KISC

KAUA'I INVASIVE SPECIES COMMITTEE

2017 to 2022 Strategic Plan

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EXECUTIVE SUMMARY

The introduction of invasive nonnative species to Hawaii is the primary driver behind decreasing agricultural productivity, biodiversity loss, and watershed degradation. Additionally, control costs are an increasing and ongoing economic burden upon public and private landowners as well as the agricultural industry.

The costs associated with invasive species are enormous. A Legislative Reference Bureau report commissioned by the legislature in 2002 and updated in 2015, estimated an annual budget of $50 million dollars is necessary to address the invasive species problem in Hawaii. The report estimated Hawaiian produce losses due to fruit flies at $300 million annually. This figure is attributed to just a single species. Models are not available to look at the entire economic impact to the state and must be generated for each taxon, a costly and complicated endeavor. It is certain, however, that the losses are significant.

More native species have been eliminated in Hawaii than anywhere else in the United States. According to the U.S. Fish and Wildlife Service (USFWS), Kauai's rate of endemic plants is the highest in the Hawaiian archipelago with threatened and endangered listings for 161 species. Unless prevented and controlled, the impacts of invasive nonnative species on this unique native biota will continue down the path of decreasing biodiversity, ecosystem degradation and extinction. Agricultural impacts include unpalatable species infesting pasturelands, rose-ring parakeets increasing predation on both fruit and seed farms and barriers to commerce due to export/import restrictions from infested zones. Invasive species also pose threats to Hawaii's watersheds and water resources due to their characteristic of forming monotypic stands and shading out understory plant communities, which expose bare soil and increase erosion. Kauai Invasive Species Committee (KISC) uses a science-based approach to address the problem by making decisions using research and observations from field crews, partners and the public. It is the opinion of this committee that given enough time, resources and research many of these invasions can be prevented or reversed.

KISC was formed in December 2001, as a voluntary partnership of community members, business owners, private organizations, and government agencies. The formation of KISC and other island invasive species committees occurred under the University of Hawaii. The Invasive Species Committees are meant to help fill jurisdictional and response "gaps" that exist between natural resource agencies (Kraus & Duffy 2010). KISC is a consensus-based committee that adopted a mission statement, an action plan (2007), and a prioritized list of targeted incipient invasive plants and animals with Miconia (*Miconia calvescens)* as its top priority. In 2015, the committee changed governance at the request of its chair and is now an executive committee that consists of a chair, chair elect and past chair. Meetings are advertised and open to the public.

To understand the role of an invasive species committee's responsibility within Hawaii's management regime it is useful to discuss *M. calvescens*. *M. calvescens* response in

Kauai is considered a “poster child” of early detection and rapid response due the prompt actions of the conservation community in the Wailua area in the mid 1990’s. *M. calvescens* is of concern due to its persistent ability to act as an exclusion canopy, shading out understory plants. This creates monotypic stands of *M. calvescens* reaching to 50 feet. Because of its large leaves, shallow roots and competition with understory species *M. calvescens* can destroy watershed function. Large leaves concentrate rainfall into steady streams, which hit exposed soil. Due to the lack of an understory, this creates surface runoff events followed by erosion, leading to landslides as shallow roots give way in saturated soils. If *M. calvescens* escapes the Wailua area and becomes established in the rugged terrain of the Halelea Forest Reserve, it will challenge all of Kauai’s resources to control it. Approximately 158,000 (Vorsino 2014) acres of native wet forest, prime habitat for *M. calvescens*, are at risk. However, ongoing control work has restricted the infestation to 6,575 acres; control work is ongoing monthly to remove seedlings from known infestation sites and quarterly helicopter surveys are conducted to catch juveniles located in new areas before plants mature and seed. Of note is that changes in management strategy directed through new scientific information has led to the location of five new adult plants within 6 months of being implemented in 2016.

KISC also targets specific invasive animals and insects such as the coqui frog (*Eleutherodactylus coqui*), and little fire ant (*Wasmannia auropunctata*). Prevention, early detection and rapid response for species that threaten Hawaii, such as the small Indian mongoose (*Herpestes auropunctata*) and brown tree snake (*Boiga irregularis*), are also important aspects of KISC’s overall program goals. Education and public outreach programs to increase awareness in the community for both children and adults will help to increase KISC’s capacity in detecting and preventing introductions of invasive species from other islands.

MISSION STATEMENT

To prevent and control introduced invasive pests from becoming established or widespread on Kauai.

POLICY STATEMENT

The continued introduction and spread of unwanted pests and invasive organisms harms our economy, water supply, native bio-diversity, health, and the lifestyle and culture unique to this island.

Kauai Invasive Species Committee (KISC) is a voluntary partnership of government, private, non-profit organizations, and individuals working together to:

- Prevent the introduction of potentially damaging pest species to the island,
- Eliminate recently arrived (incipient) pests before they spread beyond control,
- Manage established pests in order to reduce their negative impacts, and
- Educate and involve the public as to the magnitude of the invasive species problem and the need for control programs such as KISC.

KISC is intended to supplement existing programs and aims to assist in the coordination of efforts island-wide.

KISC's priorities will be those species that are recognized as having the greatest potential to harm human welfare and native biodiversity, and where the use of limited resources are most likely to be successful. KISC field of operations is focused on incipient infestations as described in the following diagram:

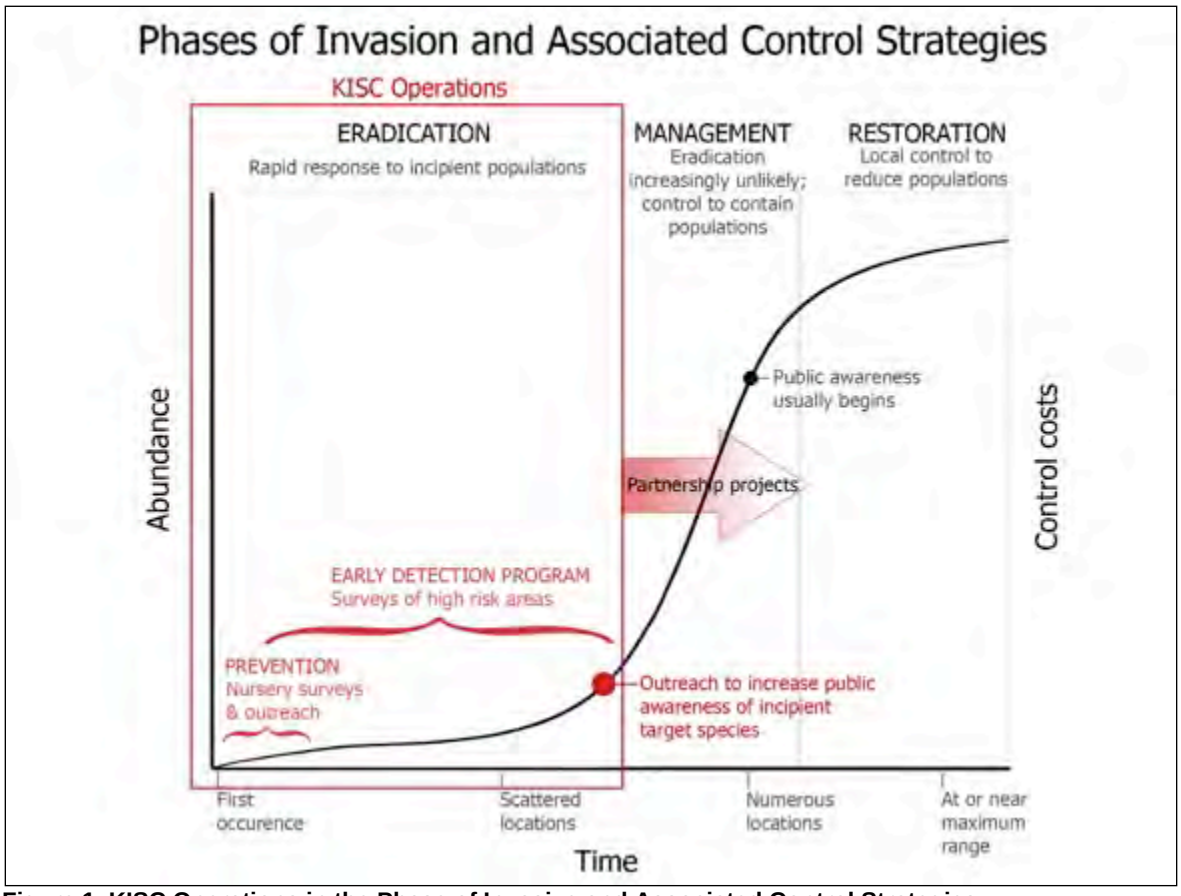


Figure 1 KISC Operations in the Phase of Invasive and Associated Control Strategies.

PROJECT NEED

THE IMPORTANCE OF INVASIVE SPECIES CONTROL ON THE ISLAND OF KAUAI

Hawaii's Alien Species Dilemma

Alien species are increasingly recognized as a threat to biological diversity and human welfare worldwide. An article in the Journal of Science stated: "Many fear that another century or so of frenetic international traffic will lead to an 'ecological homogenization' of the world, with a small number of immensely successful species" (Enserink 1999). Oceanic islands are particularly vulnerable to invasive species, and Hawaii especially so because of its role as a transportation hub. Because their biotic systems have evolved in isolation from typical continental selection forces, ecosystems of the Hawaiian Islands are substantially more vulnerable than most global ecosystems.

The introduction rate in Hawaii results in an average of 17 new alien species becoming established every year. This has created a situation where some groups of species are represented by more alien species then their native counter parts. (Rago & Sugano 2016)

The Cost of Invasive Species

While difficult to model, it is possible to estimate the economic impacts from individual invasive species through such methodologies as tracking pesticide consumption, exterminator services, crop loss reports, etc. More difficult to model are losses of ecosystem services such as groundwater recharge rates and biodiversity losses that resonate through the ecosystem such as extinction of pollinators.

The following excerpt from the 2015 Legislative Reference Bureau report: Can't See the Forest for the Albizia Trees: An Invasive Species Update (Rago and Sugano 2016), which summarizes the general economic impacts to the United States.

> "*Overall, invasive species have an enormous impact on the economy. According to a 2004 Hawaii Business article, invasive species in the U.S. cost approximately $137 billion each year. More recently, a 2013 Congressional Research Service article explained that, in the United States, potential economic costs associated with nonindigenous species are estimated at $129 billion per year*".

The federal response to invasive species is low compared to the actual cost of the impacts with the "*federal government spending $2.2 billion in FY2012*".
The variables associated with these costs include:

- **Prevention** such as port inspectors or quarantine facility costs
- **Eradication** such as KISCs elimination of coqui frogs in Lawai or work on Kalihiwai little fire ant (LFA)

- **Control** such as Kokee Hawaii State Department of Land and Natural Resources (DLNR), Natural Area Reserves Systems (NARS) and Kilauea Point National Wildlife Refuge (KPNWR) fencing to exclude pigs/predators
- **Restoration** such as out planting native species or repairing power lines struck by albizia branches.
- **Direct Losses** such as destroying infested nursery plants or crop damage
- **Predicted Losses** such as the inability to export certain products due to disease risk.

Other costs that are difficult to quantify include alteration of ecosystem processes, loss of biodiversity and quality of life.

If brown tree snakes, established in Guam but not yet established in Hawaii, were to become established here, the annual economic impact is estimated to be from $593,000,000 to $2,140,000,000 due to power outages, tourism loss, etc.

As a familiar example, Hawaii residents have been paying almost $150,000,000 in treatment and damage repair costs each year due to invasive Formosan subterranean termites that were introduced to the islands in the early 1800's.

Tourism

> *Hawaii's main economic engine is tourism. Figures for 2015 show an annual value of $14.8 billion dollars generated from visitor spending. Risks to this industry from invasive species are very real as noted in Rago and Sugano (2016) "….for example, little fire ants cause harm to residents and tourists with their powerful sting. Coqui frogs, already well established on the Island of Hawaii, have a shrill night mating call, which negatively impacts both property values and tourism. Invasive algae, such as* Hypnea musciformis*, rot and produce a foul odor, decreasing property values and hotel occupancy rates in affected areas. Specifically, algae blooms have been estimated to decrease property values by $9,400,000 annually and hotel and condominium income by $10,800,000 per year. Invasive algae caused net losses of more than $20,000,000 per year in Maui because of the cost of removing the algae from beaches.*

Finally, the establishment of diseases such as malaria and dengue, reproducing populations of snakes or the introduction of rabies into the feral cat population would likely suppress tourism profits for the foreseeable future.

Agriculture

Agriculture is of both economic and cultural importance to Hawaii. Though the $600 million industry is small compared to California, the number of jobs it creates on island is significant. As an example the National Agriculture Statistics Service notes the "2014 preliminary value of Hawaii's floriculture and nursery products is estimated at $67,200,000" which is a significant contribution to the state's economy. In addition, land under cultivation/pasture is less likely to harbor fewer invasive species due to weed and

insect suppression or grazing. Land under active management can help reduce the risk of pests transferring from the farm to the forest. Fallow lands are quickly re-invaded.

Environment

The native ecosystems of Hawaii are highly diverse and endemic. However, biodiversity health is severely compromised by the continued advance of established and incipient weed, tree, aquatic, insect, pathogens and wildlife pests. As noted in Rago and Sugano (2016):

> *Invasive species play a major role in degrading the environment by disrupting the delicate balance needed to achieve efficient ecological services, such as water purification, soil stabilization, and climate control, because invasive species outcompete native species that contribute to this balance. For example, feral pigs and M. calvescens have the potential to damage watershed functions because both contribute to eroding the top layer of water retaining soil. This becomes a cost when the watershed is damaged and other ways to obtain water must be developed. Such costs could be significant when one considers that, for example, the Koolau mountain watershed, Oahu's primary source of fresh water, is estimated to be valued between $7,400,000,000 and $14,000,000,000.*

On Kauai, there are thirteen water systems with 400 miles of pipelines delivering water to 20,000 customers. Loss of groundwater recharge capabilities, landslides caused by monotypic stands of invasive trees and contamination are all invasive species generated threats to the island's sustainability.

Other examples of environmental costs incurred by invasive species establishment include the degradation of Hawaii's coral reefs that provide a natural barrier protecting the islands from severe weather such as hurricanes and seismic events like tsunamis, expanding albizia forests creating nesting habitat for rose-ringed parakeets and reducing surface flows thorough evapotranspiration and many other threats.

Although habitat destruction has been an important cause of extinction and endangerment, the introduction of alien species has been the predominant cause of bio-diversity loss in Hawaii for over one century.

Prevention vs. Passiveness Calculation

It is common knowledge that many current pest problems could have been avoided through preventative measures at a fraction of the cost. It is very difficult to raise an alarm bell to threats that exist offshore given the intense competition for public funds among sectors such as transportation, health and education. From Rago and Sugano (2016),

Commentators suggest that the costs of constant prevention are actually lower than the costs of damage and control associated with an established invasive species. For example, in 1999, the California Legislature allocated $40,000,000 over five years to eradicate red imported fire ants. In contrast, it was estimated that the ants, if established, would cost $250,000,000 per year. While $40,000,000 may seem like an exorbitant amount of money, prevention seems like a bargain when compared to the cost if the ants had become established in California. Similarly, in Hawaii, the DOT had projected that maintenance costs to control invasive species such as fireweed, coqui frogs, fountain grass, and albizia trees along state roadways could reach $4,200,000 annually. In 2012, the DOT Highways Division launched a strategic ten-year plan to curb the introduction, spread, and negative impacts of invasive species along highways and roadways. With the implementation of new control measures, DOT predicts as much as an eighty percent reduction in costs.

The Formation of KISC

KISC formed as a voluntary partnership of community members, private organizations, and government agencies. The first meeting was held in December of 2001. KISC has developed a consensus-based committee that has adopted a mission statement, an action plan (2007), and a prioritized list of targeted incipient invasive plants and animals with *M. calvescens* as the top priority. KISC members realize that a unified effort is needed to effectively tackle the invasive species problem. KISC members include: concerned community members and groups, ranchers, farmers, nurserymen, visitor industry members, private land owners, the Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW), Natural Area Reserve System (NARS), and State Parks, Kokee Resource Conservation Program (KRCP), Hui o Laka / Kokee Museum, Kauai Forest Bird Recovery Project (KFBRP), Kauai Endangered Seabird Recovery Project (KESRP), Kamehameha Schools, Hawaii Department of Agriculture (HDOA), Hawaii Department of Health (DOH), Hawaii Ant Lab (HAL), National Tropical Botanical Garden (NTBG), The Nature Conservancy (TNC), the Kauai Group Sierra Club, United States Fish and Wildlife Service (USFWS), United States Department of Agriculture (USDA), USDA Animal & Plant Health Inspection Service (USDA-APHIS), USDA-APHIS Wildlife Services and United States Forest Service (USFS), Kauai Department of Water, Kauai Community College, Grove Farm LLC, Kauai County Farm Bureau (KCFB), A&B Properties, USDA Natural Resource Conservation Service (NRCS), Garden Island Resource Conservation & Development, Inc. (GIRC&D), Pacific Missile Range Facility (PMRF), Hawaii Army National Guard (HIARNG), University of Hawaii (UH) College of Tropical Agriculture and Human Resources (CTAHR), UH Sea Grant, Kauai Landscape Industry Council (KLIC), and the County of Kauai. KISC is also receiving support from the Hawaii Invasive Species Council (HISC) as well as coordinated efforts between all island Invasive Species Committees (ISCs) and the Coordinating Group on Alien Pest Species (CGAPS). KISC is also a founding member of the Kauai Conservation Alliance (KCA).

KISC is focused on island-wide invasive species issues concerning, but not limited to, the threat to Kauai's watershed areas, native forests and diverse native species, pasturelands, agricultural crops, recreational resources and the visitor industry. As stated in our Mission and Policy Statements, KISC's priorities are eradicating incipient invasive species, controlling the spread of established invasive populations, preventing the entry of new invasive species, and early detection and rapid response to newly discovered invasive threats. Under present conditions, Kauai faces the unchecked threat of pest introductions due to the lack of adequate quarantined transportation of people, goods, and plant materials to Kauai. Because of this, it is vital that early detection protocols and surveys be fully functional and implemented at all times.

The demand for KISC's services here on Kauai is high and with the support of the community at large, the State of Hawaii, and partner's funding sources, KISC will make a significant impact on both the preservation of our irreplaceable resources and the prevention of possible negative effects on the local economy.

KISC's role in Island-wide Response

Resource managers, ranchers, farmers, and other concerned community members recognize that although active on-site vigilance and management are essential for protecting native ecosystems, pastures, and crops, long-term protection of these areas may depend more than anything else on the success of keeping new alien plant and animal species from becoming established and spreading island-wide. Preventing establishment and spread of new introductions is not only cost-effective, but also practical. Likewise, resource managers recognize the need to work together on invasive species problems and solutions.

KISC is a grass-roots organization that has the capacity to survey, map, and control incipient invasive pests, act as an early-detection rapid-response team, as well as conduct long-term invasive species management. The majority of KISC's funding is sourced from Federal, State, and County level agencies such as: the USFS, USFWS, HISC, the State of Hawaii, and the County of Kauai. Invasive Species Committees (ISCs) have now become established on all of the main Hawaiian Islands: Maui County was the first to form a committee, Maui Invasive Species Committee (MISC), in 1997; Molokai has its own subcommittee called Molokai Maui Invasive Species Committee (MoMISC); Big Island (Hawaii) established a Melastome Action Committee (BIMAC) in 1995 that focused on *M. calvescens* and expanded its focus to become Big Island Invasive Species Committee (BIISC) in 1999; Oahu Invasive Species Committee (OISC) was formed in the fall of 2000.

Each island has a different mix of agencies, stakeholders, and interest groups, with each contributing uniquely toward effective grassroots action against invasive species. As the earliest ISC formed, MISC's successes and failures guide efforts statewide. In addition, the ISCs have the potential for contributing to national and world models for such efforts. The ISCs work on several levels: building partnerships on each island to combat the worst invasive pests facing that island; with each other on common goals to

prevent the spread of species from island to island; and with the statewide CGAPS in an effort to prevent new pests from entering the state by changing or enacting more effective policies, procedures, and legislation.

The management challenges for species such as *M. calvescens* and other aggressive alien invaders provide examples of why committed, long-term funding is crucial to the effective control strategy for Kauai's worst pests. Populations of targeted invasive species remain, established seed banks persist, landowner access is pending in some areas, new areas need to be surveyed, and there is a steady stream of new introductions that have the potential to highly impact the state of Hawaii and Kauai's economy, environment, and quality of life. KISC is committed to early detection and a quick response with long-term sustainable efforts to eradicate and control these unwanted invaders.

KISC has an active outreach program to distribute the latest knowledge and issues relating to invasive species issues. KISC targets school curriculums, develops educational materials, acts as liaison to the landscaping and horticultural trade, and interacts with the public at various venues across the island. The public's support will be a critical factor in the success of KISC's objectives.

With continued funding KISC has been able to establish an office/base-yard that serves as their hub of operations. This facility is located at the CTAHR Kauai Agricultural Research Station located in Wailua.

Staffing and Governance

In FY 2015, sufficient funds were released by the legislature to allow KISC to fill all positions. These include, filling two vacant crew positions, a full-time outreach specialist and the addition of an early detection botanist (see Fig 2). The chair elect also suggested the formation of an executive committee to consist of a committee chair, a chair elect and a past chair. This streamlined governance was adopted during the KISC annual meeting in October 2014, where the attendees selected a new chair and chair elect.

In the early days of KISC's formation, the committee was larger and meetings held more frequently. As the nature of the problem revealed itself to be long-term repetitive management actions (e.g. repeated monthly sweeps for *M. calvescens* until the seed bank is exhausted in as much as 23 years) there were less management actions for the committee to decide and less diversity for KISC reporting. In 2014, eight years had passed since the last action plan was authored and it was determined that old strategies and actions needed to be updated and the early detection and priority target lists revisited. 2015-2016 was used as a data synthesis time where seven years of hardcopy data were entered into the KISC database, trend analysis was conducted and an early detection program implemented. The early detection botanist has identified possible new target species which will be evaluated in 2017 and beyond for staff action.

Beginning in 2017, executive committee meetings will be held quarterly focusing on deliverables met during the previous three months, trends discussed, votes on adding new targets or removing old ones and budget updates. The executive committee is a voting body that will direct actions of the KISC operations. The committee will also act as a personnel liaison between KISC staff and the Pacific Cooperative Studies Unit (PCSU) at the University of Hawaii Manoa campus. The committee will accommodate any number of "technical advisors" deemed necessary for assisting informed decision making, though voting power will reside with the executive committee. All meetings are open to the public and announcements will be sent out on the KISC Listserve.

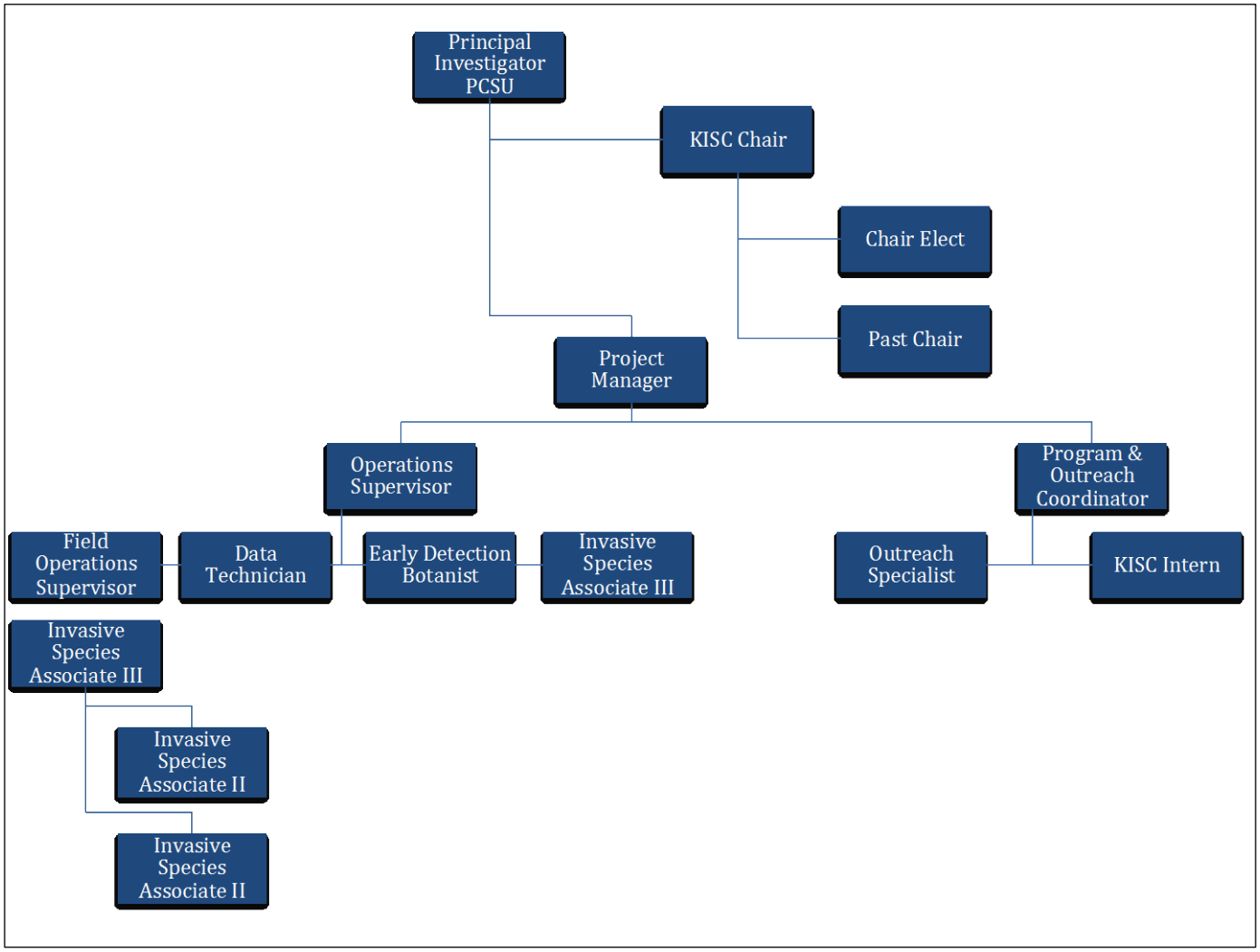


Figure 2 KISC Employee flowchart

PLANTS

EARLY DETECTION PROGRAM

The environmental and economic benefits of identifying and controlling alien plants during their incipient stage are well established. KISC's 2017-2022 strategic plan seeks to incorporate new methods to increase the value of early detection data, better inform management decisions, and build on previous early detection efforts.

Past projects associated with KISC's Early Detection Program have included:

- Compilation of a map showing publicly available roads on Kauai using a GIS platform.
- 2007 Island-wide survey contracted to NTBG Staff.
- 2010 Island-wide survey contracted to OISC Early Detection Botanists.
- 2014 State road survey contracted to OISC Early Detection Botanists in fulfillment of the Hawaii Department of Transportation's Statewide Noxious Invasive Pest Program (SNIPP).
- Production of a plant prevention field guide; a book of additional invasive pests (taken out daily with by the ground crew) containing information on plants with a high potential of arriving on Kauai from neighboring islands.

Conceptualization

Kauai's alien plants are comprised of both intentional and unintentionally introduced species and factors affecting their rate of spread are tremendously variable and not always well understood. These factors include the number of individuals introduced (e.g. occasional ornamental vs. large forestry planting), time since arrival and habitat suitability of the originally colonized area. Furthermore, Kauai's lowlands are largely dominated by alien species while high elevation native ecosystems are being managed to control encroaching alien species, many of which differ from those that dominate lowlands. As KISC strives to target eradicable species with the highest invasive impacts, the complexity of Kauai's flora necessitates a data-rich strategy to make sound management decisions. Thus, the Plant Early Detection strategy will focus on compiling and contributing to three main types of data: 1) Taxonomic, 2) Ecological and 3) Geospatial. These data will be amassed into a Kauai Alien Plant Database which will be queried to inform KISC's Prioritization and Feasibility of Control (PFC) process (see Appendix A). This concept is represented in the figure 3 below, with circles representing the critical information necessary to make management decisions and the overlapping areas describing the risk of wasting resources by acting on insufficient data.

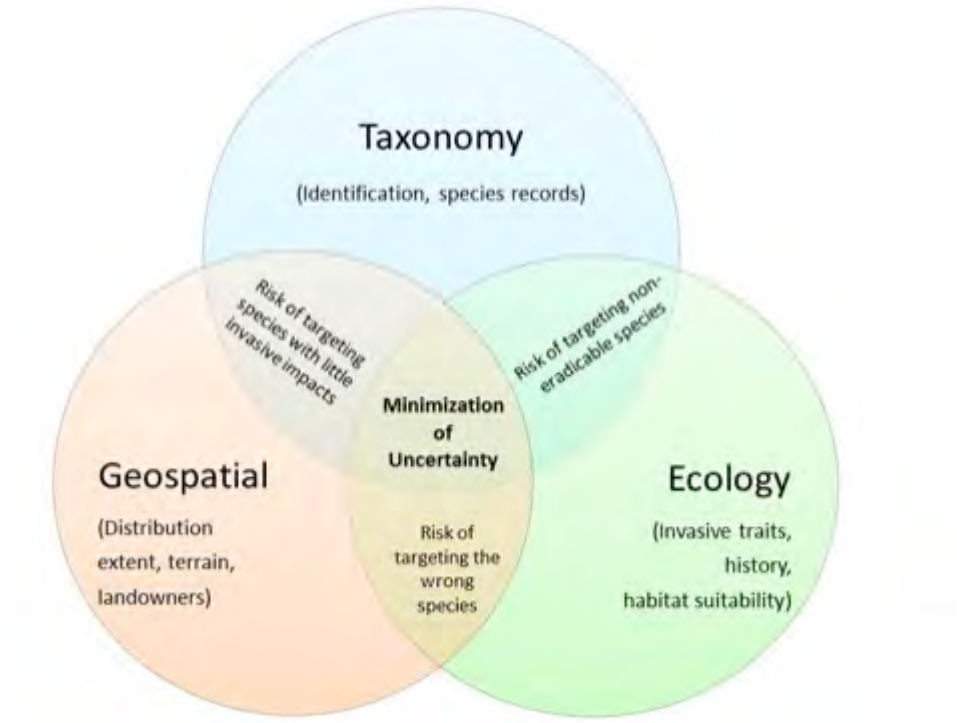


Figure 3 Conceptualization of information to make management decisions about eradicating species.

