, thus causing a resurgence in the EGW populations. Robert stated that the *Eurytoma* are raised during the non-flowering season to ensure a vigorous population necessary to combat the EGW. Jen added that the challenge with this effort is the lack of follow up and limited continued monitoring from the Department of Agriculture.

When asked about indicators of an infested *wiliwili*, Jen explained that after the EGW deposits its eggs in the stems and leaves of the tree, as the larvae develop it forms a gall. When the wasp emerges, they burrow out of the leaves and stems leaving behind small holes. If a *wiliwili* is prodigiously infested with the EGW, it will then undergo a series of stages before perishing, which includes galling, loss of leaves, decrease in seed production, and discoloration of the branches and trunk. Although the EGW is the main threat to *wiliwili*, Jen and Robert noted that there are a variety of other pests that also affect the *wiliwili*. Smaller insects such as spider mites, lace bugs, thrips, and scales are seen on the flowers, leaves, and branches of the tree. Prior to fencing the preserve, Jen noted that goats were a serious pest as they eat the leaves and branches of healthy *wiliwili*. Jen recalled that since the removal of these ungulates, *wiliwili* canopies have improved and the branches of the tree can sprawl outward over lava. Another concern that was shared includes the threat to the *wiliwili* seeds which are eaten by rats and other insects.

Although Jen is a proponent of biocontrol, she explained that the proper research must be conducted, and that dissemination of that research should be provided to the affected communities. She expressed that one of the main challenges will be garnering public support for the proposed action because of preconceived notions that are heavily influenced by the historical and unsuccessful application of biocontrol. Although Jen was aware of the extensive research that is conducted prior to the release of any biocontrol agent, she remarked that such research is not always effectively shared with the communities. She added that the lack of public information and transparency only exacerbates misconceptions thereby making community support difficult to establish. In light of this, Jen recommended that DOFAW and other associated agencies restructure informational public meetings to be engaging and inclusive of community input as she believes this may improve trust between the affected communities and the agencies. Additionally, she strongly advocates for a more collaborative partnership between the DOFAW and its agencies as a way to promote a more open dialogue between the agencies and community groups who work closely with some of these invasive species. Jen and Robert also recommended that more consistent post-release monitoring be conducted and that such efforts should be done in conjunction with established community groups.

FOREST AND KIM STARR

On May 31st, 2019, Lokelani Brandt and Aoloa Santos met with Forest and Kim Starr at their home in Olinda, Maui. Born and raised on Maui, Forest always enjoyed nature. He later moved to New York to attend Cornell University and in 1992 met his now wife and business partner, Kim, who is of Hawaiian descent but was *hānai* (adopted and raised) by a Japanese-Italian family. Since then they have done numerous volunteer and contract work in the conservation field. They currently co-own Starr Environmental and serve as biologists and environmental consultants for developers and federal and state agencies. Forest and Kim have extensive experience in botanical and environmental restoration work in the Hawaiian Islands. Forest shared that they have assisted in prior biocontrol releases but they primarily focus on the early detection of introduced species.

When asked about their knowledge of traditional cultural uses of *wiliwili*, Forest and Kim shared that people utilize the seeds for *lei* and use the wood for floats. Forest stated that over the years, concerns have been raised regarding the impacts that biocontrol agents may have on other native plants all of which are of ecological importance and some of which are extensively utilized in a Hawaiian cultural context. In their dedication to perpetuating native Hawaiian flora, which they cultivate on their property, Forest and Kim shared that *hālau hula* and other native Hawaiian groups visit their garden to gather plants for medicinal and ceremonial uses, *lei* and dye-making, and as *hula* adornments. The ongoing traditional practice of gathering native plants for an array of cultural uses are some of the reasons they desire having an environment dominant with native plants. Forest also stated that cultural practices and traditions drive necessary actions to help protect these plants and that the loss of native plant habitat from invasive species affects the “sense of place and endemism that makes Hawai‘i unique.”

Forest and Kim also spoke about the past biocontrol efforts to combat EGW. Forests stated that the initial release, in his opinion, “did an amazing job” and since then, Kim stated she has not recently seen galling on the trees by the EGW. Forest also shared about the first time they detected the EGW on Kaho‘olawe Island and observing a *wiliwili* tree that was just beginning to bloom. He recalled telling a group of students that this may be the last time this tree will ever flower, to which a Hawaiian student in the group replied, “that’s one of the saddest things I’ve ever heard.” Forest reminisced that this statement stressed the cultural significance of the *wiliwili* and the deep connection between the native people of these islands and their native plants. He added that if these plants were no longer in existence, it would remove that cultural connection for future generations. Forest and Kim also highlighted the increasing threat of the seed beetle that drills holes into the *wiliwili* seeds which renders the seeds unpropagatable. Therefore, they both agreed that this threat will need to be dealt with very soon or the *wiliwili* may suffer much larger consequences than the damage done by EGW.

Forest described much of the vegetation that dominates the islands as a “rag-tag assemblage of pantropical invasive species” and opined that this sort of global homogenization of the islands’ plant life is exacerbating the spread of really aggressive species. Adding to this, Forest expressed that changes in the environment are inevitable and noted that these changes are difficult for many to accept. Forest and Kim believe that biocontrol is a method that can help mitigate or slow the growth of species but “it never eradicates, it just reduces the numbers” and cited the example of the EGW and the *panini* cactus (*Opuntia ficus-indica*) which have had biocontrol agents released against them. Both Forest and Kim explained that over the course of many years they have seen limited success where biocontrol has resulted in complete eradication.

When asked about their thoughts on the cultural appropriateness of biocontrol, Forest and Kim shared that they have witnessed the culture and traditions of these islands evolve within an inevitable changing environment. Forest emphasized that the mixed-culture of Hawai‘i has been able to co-exist with the changing environment and they have seen various cultures including Hawaiian culture utilize introduced plants in place of rare or extinct native plants in order to perpetuate their traditional cultural practices. In spite of these cultural adaptations, they feel that biocontrol can be useful in protecting native plant habitats which are both ecologically and culturally important and remain open-minded to these types of undertakings.