This strategy makes use of data generated by other organizations while illuminating knowledge gaps that need to be filled by the KISC Early Detection Botanist via field surveys. As of 2016, the following data sources are currently being, or are planning to be, utilized:

Taxonomy

- National Tropical Botanical Garden on-island herbarium (PTBG), NTBG specialists, and library resources used to identify specimens.
- Digitized herbarium records from NTBG, Herbarium Pacificum (BISH; Bernice Pauahi Bishop Museum herbarium) and Pacific Consortium of Herbaria used to generate Kauai-specific alien plant lists.
- State Native/Naturalized checklist compiled by Bishop Museum used to inform which species are considered naturalized on Kauai.
- Forestry Planting Records are used to see which species were historically planted in certain areas.

Ecology

- Hawaii Pacific Weed Risk Assessment (HPWRA) is used to help predict the likelihood of naturalization and potential invasive impacts.
- State Native/Naturalized checklist compiled by Bishop Museum used to inform which species have naturalized on which islands across the Hawaiian archipelago, which helps predict the likelihood of naturalization on Kauai.

- Digitized herbarium records listing specific locations are used to determine patterns in habitat use and predict which habitats on Kauai would be most impacted.
- Data is mined from numerous publications documenting invasive history to predict likelihood of naturalization and invasive impacts (e.g. Pacific island weed inventory, globally recognized invasive plant databases, etc.).

Geospatial

- Previous early detection survey data are used to generate maps where locations of potentially incipient species have been recorded.
- Locations of rare plants as indicated by “popref” polygons will be used to determine overlap with incipient plant data points to help predict future threats to endangered taxa.
- GIS layer of Kauai TMKs (Tax Map Key) is used to determine the identity and number of landowners overlapping an infestation and should be updated annually.
- Aerial imagery and maps indicating topography and access for control crews are used to determine whether control efforts are safe and feasible.
- GIS layers of districts, watersheds, and pop refs are used to designate and report on management areas.
- Digitized herbarium records listing specific locations will be imported into ArcMap to supplement delimiting survey data to determine the extent of the infestation.

Implementation

Botanical surveys will be conducted on a recurring basis to generate reliable distribution information and accurate plant identifications. Vouchers and observations of alien species including new island records and important range extensions will be collected to contribute to the basic understanding of Kauai’s flora. These data will be continuously entered into the Kauai Alien Plant Database, which may be useful to other Kauai conservation groups for decisions regarding detection, control and restoration when properly formatted. An overview of how the Early Detection Program will be implemented to influence the KISC Target Species list is represented in Figure 4 below. This framework is followed to identify actions to be taken when alien species are detected and illuminate options for control (i.e. eradication by KISC alone, partnership projects, requiring out-of-scope funding, etc.).

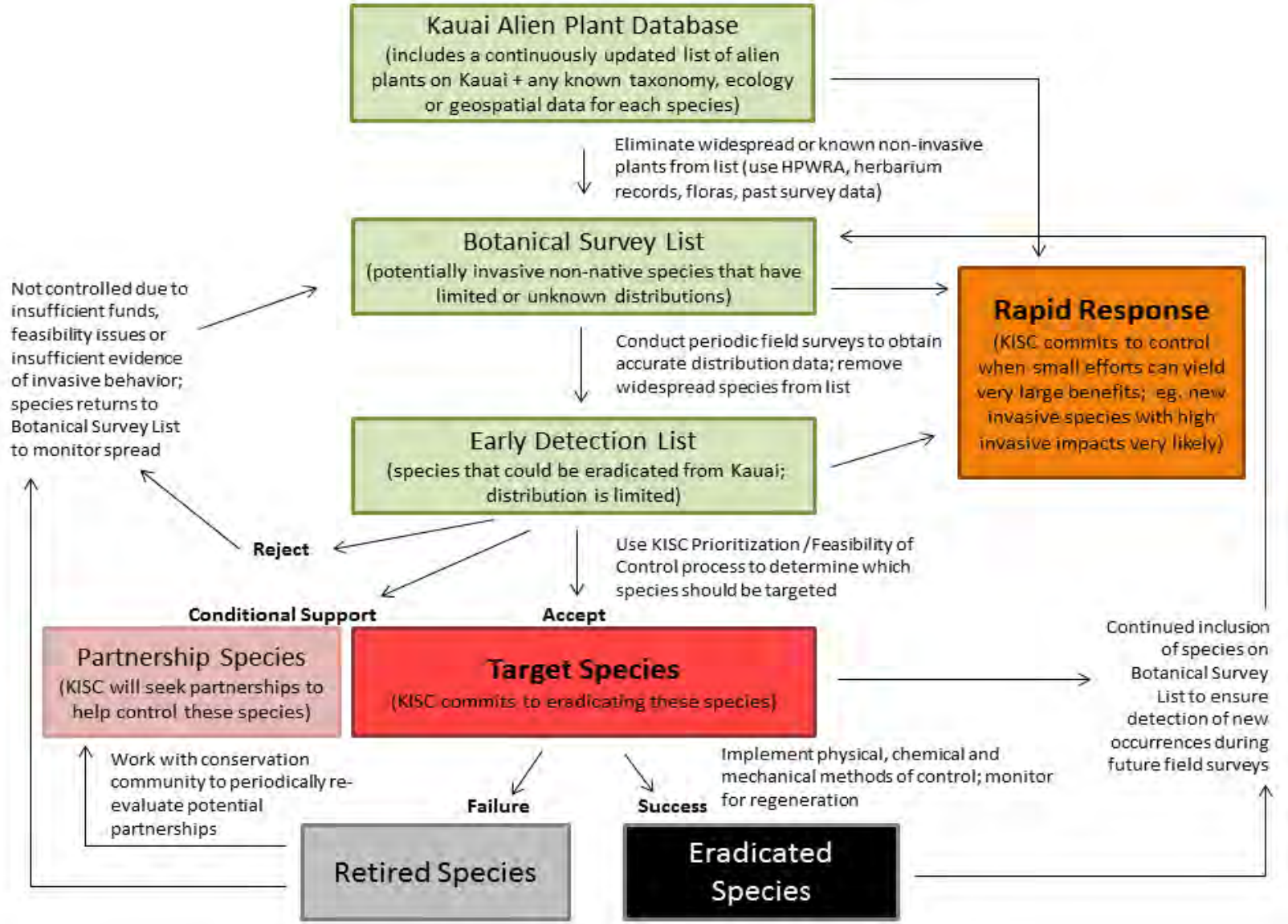


Figure 4 Outline of the KISC Plant Early Detection Program (Brock & Keanini 2016).

Early Detection Surveys

Botanical Survey List

A Botanical Survey List will be developed for use during field surveys for which GPS and other data (see Early Detection Surveys Section below) will be collected for each listed species encountered. This list will be derived from the Kauai Alien Plant Database by prioritizing species with apparently limited (or unknown) distribution statuses and evidence of invasive traits or invasive behavior. Local botanists and land managers will be contacted regularly for their input.

Early Detection List

Early detection surveys will be conducted in order to determine distribution status of the species on the Botanical Survey List and detect new species. Once >80% of surveyable areas have been completed, an Early Detection List will be constructed by removing species from the Botanical Survey List that are not eradicable. Areas considered likely sites for incipient plant species invasions will be surveyed, including:

- All accessible roads on Kauai
- Nurseries and Seed stores
- Public Gardens and Arboretums
- Ports of Entry
- Uncultivated areas adjacent to nurseries, gardens and other areas of plant cultivation.
- The first mile of every popular hiking trail
- Field Landing Zones
- Large Developments/construction sites
- PMRF
- Inter-island traffic (Fed Ex, UPS, etc.)
- Known invaded sites based on expert opinion (HDOA survey sites, Old Botanical garden in Kalaheo, Fruit Farm on Oo Road)

To maximize detection of all populations, digitized herbaria data as well as Kauai conservation partners will be queried for current or past locations of plants on the Early Detection List. Detailed delimiting surveys including location, as well as size and structure of the population will be conducted for species on the Early Detection Species List. This data will be entered into the KISC database and collections of specimens will be deposited in PTBG and BISH herbaria. Plants considered “Early Detection Species” from previous surveys are listed in Table 1 below and will be assessed using KISC’s annual report that will be distributed to the KISC committee, collaborators and interested parties will include the following:

- A map of areas surveyed
- A list of all species encountered on the Early Detection Survey List and their assigned distribution rank
- Distribution maps for species on the Early Detection Survey List

- A Prioritization and Feasibility of Control assessment for potentially eradicable species (see Appendix A)

Rapid Response

Construction of the Kauai Alien Plant Database and communication with statewide ISCs and conservation groups will provide a useful consolidation of knowledge necessary to identify and act on high-impact, newly colonized alien plants. Information regarding species that pose significant environmental or economic threat, is dispersed through KISC outreach events and information pamphlets to increase the likelihood of detection by the public. In the event that one of these species is detected, KISC will promptly attempt to eradicate the species before it spreads. If a significant amount of resources are being spent, KISC will implement a Prioritization and Feasibility of Control assessment with executive committee consultation to determine whether control methods should continue. As part of this commitment, KISC maintains and adapts its resources to ensure it can rapidly delineate and organize control of incipient invasive species populations. This includes maintenance of current map data, appropriate field equipment, property access information, and trained staff.

EARLY DETECTION PLANT SPECIES

From 2002 until recently, KISC has regarded 27 taxa as early detection species (Table 1), which are thought to be of limited distribution on Kauai (Figure 4; Early Detection Surveys section (pg. 18)). These species were designated based on a variety of factors including public reports, expert opinion, early detection surveys and assessing neighbor island ISC targets. Table 1 lists all the early detection species that have considered since the creation of KISC, including the number of active, monitored, and eradicated sites as well as the number of work hours contributed to each species. Four species including *Calliandra houstoniana* var*. calothyrsus, Cissus nodosa, C. verticillata* and *Morella cerifera* are elaborated on below due to high amount of work hours contributed, as well as notable control methods. More species will be added to the early detection list once early detection surveys are 80% completed. This list will subsequently undergo target species evaluation via KISC's Prioritization and Feasibility of Control process (Figure 4, Appendix A).

Table 1 Historic Early Detection Species

Scientific Name	Common Name	Work Hours	Year	Locations	Active Sites	Monitoring Sites	Eradicated Sites
Alstonia macrophylla	devil tree	10	2011	2	0	0	0
Bischofia javanica	bishopwood	8	2011	4	0	0	0
Calliandra houstoniana var. calothyrsus	calliandra	323	2014-2016	3	1	0	0
Calotropis procera	small crownflower	12	2009-2015	2	0	0	0
Cenchrus logisetus	feathertop	6	2011	2	0	0	0
Chromolaena odorata	bitterbush, siam weed	29	2013-2015	0	0	0	0
Cirsium vulgare	bull thistle	8	2009	5	0	0	0
Citharexylum caudatum	fiddlewood	34	2002-2013	50+	0	0	0
Citharexylum spinosum	fiddlewood	33	2003-2007	30+	0	0	0
Cissus nodosa	Javanese treebine	125	2008-2014	2	0	2	0
Cissus verticillata	princess vine	180	2011-2015	11	0	1	0
Clerodendrum glabrum	Natal glory bower	12	2009	3	0	0	0
Clerodendrum wallichii	clerodendrum	20	2012	2	0	0	0
Cryptostegia madagascariensis	rubber vine	80	2011-2012	14	0	0	0

Scientific Name	Common Name	Work Hours	Year	Locations	Active Sites	Monitoring Sites	Eradicated Sites
Dillenia suffruticosa	simpoh ayer	36	2010-2014	2	1	0	1
Derris elliptica	tubaroot	4	2011	1	0	0	0
Elaeagnus triflora	silverberry	44	2008-2009	2	0	0	0
Hiptage benghalensis	hiptage	60	2003-2005	11	0	0	0
Leptospermum scoparium	broom tea tree	32	2004	1	0	0	0
Ligustrum sinense	chinese privet	6	2011-2012	5	0	0	0
Morella cerifera	firetree	75	2011-2015	3	0	0	2
Nicotiana glauca	tree tobacco	1	2008	2	0	0	0
Odontonema cuspidatum	fire spike	24	2009	14	0	0	0
Pereskia aculeata	barbados gooseberry	120	2011-2016	8	2	1	3
Pueraria montana var. lobata	kudzu	2	2002-2003	1	0	0	0
Rubus sieboldii	Molucca raspberry	632	2009-2016	7	1	0	0
Salvinia molesta	salvinia	190	2003-2016	6	1	0	0
Tamarix aphylla	athel tamarisk	95	2011-2014	5	0	2	0

Trend Analysis

Tracking target trends through regression analysis is a new function of KISC's data stewardship program. The analysis uses the method known as "Catch per Unit Effort" (CPUE). This is a value representing *average* ($\bar{Y}$) number of plants controlled per hour over a given year.

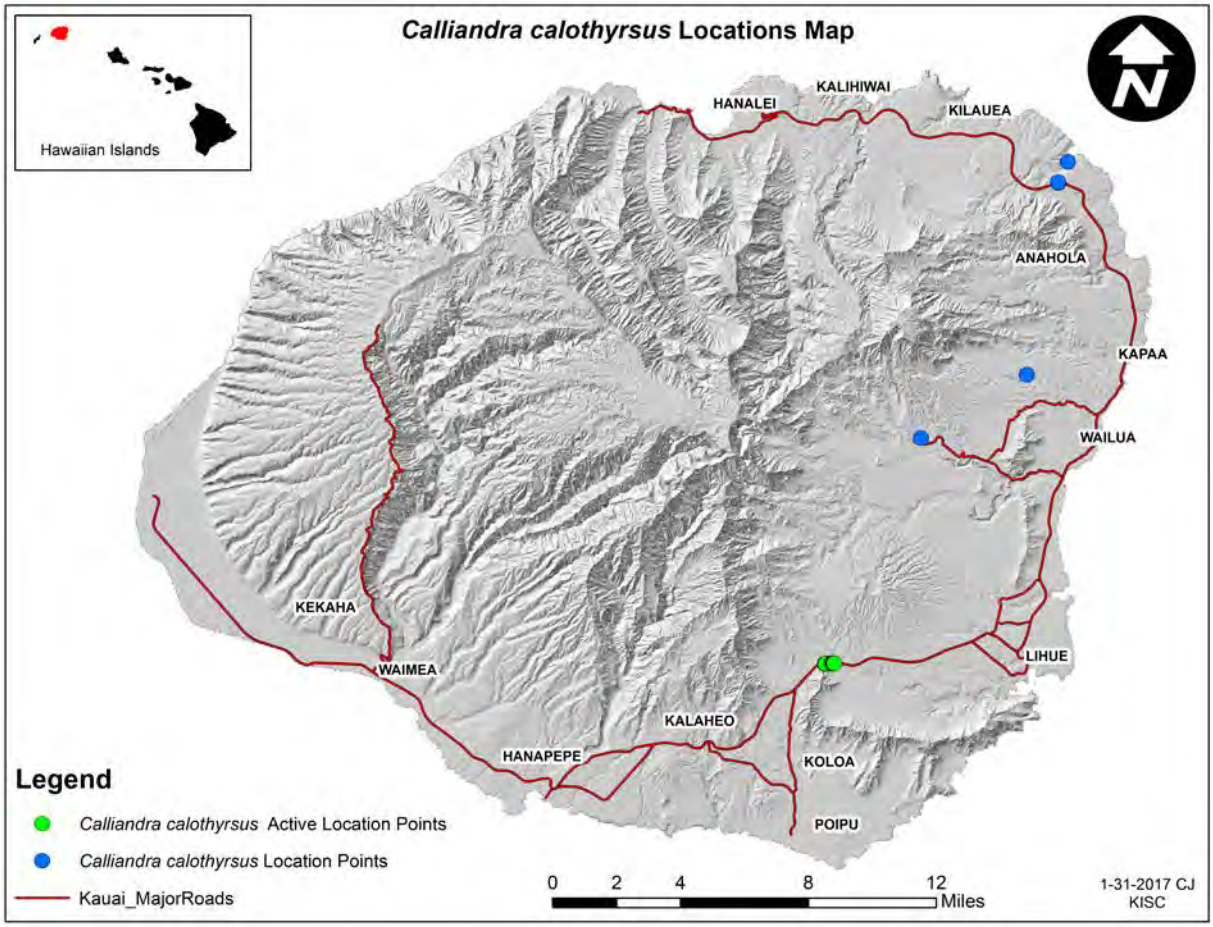
The concept is that it should take field crews more time finding targets if you are decreasing the population over time. KISC can analyze individual management units so the area is held constant, however combining all units for a given taxa is useful for looking at general trends. These trends will inform the committee and funders if we are winning, losing or somewhere in the middle. ***It is important to note that CPUE can only be generated on actively managed (control + monitoring) sites***. Known sites that are not currently managed must be factored into feasibility decision-making. The current CPUE graphs will be constantly updated and are a good indication of KISC's ability to control a specific taxon.

The trends will also inform our management decisions such as providing an estimated time to eradication. It is also useful in determining when a target has become unmanageable given KISC resources or if work should continue with the expectation that trend lines will begin to improve in the near future based on qualitative variables.

All graphs are generated from excel pivot charts from the KISC master taxa spreadsheet. Annual data inputs automatically update the charts.

The following species accounts, as well as those within the target and eradicated target species sections (pg 32 and pg 64, respectively) detail each of KISC targets and trends.

Calliandra (*Calliandra houstoniana va calothyrsus)*



Map 1 Calliandra houstoniana var calothyrsus

Status: Early Detection Species

Photo 1 *C. houstoniana var calothyrsus* flower along Halfway Bridge

Background: Calliandra (*Calliandra houstoniana var. calothyrsus*) (Photo 1) is a small nitrogen-fixing tree or large shrub that is native to Central America and Mexico. Outside of its native range it has been utilized for agroforestry purposes and has become naturalized along riverbanks and disturbed areas. In the state it is naturalized on Maui, Lanai, Hawaii Island, and Kauai. On Kauai most plants are located at the Hawaiian Mahogany Inc. planting site located east of Kahoaea and west of Halfway Bridge on Hwy 50 where it was planted as a nurse crop for *Eucalyptus* (Map 1). However, both the nurse crop and the *Eucalyptus* remains unharvested. More recently, 2 more locations have been found in

Moloaa. Past control of this plant has been focused on saplings adjacent to Hwy 50 as part of Hawaii Department of Transportation's Statewide Noxious Invasive Pest Program (SNIPP) (Figure 5). Early detection survey data from 2016 confirm that mature trees continue to grow on the planting site.

Objective: Evaluate

Strategy: Conduct KISC Prioritization and Feasibility of Control assessment (Appendix A) to determine if species should become a KISC target.

Actions:

- Continue island-wide early detection surveys to detect new populations
- Continue delimiting surveys to establish the extent of known locations
- Contact landowners to determine access feasibility

Treatment methods:

- Trees are cut by chainsaw, handsaw, or machete. Stumps are treated with Garlon4 Ultra mixed with forest crop oil at a 50/50 ratio. Debris is left on site.
- Seedlings receive a foliar application of Garlon4 Ultra at 8% mixed with water.

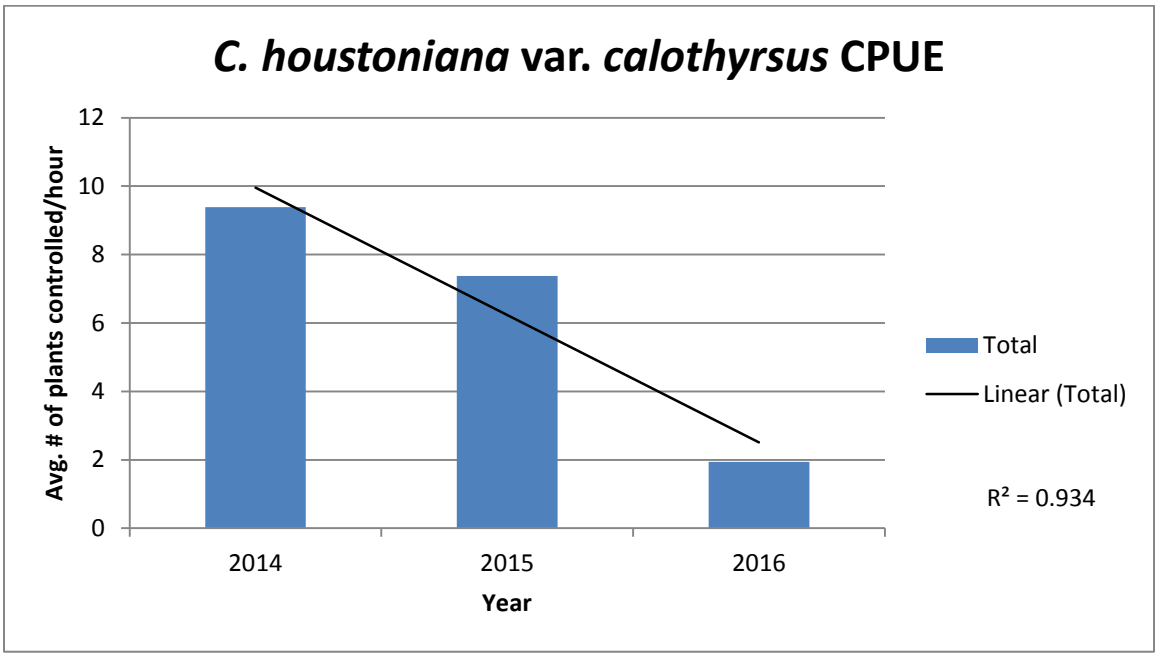
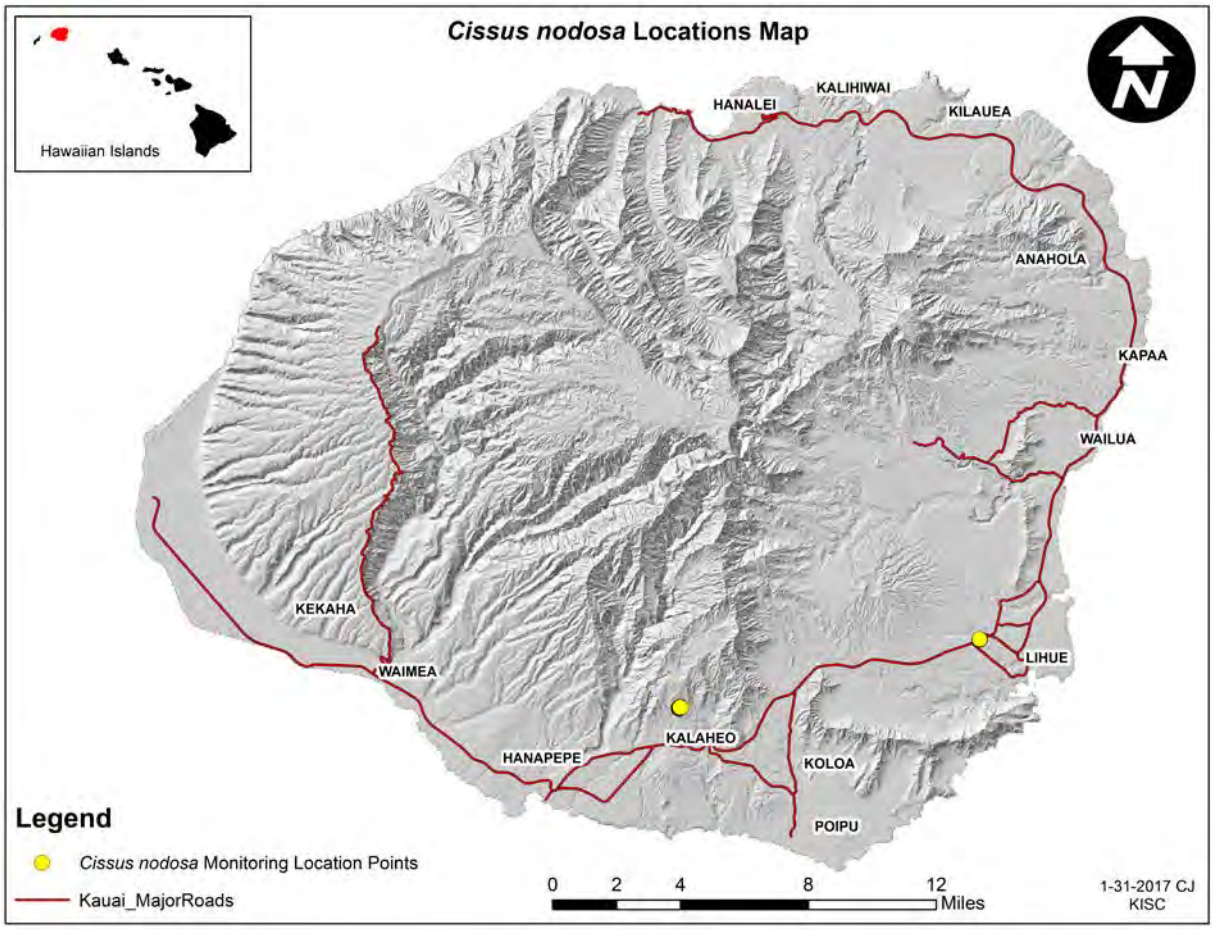


Figure 5 Linear regression of *C. houstoniana* var. *calothyrsus* In the HDOT right-of-way at Halfway Bridge showing CPUE trending down. However, it should be noted that deep guinea grass hiding seedlings may be obscuring the trend. Additionally, a large planting adjacent to this site (planned for removal) is likely reseeding into the area.

Grape Ivy (*Cissus nodosa*)



Map 2 *C. nodosa* locations

Status: Early Detection Species

Background: Grape ivy (*Cissus nodosa*) is a large vine (Photo 2) native to Indonesia and Malaysia with a climbing habit, growing over nearby trees and structures. It has naturalized on Oahu, the Big Island, and Kauai (Map 2). KISC has tried multiple herbicides to control this plant with little success. Treating this plant has proved labor intensive and ineffective (Figure 6), and good taxonomic skills are required to identify grape ivy from other vines growing at infested sites.

Objective: Evaluate

Strategy: Conduct KISC Prioritization and Feasibility of Control assessment (Appendix A) to determine if species should become a KISC target.

Photo 2 *C. nodosa* climbing a tree

Actions:

- Continue island-wide surveys to detect new populations
- Provide crew training in identification
- Work with Dr. James Leary of CTAHR to determine effective treatment methods
- Continue delimiting the extent of known locations if effective treatment methods are discovered.

Treatment methods:

The following trial application have had the most success:

- Fill in Notch/scrape method: vine bark is scraped (about 3 to 4 inches) and 50% Garlon4 Ultra/crop oil mix is applied to wound.

The following trial applications have been attempted with little success:

- Foliar Application of Stalker (Imazapyr) applied at 3% and diluted with water. Sprayed on foliage using squirt bottles/ back pack sprayers
- Drizzle Application of 20% Stalker diluted with water
- Foliar Application of Milestone (aminopyralid) at 3% diluted with water.
- Foliar Application of Milestone at 3% mixed with ammonia sulfate and water
- Foliar app of Milestone at 7% mixed with water
- Foliar app of Milestone at 7% mixed with water and ammonia sulfate.
- Foliar app of MCP Amine 4 (2-Methyl-4chlorophenoxyacetic/2-4D) at 1% mixed with water
- Foliar app of MCP Amine 4 at 3% mixed with water

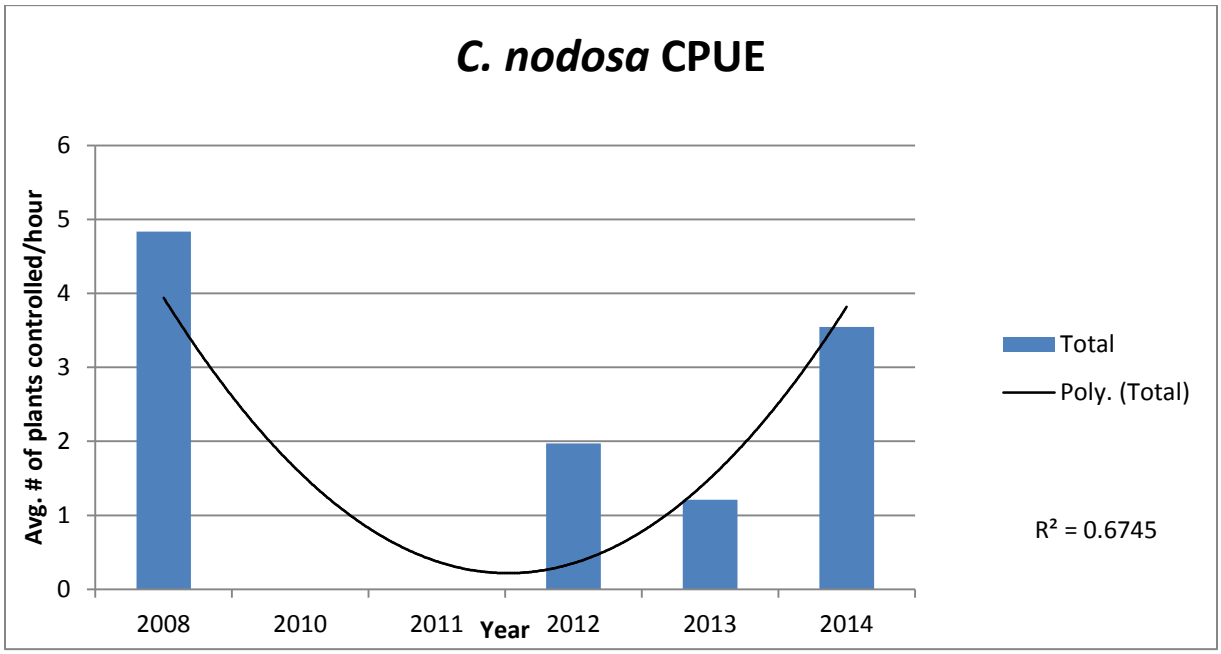
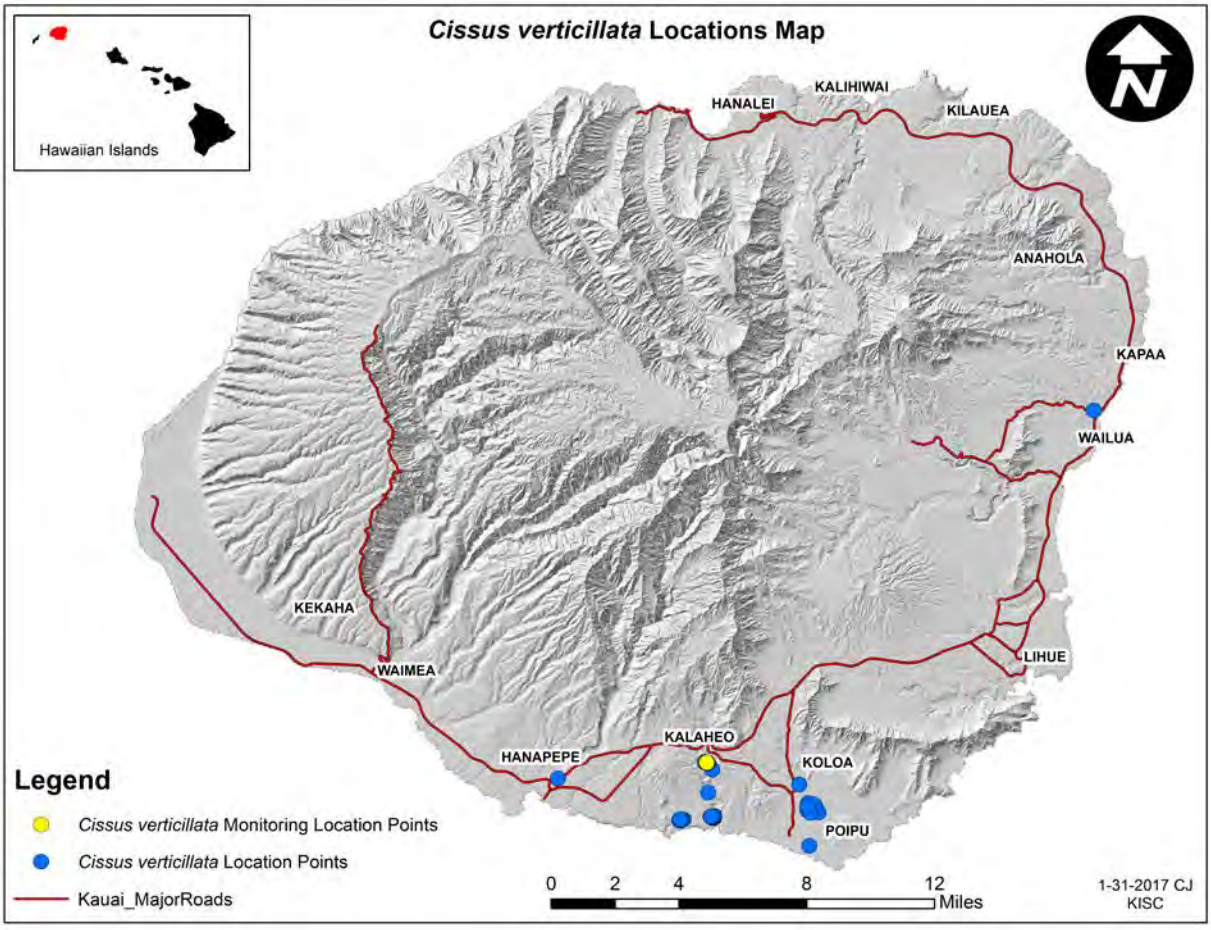


Figure 6 Linear regression of both known *C. nodosa* sites indicating an overall trend of decreasing and then increasing despite control efforts, decreasing the likelihood of selecting this species as a KISC Target.

Season Vine (*Cissus verticillata*)



Map 3 *C. verticillata* locations

Status: Early Detection Species

Background: Season vine (*Cissus verticillata*) is a large woody vine (Photo 3) native to Central and South America that has naturalized on Kauai and Oahu. It can grow in a wide range of habitats from sea level to 2500 m. Additionally it is an alternate host for Hibiscus mealybug (*Maconellicoccus hirsutus*). Eleven locations of this plant were detected during a roadside survey in 2010 (Map 3). KISC has tried multiple methods to control this plant with little success (Figure 7) and one location is on agricultural land where herbicide must be used with caution.

Photo 3 *C. verticillata* treated with herbicide

Objective: Evaluate

Strategy: Conduct KISC Prioritization and Feasibility of Control assessment (*Appendix A*) to determine if species should become a KISC target.

Actions:

- Continue island-wide surveys to detect new populations
- Work with Dr. James Leary of CTAHR to determine effective treatment methods
- Continue delimiting the extent of known locations if effective treatment methods are discovered.

Treatment methods:

The following trial applications have been attempted with little success:

- Notch/scrape method- vine bark is scraped (about 3 to 4 inches) and 50% Garlon4 Ultra/crop oil mix is applied to wound.
- Foliar Application-Stalker (Imazapyr) applied at 3% and diluted with water. Sprayed on foliage using squirt bottles/ back pack sprayers
- Drizzle Application- 20% Stalker diluted with water
- Foliar Application of Milestone (aminopyralid) at 3% diluted with water.
- Foliar Application- Milestone at 3% mixed with ammonia sulfate and water
- Foliar app- Milestone at 7% mixed with water
- Foliar app- Milestone at 7% mixed with water and ammonia sulfate.
- Foliar app- MCP Amine 4 (2-Methyl-4chlorophenoxyacetic/2-4D) at 1% mixed with water
- Foliar app- MCP Amine 4 (2-Methyl-4chlorophenoxyacetic/2-4D)

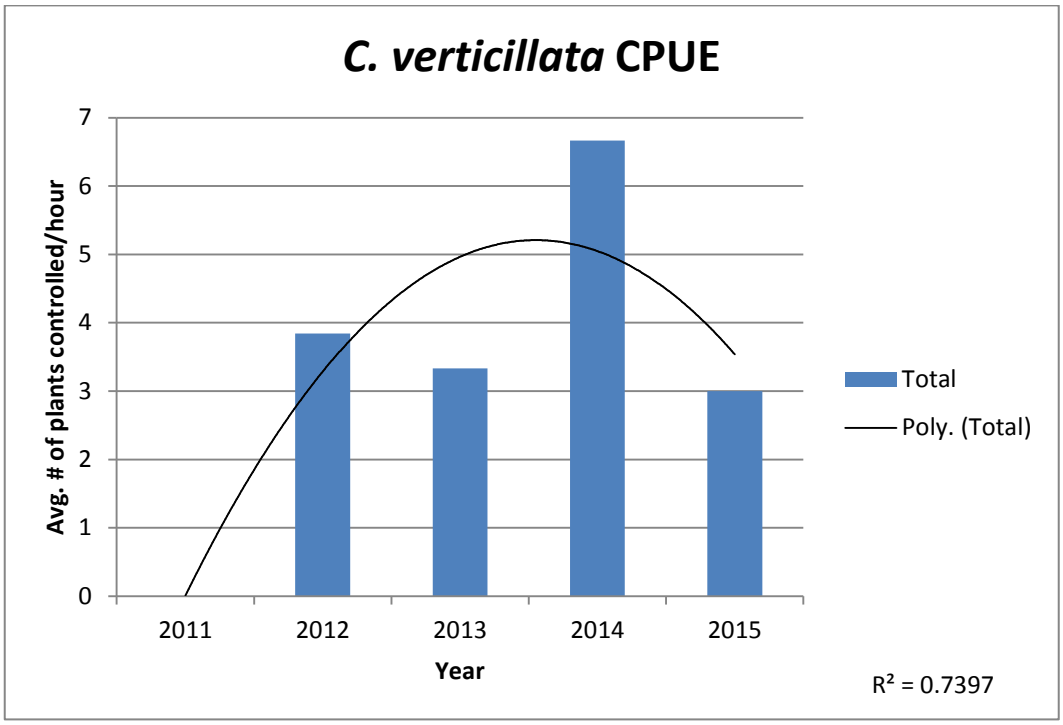
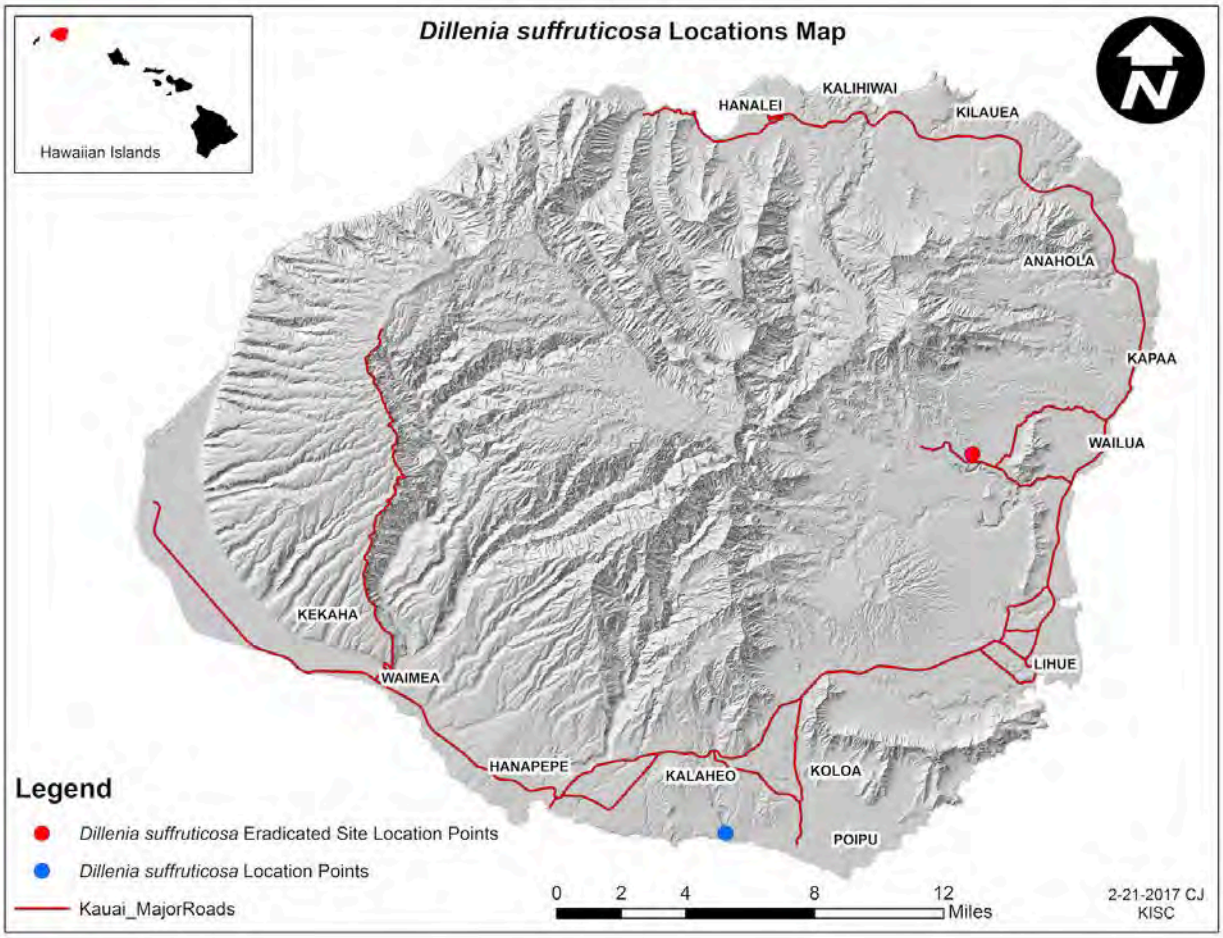


Figure 7 Depending on new populations, this is a positive trend though too short term for value.

Simpoh *Ayer* (*Dillenia suffruticosa*)



Map 4 *D. suffruticosa* locations

Status: Early Detection Species

Background: Simpoh ayer (*Dillenia suffruticosa*) (Photo 4) is a shrub that is native to Southeast Asia that rapidly occupies moist habitats. This plant is well known as an invasive in Singapore and has been observed forming dense thickets with no understory on low elevation ridges of windward Oahu. One remaining location of this plant exists at NTBG (Map 4) and the remaining location outside of NTBG has been eradicated (Figure 8).

Objective: Evaluate

Strategy: Continue monitoring and early detection surveys

Photo 4 *D. suffruticosa* flower
Photo credit: Wilbowo Djatmiko (Wie146)

Actions:

- Continue island wide surveys to detect new populations
- Continue monitoring eradicated site
- Determine monitoring duration
- Work with NTBG staff to determine feasibility of removing this species from their living collection

Treatment methods:

- Cut Stump treatment- Trees are cut by chainsaw, handsaw, or machete. Stumps are treated with Garlon4 Ultra mixed with forest crop oil at a 50/50 ratio. Debris is left on-site.

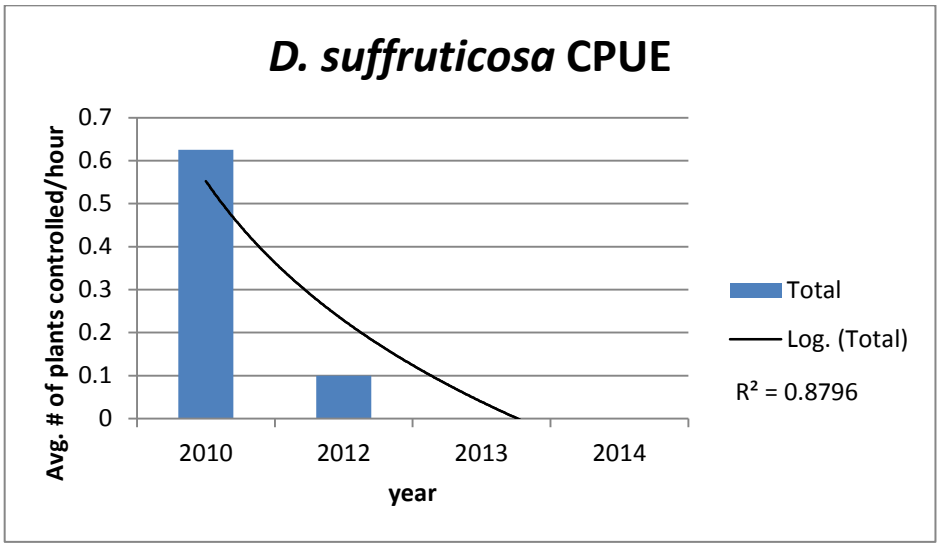
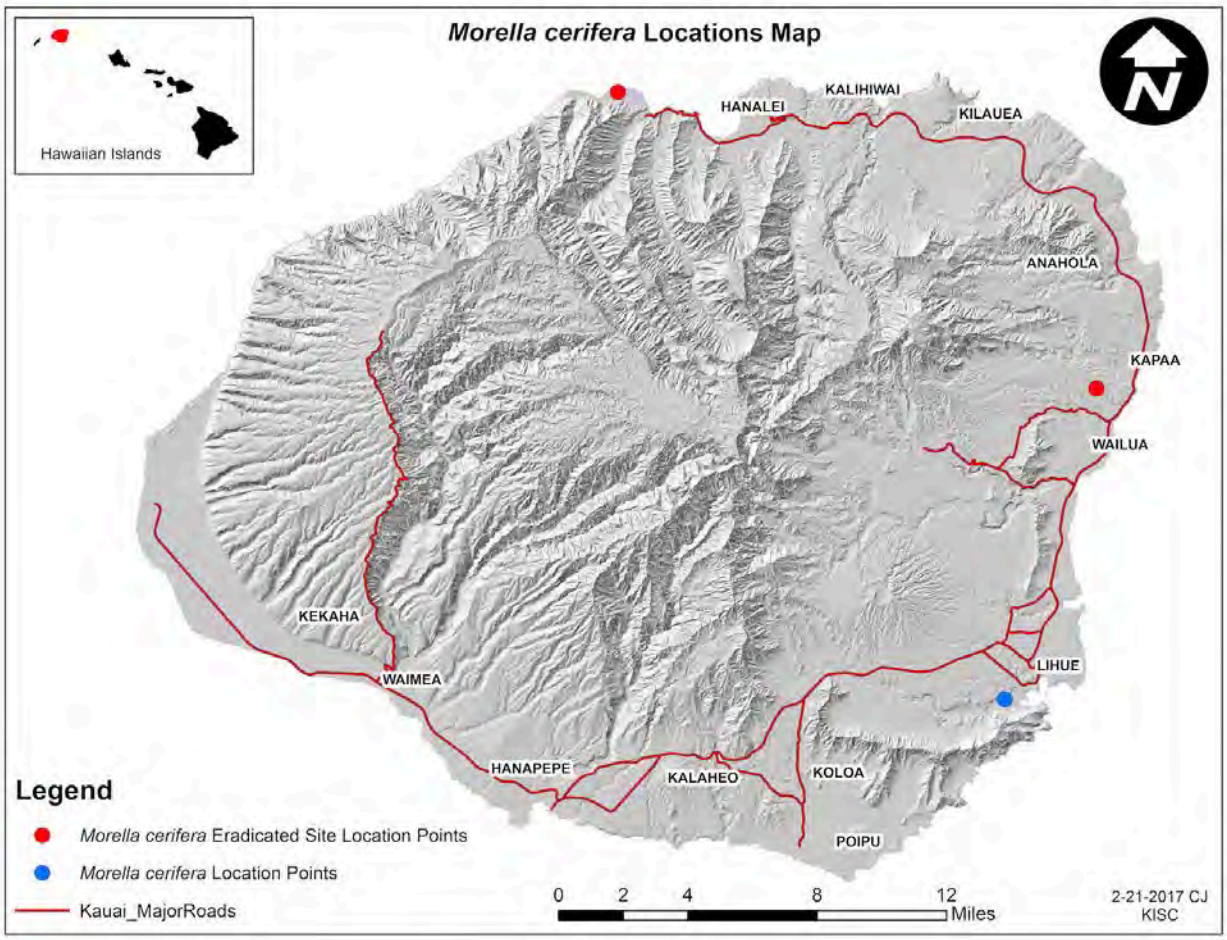


Figure 8 Linear regression for one location of *D. suffruticosa* with CPUE trending down to 0, representing an ideal Early Detection – Rapid Response curve.

Wax Myrtle (*Morella cerifera*)



Map 5 *M. cerifera* locations

Status: Early Detection Species

Background: Wax myrtle *(M. cerifera)* is nitrogen-fixing shrub (Photo 5) that is native to coastal regions of the southeastern United States. It is an early successional species that has been known to colonize watersheds on Maui and young lava flows on the Big Island. On Kauai, this plant is known from two locations (Map 5) at Haena and Kapaa where it has been successfully eradicated (Figure 9) and one location at Nawiliwili that hasn't yet been treated.

Objective: Evaluate

Strategy: Conduct KISC Prioritization and Feasibility of Control assessment (Appendix A) to determine if species should become a KISC target.

Photo 5 leaves of *M. cerifera*

Actions:

- Continue island wide surveys to detect new populations
- Conduct delimiting surveys to establish wether the existing population has spread
- Monitor eradicated sites

Treatment methods:

- Cut Stump treatment- Trees are cut by chainsaw, handsaw, or machete. Stumps are treated with Garlon4 Ultra mixed with forest crop oil at a 50/50 ratio. No regrowth has been noted after initial treatment.

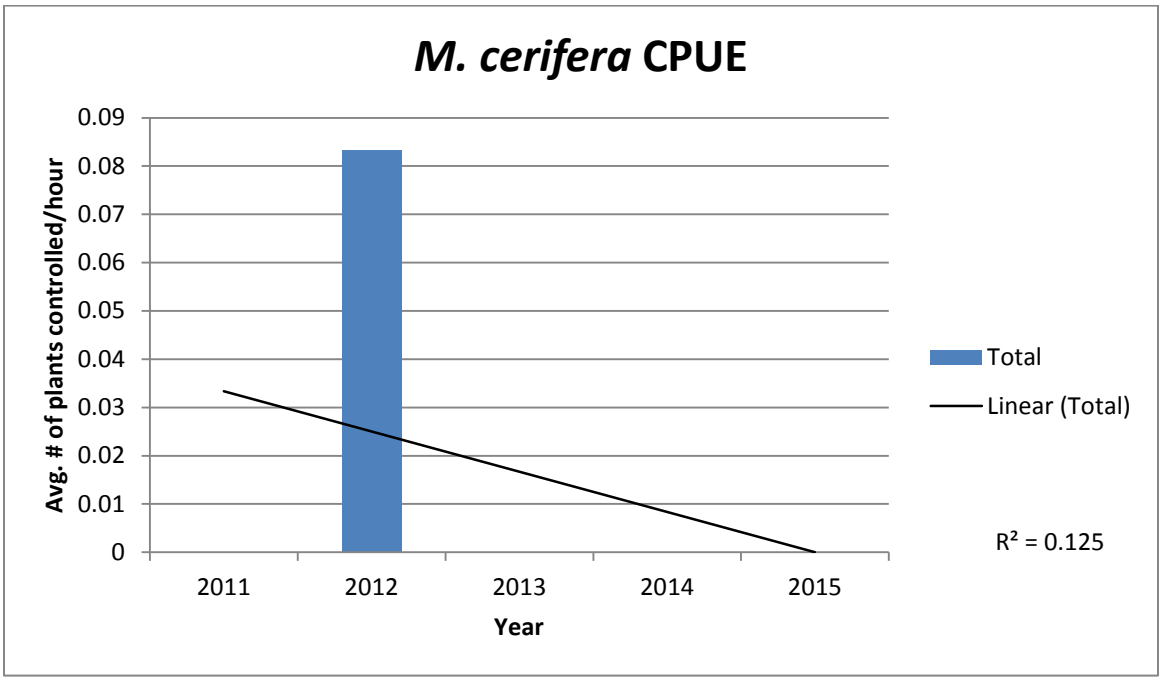


Figure 9 Linear regression for treated locations of *M. cerifera*. Since so few plants were treated, trend is uninterpretable but shown for consistency.

TARGET PLANT SPECIES

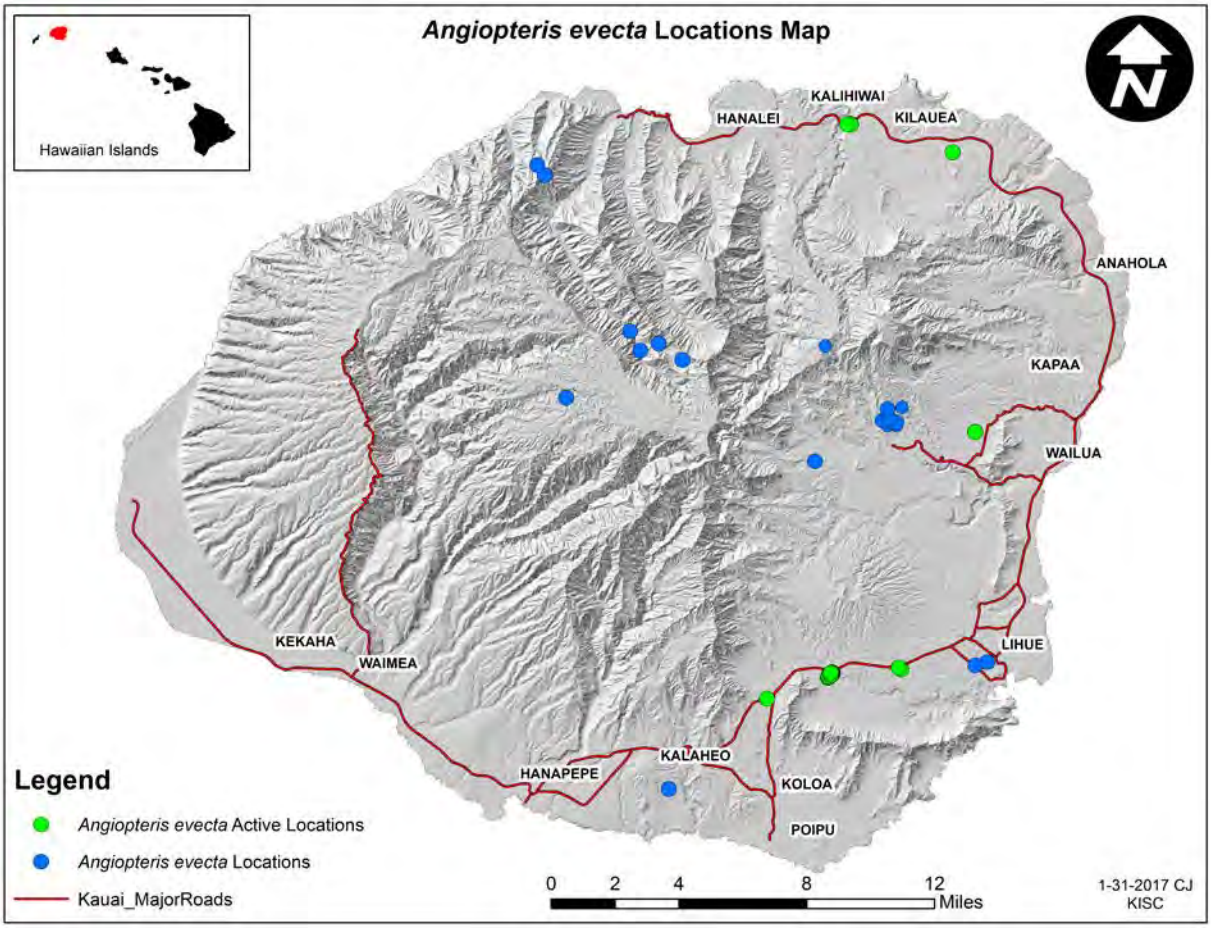
KISC currently targets 14 plant species for control with the intent of eventual eradication from Kauai. These species were prioritized using variable criteria, although in the future, species will be selected as targets using the Prioritization and Feasibility of Control assessment (Appendix A; Figure 4). This tool identifies species that are perceived as highly invasive, are detrimental to environmental/agricultural ecosystems, have limited distributions, and are feasible to eradicate (e.g. are accessible and responsive to control efforts).

Populations of target species are generally delineated by conducting searches within a 200m buffer of the known target location and in ideal habitat (if known) within an 800m buffer. Site-specific delimitation surveys are determined by species and species distribution potential. Search methods may vary depending on terrain, property access and degree of landscaping for each site. Sites where initial control is applied or the target species re-establishes after control is applied are designated as “active sites” that will be revisited until the target is eradicated from the site. Sites where the target fails to re-establish after a suitable time has elapsed are placed on an infrequent monitoring schedule or are completely decommissioned for low risk sites (e.g. site was paved). The time interval allowed to expire between both active site revisits and demotion of active sites to infrequent monitoring or eradicated status is determined on a site-specific basis that reflects species biology and site conditions. The following table summarizes the control history for each of the KISC target plants species.

Table 2 Control History of KISC Target plant species

Scientific Name	Common Name	Work Hours	Year	Number of known locations	Number of active sites	Area of active sites (acres)	Number of monitor-ing sites	Area of monitor-ing sites (acres)	Number of eradicate-ed sites	Area of eradicate-ed sites (acres)	Area of not yet treated sites (acres)	Total area (acres)
Angiopteris evecta	mule's foot fern	482	2010-present	18	6	5,520	-	-	-	-	7,715	13,235
Arundo donax	giant reed grass	3771	2002-present	29	9	2,953	9	5,463	11	5,880	1,419	15,715
Cenchrus setaceus	fountain grass	432	2003-present	13+	0	-	1	631	1	237	8,251	9,119
Clerodendrum macrostegium	velvet leaf glory bower	208	2011-present	4	0	2,037	4	238	-	-	-	2,275
Coccinia grandis	ivy gourd	5354	2002-present	30	13	7,149	6	1,289	11	3,687	1,164	13,288
Juncus effusus	common mat rush	6	2015-present	2	1	784	1	-	-	-	1,785	2,569
Macaranga mappa	bingabing	435	2011-present	5	1	779	3	1,592	1	781	822	3,9745
Miconia calvescens	miconia	7184	2001-present	6	5	5,427	-	-	1	776	-	6,204
Pereskia aculeata	barbados gooseberry	120	2011-present	8	2	1,797	3	489	3	2,980	-	5,267
Piper auritum	false kava	2521	2002-present	27	18	10,660	5	1,934	4	2,241	1,969	16,804
Prosopis juliflora	long thorn kiawe	9801	2001-present	22	8	4,503	11	2,741	1	473	2,743	10,461
Rubus sieboldii	Molucca raspberry	632	2009-present	7	1	1,191	-	-	-	-	3,955	5,146
Solanum torvum	turkey berry	187	2014-present	4	3	2,520	1	671	-	-	713	3,904
Typha latifolia	cattail	2147	2002-present	37	0	-	0	-	0	-	23,263	23,263

Mule's Foot *Fern* (*Angiopteris evecta*)



Map 6 *A. evecta* locations

Status: Target Species, re-evaluate

Photo 6 KISC crew climbing to treat *A. evecta*

Background: Mule's foot fern (*Angiopteris evecta*) is a large fern (Photo 6) native to Australia and New Guinea, Melanesia, Micronesia, and Polynesia that is recorded as naturalized in Hawaii and Jamaica. In Hawaii, natural ecosystems are altered by dense stands of this plant, which crowds out native species. Currently this plant appears to be less abundant on Kauai than other Hawaiian islands, although several sightings have been reported to KISC (Map 6). Three KISC sites near lowland cultivated areas were discovered by herbarium records and partners. Partners have indicated that this plant has occasionally been seen on Kauai in moist areas at various elevations.