Based on their knowledge of the efficacy of former biocontrol efforts, Forest and Kim shared that generally, the way a biocontrol agent is introduced is not very effective and that for the most part, in order for the biocontrol to be entirely successful a large number of biocontrol agents must be introduced. Kim stated that although the purpose of biocontrol is to introduce an organism that is specific to a target plant, the efficacy is oftentimes underwhelming and as a result, there have been a few unintentional consequences. Kim shared that although biocontrol agents are introduced with good intentions, “the unknown,” meaning its potential to cause unforeseen impacts to a non-target species, is the main factor that contributes to the general resistance to implement biocontrol. Additionally, Forest and Kim both stated that once a biocontrol agent is released there is very limited and often times no follow-up by the agencies that have invested in the pre-release studies. In light of this, Forest and Kim recommended that post-release

monitoring should be held to the same standard as the pre-release of a biocontrol agent. Forest described that “mother nature is so crafty” and that changes are often muted or other factors become more significant than the release, therefore on-going post-release monitoring is a crucial component to this process. Forest also stated that misinformation has been detrimental to these biocontrol efforts and believes that more should be done to effectively communicate these types of undertakings to the public.

MANAIKALANI KALUA

On June 6th, 2019, Lokelani Brandt conducted an interview with Manaiakalani “Manai” Kalua, a *kumu hula* and life-long Hawaiian cultural practitioner. Born and raised in the Hawaiian homestead community of Keaukaha, Manai has dedicated his life to *hula* and because of this, he has had extensive interactions with Hawai‘i’s native plant life, which is a fundamental element to traditional *hula* practices.

When asked about his knowledge of traditional cultural uses and beliefs associated with the *wiliwili*, Manai explained that the *wiliwili* is a *kino* (embodiment) of Kapō‘ulakīna‘u. When asked if he could further explain the Hawaiian cultural understanding of Kapō‘ulakīna‘u, Manai stated that this female deity is a sibling to Pele and that her volcanic form is the ‘a‘ā lava, which he described as the slow-moving and crumbly type of lava. In referencing the genealogy of Haumea and Moemoe‘a‘ali‘i, Manai illuminated that Kapō‘ulakīna‘u is a younger sister of Pele who was born from her mother’s (Haumea) *kuli* (knees). Manai explained that he has observed in the Ka‘ū District as in other parts of Hawai‘i Island, the *wiliwili*’s preference for growing in the ‘a‘ā lava fields. Manai noted other attributes of Kapō‘ulakīna‘u, which associates her with life forms that are parasitic, semi-parasitic, and toxic. He noted that part of Kapō‘ulakīna‘u’s role in the natural environment is related to the cultural understanding of *noho* (possession), so many of her physical forms share the same attribute. Manai explained that other plant forms that share a semi-parasitic relationship with other plants could be considered embodiments of Kapō‘ulakīna‘u. He added that old proverbial sayings, such as *pua ka wiliwili*, *nanahu ka manō* further emphasizes this plant’s importance to *kupuna* (elders or ancestors), who made astute observations (*kilo*) between the blossoming *wiliwili* and increased shark activity in near-shore waters.

Manai also spoke about some of the cultural uses of the seeds, which were strung into brightly colored *lei*. He noted that although the preparation of this type of *lei* is labor-intensive while growing up, he frequently saw this *lei* being worn by dancers and *kupuna*. He added that unlike *lei* made from natural foliage—which is typically worn once, then returned to the forest—the *lei wiliwili*, if preserved well, could be worn multiple times, if not throughout one’s lifetime. He expressed that today, these types of *lei* are less frequently seen, much less worn.

Manai spoke at length about the ways in which invasive species are changing traditional cultural practices specific to *hula*. He explained that within his *hula hālau* he teaches about the proper way to harvest plants in addition to practices that will help limit the spread of invasive species. He now stresses the importance of cleaning all clothing, equipment, and cars after every visit to the forest. He stated that invasive species are a serious problem that has major environmental and cultural implications and cited the example of Rapid ‘Ōhi‘a Death (ROD), which has significantly impacted *hula* practices. He noted that culturally, ‘ōhi‘a is an important part of *hula* adornments and rituals, since becoming aware of ROD, he no longer gathers ‘ōhi‘a nor does he condone the gathering of this plant. He explained that not being able to utilize ‘ōhi‘a has required him to be more creative with his cultural practices.

When asked about his thoughts on the cultural appropriateness of utilizing biocontrol, Manai explained that we have a long history of unsuccessfully utilizing biocontrol and cited examples including the introduction of the mongoose to control rats and the scale insect to control strawberry guava. Manai expressed concern for the idea of introducing other foreign insects that may adversely impact its intended target but whose impacts are somewhat unknown to the many other species that grow in the same habitat as the target species. He questioned, what will happen to the introduced biocontrol once the target species is eliminated, and what are the long-term impacts of utilizing biocontrol? He noted that we are living with the repercussion of previous biocontrol choices that we still cannot manage. Although Manai is not a proponent of utilizing biocontrol, he understands that the shift to use biocontrol suggests that all other methods for controlling these invasive species have been exhausted. He was aware that utilizing biocontrol is a much slower process and stated that the government does not have the means to manually eradicate Hawai‘i’s invasive species. He stated that there are also risks associated with the manual removal of invasive species.

While Manai remains skeptical of the effectiveness of biocontrol, he believes that the government must develop stricter laws and policies to stop the introduction of invasive species. He noted that in his travels to other parts of the world, including Japan and New Zealand, their customs entry process is far more thorough and intensive. He believes that these countries and exemplary models where the emphasis is placed on stopping the introduction instead of trying to combat its spread. He also advocates for a more rapid response to known invasive species and cited the example of

the coqui frog, which on Hawai‘i Island is now widespread and unmanageable. He believes that rapidly responding to invasive species, especially when populations are far more contained, could be far more effective.