Objective: Eradicate

Strategy: Re-evaluate suitability of target designation while continuing the standard control and monitoring.

Actions:

- Conduct KISC Prioritization and Feasibility of Control assessment (Appendix A) to determine if the species should remain a KISC target.
- Continue island wide surveys to detect new populations
- Continue controlling known infestations
- Compile partner information and point data relating to the distribution of this plant across the island. (e.g. KRCP)
- After feasibility assessment, discuss possible partnerships to eradicate/contain this species island wide.

Treatment methods:

- Utilize IPA (incision point application) with Garlon 4Ultra at 50% mixed with forest crop oil. Brain of fern (apical meristem) is notched and herbicide is applied to the notch.
- Foliar Application- Garlon4 Ultra at 8% mixed with forest crop oil. Used on small seedlings.

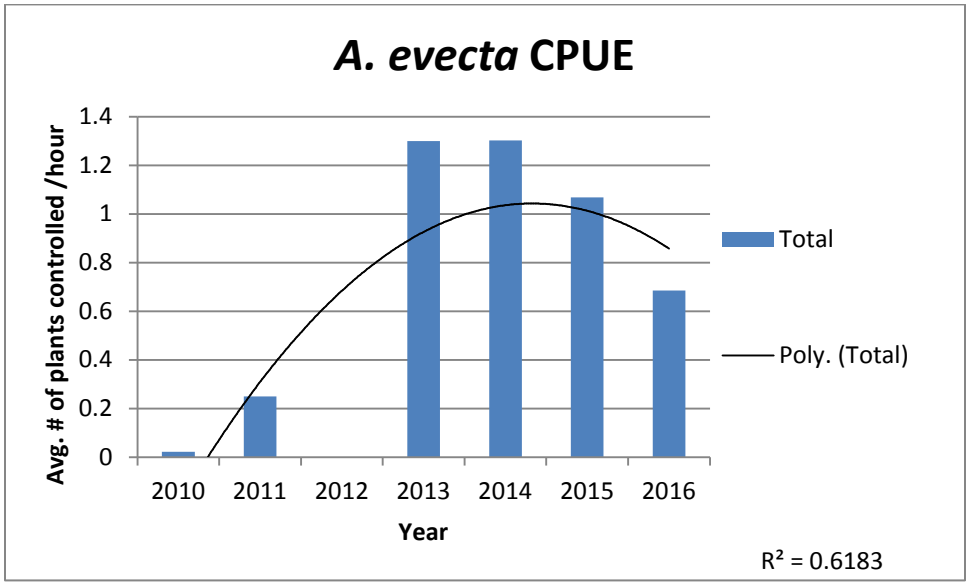
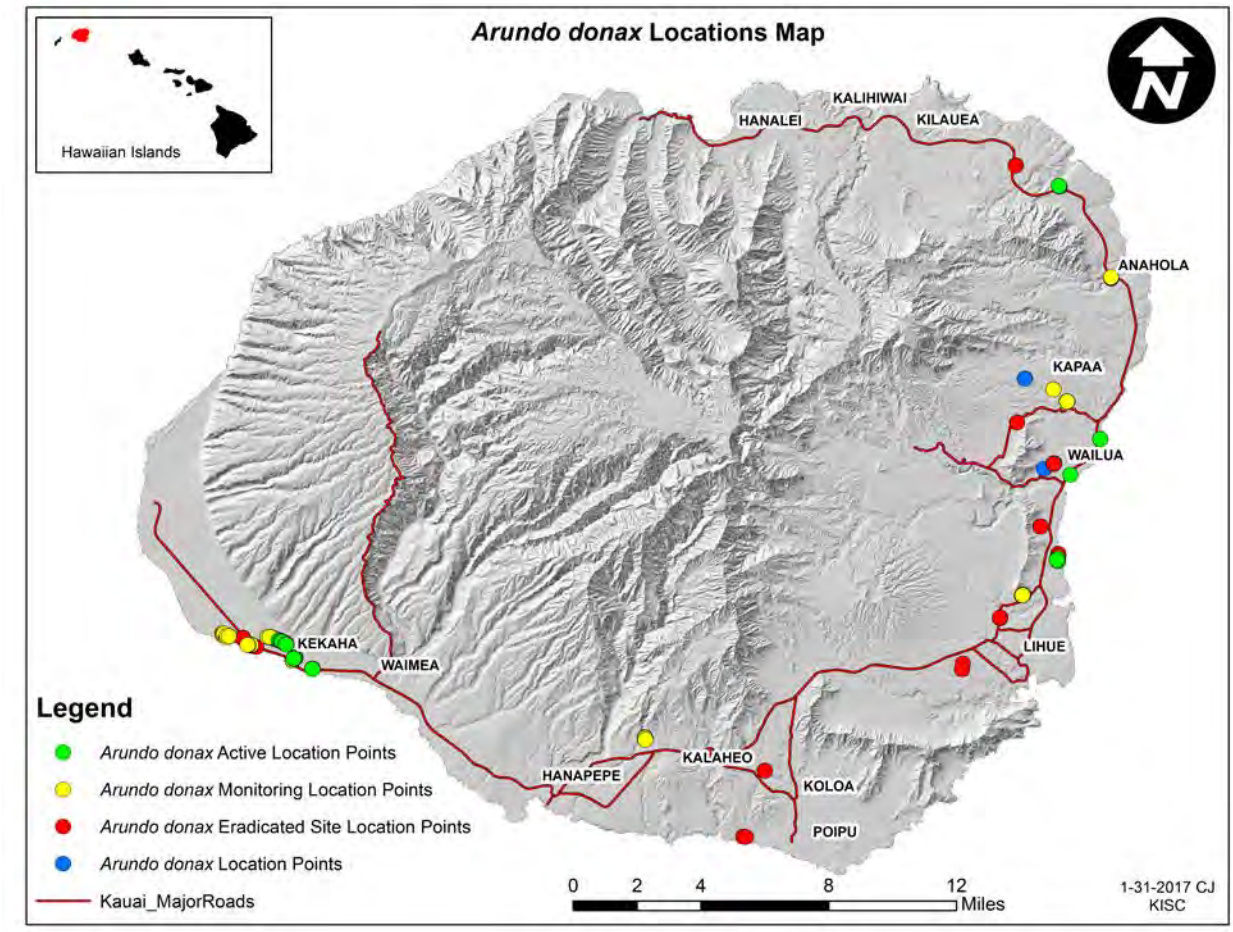


Figure 10 The best fit for *A. evecta* is showing a downward trend however this incorporates resurveying controlled sites. Of note is the fact that extended buffer miconia searches have located new plants to the west of CTHAR. This fact coupled with detections at "Blue Hole" and high altitude sites indicate that the infestation may extend from near sea level to mountaintop an infestation area considered "widespread".

Giant Reed Grass (*Arundo donax)*



Map 7 *A. donax* locations

Photo 7 *A. donax*

Status: Target Species

Background: Originally from the Mediterranean region, giant reed grass (*Arundo donax)* has been cultivated for human cultural and practical uses such as making fishing poles and roofing fiber for many centuries. It was first introduced into California in the 1800's and has since become naturalized in much of the Southern United States. This tall reed spreads mainly by underground rhizomes, forming dense stands in moist to wet sites. It is invasive in Florida and California, along riparian areas and roadsides. The dense vegetation interferes with flood control, displaces native plants and animals, and is a potential fire hazard. It has been reported to have growth rates up to .7m per week in favorable conditions (Perdue 1958). *A. donax* forms a rhizome, creating dense

monotypic stands that can choke out waterways. In addition, *A. donax* is transported easily by flooding waterways or as green waste and can re-sprout from plant matter. Once established, *A. donax* is hard to kill. On Kauai, sites are found predominantly on the Westside in old irrigation ditches, deserted pastures, near road sides, or in abandoned lots. A few populations exist on the East and North side of the island mostly on residential or industrial land.

Objective: Eradicate

Strategy: Standard control and monitoring

Actions:

- Continue island wide surveys to detect new populations
- Continue controlling known populations
- Continue monitoring treatment sites
- Respond to new sightings
- Determine number of years to monitor sites
- Continue outreach

Treatment methods:

- Large stands of *A. donax* are cut at the base of the stem and left to resprout. It is then treated with Kleanup (if away from water source) or AquaMaster (if near water source), mixed with a surfactant and H2O for an 8% dilution rate, and applied with a backpack or drizzle sprayer.
- Small re-growth patches are treated with an 8% mixture of Kleanup or AquaMaster, water, and surfactant applied with a drizzle sprayer**.**
- If only a few large plants are present, a cut stump method is used, and stumps are treated with a 50% rate of Kleanup or Aquamaster (depending on presence of water)

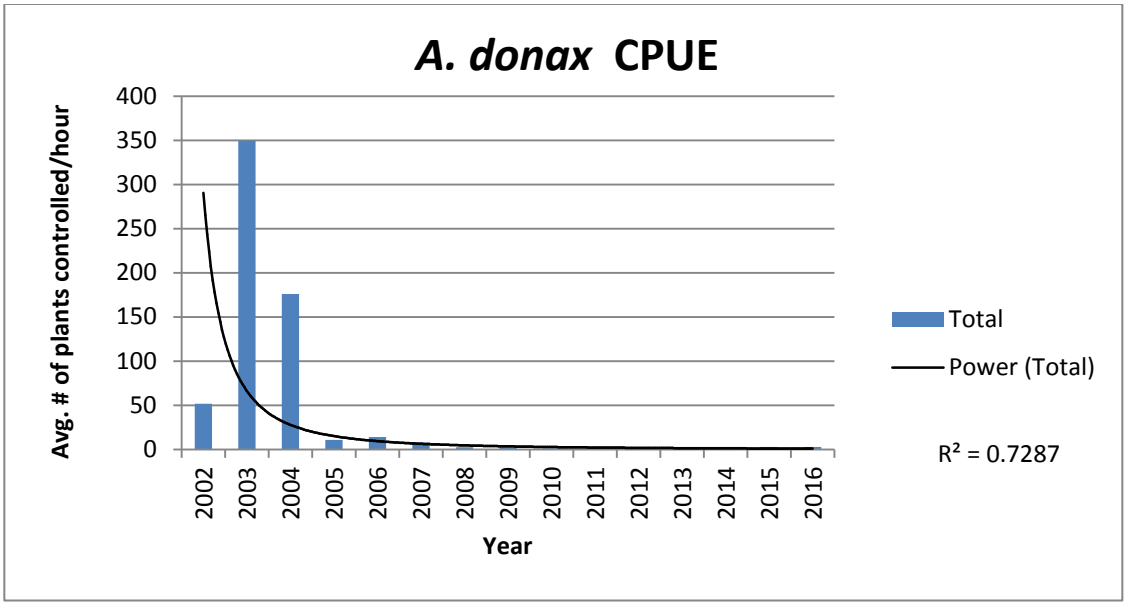
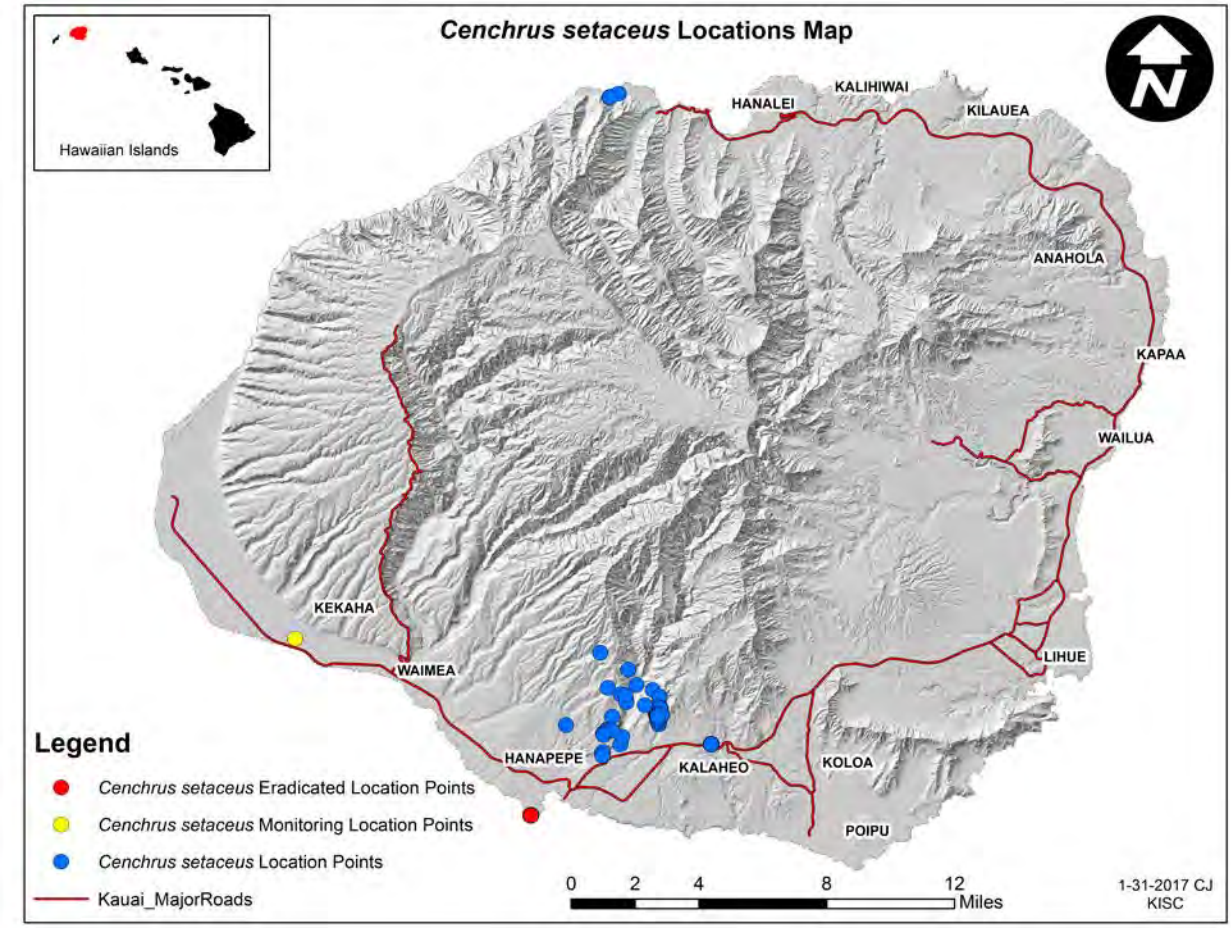


Figure 11 Due to rhizomes *A. donax* is a long-lived pest requiring repeated treatments.

Fountain Grass (*Cenchrus setaceus*)



Map 8 *C. setaceus* locations

Photo 8 *C. setaceus*

Status: Target Species, re-evaluate

Background: Originally introduced as an ornamental, fountain grass has become an aggressive invader and is currently listed on Hawaii's Noxious Weed List by the HDOA. *Cenchrus setaceus* degrades pasturelands and is not nutritionally preferred by livestock therefore resisting any grazing pressure. Unlike other non-native grasses, *C. setaceus* colonizes bare or sparsely vegetated areas, such as lava flows, thus threatening primary native ecosystems. *C. setaceus* is a significant fire hazard and is in fact stimulated by fire; thus further endangering the native woody plant communities it invades. Seeds are spread easily by vehicles, humans, wind, and water, and can become established at elevations ranging from sea

level to over 8000 feet. Although it has a wide elevation range, it is usually limited to areas with a median annual rainfall of less than 50 inches.

Kauai has 3 known sites of *C. setaceus*: in Kalaheo, Hanapepe, and possibly one on the North Shore, which is unconfirmed with a voucher specimen. The core population is located mountainside of Kalaheo and is believed to have been there since the early 1930's. It is assumed that this population has remained pretty much contained due to the higher average rainfall in this area. There have been sightings of plants along the cliffs above Hanapepe River, indicating that this pest is moving west. Most of this core population is located on private land on rugged terrain, and may be inaccessible by ground crews alone.

Objective: Eradicate

Strategy: Re-evaluate suitability of target designation while continuing the standard control and monitoring.

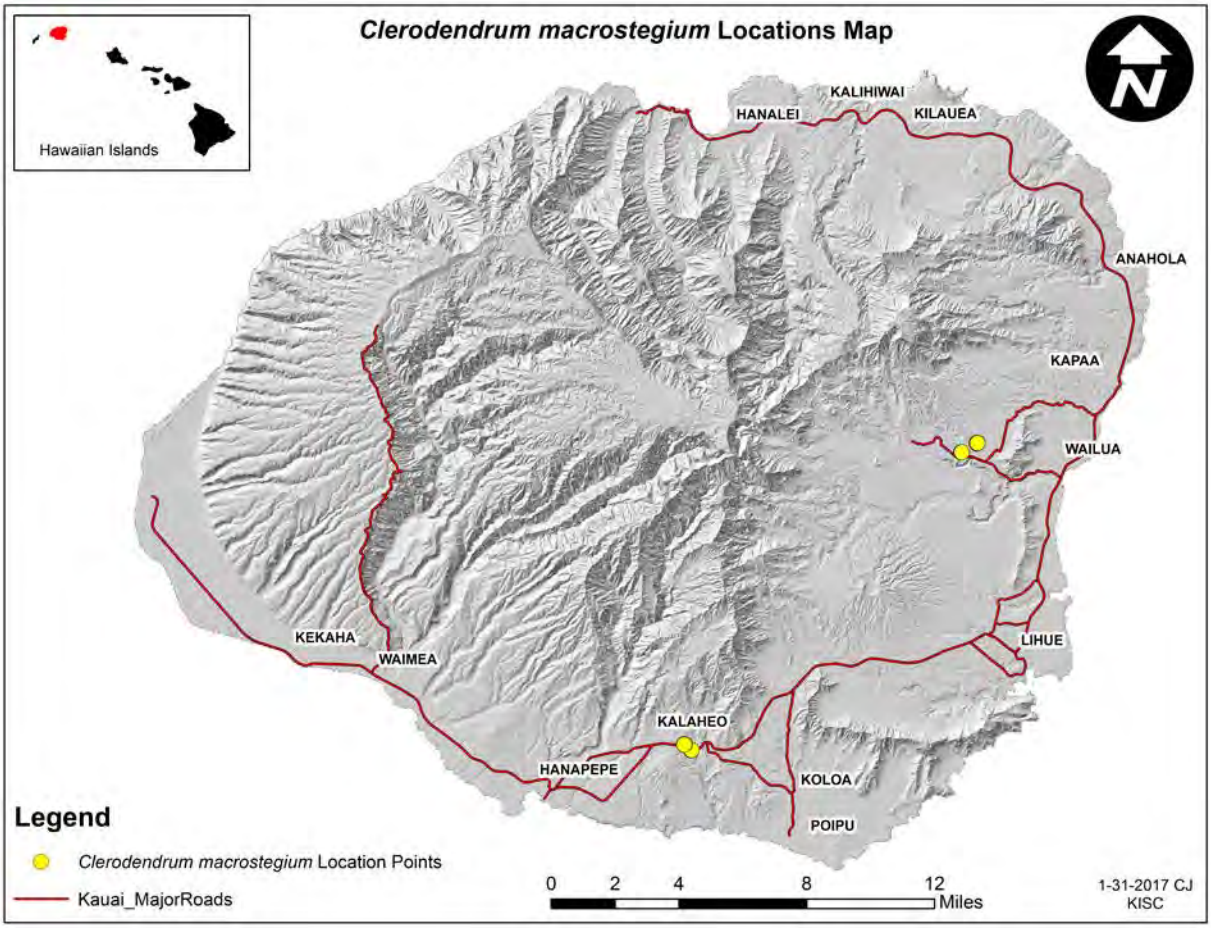
Actions:

- Conduct KISC Prioritization and Feasibility of Control assessment (Appendix A) to determine if the species should remain a KISC target.
- Continue island wide surveys to detect new populations
- Continue working with HDOA to control known locations outside of main infestation area. (e.g. Port Allen airstrip)
- Continue treatment on accessible land in main infestation until Feasibility assessment is complete.
- Conduct aerial survey in 2017.
- Complete ground survey on Hanapepe ridge.
- KISC and HDOA will seek access to private lands to treat outlying populations of *P. setaceus*. Utilize HDOA connections with landowner.
- KISC and HDOA will seek access to acquire a voucher specimen from a possible population on the north shore above Haena Beach Park.
- Continue outreach: key messages include fire risks and livestock non-palatability.

Treatment methods:

- Survey areas for re-sprouts, which have been previously treated.
- When accessible, remove any seed-heads from plants and discard in a plastic bag to prevent further seed spread.
- For treatment of non-seeding plants drizzle spray with 8% Round-up mixed with water.
- Hand treatment not feasible for large scale.
- Fountain grass is known to hybridize, accurate identification is important.

Velvet leaf (*Clerodendrum macrostegium*)



Map 9 *C. macrostegium* locations

Status: Target Species

Background: Velvet leaf (*Clerodendrum macrostegium*) is a large shrub native to the Philippines that has proved to be invasive in gardens on Pacific islands through prolific root suckering. It has escaped cultivation in Oahu where it can form dense thickets. This plant was brought to KISC's attention through roadside surveys where it was discovered in areas around Wailua and Lawai. Three of the sites are being successfully treated while KISC is awaiting property access to treat the fourth known population.

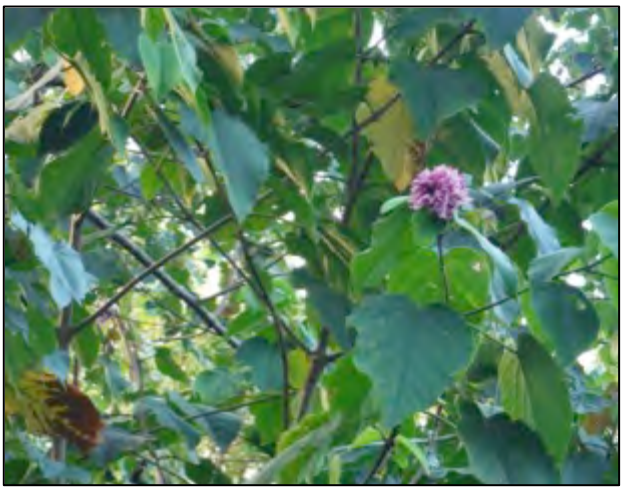


Photo 9 *C. macrostegium* flowering

Objective: Eradicate

Strategy: Standard control and monitoring

Actions:

- Continue island wide surveys to detect new populations
- Continue controlling known infestations
- Continue monitoring treatment sites
- Respond to new sightings of *C. macrostegium*
- Continue outreach

Methods:

Cut Stump treatment- Trees are cut by chainsaw, handsaw, or machete. Stumps are treated with Garlon4 Ultra mixed with forest crop oil at a 50/50 ratio. Seeds are collected, bagged, and brought back to baseyard to be burned or stored until they rot out. Debris is left on-site.

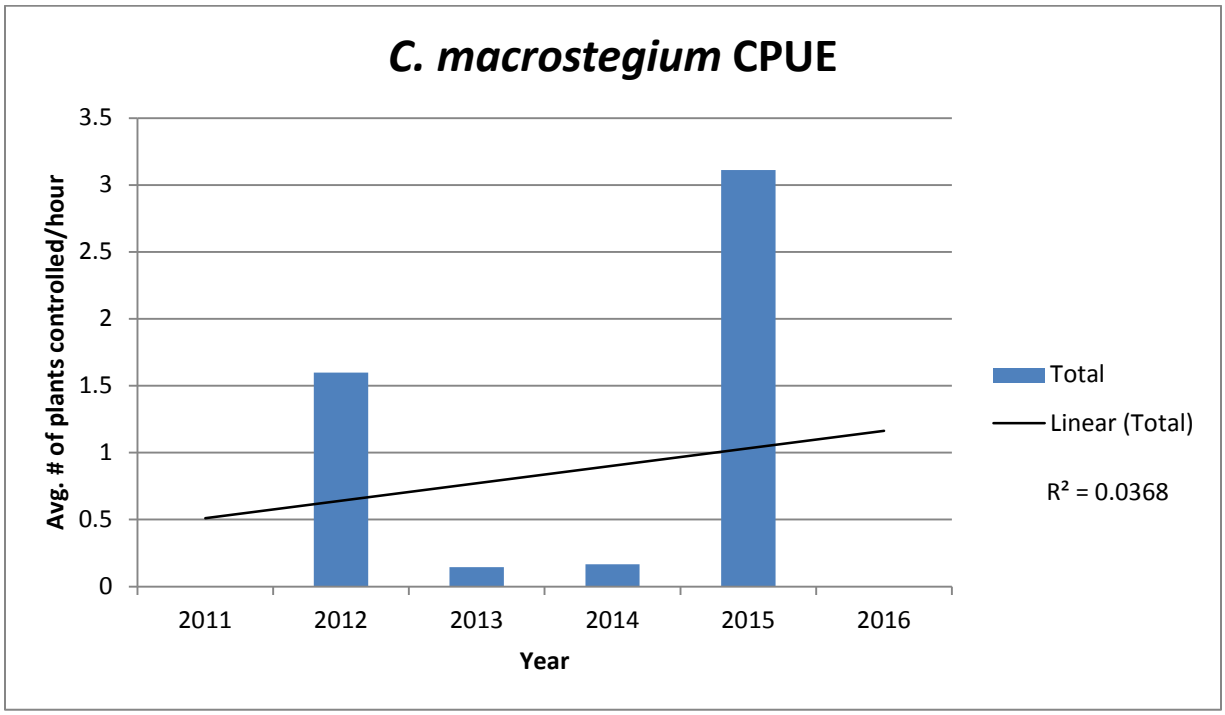
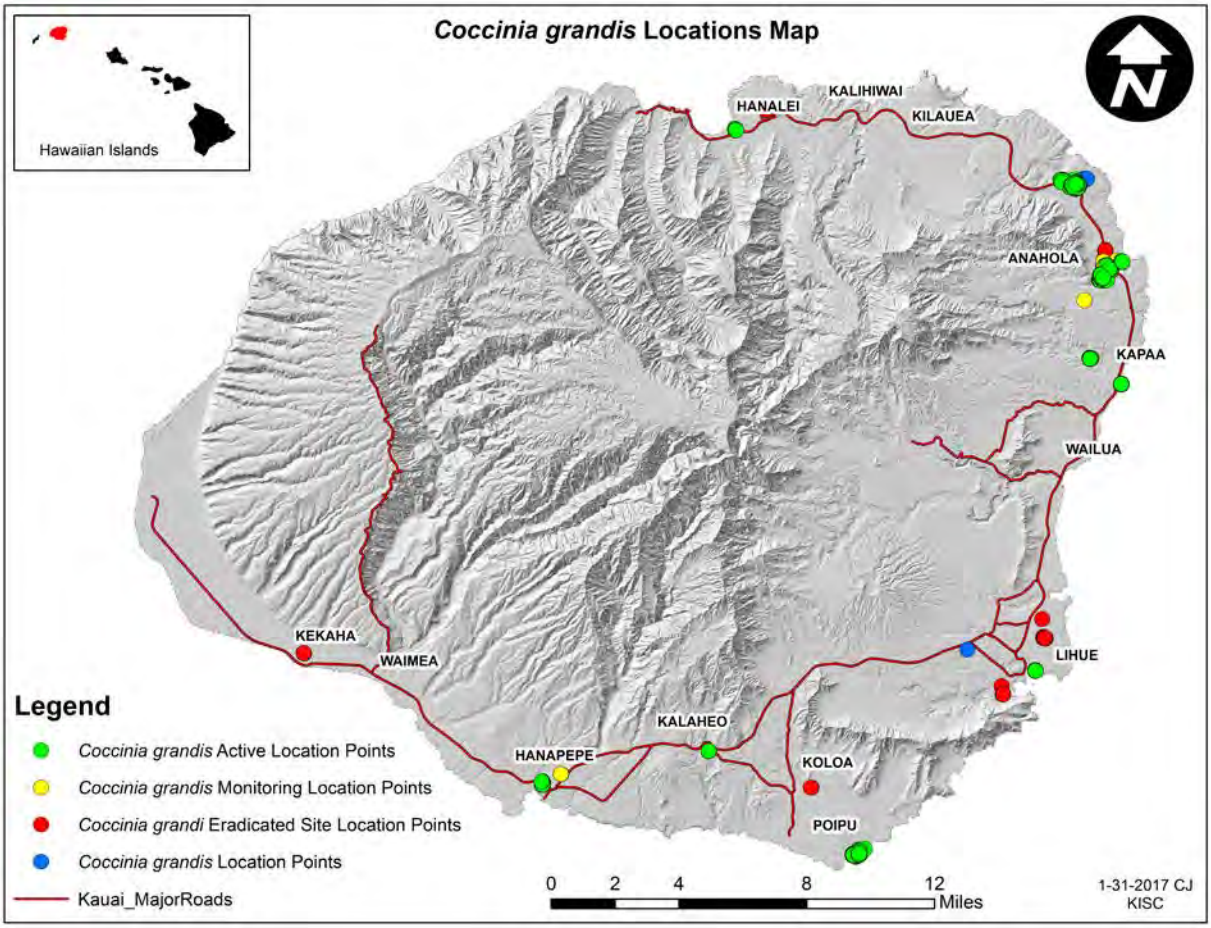


Figure 12 Low R^2 value indicates low number of targets analyzed.

Ivy Gourd (Coccinia grandis)



Map 10 *C. grandis* locations

Status: Target Species, re-evaluate

Photo 10 *C. grandis* flower and leaf

Background: Ivy Gourd, *Coccinia grandis*, (on Hawaii Noxious Weed List) is commonly used in food preparation exploded on Oahu and the Big Island in Kona in the 1980s, creating problems for agriculture and conservation of lowland sites. *C. grandis* is a choking vine that produces a cucumber-like fruit. Seeds are dispersed mainly by birds and humans and can persist in the seed-bank for up to 4 years. This plant is considered eradicable because it requires both sexes to pollinate; therefore spread is relatively contained and slow. It is important to mention that this target is difficult to kill on the first treatment because of the sheer mass of the vine network as well as the difficulty in finding the main vine in dense vegetation. Repeated treatment is necessary and does show

success over time. There are 30 known sites of *C. grandis* on Kauai, located in Anahola, Moloaa, Kapaa, Lihue and Mahaulepu, which cover over 20 acres.

Objective: Eradicate

Strategy: Re-evaluate suitability of target designation while continuing the standard control and monitoring.

Actions:

- Conduct KISC Prioritization and Feasibility of Control assessment (Appendix A) to determine if the species should remain a KISC target.
- Continue island wide surveys to detect new populations (e.g. green waste stations)
- Conduct deliminating surveys at known infestation sites.
- Continue controlling infestations at known locations.
- Monitor sites on a monthly basis.
- Continue outreach.
- Follow up on biocontrol release and look at density dependent success.

Methods:

- A notch/scrape method with a 50% Garlon4 Ultra/crop oil mix seems to work well.
- Any fruit found should be removed and bagged and properly disposed of to slow the spread of new plants.

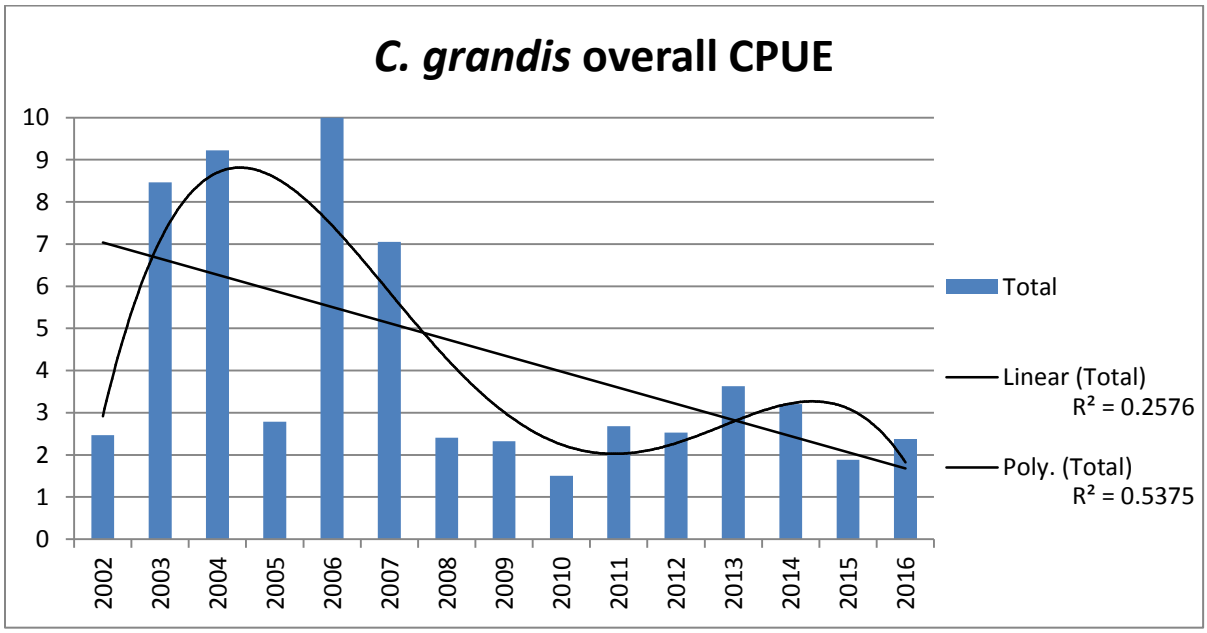
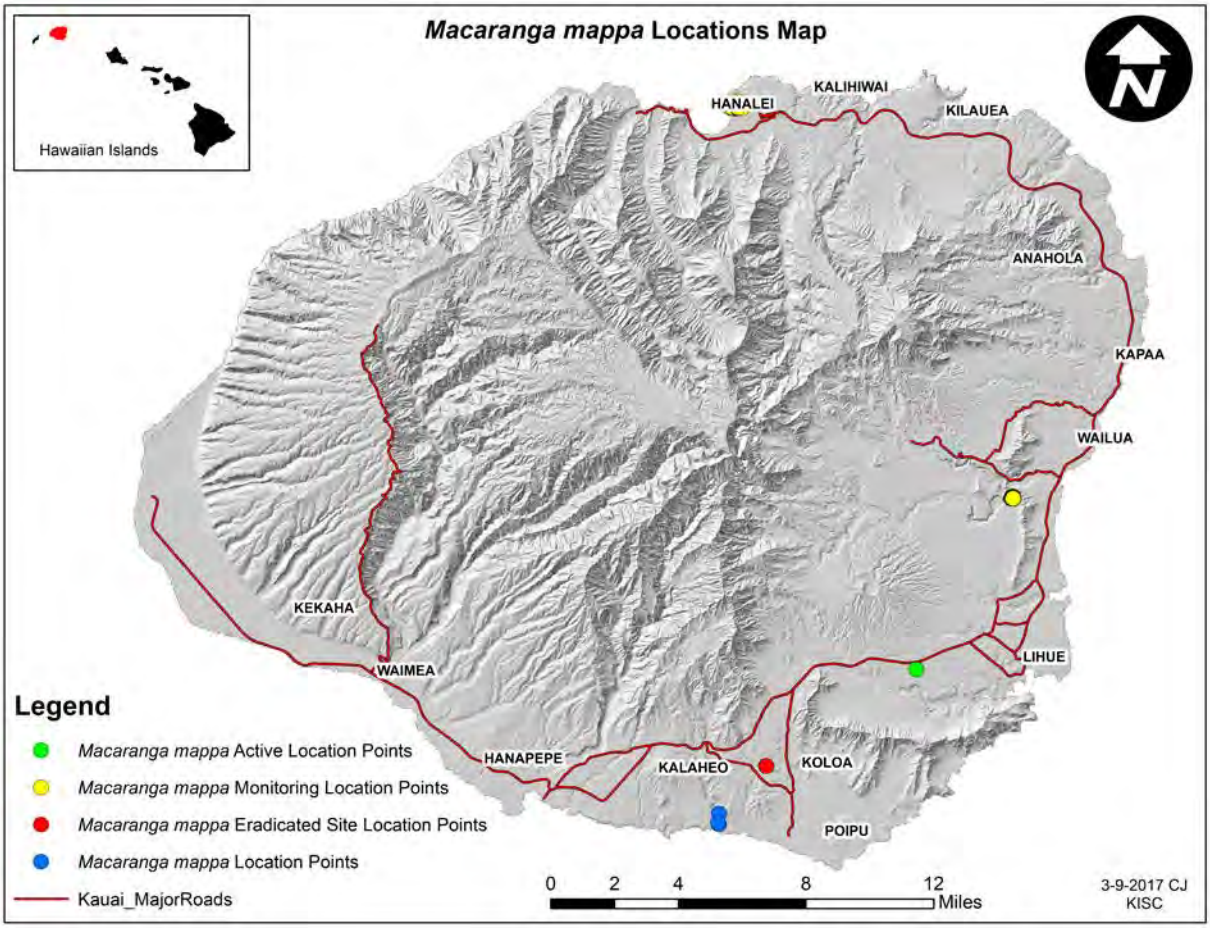


Figure 13 4th order polynomial describes the fluctuation of *C. grandis* CPUE as controlled populations respond to treatment and new populations are discovered. Given dispersal through birds satellite populations can become established a long distance from the mother plant. It is unknown whether disturbance is required for germination.

Bingabing (*Macaranga mappa*)



Map 11 *M. mappa* locations

Status: Target Species

Background: Bingabing (*Macaranga mappa*) is a large leafed tree that is native to the Philippines. It has naturalized in moist to mesic areas of lowlands, 0-220 m (722 ft.), on Oahu and Hawaii where it forms large dense stands that shade-out understory vegetation. There are 5 known sites; the largest is near the Hanalei River mouth. This site of mature trees was first delineated in 2014 and has not been treated due to landowner access issues. Other individual plants have been removed.

Objective: Eradicate

Strategy: Standard control and monitoring

Actions:

- Continue island wide surveys to detect new populations
- Continue controlling known populations
- Continue monitoring treatment sites
- Respond to new sightings
- Determine number of years to monitor sites
- KISC will continue to work with landowners to gain access to Hanalei site
- Utilize the Wagner Manual of Flowering Plants for identification as leaf size often results in misidentification
- Continue outreach: side-by-side comparisons of bract and calyx color with parasol tree (*M. tanarius)* for identification purposes.

Treatment methods:

- Cut Stump treatment- Trees are cut by chainsaw, handsaw, or machete. Stumps are treated with Garlon4 Ultra mixed with forest crop oil at a 50/50 ratio. Debris is left on-site.

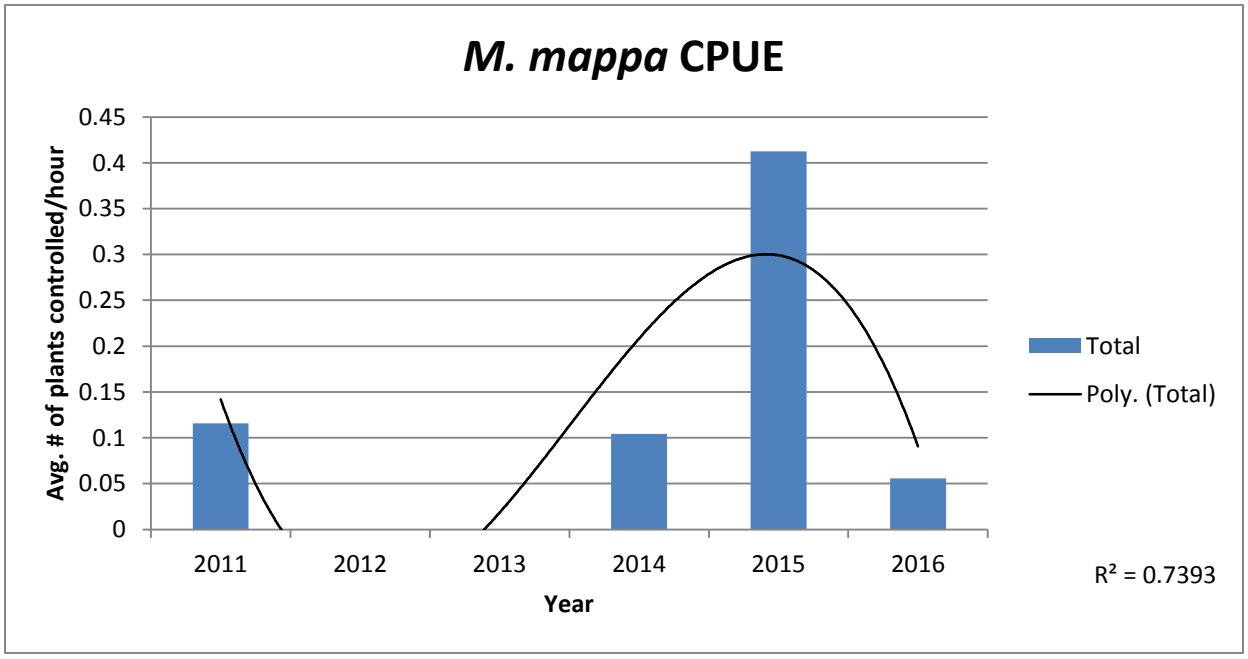
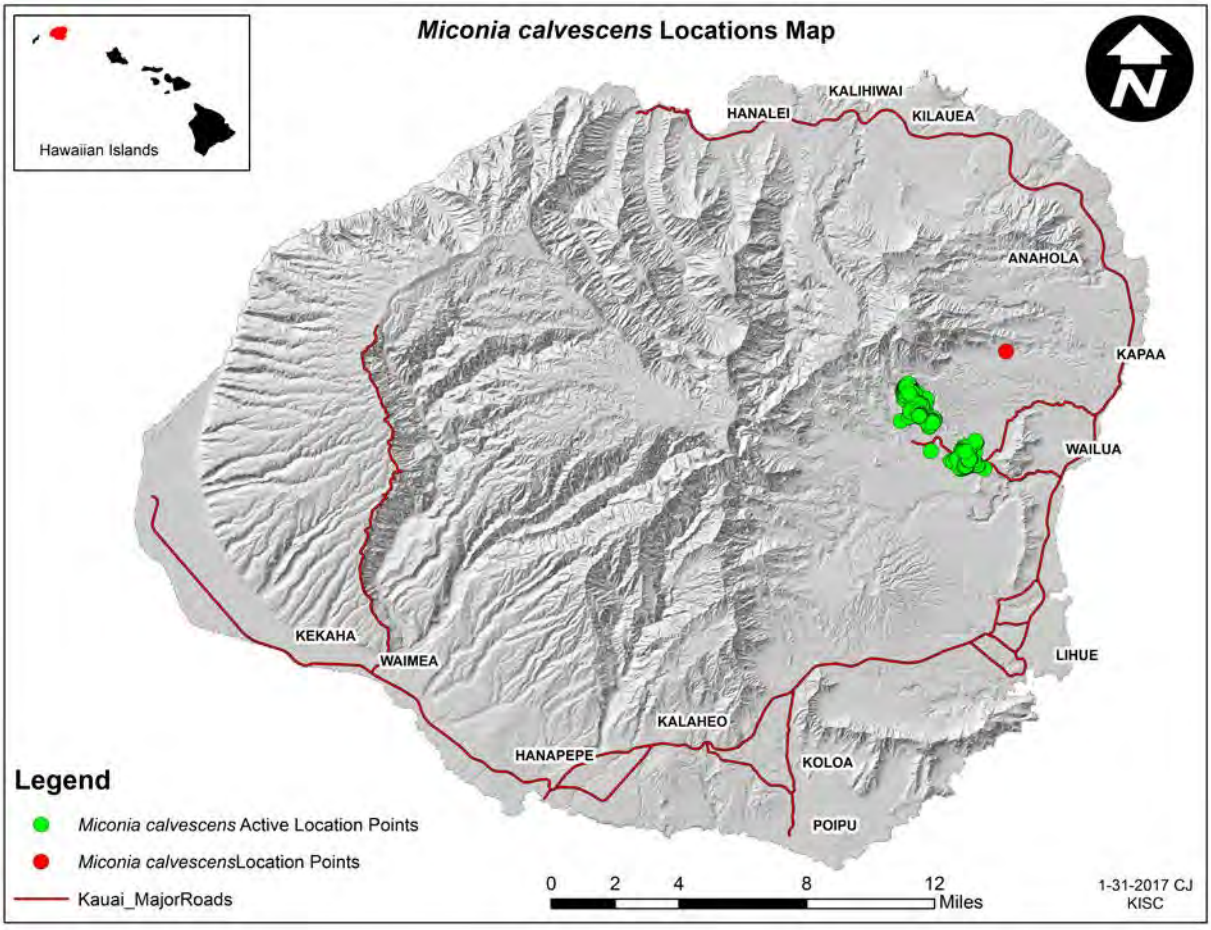


Figure 14 This CPUE value shows progress; however, there is a large population on private property which is currently inaccessible on the North shore.

Miconia (*Miconia calvescens*)



Map 12 *M. calvescens* locations

Status: Target Species

M. calvescens is KISC's number one targeted plant species. It is the top priority and will receive the time and resources necessary to eradicate all discovered populations and individual plants.

If *M. calvescens* escapes the Wailua area and becomes established in the rugged terrain of the Halelea Forest Reserve, it will challenge all of Kauai's resources to control it. Approximately 158,000 acres of native wet forest, prime habitat for *M. calvescens*, are at risk.

Photo 12 *M. calvescens* plant
Photo credit: Forest and Kim Starr

Background: *M. calvescens* is native to South and Central America and was introduced to the Hawaiian Islands in the 1960's via the horticultural trade for its landscaping appeal. Also known as the velvet tree, *M. calvescens* is a unique plant with large, velvety green and purple leaves. Annual seed production for a single *M.*

calvescens plant is well over one million seeds, which are dispersed via birds, wind, water, animals and humans. With this enormous reproductive capacity it did not take long for this landscape ornamental to escape its cultivated surroundings. *M. calvescens* is not a dominant species in its native forests; however, the species has thrived on the Pacific islands. In Tahiti, *M. calvescens* dominates over 70% of the forests and causes significant erosion problems. Control of *M. calvescens* on the island of Kauai began in the mid-1990s after plants were reported in the Wailua Homesteads area. An effort coordinated by HDOA personnel resulted in the removal of several dozen plants, primarily from private properties near the nursery. Another dozen plants were located on State land nearby in the canyon of the Wailua River State Park (WRSP).
In September of 2000, after a period of no activity, reports by the Kauai Sierra Club of a reemerging *M. calvescens* population reached the DOFAW. DOFAW, assisted by volunteers and staff of the KRCP, began systematic searches of the WRSP. In 2002 KISC organized *M. calvescens* searches in the Wailua Homesteads area, and a public awareness campaign was also resumed.

Aerial surveys were conducted by KISC in 2003 in the Wailua Game Management Area (WGMA) where a population of flowering and fruiting mature trees were discovered. This new discovery drastically increased Kauai's known infestation area and ground surveys were initiated to eliminate all detected plants.

Currently, the potentially "contaminated" area on Kauai is to 6,575 acres in these three areas: Wailua Homesteads, WGMA, and WRSP. This is based on the experience of control teams on the islands of Maui and Hawaii, where juvenile *M. calvescens* have been located as far as 1,000 meters away from the nearest adult plant. However, *M. calvescens* are often found as far as 2,000 meters up or downstream from the source in river valleys. This probably reflects transport by birds using the river corridor as a flyway, pigs collecting seeds on fur or hooves through rooting or by water movement. On Kauai, measurements are also based on species of individual birds found and how far they are capable of flying while distributing eaten seeds.

Generally, a period of two years is allowed to elapse between visits to infestation areas as it allows newly germinated plants to grow to a height where they can be easily seen but without any danger of them reaching maturity. However, it is supposed that plants germinating deep within the thick uluhe (staghorn fern) may take longer to reach maturity in that darkened environment.

Aerial surveys are conducted quarterly throughout the entire 1,000 meter buffer area primarily in the WGMA. Aerial surveys also utilize Herbicide Ballistic Technology (HBT) to immediately treat any found plants. Plant locations spotted by air are marked with a GPS unit and ground crews follow up with more thorough ground surveys and treat any additional plants that are found. Occasionally, aerial surveys are conducted outside of the traditional core area in order to account for seed dispersal by wind, water, pigs and far ranging birds.

The known population of *M. calvescens* on Kauai is relatively small and has been managed successfully by striving to eliminate plants before they become mature. Because the seed-bank can persist for >16 years, we must maintain our ground efforts coupled with survey flights at least quarterly.

Objectives: Eradicate

Strategy: Standard control and monitoring

Actions:

- Continue island wide surveys to detect new populations
- Continue to search the WRSP and all other lands considered high-risk areas, map, and treat all plants discovered.
- Perform aerial surveys of appropriate areas, such as the WGMA and surrounding Halelea Forest Reserve, utilizing HBT http://www.ctahr.hawaii.edu/invweed/conservation.html
- Conduct monitoring of sites where mature plants have been found and mapped, and remove any seedlings. Work with DOFAW to carry out monitoring in the Forest Reserve.
- Determine most likely seed distribution pattern (pig trails, birds).
- Determine viable schedule for revisiting core infestation sites.
- Contact landowners for access permission and re-survey likely *M. calvescens* habitats on private property in the Wailua Homesteads area.
- Continue to prioritize resources towards *M. calvescens* as KISC's number one target, for the long term, to insure adequate follow-up takes place. KISC will review progress and develop a strategic plan for continuing a comprehensive *M. calvescens* eradication program.
- Outreach to both the general public and residents in and around the infected zone.
- Determine frequency of entry for non-core areas.
- Support research into existing biocontrol with CTAHR.
- Participate in *M. calvescens* journal bi-monthly meetings led by CTAHR.

Methods:

- Current distribution data is being used within GIS to quantify specific habitat parameters (such as elevation, precipitation, temperature and land-cover type) in order to make a habitat selection model for *M. calvescens*. This will increase our search protocol and effectiveness.
- Digitize albizia layers to identify canopy areas blocking aerial detection.
- Organize transects to allow thorough coverage of search area.
- Seedlings and small trees are pulled, and hung upside-down in trees for roots to dry. Large trees are cut and immediately treated with 100% Garlon-4 (in accordance with the label). For any mature trees found, all panicles with fruits are removed and bagged for incineration and metal marker tag attached indicating date and size of tree.
- The utilization of HBT with aerial surveys as well as ground surveys in areas of difficult access will be carried out.
- All survey areas are mapped using GPS with data and GIS entered into KISC database; all gear worn or used during *M. calvescens* surveys and treatments are dedicated and only used for *M. calvescens* field operations. A dedicated *M.*

calvescens washing machine/ dryer at the KISC base-yard where all gear is decontaminated, according to protocol, and stored in a separate room.

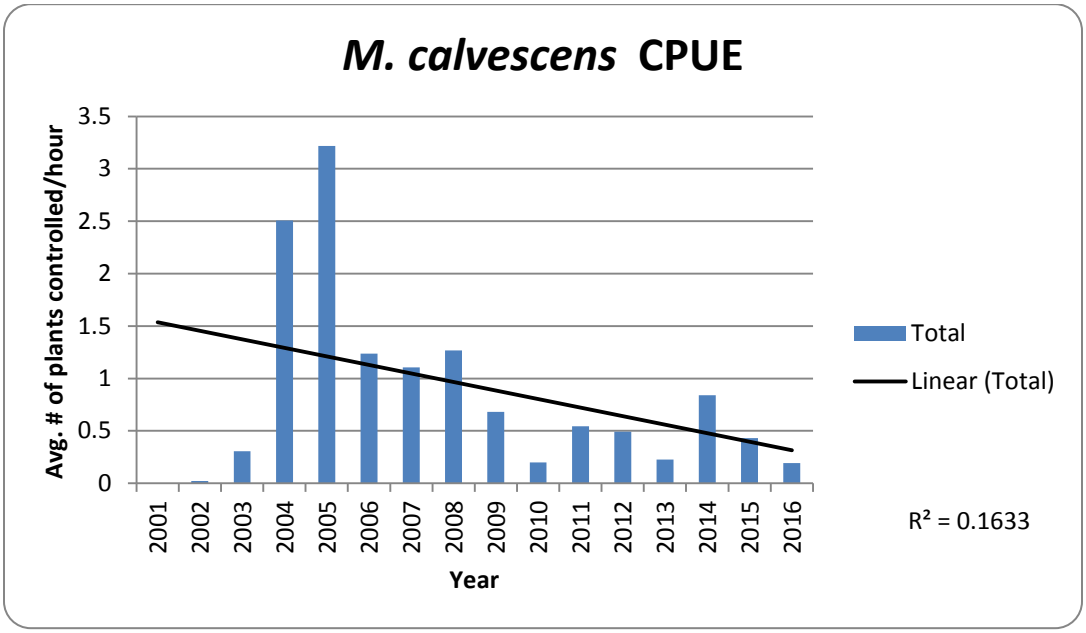


Figure 15 The downward trend has a poor R^2 value due to detection fluctuations from 2010 on. It is also a result of concentration of effort in the known "hotspot" and recent exploratory surveys into new territory.

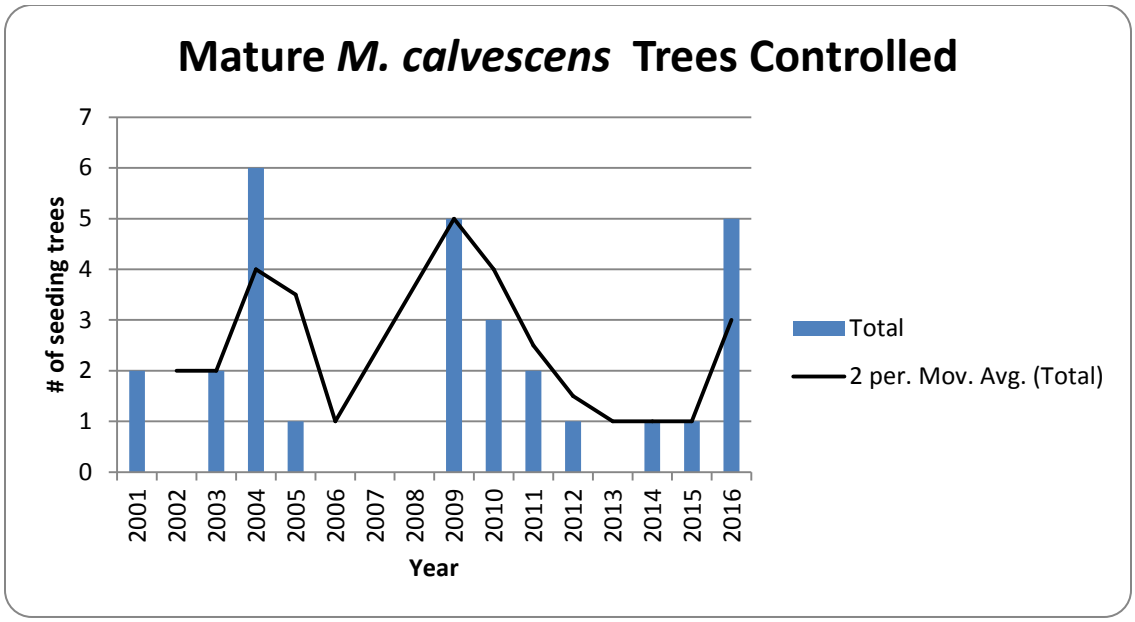


Figure 16 Of most importance is the fact that just as many adult seeding *M. calvescens* were discovered in 2016 as 2009 and one less than the peak discovery in 2004. Changes in survey technique discovered the new trees.

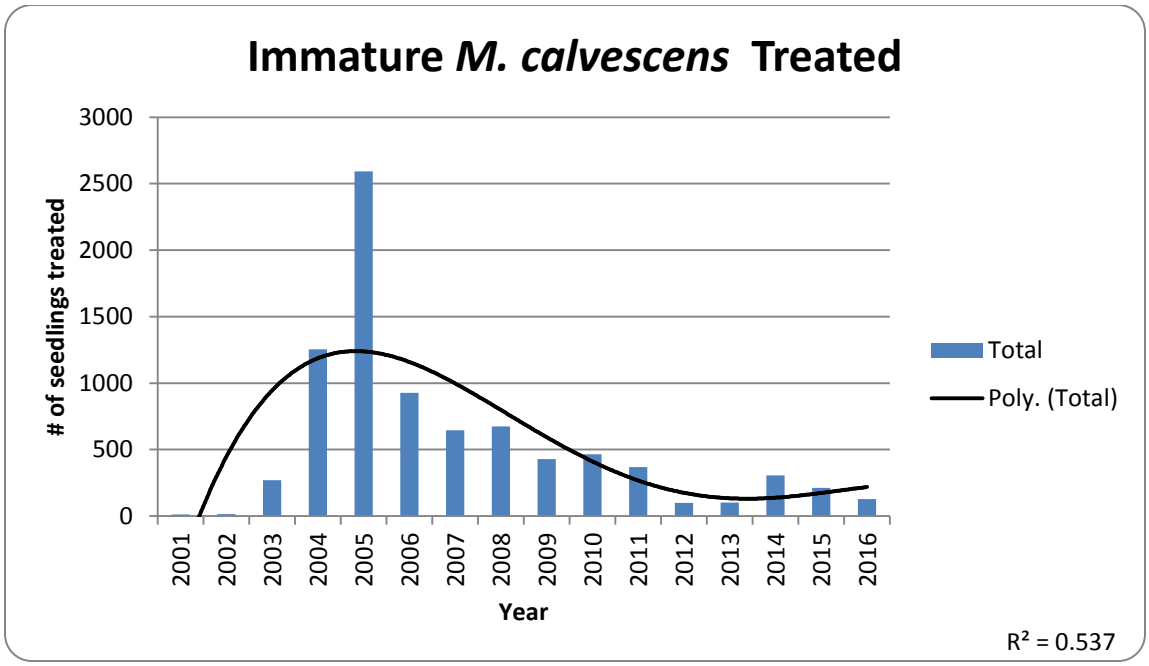


Figure 17 The best fit for immature plants was a third order polyline which shows a slightly increasing trend.