DENNIS KANA‘E KEAWE

On August 13, 2019, Aoloa Santos conducted an interview with Dennis “Kana‘e” Keawe, a retired Commercial Services Consultant for Hawaiian Electric Light Company (HELCO) and former lecturer at the University of Hawai‘i at Hilo (UH Hilo). Born and raised on O‘ahu, Kana‘e moved to Hawai‘i Island in November of 1974, to help his father with his coffee farm in Hōnaunau, Kona. Following his retirement from HELCO at age 55, he was asked to teach a Hawaiian studies ethnobotany course at the UH Hilo. Kana‘e stated that when he was asked to teach the course, his botanical vocabulary and knowledge were appropriate for teaching young children and therefore acknowledged that in order to instruct at the university level, he needed to expand and develop his botanical nomenclature. Through this process, Kana‘e learned that many varieties of Hawai‘i’s native plants “exist within the tropical belt around the world” and having in-depth knowledge of scientific names and identifiers allowed him to effectively communicate with people well-versed in similar plants of those regions. Additionally, Kana‘e is a renowned Hawaiian artisan and cultural practitioner endearingly referred to by many as “the all-around guy.” He has been recognized for his expert-crafted oeuvres, such as *hula pahu* (drum), *kapa* (bark cloth), *i‘e kuku* (*kapa* beater), and feather crafts. As a result of his artisanship, he has been afforded opportunities and invitations to visit communities and institutions around the world, notably the Smithsonian Museum, an institution that houses a large collection of Hawaiian antiquities.

When asked about any traditional cultural uses of *wiliwili*, Kana‘e mentioned the use of the wood for surfboards and canoe outriggers. He added that he was aware of cultural practitioners who still utilize *wiliwili* for surfboards but believes it may be a rare practice due to rising concerns of the dwindling *wiliwili* populations and the desire for more durable materials such as polyurethane foam. He is unsure if *wiliwili* is still used today for canoes, noting that the wood weathers easily and is extremely delicate. Kana‘e further shared that *wiliwili* is not ideal for *hula pahu* and *i‘e kuku* because the wood is “too soft.” He also pointed out that the seeds which are commonly used *lei*, produces four different colors: purple, orange-red, yellow, and white. In other parts of the Pacific, particularly in Rapanui, Kana‘e shared that “the people use the flower and stems” of their native *wiliwili* as spacers in *lei*, similar to the straw and paper *lei* that children make. He is, however, unaware of that practice being used for *lei* in Hawai‘i. During his visit to the Smithsonian, Kana‘e viewed and photographed several of the *hula ki‘i* that were part of the Nathaniel B. Emerson collection. *Hula ki‘i* was a style of *hula* performance that used puppet dolls whose heads were made of *kukui* or *wiliwili*. Kana‘e described the *hula ki‘i* as if he were “seeing small people in their coffins” dressed in modern clothes. He observed that the clothes were possibly sewn using a sewing machine, as evident by the seams near the wrist and neckline (Figures 24 and 25). He strongly agrees that the dolls’ wooden components, such as the head, were made of *wiliwili* or *kukui*, as described by Emerson since the wood is “soft and easy to carve, as well as lightweight to manipulate during the show or presentation.” Additionally, Kana‘e revealed that there is possibly a space in the back of the dolls that were large enough to fit a hand, suggesting that it was used as puppets and possibly in the same fashion as ventriloquism. In comparing the drawings and narratives published by Emerson to Kana‘e’s photographs, he infers that only four of the six *hula ki‘i* are currently at the Smithsonian (Figures 26 and 27), reasoning that Emerson may not have been able to purchase the entire marionette collection. Kana‘e imparted that “it was a good collection and a small part of the *hula* culture, but the puppets are just a small part of that segment where the language was the key to the entire presentation.”

When asked about his thoughts on the cultural appropriateness of biocontrol, Kana‘e expressed his support and did not foresee any major cultural impacts if extensive studies and testing is done prior to its release. He added that although there are unknown variables to this method, humans can only do so much, especially in the current state of our environment and the rapid growth of invasive species.



Figure 24. Top—Emerson's (1909:90) drawing of two marionettes named Maile Pakaha (left) and Nihi-Au-Moe (right). Bottom—Original marionettes of the above drawing at the Smithsonian Museum, photos by Dennis Kana'e Keawe.



Figure 25. Close up of seams near the hand of Emerson's marionette collection at the Smithsonian Museum. Photo by Dennis Kana'e Keawe.



Figure 26. Left—Emerson’s (1902:92) drawing of the marionette named Maka-Kū. Right—Original Maka-Kū marionette at the Smithsonian Museum, photo by Dennis Kana’e Keawe.



Figure 27. Original marionette from Emerson’s collection at the Smithsonian Museum. Photo by Dennis Kana’e Keawe.

ILIAHI ANTHONY

On September 3rd, 2019, Lokelani Brandt interviewed Iliahi “Ili” Anthony, a *hula* dancer, *lauhala* weaver, *lei* maker, and natural dye expert. Ili is also an art teacher at Ka ‘Umeke Kā‘eo Hawaiian Immersion Public Charter School and has a background in designing furniture and exhibit spaces. Ili grew up in the community of Keaukaha and has been dancing *hula* since the age of four. As a life-long *hula* dancer for Hālau O Kekuhi, Ili explained that her knowledge of Hawai‘i plant life comes from years of gathering foliage (primarily indigenous and endemic species) and other natural resources for their *‘a‘ahu* (costume), *lei*, and *hula* implements. Ili recalled as a child being accompanied by her *kumu hula* and family members into their gathering areas where they taught her about the Hawaiian cultural significance of the plants, gathering protocols, how to identify them in the forest, and how to sustainably gather and prepare them to be used in the context of *hula*. She emphasized that as a small kid, she learned about these practices by watching and listening to her *kumu* and relatives and stated that when you are that young, you’re not keenly aware of what it is they are teaching you, but as an adult, those teachings remain and are better understood. Ili openly stated that although she is not of Hawaiian ancestry, she has been raised by native Hawaiians and has learned about many of the traditional practices and customs. She expressed that although she chooses to remain respectful when it comes to Hawaiian issues and matters, she is willing to share her knowledge when asked and feels that she has something to offer.