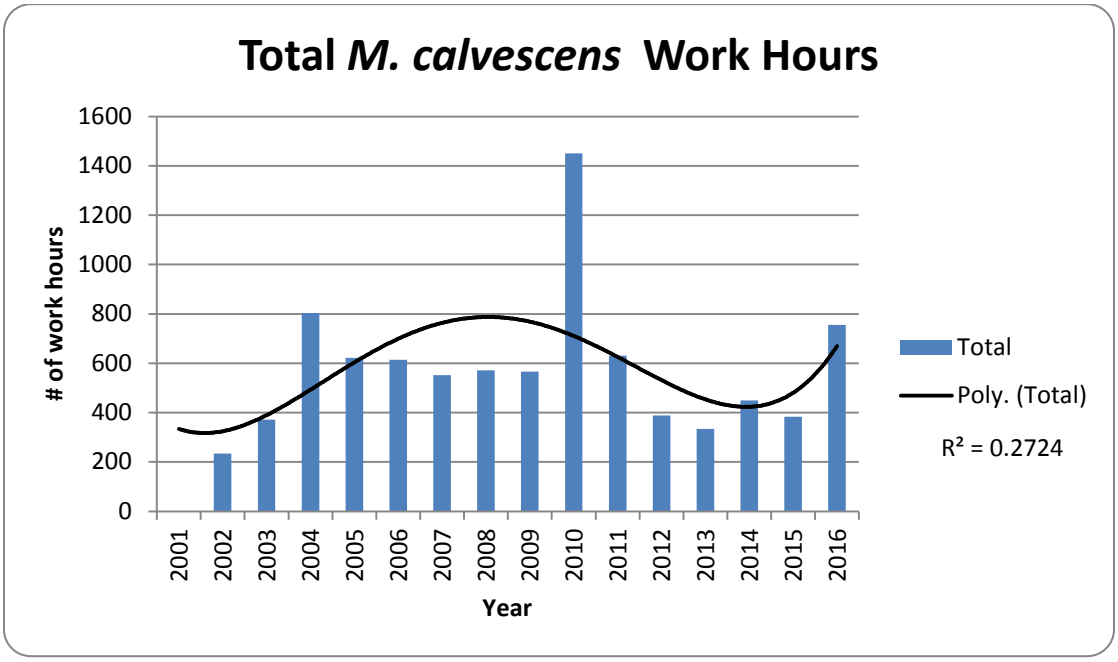
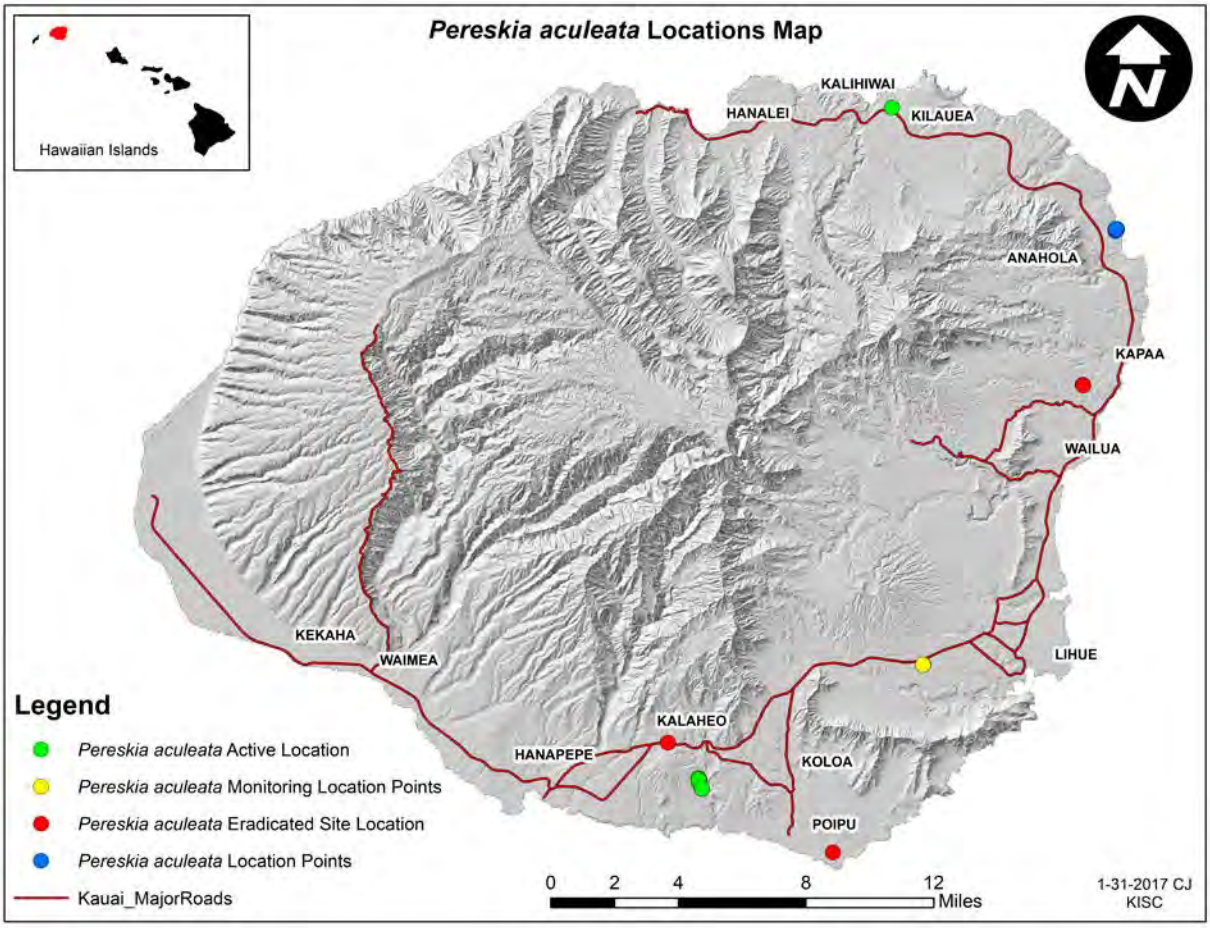


Figure 18 *M. calvescens* work hours decreased from 2010 until 2014. After a brief rise in 2014 effort was reduced in 2015 while all known *M. calvescens* data on island was consolidated into digital format. In addition, the Wailua watershed albizia cover was digitized prioritizing unexplored areas within the infestation buffer.

Barbados Gooseberry (*Pereskia aculeata)*



Map 13 *P. aculeata* locations

Photo 13 *P. aculeata* climbing

Status: Target Species

Background: Barbados gooseberry (*Pereskia aculeata*) is native to the West Indies, coastal northern South America and Panama that is cultivated as an ornamental and is known to be invasive outside of its native range. It forms a woody shrub when young and grows into climbing, leafy vine, with branches up to 11m (33 ft.) long when mature. It forms dense, thorny thickets in low elevations that overgrows and replaces other plants on Molokai and Oahu. The seeds are spread by birds and other animals that consume the fleshy fruit. This plant was first noticed on Kauai at the end of Papalina road, Kalaheo near NTBG and has been known to grow out of plant waste piles. Several plants have been removed by KISC from nurseries such that no Kauai nurseries are currently selling this plant that we are aware of. However, one

known site of landscaped *P. aculeata* is still known on the island and KISC is working to acquire landowner cooperation.

Objective: Eradicate

Strategy: Standard control and monitoring

Actions:

- Continue island wide surveys to detect new populations
- Continue controlling known populations
- Continue monitoring treatment sites
- Respond to new sightings
- Determine number of years to monitor sites
- Continue outreach: create visual media using side-by-side comparisons of all species

Treatment methods:

- Cut Stump treatment- All branches and fruits are cut and brought back to baseyard for disposal (either burned or stored till it rots). Base of stump is treated with Garlon 4 Ultra mixed with forest crop oil for a 50/50 ratio.

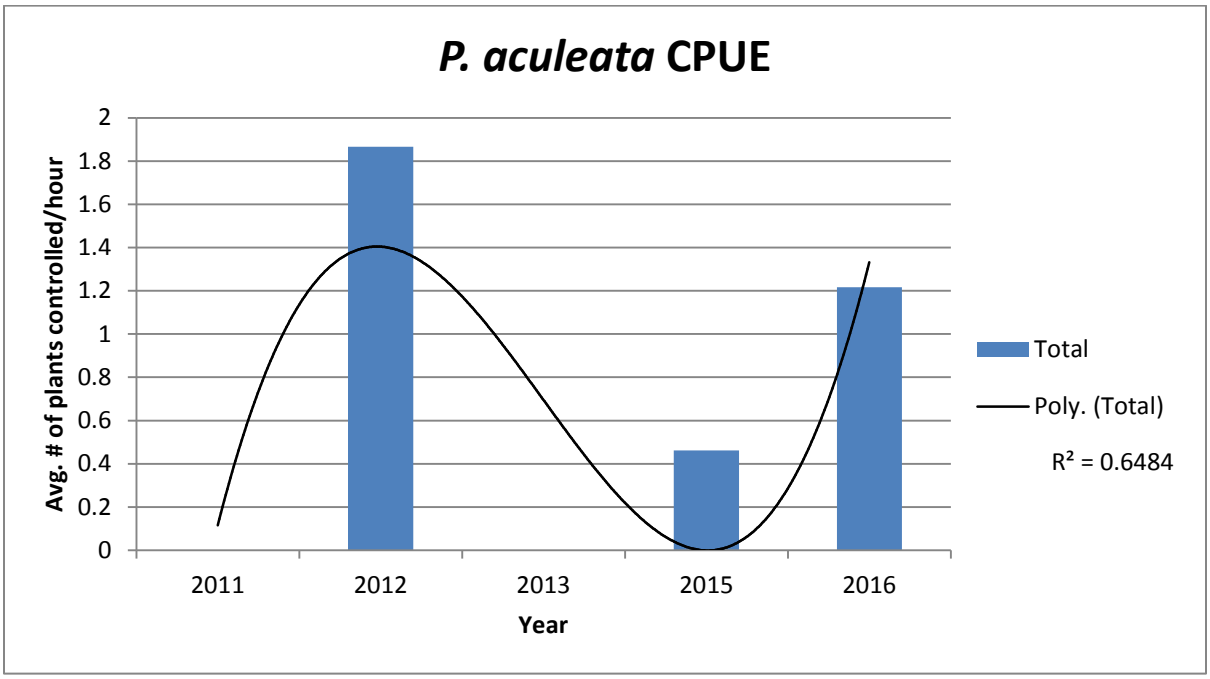
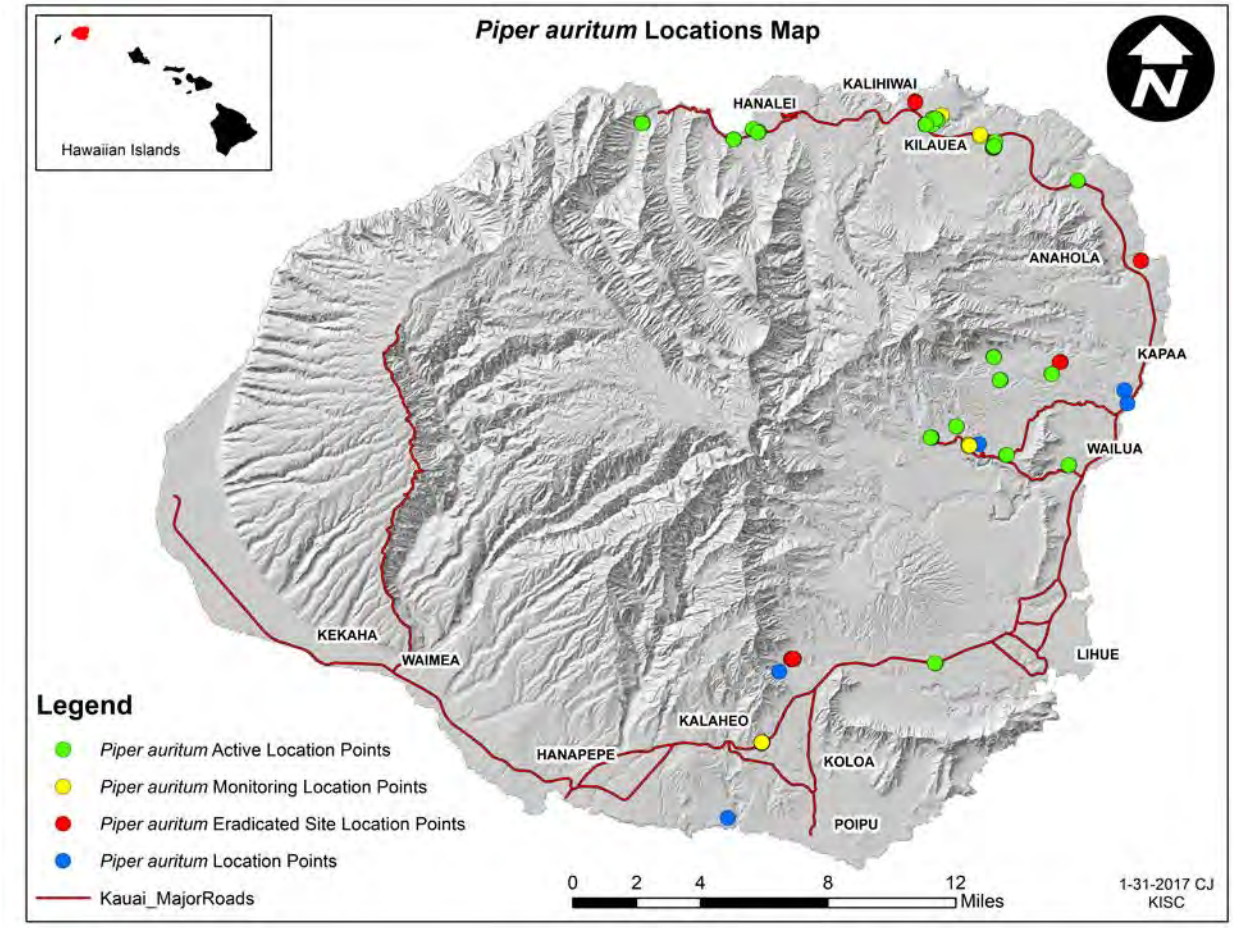


Figure 19 Though the 3rd order polynomial line indicates a rise there is only one remaining population that is currently cultivated and KISC does not have permission to control.

False Kava or "Golden False awa" (*Piper auritum*)



Map 14 *P. auritum* locations

Status: Target Species

Background: False kava, *Piper auritum*, is easily mistaken for true Awa when it is small and poses serious problems for the Awa, *P. methysticum*, industry. Primarily *P. auritum* "dilutes" the quality of genuine *P. methysticum* by being harvested and unintentionally mixed. When buyers, both in the Pacific and in larger external markets, learn of this, shipments may be rejected and local and export markets lost. Secondly, it is larger than *P. methysticum*, grows more vigorously, and can be a weed interfering with the growth of other crops. It may also be an alternate host for pests and pathogens of *P. methysticum* but this has yet to be demonstrated

Photo 14 *P. auritum* regrowth

(Englberger 2001; Pest Alert 19). *P. auritum* is spread by rhizome and seeds via birds, bats, and possibly rodents. All plant parts are considered plant propagules as rooting can take place even from a leaf or stem piece.

There are 27 known sites of *P. auritum* on Kauai. Four of these populations have been eradicated. Continued monitoring is necessary even with such a small population in order to insure total treatment success. Further surveys will most likely be focused on residential areas were the plant might be intentionally planted.

Objectives: Eradicate

Strategy: Standard control and monitoring

Actions:

- Continue island wide surveys to detect new populations
- Continue controlling known populations
- Continue monitoring treatment sites
- Respond to new sightings
- Determine number of years to monitor sites
- Continue outreach: focus on using *P. methysticum* photos and living plants

Treatment methods:

- Cut stump treatment is used followed with application of Garlon 4 in forest crop oil mixed at 50%.
- The cut plant is placed in a plastic bag and properly disposed

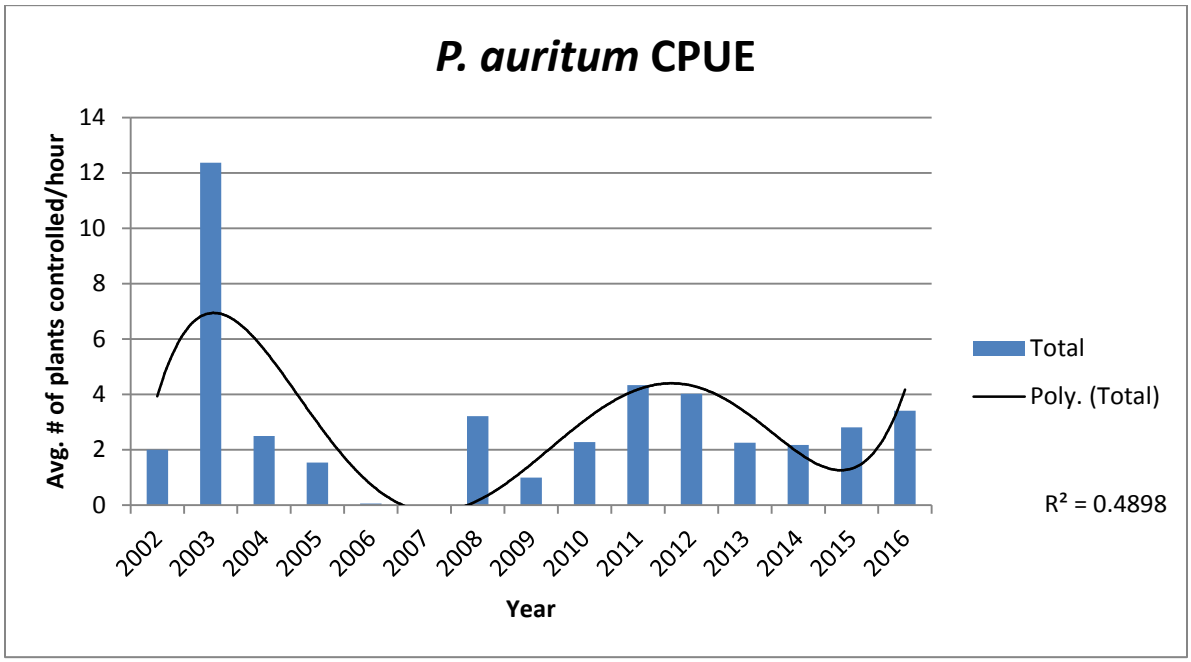
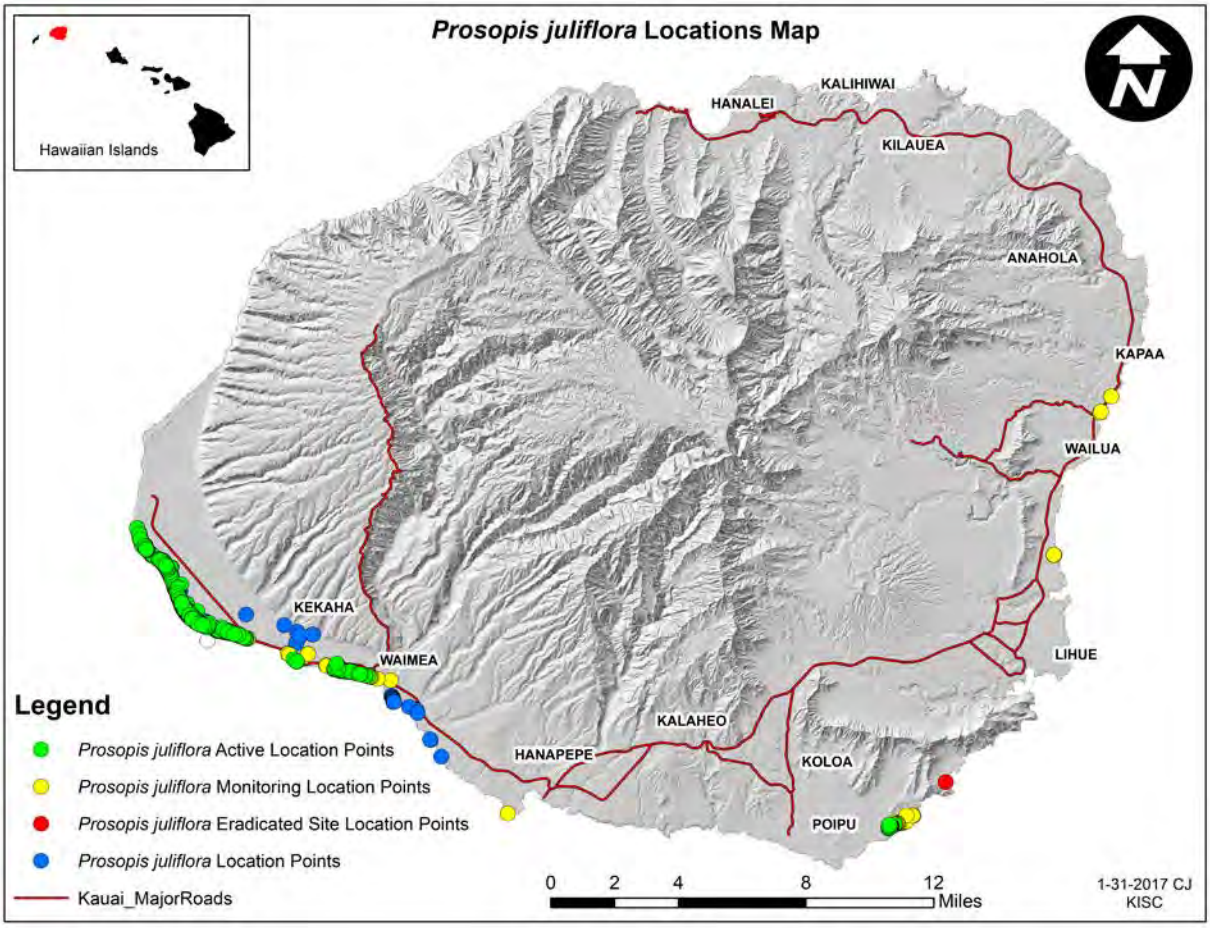


Figure 20 Increases in *P. auritum* detections are likely related to the strong emphasis placed on this taxon by the outreach program.

Long Thorn Kiawe (*Prosopis juliflora*)



Map 15 *P. juliflora* locations

Photo 15 *P. juliflora* thorn

Status: Target Species

Background: It must be noted that Long thorn kiawe (*Prosopis juliflora)* varies from the more common species of Kiawe *(Prosopis pallida)* found on Kauai. *P. juliflora* contains thorns up to several inches long, which are sharp enough to pierce through automobile tires. This long-thorned variety first appeared in Hawaii about 1978, and is found on Oahu, Kauai and Niihau. There are 22 sites with the majority of sites on the west side of the island from Pakala Point to PMRF. The potential range for *P. juliflora* is within a few hundred feet of the high water mark from Nawiliwili to the Napali Coast (approx. 40 miles). *P. juliflora* is in the legume family, producing multiple seedpods which can tolerate saltwater, are drought resistant, and persist in the soil for multiple decades. *P. juliflora* is considered a major threat to the tourism industry on Kauai not only because of its

treacherous thorns, but because it restricts access to the beaches. *P. juliflora* also seriously threatens endemic coastal strand vegetation by creating a monotypic, impenetrable bramble that no native vegetation can grow through. Mechanical control and the herbicides Spike and Garlon-4 have been identified as the most efficacious means to control *Prosopis*.
P. juliflora is a long-term target for both KISC and HDOA. The relatively slow growth rate of *P. juliflora* makes it a manageable target that does not require rapid response but its ability to out-compete native vegetation in combination with the persistent seed-bank make it a primary target that can be managed over the long term.

Objective: Eradicate

Strategy: Standard control and monitoring

Actions:

- Continue island wide surveys to detect new populations
- Continue controlling priority sites
- Continue monitoring treatment sites
- Respond to new sightings
- Continue work at the well-established hedge in the Mana area that spans about 4 miles along the coast. Because of sensitive cultural aspects of the area where the hedge is located, mechanized control is not a viable option. Manual removal of Kiawe is very time and labor intensive requiring persistent effort and an appropriate management time frame spanning multiple seasons.
- Complete Mana eradication and evaluate new Kekaha population (Nov. 1, 2016)
- Opportunistically partner with the PMRF on mechanical removal of *P. juliflora* at the base.
- Create restoration pilot area post- *P. juliflora* removal on HIARNG firing range.

Treatment methods:

- Hand pull newly emerged seedlings. The root system is too well developed on plants any larger than ~1'.
- On larger plants we use a cut stump treatment; cutting the tree with a chainsaw horizontally as close to the ground as possible. A 50% Garlon/forest crop oil mixed herbicide is applied immediately after the fresh cut for the most efficient herbicide translocation into the root system.
- Plant material is left at the site and we are investigating ways of mulching the downed trees to make access to seedlings easier upon post treatment monitoring.

A collaborative *P. juliflora* removal project with KISC and PMRF is utilizing mechanized removal of the trees via a hydro-axe which grinds the tree to mulch, followed by a bulldozer which scrapes debris away from the stump (being careful not to disturb possibly culturally sensitive areas). This is then followed up by ground crews making a fresh cut of the stump and immediately applying chemical. PMRF cleared all known *P. juliflora* on base in January 2016. KISC will be responsible for the monitoring and treatment of seedlings after initial removal.

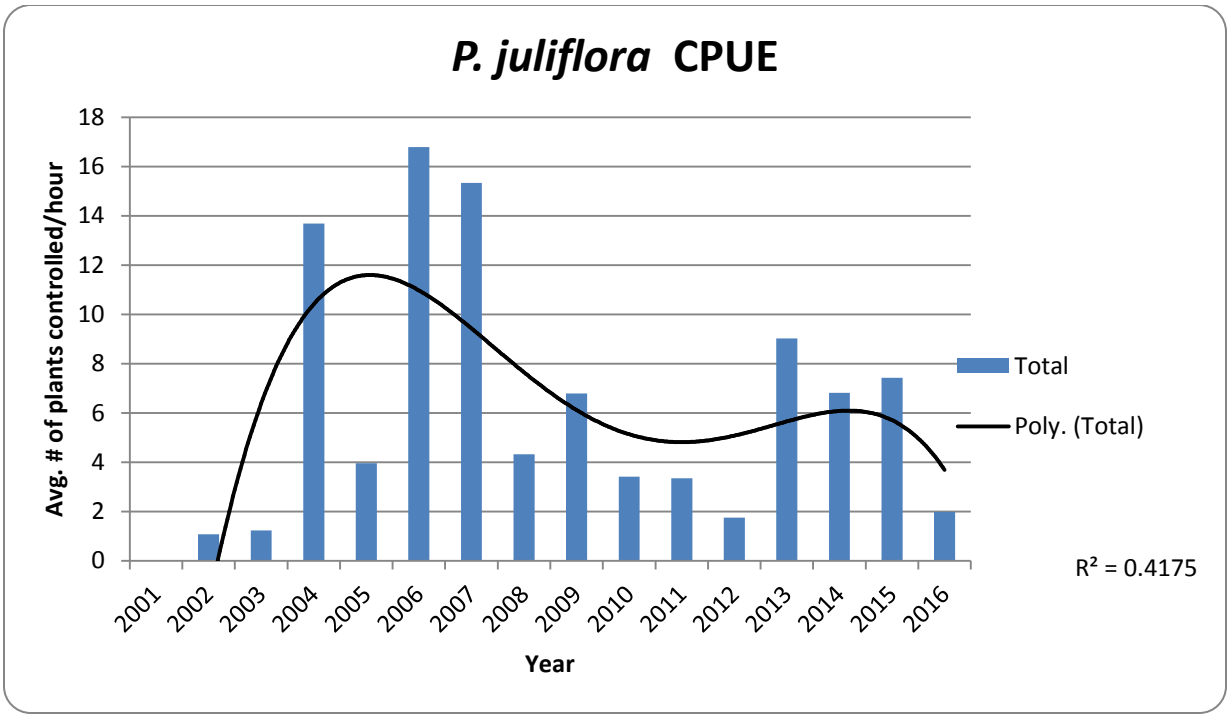


Figure 21 More thoroughly explained in the following graph, effort control for new seedlings is decreasing as seedlings growth decreases over a consistently monitored area.

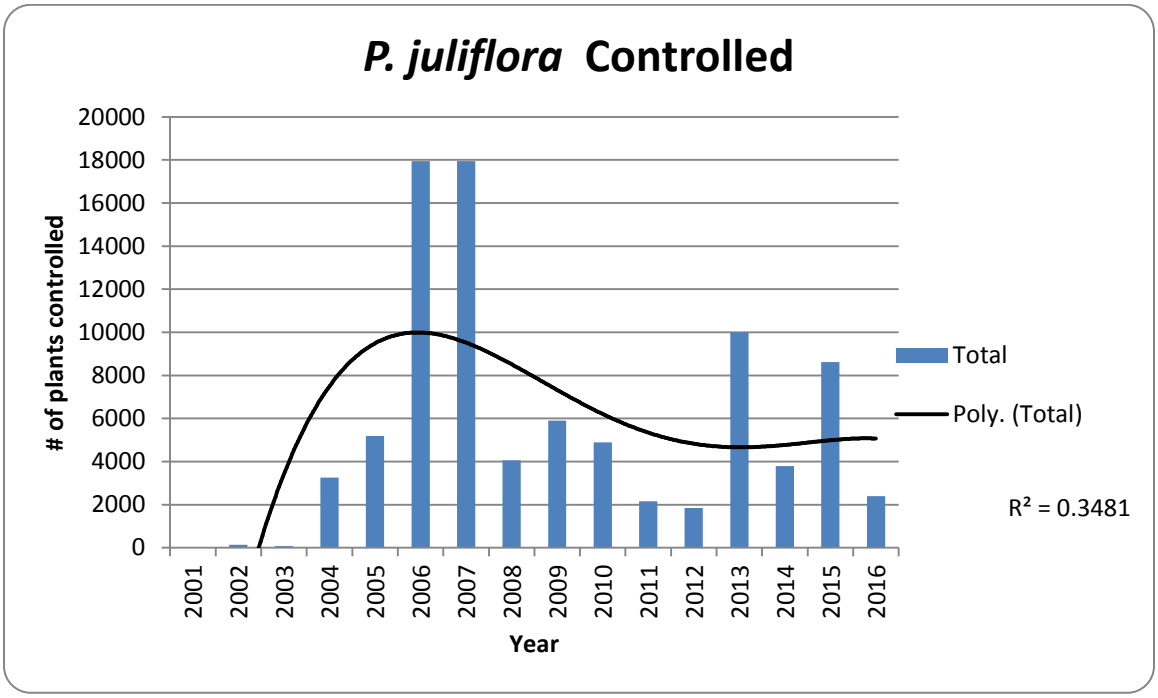


Figure 22 The number of *P. juliflora* plants controlled fluctuated over time giving the polynomial trend line the best fit though not a strong one. This reflects multiple variables including hydro-axing adults combined with follow-up seedling suppression. The drop in actual plants controlled in 2016 coupled with a rise in work hours is indicative of the removal of seeding adults from the entire stretch of coastline from the HIARNG firing Range to the end of the infestation at PMRF. Seed banks are being exhausted without addition of new seeds as in the past.

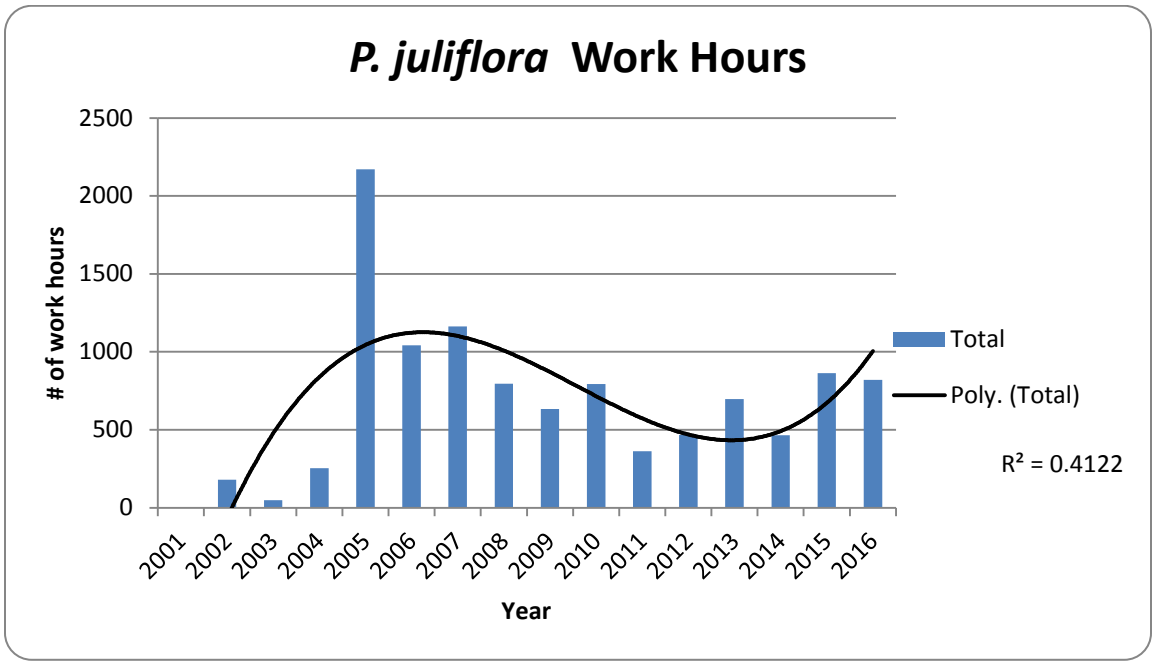
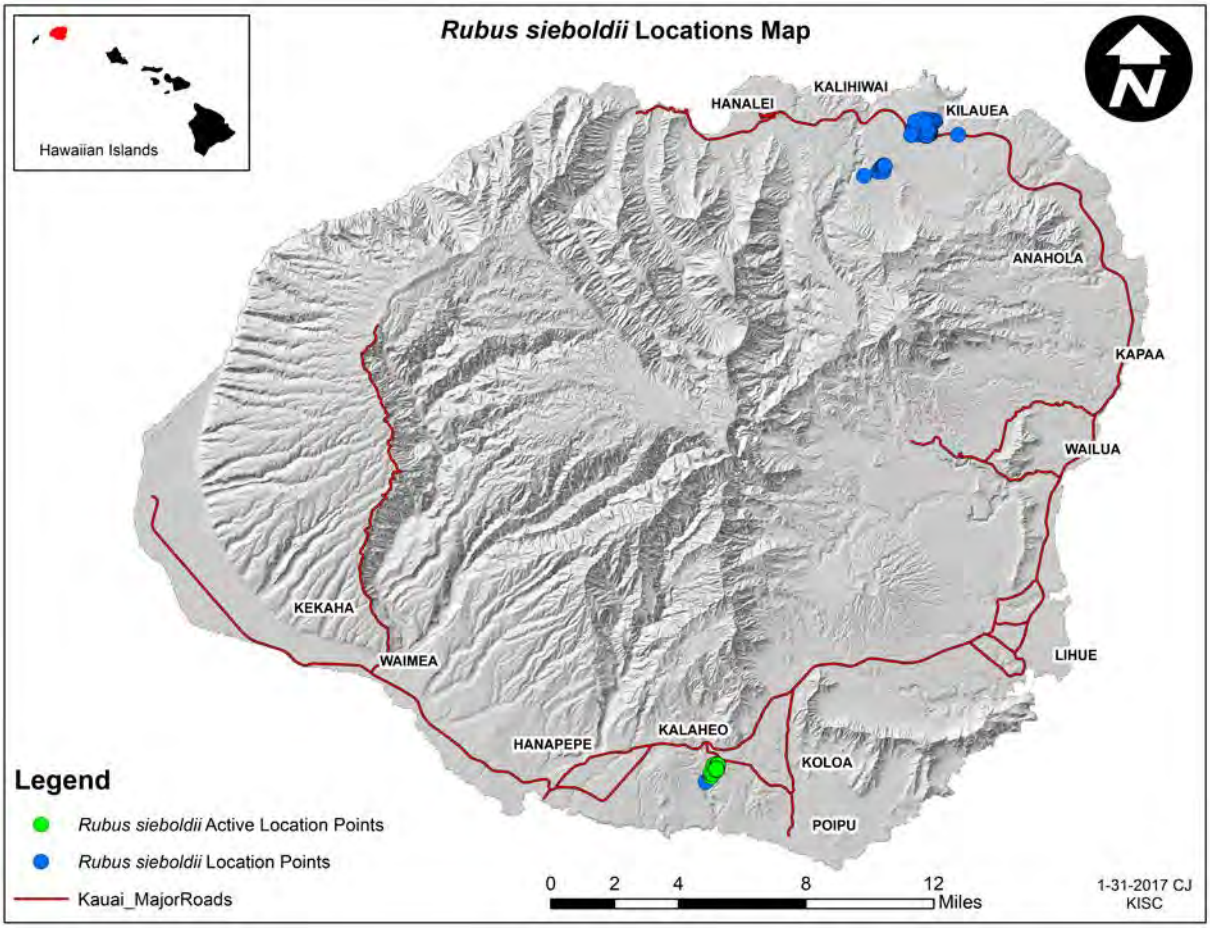


Figure 23 Over time KISC work hours on *P. juliflora* have remained flat between 600-700 hours per year. The best trend fit for annual hours is a 3rd order polynomial which shows increased efforts in 2015 & 2016 with the advent of the Tetra Tech Hydro-axing project on PMRF where KISC crews controlled seedlings on a long stretch of coastline.

Molucca Raspberry (*Rubus sieboldii*)



Map 16 *R. sieboldii* locations

Status: Target Species, re-evaluate

Background: This spiny shrub is native to Australia and western Asia and is known to occupy a wide range of elevations and environmental conditions in its native range. It was brought to Kauai as a cultivated plant where it was noticed naturalizing in the 1970's in Lawai Valley and Kilauea. This plant appears to be becoming more abundant on Kauai as sightings from the field crew and partners have been increasing around Kilauea. However, the population at Kilauea may be too large to eradicate. *Rubus spp*. is on multiple noxious/invasive lists statewide with the exception of native *Rubus hawaiensis*.

Photo 16 *R. sieboldii* Lawai infestation

Objective: Eradicate

Strategy: Re-evaluate suitability of target designation while continuing the standard control and monitoring.

Actions:

- Conduct KISC Prioritization and Feasibility of Control assessment (Appendix A) to determine if the species should remain a KISC target.
- Continue island wide surveys to detect new populations
- Continue controlling infestation site in Lawai.
- Survey and monitor Kilaueau population.
- After feasibility assessment, discuss possible partnerships to eradicate/contain this species island-wide or site specific plans (e.g. Kilauea)

Treatment methods:

- Drizzle application- Garlon4 Ultra at 20% mixed with forest crop oil
- Foliar Application- Garlon4 Ultra at 8% mixed with forest crop oil

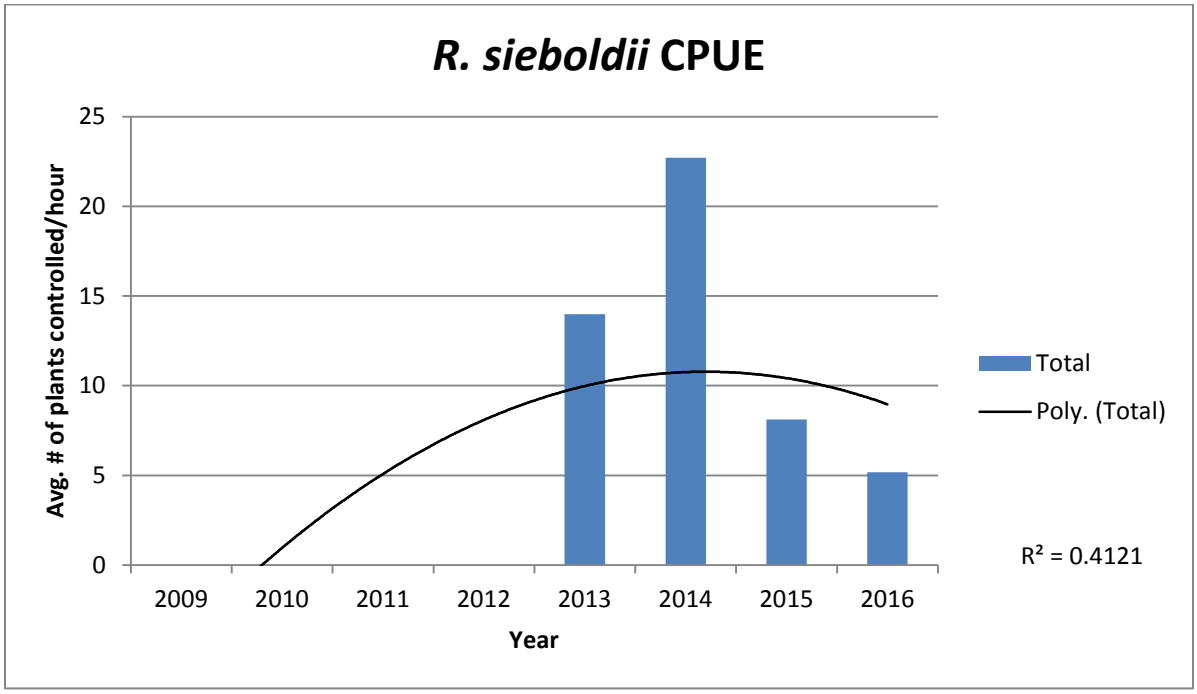
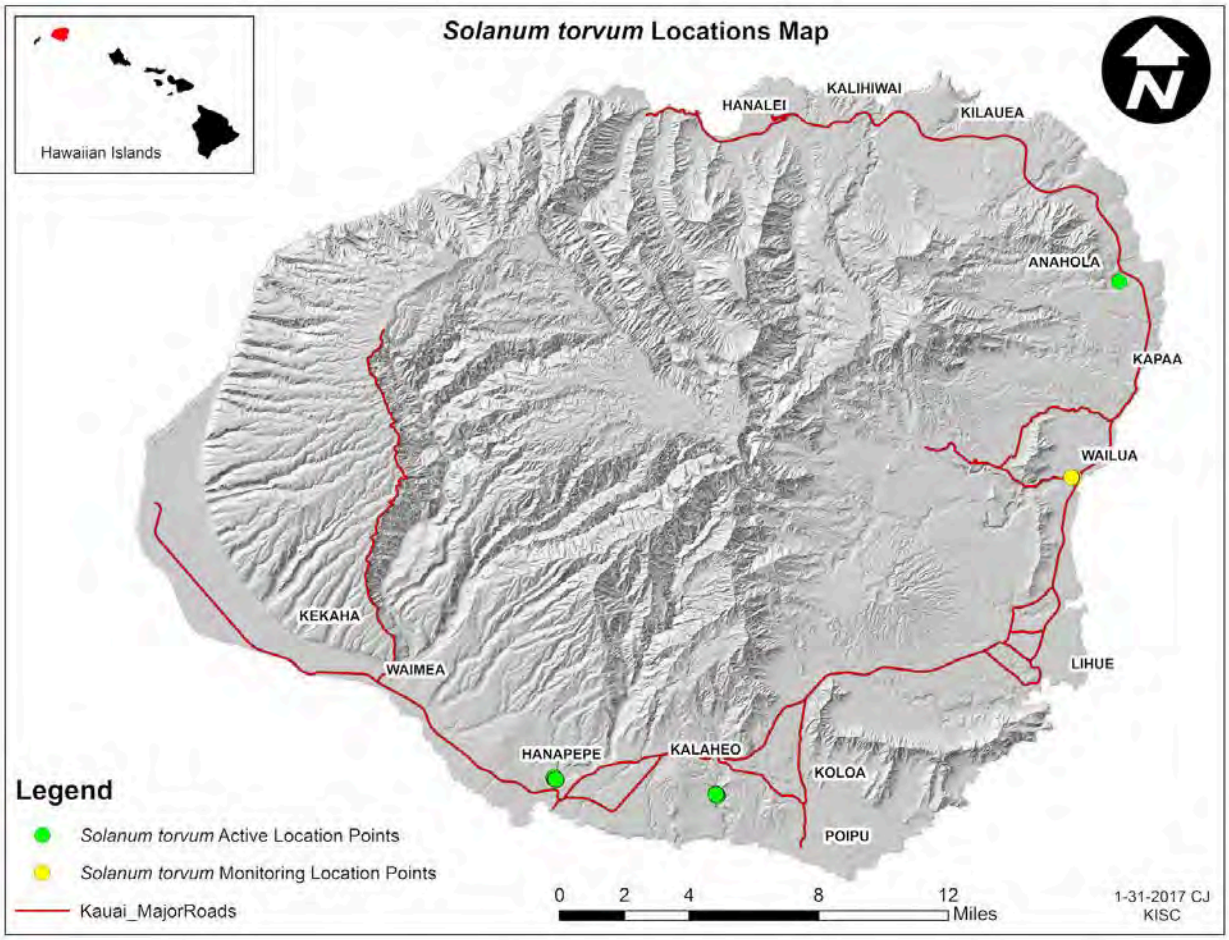


Figure 24 Progress is significant at the one control site.

Turkeyberry (Solanum torvum)



Map 17 *S. torvum* locations

Status: Target Species

Background: HDOA identified *S. torvum* as likely having a limited distribution on island. In October of 2014, HDOA requested for KISC to help with the survey and treatment of *S. torvum*. At the time, there was only one location of S. torvum known on island. After initial treatment, *S. torvum* was added to the KISC Early Detection list. Two additional infestations have been located, one in Hanapepe and one in Lawai. One single plant was found at a *C. grandis* infestation site.

Photo 17 *S. torvum*

Objective: Eradicate

Strategy: Standard control and monitoring

Actions:

- Continue island wide surveys to detect new populations
- Work with HDOA to continue controlling known populations
- Continue monitoring treatment sites
- Conduct deliminating surveys of all known locations
- Respond to new sightings
- Continue outreach

Treatment methods:

- Cut Stump treatment- Trees are cut by chainsaw, handsaw, or machete. Stumps are treated with Garlon4 Ultra mixed with forest crop oil at a 50/50 ratio. Seeds are collected, bagged, and brought back to baseyard to be burned or stored until they rot out. Debris is left on-site.

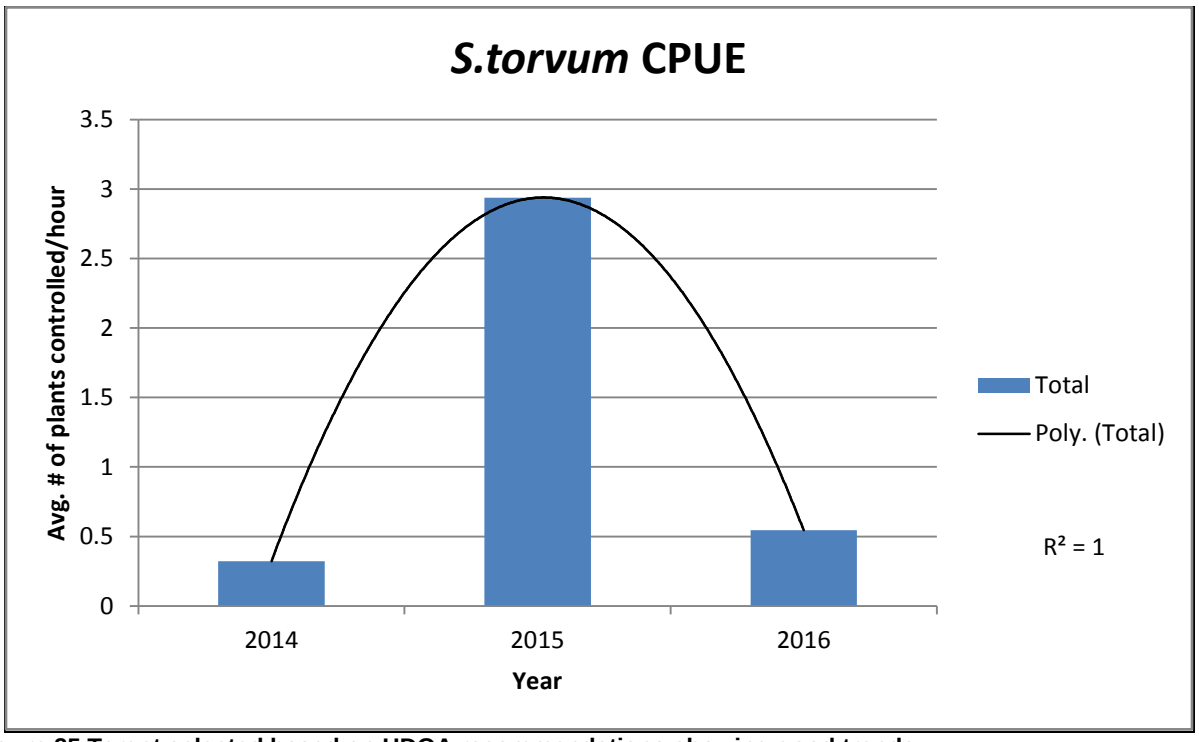
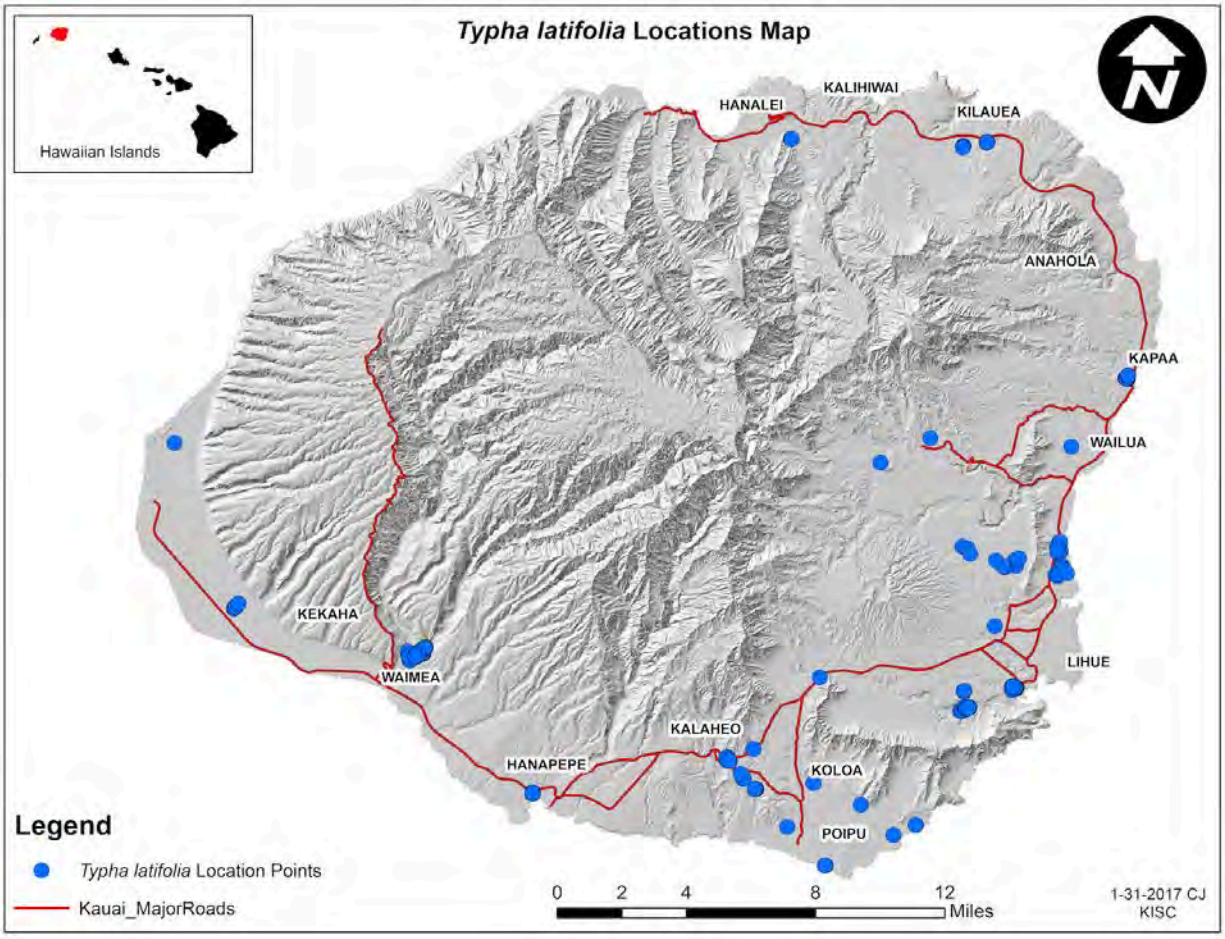


Figure 25 Target selected based on HDOA recommendations showing good trends

Cattail (*Typha latifolia*)



Map 18 *T. latifolia* locations

Status: Target Species, re-evaluate

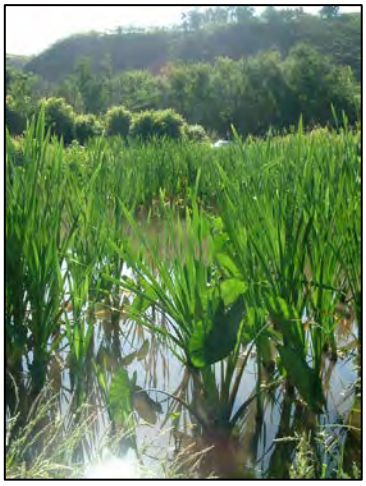


Photo 18 *T. latifolia* invading loi

Background: Cattail (*Typha latifolia)* is an invasive wetland rush, which occurs naturally in Eurasia, North Africa and North America. It spreads via air-blown seeds and underground vegetative runners. It was first collected on Oahu in 1979 and has since spread to the Big Island and Kauai. If left unchecked, this plant can form dense, monotypic stands, effectively eliminating all open water in shallow water habitats, areas vital to species such as endangered Hawaiian stilts. *T. latifolia* is also a major threat to the taro industry encroaching into both cultivated and fallow loi. Given the healthy condition of endangered water birds on Kauai, the eradication of this invasive wetland plant should be considered as appropriate water bird habitat management. At present, there are several known populations of *T. latifolia* on Kauai;

on the North shore in Hanalei, Omao, Poipu Beach Park, Kapaa stream, a large area in Kapaia, and a large 4+ acre population in Makaweli Valley, Waimea. Another population is located on USFWS land in Huleia and was being monitored and treated by USFWS staff.

Objective: Eradicate

Strategy: Re-evaluate suitability of target designation while continuing the standard control and monitoring.

Actions:

- Conduct KISC Prioritization and Feasibility of Control assessment (Appendix A) to determine if the species should remain a KISC target.
- Continue island wide surveys to detect new populations
- Dertermine priority treatment areas.
- Conduct deliminating surveys around all known locations.
- Map out extent of infestation
- Coordinate with Taro farmers
- Compile and evaluate data from all sites to identify total acreage of treatment areas to determine if any additional DOH National Pollutant Discharge Elimination System (NPDES) permits are required.
- Compile partner information and point data relating to the distribution of this plant across the island. (e.g. KRCP)
- After feasibility assessment, discuss possible partnerships to eradicate/contain this species island wide.

Treatment methods:

- Monitor cleared sites (cattail seeds can remain viable for up to 100 years)
- Cut seed heads before they flower
- Treat with a solution of AquaMaster while carefully tracking dosage restrictions
- *T. latifolia* is treated with a 20% mixture of AquaMaster/ water/ surfactant and applied by drizzle spray method.
- Seed heads are carefully picked and placed into a plastic bag for proper disposal.
- Makaweli Valley requires some habitat modification prior to treatment, which includes removing vegetation and re-aligning and deepening an old drainage ditch in order to drain the backwater area where the *T. latifolia* are located.

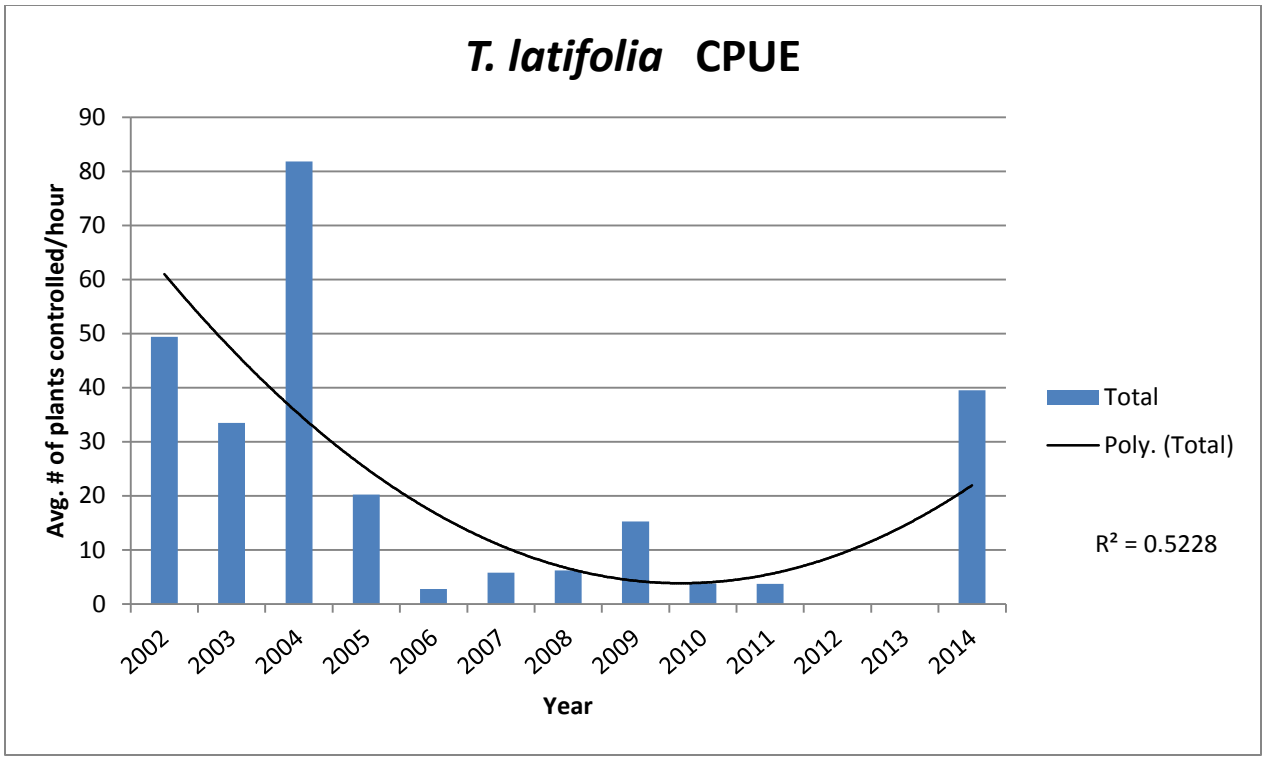


Figure 26 ***T. latifolia*** **will need to be reevaluated as a target.**

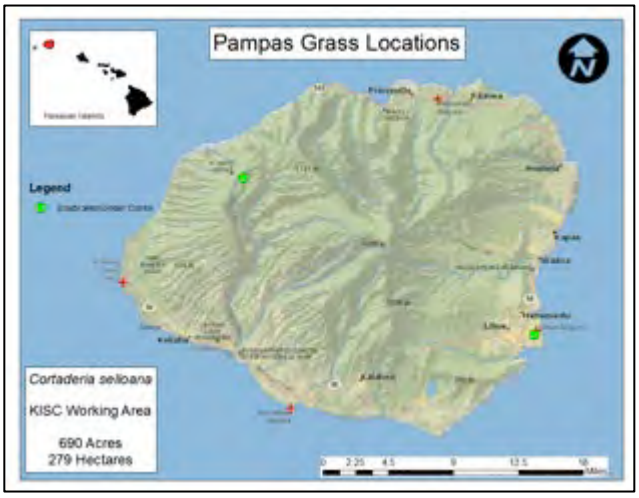
ERADICATED TARGET PLANT SPECIES

The time interval allowed to expire between both active site revisits and demotion of active sites to infrequent monitoring or eradicated status is determined on a site-specific basis that reflects species biology and site conditions. The following table summarizes the control history for each of the KISC target plants species.