Ili explained that as a *hula* dancer, she has learned to depend on other cultural practices to help her with gathering certain natural resources needed in *hula*. She described going on expeditions with her brother, who is a hunter, to gather *maile* (*Alyxia spp.*). Ili explained that her brother knows the trails very well and is very particular about how they cut *maile*, and how much they take from any one plant. She added that although her brother is not necessarily a *lei* maker, he knows this plant and forest resources very well. She explained that she also relies on her father who is a woodcarver to help her make certain *hula* implements. Ili also described gathering with other *hula* dancers, some of whom have a background in native plants and botany, and shared that when she gathers with them, they often teach her about the names and can point out the subtleties that are not obvious to her. Ili believes that this demonstrates the interconnectedness of cultural practices and stated that even people who we think may not use plants, such as hunters and fishers, do often know a lot about native plant life. She stressed that as a *hula* practitioner and in terms of plant resources, she relies greatly on other practices that are not necessarily defined as *hula*.

With respect to learning about and identifying plants, whether native or non-native, Ili shared that unless someone shares that knowledge with her, then she would most likely not know about it. She expressed that when she has gone to get gathering permits from DLNR, she recalled seeing various informational posters in their office which she finds useful for learning about Hawai‘i’s plant life and invasive pests. Although Ili is familiar with *wiliwili*, she shared that this is not a plant that she frequently interacts with because it is not found in the area in which she lives and is therefore not readily accessible to her.

While Ili supports the removal of invasive species, especially if they are directly impacting native plants or native plant habitat, she cautioned that some plants that have been dubbed “invasive” are utilized for various traditional and contemporary cultural purposes. Ili opined that today, people utilize various “rubbish plants” to make adornments such as *lei* and that such plants if properly arranged can be turned into something beautiful and wearable. She also noted that weedy plants such as *laukahi* (*Plantago major*) and the introduced guava (*Psidium guajava*) have become incorporated into Hawaiian *lā‘au lapa‘au* (plant healing) practices. While she believes that finding a cultural purpose for an invasive plant is not a strong reason to halt invasive species management efforts, she cautioned that people have come to rely on certain invasive species to perpetuate select cultural practices because they are easily accessible and abundant. Adding to this, Ili expressed that people have and will continue to adapt to living with invasive species. Ili also worries that if invasive species, particularly those that are used for cultural purposes become less abundant and available, then people will likely have to find a more readily available substitute, which could result in people gathering indigenous or endemic species. She stated that people tend to use invasive species because they are abundant and easily accessible.

Ili shared that over the years she has observed an increasing number of pests on native plants and made specific reference to *‘a‘ali‘i* (*Dodonaea viscosa*), which now seems to be infested with spiders. She shared that as a *lei* maker, she often brings these plants into her home and disposes of her *hakina* (scrap pieces) in her yard. Although she has not seen those spiders move onto the plants at her home, Ili expressed a sense of uncertainty with gathering and possibly transporting unknown pest.

Ili also spoke about the need to improve our understanding of the ecological relationships that may exist between native and non-native species. She shared that some native plants such as *‘iliahi* (sandalwood; *Santalum ellipticum*) is semi-parasitic and relies on a host plant to thrive. She added that we know that native plants have adapted to each

other and wonders if native species may have adapted or are adapting to living amongst non-native species as well. She pondered on the idea of removing invasive species and the possibility of causing indirect impacts to native species that have come to rely on them for some life-giving element.

When asked about her thoughts on the cultural appropriateness of using biocontrol, Ili opined that this is a difficult question to answer and lightheartedly stated that “basically, you’re introducing another culture into the culture.” She asked, what things have we introduced in the past that actually worked? Ili added that she feels there have been more things in the past that have been introduced that have not worked in comparison to those that have actually worked. Ili stated that introducing more foreign species to the islands is a scary thought and wondered what the future would look like. She asked, will we have to continually introduce more foreign species to combat those we previously introduced? Additionally, she wondered what would take the place of these invasives once they are removed?

When asked about her thoughts and recommendations about the proposed action, Ili believes the state could do more in terms of educating the public about identifying invasive species and the ways in which everyone can help limit the spread. She stated that there is a general lack of awareness and believes that providing more information to those who are obtaining gathering permits may be one way to improve awareness. She stressed that the information needs to be presented in a reasonable manner that would not deter people from obtaining a gathering permit. Ili shared that since the events taking place on Mauna Kea, she believes there is growing alertness amongst the people about land and culture-related issues. She has noticed an increasing awareness in schools where teachers are working with students to better understand and to seek solutions to these issues. She believes that the state should improve support to the schools so that the information is more accessible to students and teachers. Ili explained that many teachers want to do more of these kinds of projects with their students but there are many challenges that hinder their ability to execute such projects, including accessibility, funding, time, and finding a good resource person that can connect them to specific places and resources. She expressed that teachers can only guide and facilitate these kinds of projects, but they are not plant experts. She believes that education can be a key component in improving public awareness. She also added that while there may be a robust amount of scientific information about the potentially positive aspects of biocontrol, it needs to be condensed and expressed in layman’s terms to that the general population can actually understand and connect to what scientists are discovering. She lamented that otherwise, people won’t listen or hear what is being said because they can’t connect to or understand what the scientists are saying. Ili made reference to the tremendous educational efforts that were put into improving public awareness about Rapid ‘Ōhi‘a Death and noted that their outreach team was doing big and small things such as community talks, stickers, hats, and being present at various local community events. She believes that more of these kinds of efforts could be undertaken for other invasive species.

Ili also shared that many scientists are not practitioners and opined that these two groups, although they may share an affinity for preserving plants, both have two completely different relationships with the resource. She believes that the relationship between scientists and practitioners should also be improved because both groups can help to elevate and improve each other’s practices if they are willing to work collaboratively. While she feels that this dynamic has been changing, she thinks its especially important as we move towards the possibility of using biocontrol in native plant habitats.

4. IDENTIFICATION AND MITIGATION OF POTENTIAL CULTURAL IMPACTS

The OEQC guidelines for assessing cultural impacts identify several possible types of cultural practices and beliefs that are subject to assessment. These include subsistence, commercial, residential, agricultural, access-related, recreational, and religious and spiritual customs. The guidelines also identify the types of potential cultural resources, associated with cultural practices and beliefs that are subject to assessment, which “may include traditional cultural properties or other types of historic sites, both man-made and natural, including submerged cultural resources”(Office of Environmental Quality Control (OEQC) 1997:1). The origin of the concept of traditional cultural property is found in National Register Bulletin 38 published by the U.S. Department of Interior-National Park Service (Parker and King 1998). A traditional cultural property can be generally defined as:

...one that is eligible for inclusion in the National Register because of its association with cultural practices and beliefs of a living community that (a) are rooted in that community’s history, and (b) are important in maintaining the continuing cultural identity of the community. (Parker and King 1998:1)

This definition also implies that any identified traditional practices and beliefs of an ethnic community, or members of that community, exceeds fifty years. “Traditional” as defined in the National Register Bulletin 38 “refers to those beliefs, customs, and practices of a living community of people that have been passed down through the generations, usually orally or through practices (ibid.). Whereas, “Culture” refers to “a system of behaviors, values, ideologies, and social arrangements” in addition to “tools and expressive elements such as graphic arts” (ibid.). The use of the term “Property” defines this category of resource as an identifiable place. Traditional cultural properties are not intangible, they must have some kind of boundary; and are subject to the same kind of evaluation as any other historic resource, with one very important exception. By definition, the significance of traditional cultural properties should be determined by the community that values them.

It is however with the definition of “Property” wherein there lies an inherent contradiction and corresponding difficulty in the process of identification and evaluation of potential Hawaiian traditional cultural properties because it is precisely the concept of boundaries that runs counter to the traditional Hawaiian belief system. The sacredness of a particular landscape feature is often cosmologically tied to the rest of the landscape as well as to other features on it. To limit a property to a specifically defined area may actually partition it from what makes it significant in the first place. However offensive the concept of boundaries may be, it is nonetheless the regulatory benchmark for defining and assessing traditional cultural properties. As the OEQC guidelines do not contain criteria for assessing the significance for traditional cultural properties, this study will adopt the state criteria for evaluating the significance of historic properties, of which traditional cultural properties are a subset. To be significant the potential historic property or traditional cultural property must possess integrity of location, design, setting, materials, workmanship, feeling, and association and meet one or more of the following criteria:

- a Be associated with events that have made an important contribution to the broad patterns of our history;
- b Be associated with the lives of persons important in our past;
- c Embody the distinctive characteristics of a type, period, or method of construction; represent the work of a master; or possess high artistic value;
- d Have yielded, or is likely to yield, information important for research on prehistory or history;
- e Have an important value to the native Hawaiian people or to another ethnic group of the state due to associations with cultural practices once carried out, or still carried out, at the property or due to associations with traditional beliefs, events or oral accounts—these associations being important to the group’s history and cultural identity.

While it is the practice of the DLNR-SHPD to consider most historic properties significant under Criterion d at a minimum, it is clear that traditional cultural properties by definition would also be significant under Criterion e. A further analytical framework for addressing the preservation and protection of customary and traditional native practices specific to Hawaiian communities resulted from the *Ka Pa‘akai O Ka ‘Āina v Land Use Commission* court case. The court decision established a three-part process relative to evaluating such potential impacts: first, to identify whether any valued cultural, historical, or natural resources are present; and identify the extent to which any traditional and customary native Hawaiian rights are exercised; second, to identify the extent to which those resources and rights will be affected or impaired; and third, specify any mitigative actions to be taken to reasonably protect native Hawaiian rights if they are found to exist.

Summary of Culture-Historical Background, Consultation, and Significance Assessment

The use of *wiliwili* in Hawaiian culture and its appearance in traditional legendary accounts are both extensive and well-documented. According to the *Kumulipo*, a Hawaiian cosmogonic chant, the *wiliwili* emerged as a forest dweller alongside its paired aquatic counterpart the *wili*, a sea boring animal. The story of *Nā Wiliwili O Pā‘ūla*, which was also described by Wilds Brawner associates the distinguishing characteristics of this tree with three sisters from the Ka‘ū District. According to Wilds Brawner, this *mo‘olelo* is still shared with student learners who visit the dryland forest at Ka‘ūpūlehu, North Kona. The legend of the demi-god, Māui, tells of how this determined youth secured the legs of the sun to a large *wiliwili* growing on Haleakalā to slow its daily progression through the sky. Description of native *wiliwili* habitat is expressed in the legend of Kawelo and in the epic saga of Hi‘iakaikapoliopole. The legend of Kawelo describes the *wiliwili* on Kaua‘i, which grew alongside the *lama* (*Diospyros sandwicensis*), another important dryland forest species, while the account of Hi‘iakaikapoliopole describes the *wiliwili* that grew in arid ‘Ewa plains of O‘ahu alongside the *‘ōhai* (*Sesbania tomentosa*). Reference to an extensive *wiliwili* forest in the Kohala District of Hawai‘i Island is found in the account of Kapunohu, a hero, who, in a test of strength, is said to have forced his spear

with a single thrust through some eight hundred trees. Wilds Brawner described observing many *kupuna wiliwili* (ancient *wiliwili*) trees in the North Kona District of Hawai‘i Island. Consultation with Wilds Brawner and Mike DeMotta also indicates that an extensive *wiliwili* forest was also present in the Kahikinui and Kaupō areas of Maui Island—an area that has been severely devastated by the EGW in more recent years. The account of another Kohala hero, Pupuhuluena, depicts the use of *wiliwili* wood, which was carved into an image and used to appease the gods who had taken and concealed all of the food plants at Ka Lae, in the Ka‘ū District of Hawai‘i Island.

Wiliwili clearly played a vital role in enhancing and maintaining the traditional lifestyle of the Hawaiian people. Its availability to those who settled in the leeward parts of the islands proved most useful as this lightweight and highly buoyant wood was carved into small fishing canoes but more commonly fashioned into *‘iako* (outrigger booms) and *ama* (outrigger floats) for larger canoes. All of the consulted parties spoke about the past and continued use of *wiliwili* wood for both the *‘iako* and *ama* of canoes. Jen Lawson and Robert Yagi both described practitioners harvesting fallen *wiliwili* logs from the Waikoloa dryland forest preserve which they reported were made into surfboards and *ama*. Although considered rare, canoes carved entirely of *wiliwili* were held in high regard as the wood was said to have effectively attracted the *a‘ua‘u* fish (juvenile *Istiophoridae* sp.). Traditional canoe carvers also blended the charred remnants of the *wiliwili* wood to make a plant-based smear that was painted onto the canoes during the finishing stages. The black-colored paint was said to have absorbed the shadow of the fisher, allowing him or her to remain out of sight of the fish. Following western contact, a chief named Waipa was said to have constructed a western-style vessel for Kamehameha I and utilized the *wiliwili* wood for the ship’s deck flooring. *Wiliwili* wood was also crafted into fishing floaters and used in the traditional fishing style known as *kōheoheo*, a method that was employed when catching large *mahimahi* (*Coryphaena hippurus*) fish. An early missionary account from the Ka‘ū District also notes the use of *wiliwili* wood for fencing as well as “stools” for the canoe, which is likely a reference to modern-day canoe cradles.

While fishing was an occupational pillar in traditional Hawaiian society, *he‘enalu* or surfing using carefully shaped wooden boards was a popular and esteemed pastime. For the larger *olo* or cigar-shaped surfboard, *wiliwili* was the preferred wood because of its buoyancy and lightweight. While most of the traditional uses of the *wiliwili* wood describe its use in fishing and other aquatic gear, an account written in the Hawaiian language newspapers also indicate that it was used as firewood by some people. Other accounts describe the wood being carved into wooden images that were ornately displayed in traditional *hula ki‘i*. Manaiakalani Kalua added that in certain *hula* traditional, particularly those associated with the Pele family, *wiliwili* could be associated with the goddess Kapō‘ulakīna‘u. In the dry North Kona region of Hawai‘i Island, *wiliwili* wood was carved into water troughs and placed into water collection caves.

Historical accounts and as described by several of the consulted parties, the brightly colored seeds and flowers were also utilized in traditional *lei* making. Freshly collected seeds were pierced and sewn together, while freshly picked flowers were strung together. Manaiakalani Kalua added that *lei* made from the *wiliwili* seeds if preserved well, could be worn repeatedly. On Ni‘ihau, Mike DeMotta noted that this tree was particularly prized as the *wiliwili* seeds were sometimes strewn together with the rare and delicate *pūpū o Ni‘ihau* (Ni‘ihau shells). Although the seeds and flowers were most commonly used to make *lei*, historical accounts also describe the use of the *wiliwili* wood, which was carved into a tongue-shaped pendant and threaded onto strands of carefully woven human hair to resembled the *lei niho palaoa* (ivory tooth pendant). While the *lei niho palaoa* was a status item most commonly worn by those of the ruling class, the use of the *wiliwili* was associated with the royal families of the Hilo District. The brightly hued flowers of the *wiliwili* which blooms in stunning beauty during the dry summer months was and continues to be used as an indicator for the increasing presence of sharks in nearshore waters. Several of the consulted parties spoke about the famed proverb, “*pua ka wiliwili nanahu ka manō*,” which captures the seasonal changes unique to Hawai‘i and serves as a cautionary reminder to ocean goers. The bark and flowers of the *wiliwili* were also employed in traditional healing practices. A plant-based concoction using the flowers was used to treat venereal diseases, and the bark was utilized to reduce swelling.

It is evident from culture-historical background research and from the consultation efforts that *wiliwili* was widely used in various traditional Hawaiian cultural practices. While historical accounts describing its abundance are somewhat conflicting, it is evident that *wiliwili* populations were in decline by the late 19th-century as a result of the changing political economy of the islands, particularly the shift to large scale ranching and commercial agriculture which severely impacted Hawai‘i’s dryland forest habitat. The overall decline in dryland forest habitat coupled with the impacts of private property rights are likely the key factors that have contributed to the decline in the cultural uses of this plant. Although the cultural uses of *wiliwili* may have waned during the 20th century, as evident in the consultation efforts, knowledge of the cultural and ecological significance of this plant have remained deeply embedded in the hearts and minds of Hawai‘i’s people. Though the arrival of the EGW has decimated thousands of *wiliwili* trees, it has also generated more public awareness about this plant’s importance to Hawai‘i’s dryland forest ecosystem and to Hawaiian culture.

Identification of Cultural Impacts and Recommendations

Based on the synthesis of cultural uses described above, it is clear that *wiliwili* is a culturally significant floral species and the primary habitat (Dryland forest) in which it is found could be considered a traditional cultural property that is significant under Criterion e—because it has an important value to the native Hawaiian people. For these reasons protecting all remaining populations of *wiliwili* is imperative as this will help to ensure that its environmental and cultural significance is not diminished. It is likely that increasing populations of *wiliwili* may help in the revitalization of certain Hawaiian cultural practices.

Based on the information presented in the culture-historical background and from the insights shared by the consulted parties, it is the assessment of the current study that the release of the proposed biological control agent, *Aprostocetus nitens* will not result in impacts to any valued cultural, historical, or natural resources. Conversely, cultural impacts are anticipated if no action is taken to further reduce remaining populations of the EGW from further decimating the remaining *wiliwili* trees.

While no specific cultural impacts have been identified, the consulted parties shared valuable insights, concerns, and recommendations that could reduce the potential for any future impacts and improve public transparency regarding the effectiveness of biocontrol as a conservation management strategy. Several key themes emerged from the consultation efforts, all of which are further described below:

- 1) maintain stringent pre and post-release testing and monitoring;
- 2) improved community transparency and input;
- 3) active and ongoing public outreach and education;
- 4) improve efforts to limit the introduction of potentially harmful invasive species.

While the consulted parties did not explicitly oppose the use of biocontrol, especially to aid in the recovery of Hawai'i's native plant populations, they all shared a sense of concern and spoke about the risks inherent in biocontrol activities. While they were all aware of the extensive studies that are conducted prior to the release of any biocontrol agent, they all spoke about the uncertainty of introducing another foreign insect to Hawai'i's fragile ecosystems. Several of the consulted parties noted that although pre-release host specificity test helps with the screening process, they shared that laboratory testing cannot account for all the variables found in nature. The generally held belief is that field release is merely another screening and testing procedure. Despite this element of uncertainty, all of the consulted parties agreed that some sort of action is necessary to limit the growth and spread of the EGW population. Nearly all of the consulted parties stressed the importance of thorough controlled pre-release studies to safeguard against the potential for the collateral loss of other endemic taxa or economically valuable crops. Several of the consulted parties also stressed the importance of conducting on-going and consistent post-release monitoring to ensure that the biocontrol agent does not spread beyond its intended target. These individuals noted that consistent post-release monitoring will help with early detection if it is found that the proposed biocontrol agent has unintentionally spread beyond the host plant. Wild Brawner suggested the concept of integrated pest management, particularly for native plants, where natural and cultural management practices are employed concurrently. Examples of this include, timing weed removal and planting companion plants to attract active pollinators or insects that may combat other invasive insects.

In looking to future biocontrol efforts, nearly all the consulted parties expressed the need to integrate more public input and stressed the importance of moving towards a community-based resource management structure. Based on the past release of the *E. erythrinae*, Jen Lawson felt that the public meetings held by HDOA should be restructured so that they are engaging and inclusive of community input as she believes this may improve trust between the affected communities and the agencies. Jen Lawson and Iliahi Anthony believe that supporting biocontrol research must be clearly and effectively communicated to the public using various media forms. Iliahi Anthony noted that education and outreach are key components to improve the public's understanding of biocontrol and empowering them with the knowledge and tools to help limit the spread of invasive species. Both Jen Lawson and Iliahi Anthony expressed that improving the public's understanding of the risk and benefits of biocontrol may help to build public transparency and hopefully resolve some of the misconceptions associated with biocontrol. Jen Lawson encourages the responsible agencies to consider partnering with conservation-focused non-profit organizations and community groups, especially during the field release monitoring phase as these groups are working directly with these target species daily. As noted by Kim and Forest Starr, the conventional biocontrol release methods that have been used in the past typically yields results that are underwhelming. Perhaps, the additional support from non-profit organizations could potentially improve the efficacy of biocontrol.

All of the consulted parties spoke about the many misconceptions associated with biocontrol, many of which are based on failed historical examples. While testing and screening procedures have improved significantly since the late 19th century, many people today remain resistant and skeptical to implement biocontrol. It is the authors' contention and as described by some of the consulted parties that this widely held belief stems from the agencies' lack of public outreach and education. In light of this, it is imperative that DLNR, DOFAW, and HDOA make serious efforts to participate in public outreach events and to educate the public so that these misconceptions, some of which are rooted in a historical context, can be better understood. Public outreach and education efforts should also demonstrate the potential effectiveness of biocontrol as a conservation management strategy. Iliahi Anthony spoke about the effectiveness of the Rapid 'Ōhi'a Death (ROD) community outreach efforts and believes that this could be an exemplary model. Iliahi Anthony noted that the ROD outreach team has been actively disseminating information using various media forms.

While combatting existing populations of invasive species is a critical step in managing Hawai'i's natural resources, it was noted by Manaiakalani Kalua that the State of Hawai'i must also ramp up their efforts to prevent the arrival and introduction of unwanted pest species. Manaiakalani Kalua believes that current policies and laws must be revised and strengthened. Both Manaiakalani Kalua and Iliahi Anthony noted that in their travels to other countries their customs entry process is far more rigorous and thorough. Manaiakalani Kalua believes that the State should look to other countries such as New Zealand and Japan as models to prevent the arrival of unwanted pests.

In summary, the recommendations provided above are intended to ensure that the release of *A. nitens* as a biocontrol agent for the EGW considers the culture-historical context and the concerns and thoughts shared by the consulted parties. While none of the consulted parties explicitly opposed the use of biocontrol, the concerns and recommendations offered above are intended to support the State of Hawai'i, specifically DLNR, DOFAW, and HDOA in being mindful of the cultural, social, and environmental uniqueness of Hawai'i. Conducting background research, consulting with community members, and taking steps towards mitigating any potential cultural impacts is done so in the spirit and practice of *Aloha 'Āina*, a contemporary movement founded on traditional practices and beliefs that emphasize the intimate relationship that exists between Native Hawaiians and the *'āina* (land). If DLNR, DOFAW, and HDOA assume ownership of their right and responsibility to release a biocontrol agent, we recommend it be done so in that same spirit and practice. Attention to and implementation of the above-described issues and measures will help to ensure that no such resources, practices, or beliefs will be adversely affected by the proposed release of *A. nitens*.

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APPENDIX A.
***KA WAI OLA* PUBLIC NOTICE**

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PUBLIC NOTICE

ASM Affiliates is preparing a Cultural Impact Assessment (CIA) in advance of a proposed statewide release of four (4) biological control (biocontrol) agents for four target invasive species. In brief, DOFAW is seeking to conduct a statewide field release of four (4) separate biocontrol agents on four target species:

- introduction of a wasp parasitoid (*Aprostocetus nitens*) to further control the erythrina gall wasp (*Quadrastichus erythrinae*), which has been impacting the native *wiliwili* (*Erythrina sandwicensis*);
- introduction of a small beetle (*Syphraea uberabensis*) to control weedy melastomes (*Tibouchina spp.*);
- introduction of a thrips insect (*Pseudophilothrips ichini*) to control Christmas berry (*Schinus terebinthifolia*);
- introduction of a butterfly (*Euselasia chrysippe*) to control miconia (*Miconia calvescens*).

We are seeking consultation with any community members that might have knowledge of traditional cultural uses or who are involved in any ongoing cultural practices associated with the target species (i.e. *wiliwili*, melastomes, Christmas berry, and miconia). If you have and can share any such information please contact Lokelani Brandt lbrandt@asmaffiliates.com, or Aoloa Santos asantos@asmaffiliates.com, phone (808) 969-6066, mailing address ASM Affiliates 507A E. Lanikaula Street, Hilo, HI 96720.

(Ka Wai Ola 2019:21)

**APPENDIX 2: COMMENTS RECEIVED DURING DRAFT ENVIRONMENTAL ASSESSMENT
PUBLIC COMMENT PERIOD**

Five letters of correspondence were received during the 30-day public comment period for release of *Aprostocetus nitens* for biological control of *Quadrastichus erythrinae* in Hawai'i. All letters supported the release of *A. nitens*, and therefore no significant changes were made to the draft EA in the composition of the FEA.

From: [biocontrol form](#)
To: [Wideman, Kylee K](#)
Subject: biocontrol form
Date: Tuesday, December 31, 2019 11:07:09 AM

You've got a new comment:

Comment on a Project
Target: Erythrina gall wasp (<i>Quadrastichus erythrinae</i>)
Name
Carol Kwan
Email
carol@carolkwanconsulting.com
Address
PO Box 893953 Mililani, HI 96789 United States Map It
Comments/Questions
I support the release of <i>Aprostocetus nitens</i> to complement <i>Eurytoma erythrinae</i> for the biological control of <i>Quadrastichus erithryinae</i> (<i>Erythrina</i> Gall Wasp). As a consulting arborist, I have seen the positive impact in the field of <i>Eurytoma erythrinae</i> on our native wiliwili; however, some damage is still occurring. I am hopeful that <i>Aprostocetus nitens</i> will provide the additional support needed to ensure the long term survival of this important native tree.
Do you wish to be notified during early consultation for future biocontrol projects?
<ul style="list-style-type: none">• Yes

From: [biocontrol form](#)
To: [Wideman, Kylee K](#)
Subject: biocontrol form
Date: Tuesday, January 07, 2020 1:53:58 PM

You've got a new comment:

Comment on a Project
Target: Erythrina gall wasp (<i>Quadrastichus erythrinae</i>)
Name
Fern Duvall
Email
fern.p.duvall@hawaii.gov
Address
Hawaii DLNR Division Forestry & Wildlife 685 Haleakala Hwy Kahului, HI 96732 United States Map It
Comments/Questions
I am so impressed by the thorough vetting of the EGWpredator agent for proposed release, and the noting of cultural importance of wiliwili in the document. I look forward to the EA and the culmination of planned work on the Schinus thrips and miconia lepidopteran releases. God speed with the process.
Do you wish to be notified during early consultation for future biocontrol projects?
<ul style="list-style-type: none">• Yes

From: [biocontrol form](#)
To: [Wideman, Kylee K](#)
Subject: biocontrol form
Date: Wednesday, January 22, 2020 11:10:32 AM

You've got a new comment:

Comment on a Project
Target: Erythrina gall wasp (<i>Quadrastichus erythrinae</i>)
Name
Shelley Gustafson
Email
shelley.gustafson@hawaii.edu
Comments/Questions
<p>The Hawaii Association of Watershed Partnerships (HAWP) supports the proposed release of the biological agent, <i>Aprostocetus nitens</i>, to facilitate control of the invasive Erythrina Gall Wasp (EGW). <i>Aprostocetus nitens</i> will complement existing biocontrol by <i>Eurytoma erythrinae</i>, which has been partially successful at limiting EGW impacts to our native flora. <i>Aprostocetus nitens</i> has been proven to infect smaller galls than those infected by <i>E. erythrinae</i>, such as those found on flowers, seed pods and young seedlings. Extensive testing also shows <i>A. nitens</i> as host specific, and without impacts to native Hawaiian flora and fauna. Through their complementary actions, both agents should afford greater and more comprehensive protection to important trees such as our native wiliwili, which has significant value in Hawaii as both a cultural and ecological resource. In general, HAWP strongly supports continued testing and implementation of biocontrol methods, such as the strategic release of <i>A. nitens</i>, as a means to mitigate the harmful effects of invasive species throughout Hawaii.</p>
Do you wish to be notified during early consultation for future biocontrol projects?
<ul style="list-style-type: none">• Yes

From: [biocontrol form](#)
To: [Wideman, Kylee K](#)
Subject: biocontrol form
Date: Wednesday, January 22, 2020 11:30:33 AM

You've got a new comment:

Comment on a Project

Target: Erythrina gall wasp (*Quadrastichus erythrinae*)

Name

Franny Brewer

Email

fbrewer@hawaii.edu

Address

23 E. Kawili St.
Hilo, HI 96720
United States
[Map It](#)

Comments/Questions

Aloha,
On behalf of the Big Island Invasive Species Committee (BIISC) I would like to state our support for this biocontrol release. We have reviewed the proposal and feel that adequate research has been done to ensure there is very low risk for non-target impacts from this introduction, and that the threat to our native wiliwili trees is extremely high without this action. Thank you for the opportunity to comment on this matter.

From: [biocontrol form](#)
To: [Wideman, Kylee K](#)
Subject: biocontrol form
Date: Wednesday, January 22, 2020 2:01:31 PM

You've got a new comment:

Comment on a Project
Target: Erythrina gall wasp (<i>Quadrastichus erythrinae</i>)
Name
Andrea Buckman
Email
andrea@lhwrp.org
Address
1058 Maohu St. Makawao, Hi 96768 United States Map It
Comments/Questions
Aloha no, As a practitioner of native forest restoration, I strongly support the release of a second biocontrol to help reduce the impacts of the Erythrina gall wasp on our native wili wili. Our staff assisted with the release of the first biocontrol agent for the fall wasp, and I'm hopeful this second species will complement the positive impacts the initial release had. I support further research, funding, and utilization of biocontrol as a non-chemical tool to support our native species and restore resilience and function to Hawaiian ecosystems. Mahalo. Andrea Buckman
Do you wish to be notified during early consultation for future biocontrol projects?
<ul style="list-style-type: none">• Yes