Table 3 KISC Target species that, to our knowledge, have been eradicated from Kauai.

Scientific Name	Common Name	Work Hours	Year	Total Locations	Total active sites	Total monitoring sites	Total eradicated sites
Cortaderia selloana	pampas grass	221	2002-2013	4	0	0	4
Senecio madagascariensis	fireweed	733	2002-2012	3	0	0	3

Pampas Grass (*Cortaderia jubata* or *C. selloana*)



Map 19 *Cortaderia spp*. treatment locations

Photo 19 *C. selloana* on golf course

Status: Target Species - eradicated

Background: This species, recognized as one of the worst invasive weeds in coastal areas of California, New Zealand and South Africa, was added to the Hawaii Noxious Weed List in 1993. Each plant can produce thousands of seeds that are wind-dispersed up to 20 miles and can remain viable, persisting in the soil seed bank for at least six years before germinating. *Cortaderia spp.* invades mesic and wet forests to dry alpine shrubland. *C. jubata* reproduces through the process of agamospermous apomixis. Female plants are able to produce viable, genetically identical seed without pollination. *C. selloana,* however, requires both sexes for crosspollination. On Kauai, known populations were believed to be female plants of *C. selloana* due to lack of spread. All known populations (Kokee State Park, Kauai Lagoons Golf Course, and Princeville) have been successfully eradicated.

Objective: Maintain eradication

Strategy: Continue monitoring and early detection surveys

Actions:

- Continue island wide surveys to detect new populations
- Add seed packet monitoring to survey process
- Continue monitoring eradicated sites
- Respond to new sightings
- Determine monitoring duration
- Continue outreach

Treatment methods:

- In residential and urban areas, where *Cortaderia spp.* is planted ornamentally and where the use of herbicides is discouraged, plants are dug out of the ground and burned in a safe area that can be monitored for seed emergence.
- Chemical treatment for *Cortaderia spp.* is a drizzle spray application of 8% Roundup mixed with water.

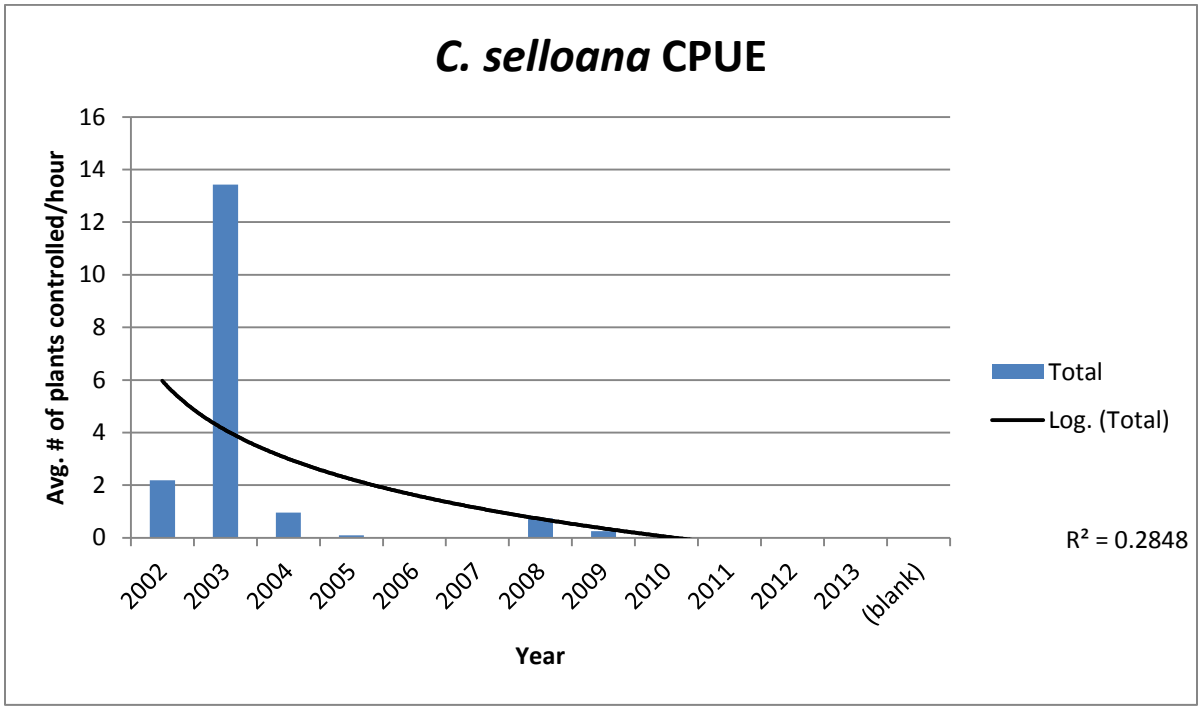
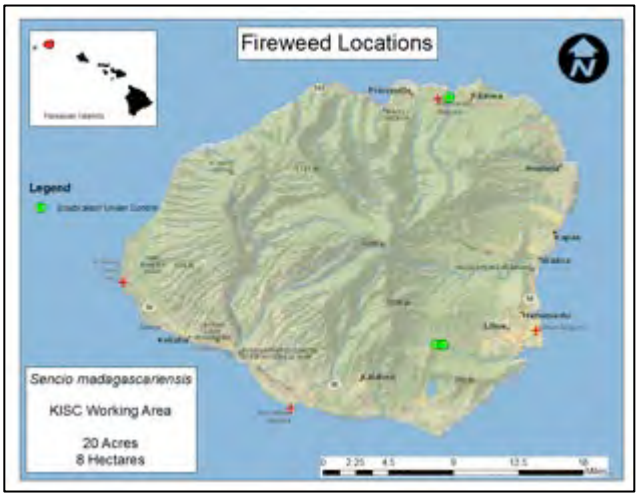


Figure 27 *C. selloana* intervention appears successful, but given its ornamental status plants may occasionally be found.

Fireweed (*Senecio madagascariensis*)



Map 20 *S. madagascariensis* treatment locations

Photo 20 *S. madagascariensis* flowers

Status: Target Species - eradicated

Background: Fireweed, *Senecio madagascariensis*, is a yellow flowering weed currently listed on Hawaii's Noxious Weed List by the HDOA. This plant poses a serious threat to pasturelands, as it is poisonous to horses, cattle, and other livestock. Each plant is capable of producing 25,000 to 30,000 seeds in a single growing season, which can persist in the soil for at least 50 years. In Australia, yearly losses of $2,000,000 are attributed to *S. madagascariensis*.

In 1990, the weed was found along the roadway near Halfway Bridge, between Lihue and Koloa on the island of Kauai. This infestation probably started with some roadside plantings of grass seeds from Australia that contained some unwanted *S. madagascariensis* seeds. Since discovery, this plant has been a target of HDOA with KISC assisting since 2002. In 2003, *S. madagascariensis* was discovered at a residence in Kalihiwai. This introduction, again, was due to unwanted fireweed seeds mixed into hydro-mulch and then sprayed onto a hillside. Due to higher rainfall in this area, rapid germination led to quick eradication at this site.

This one known population has effectively been reduced from finding an average of 1000 plants per month to finding zero in FY2006. All known populations of this plant have been eradicated from the island. Because past infestations have been introduced through hydro-mulching, KISC will be collaborating with companies to obtain a map of areas that have been hydro-mulched so they can be regularly surveyed in the future.

Objectives: Maintain eradication

Strategy: Continue monitoring and early detection surveys

Actions:

- Continue island wide surveys to detect new populations
- Continue monitoring eradicated sites

- Respond to new sightings
- Determine monitoring duration
- Continue outreach: Targeted outreach to hydro-mulch and landscaping companies (compile list of hydro mulch companies), locate weed free brands for hydro mulching.

Treatment methods:

- The plant is pulled and bagged for disposal and a granular herbicide (Snapshot™) is spread within a 3 m diameter of the area. Snapshot is a pre-emergent and works by killing seeds before they can germinate.
- If a seeding plant is found, the area is flagged and dated. KISC control team will work in coordination with HDOA to monitor and survey for outlying undiscovered populations, and re-treat any new plants within the core population

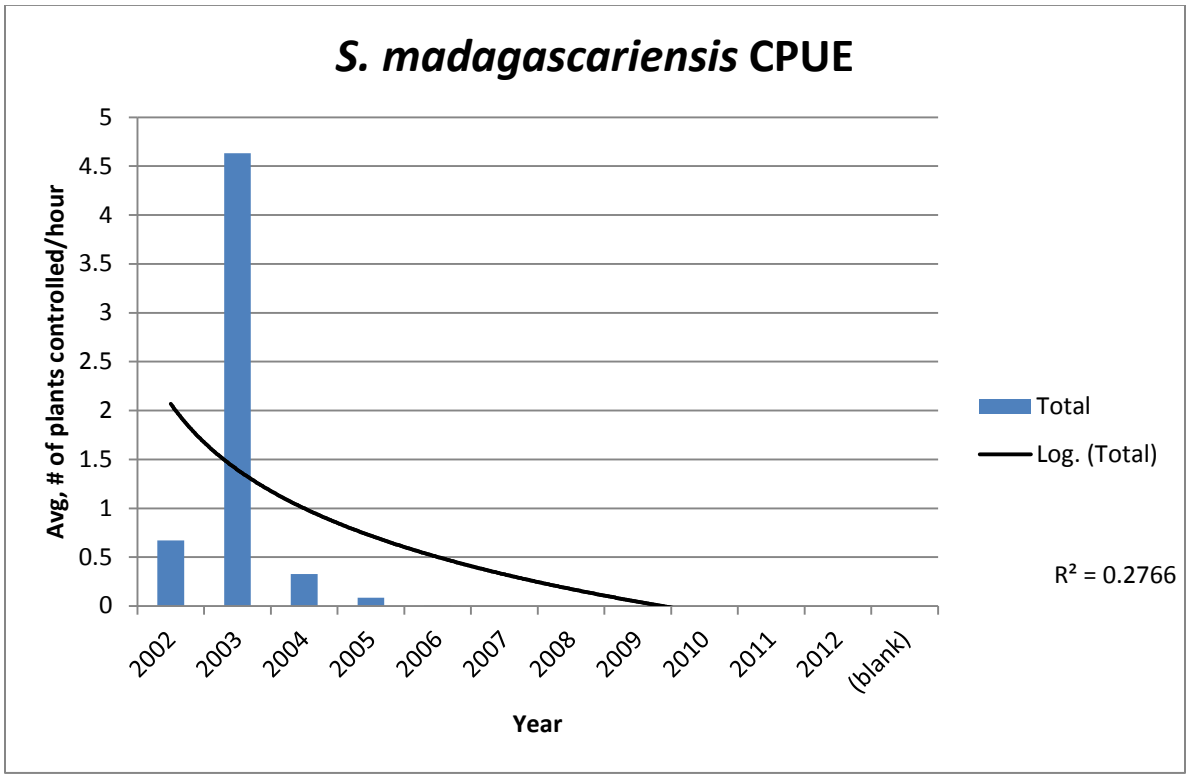


Figure 28 A classic example of ED/RR

VERTEBRATE AND INVERTEBRATE SPECIES

Many of the most damaging invasive species globally are insects, mammals, and birds. On Kauai, KISC invertebrate and vertebrate targets and early detection/ rapid response (ED/RR) species are by definition "partnership projects" in that each taxon has a responsible agency that is tasked with responding. In the organization's role as a gap-filler, KISC has provided a variety of services such as rapid response and control work as well as community outreach and education for various agencies. Rapid response and early detection protocols relating to invertebrates and vertebrates are typically different then similar actions for plants. Primarily due to the mobility of these species, border security, decontamination, and rapid response need to be tighter and faster with good coordination between the lead agency, HDOA, and KISC response teams.

TARGET SPECIES

Little Fire Ant (*Wasmannia auropunctata*)

Photo 23 LFA

Photo 22 LFA on chopstick
Photo Credit: USDA

Background: *"The little fire ant (LFA) is native to Neotropical lowlands and is considered an invasive pest in most of the places it occurs. LFA has been called other names but it received this moniker because of its very small 1/16 inch (1.5 mm) size and its long lasting fire-like burning sting. It is an agricultural pest in that it not only bothers orchard workers but also nurtures populations of Homoptera (sucking) insects that cause damage to economic plants. They also are known to have negative impacts on many animals including vertebrates and invertebrates. Populations of many insects including beetles, flies, and other ants have also been adversely affected by the presence of LFA (Wetterer and Porter 2003). Their*

Photo 21 HAL crew surveying for LFA

*invasiveness comes from having generalist feeding and nesting habits that allows them to invade new areas and succeed. They are not a subterranean species but nest anywhere it is convenient at or above the surface; under fallen leaves, branches, rocks, and in the crotches of trees. Also, unlike most other ant colonies with only one queen, super-colonies of LFA have multiple queens. Should a transported colony fragment have at least one queen, it can establish a population at its new destination." (*Null 2006)

In 1999, HDOA first discovered LFA established in Hawaiian Paradise Park south of Hilo on the Island of Hawaii. It is assumed that the population arrived there on plant material from a nursery in southern Florida. Sometime later in 1999 a container of ornamental plants was shipped to Kauai for landscaping a private estate. When it was learned that the container had some palms from an infested Big Island nursery, personnel from HDOA conducted a survey of the property. The survey resulted in documenting the presence of LFA on Kauai. Personnel from both HDOA and the Hawaii Department of Health's Vector Control Branch on Kauai initiated an eradication project by applying the proprietary pesticide Amdro at the infested site.

Subsequent to the 1999 discovery and treatment of LFA, HDOA and KISC personnel returned to the site in 2003 to resurvey the area previously infested. This survey reconfirmed the presence of LFA and, when performing surveys beyond the initial infestation it was found that the population of LFA had spread to an adjacent property. Amdro© was applied to about five acres on both residential properties. Biannual surveys were conducted through May 2006. Following each survey, the area was treated with Amdro©. Although personnel were unsure about complete eradication of LFA at this site, and because it had not spread beyond the treated area of 2004, it was believed that the population was contained and thus controlled from further spreading.

During 2005-2006 a USFWS grant was received to survey Kauai to determine if any other populations of LFA exist. This survey was completed in 2006 with over 56 nurseries, resorts, and transfer stations inspected. There were no detections of LFA. In 2009, LFA was again detected by KISC and HDOA crews at the site of the original infestation area and on an adjacent property. Planning efforts commenced in 2011 and property access was granted in 2012. Under the leadership of the HAL, KISC and HDOA crews undertook a two-phase approach to eradication that is estimated to end in 2018. (*See Appendix B: Kauai LFA Strategic Plan*)

Objective: To eradicate LFA from the known infested area and prevent LFA from becoming reestablished on Kauai.

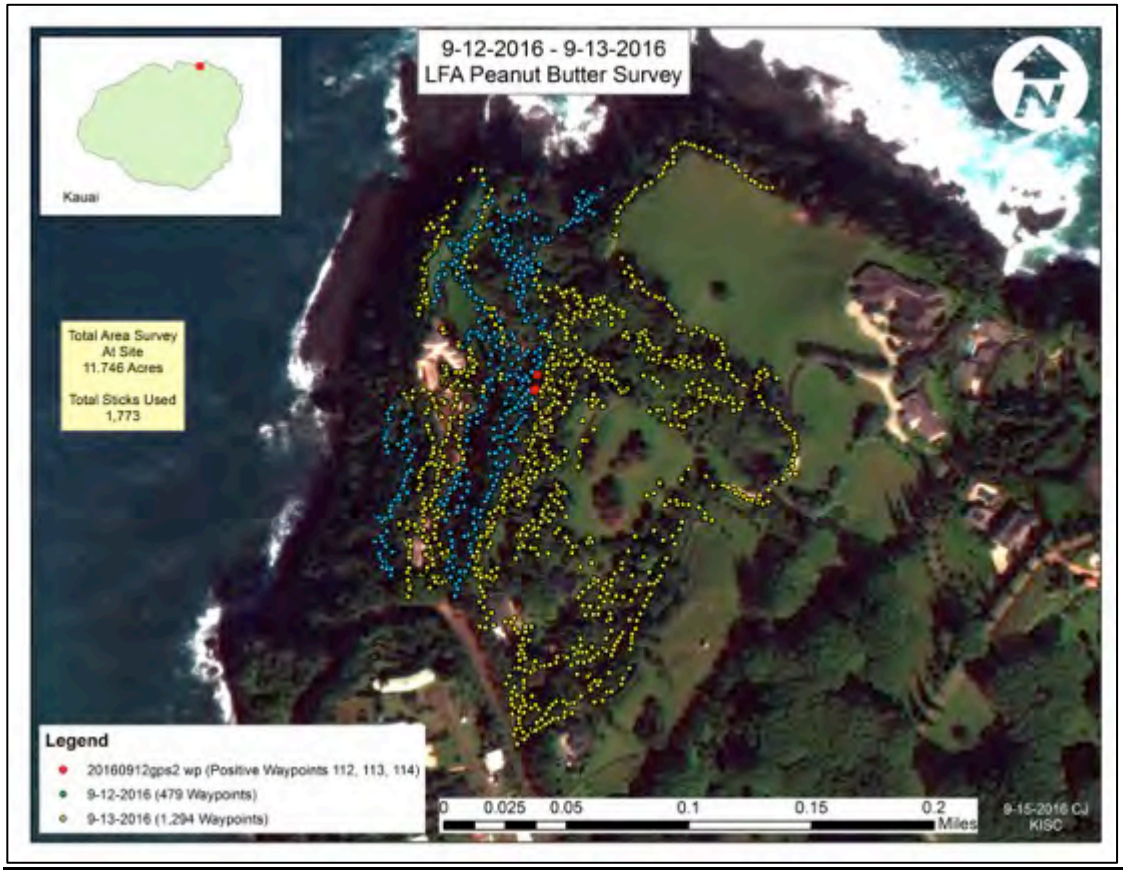
Strategy: KISC will continue to assist the HAL and HDOA with surveying, monitoring and treatments of the known population of LFA. KISC will also assist HDOA in any outreach efforts by contacting and resurveying area nurseries, hotels, and other sources with a large amount of imported plant materials.

Actions:

- Complete Phase II of LFA eradication
- Conduct preventative surveys of high risk areas with HDOA
- Provide rapid response services to HDOA
- KISC will continue to monitor previously treated populations in co-operation with the HDOA through systematic surveys
- Sustain the Pono Endorsement program with annual LFA surveys at participating nurseries (See pg. 94)

Survey / Treatment methods:

- Surveys for LFA utilize peanut butter placed in an open vial or on chopsticks.
- Each bait station is placed 10 feet apart in a grid formation.
- Bait is left out for 1 to 1½ hours and then examined for the presence of LFA.
- Tree top surveys require the use of an extension pole to place the test vials.
- A GPS waypoint is taken at each of the bait sites which corresponds to the numbered vial/ chopstick in order to pinpoint the exact location of LFA should one be found and the area is resurveyed at a spacing of 5 feet once LFA is detected.
- If a LFA is confirmed, the area is treated per guidelines of the Hawaii Ant Lab and in cooperation with local landowners, landscapers, and arborists.



Map 21 2016 LFA Peanut Butter Survey

EARLY DETECTION/RAPID RESPONSE SPECIES

Brown Tree Snake (*Boiga irregularis*)

Photo 25 KISC Operations Supervisor BTS training

Photo 24 *B. irregularis* head

Background: The brown tree snake (BTS) (*Bioga irregularis*) is an arboreal snake, which reached densities greater than 100 individuals per acre during early stages of the invasion on Guam. This invasion caused the extinction of 12 native species of bird and decreased populations of other wildlife, which in turn lowered native plant diversity by reducing pollinators. No species of snakes have become established on Kauai other than the brahimny blind snake (*Ramphotyphlops braminus*).

Objective: Prevent the BTS from becoming established on Kauai.

Strategy: Create institutional knowledge of BTS response protocols within KISC.

Actions: Maintain at least one staff member as a certified BTS responder.

Methods:

- The current Operations Supervisor attended a BTS training on Guam and should maintain certification through refresher classes
- KISC will assist lead response agencies under the direction of USGS.

Rapid Ohia Death *(Ceratocystis fimbriata)*

Photo 27 Beetle generated frass (Photo credit: CTAHR)

Photo 26 ROD mortality **(Photo credit: Outside Magazine)**

Background: In 2012, the public began to notice dying ohia trees in the Puna district of Hawaii. In 2015, the pathogen responsible for Rapid Ohia Death (ROD) was identified by researchers with the USDA Research Service and CTAHR (L. Keith, USDA 2015, pers. comm.). The work was conducted after landowners on the Big Island began reporting otherwise healthy Ohia trees (*Metrosideros polymorpha)* mysteriously dying. Infected trees show yellowing leaves and die within a matter of weeks. Large stands have become infected across the Island of Hawaii with confirmed losses currently, as of fall 2016, of around 50,000 acres. There are several questionable patches of dead ohia on Kauai though there are three common ohia diseases that show similar symptoms as ROD. On the Big Island dead stands of ohia are typically replaced with strawberry guava stands (J.B. Friday 2016, pers. comm.)

Objective: Prevent ROD from becoming established on Kauai.

Strategy: Coordinate with agencies responsible for managing ohia forests on Kauai.

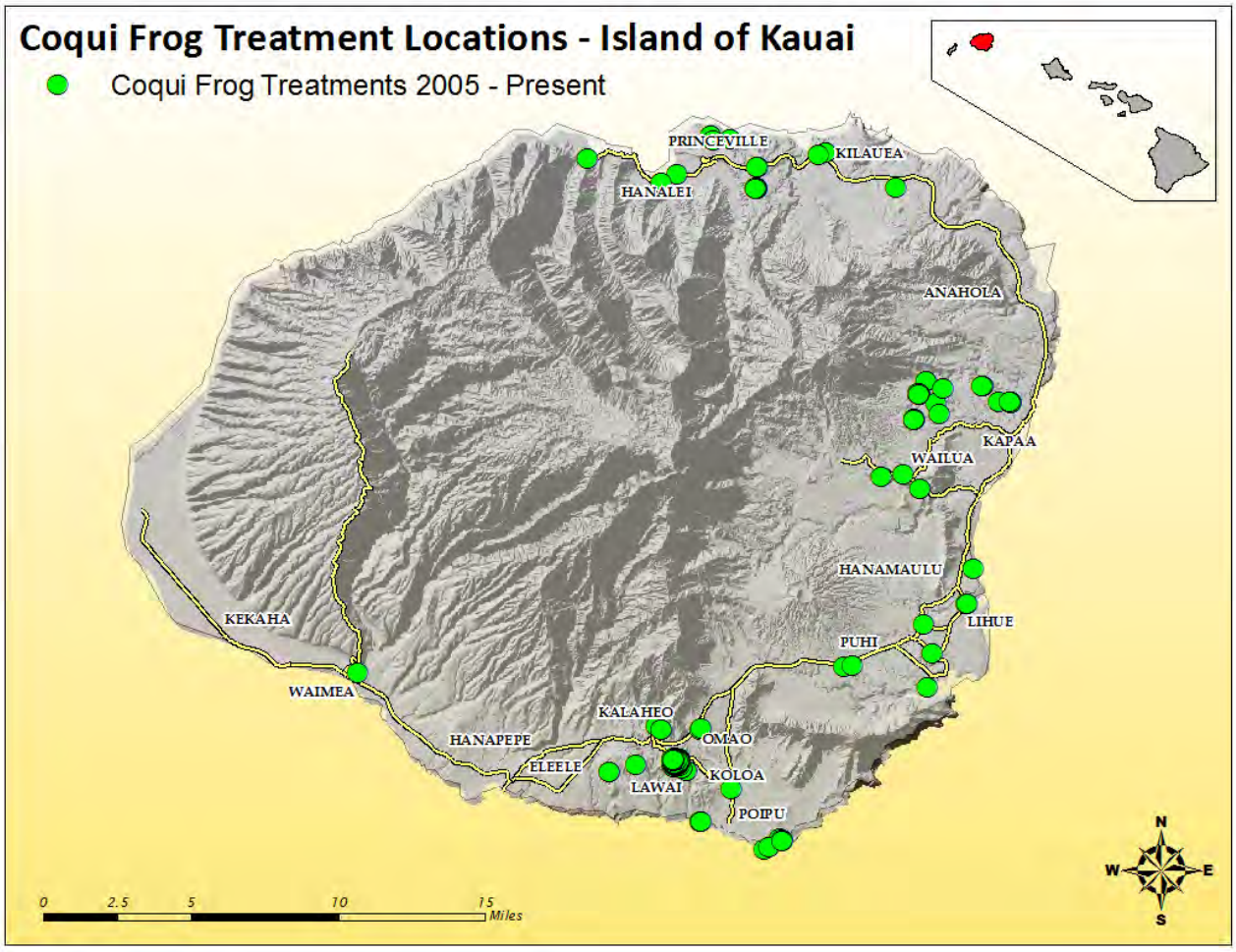
Actions:

- Form a Kauai ROD Working Group (KRODWG).
- Offer rapid response capacity.

Methods:

- Utilize the KISC outreach program to spread the word about ROD to both residents and visitors.
- Assist DLNR with installation of informational signs and boot scrubbers at trailheads leading to ohia forests.
- Participate in the Kauai ROD working group meetings.
- Certify KISC crewmembers in sampling and rapid response techniques.

Coqui Frogs (*Eleutherodactylus coqui*)



Map 22 *E. coqui* treatment and captures

Photo 28 Captured male *E. coqui*

Background: Two species of small brown Caribbean frogs of the large Neotropical genus *Eleutherodactylus* have been introduced to Hawaii within the past 10 years. *E. coqui* is colloquially called “coqui”, while *E. planirostris* is referred to as the “greenhouse frog.” *E. planirostris* is considered well established and less of a threat than the coqui on Kauai and therefore is not considered a KISC target. *E. coqui*, on the other hand, is widely dispersed on the island of Hawaii and a serious threat here. Much is known about *E. coqui* in its native Puerto Rico and from these studies we can readily deduce the problems this species could cause in Hawaii should they become widespread.

Basic ecological information relevant to determining these effects include the following:

- In Hilo Hawaii, *E. coqui* first occurred at densities up to 22,000 per acre
- They consume an average of 45,000 prey items per acre per night (approximately 16 million prey items per acre per year).
- They do not require standing water for a tadpole stage; eggs are laid in leaf axils or in leaf litter which hatch into froglets.
- Females produce 4-6 clutches per year, each clutch consisting of 16-41 eggs.
- The frogs reach sexual maturity 8 months after being laid as eggs.
- They can occur from sea level to at least mid-elevation rainforest and mesic forest (ca. 4000 feet).

As a result of these biological attributes we may expect that, if left unchecked, these frogs will soon spread and establish numbers on Kauai too large for control. If so, it is reasonable to expect that they will affect tourism, property values, and product export.

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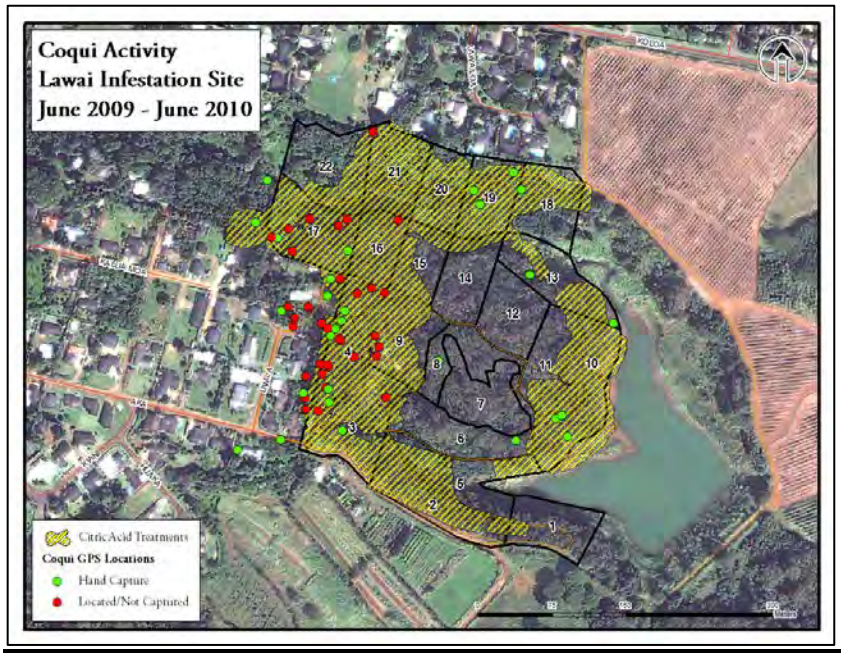
- Further, if states such as California discover that Hawaiian nurseries are contaminated by these frogs, they may refuse shipments of material not certified to be free of the pests, again increasing costs to the industry.

The primary impact of dense naturalized populations is their loud calls (emitted at 90-100 decibels) prove very annoying and disturbing to the sleep of many residents and visitors. Visitors at several hotels on Maui and Hawaii Island have complained about the noise at night, and property values on Hawaii Island have been negatively affected by the frogs' presence. These complaints have stemmed from areas having no more than 30 – 80 frogs, not the thousands that the specie is capable of attaining. *E. coqui* were considered eradicated on Kauai after the population was controlled in Lawai after ~15,000 work hours. Currently on Kauai there is no known naturalized population.



Map 23 *E. coqui* Lawai infestation site treatment and capture

Objective: Prevent the reestablishment of coqui frogs on Kauai.

Strategy: Rapidly respond to all new *E. coqui* reports.

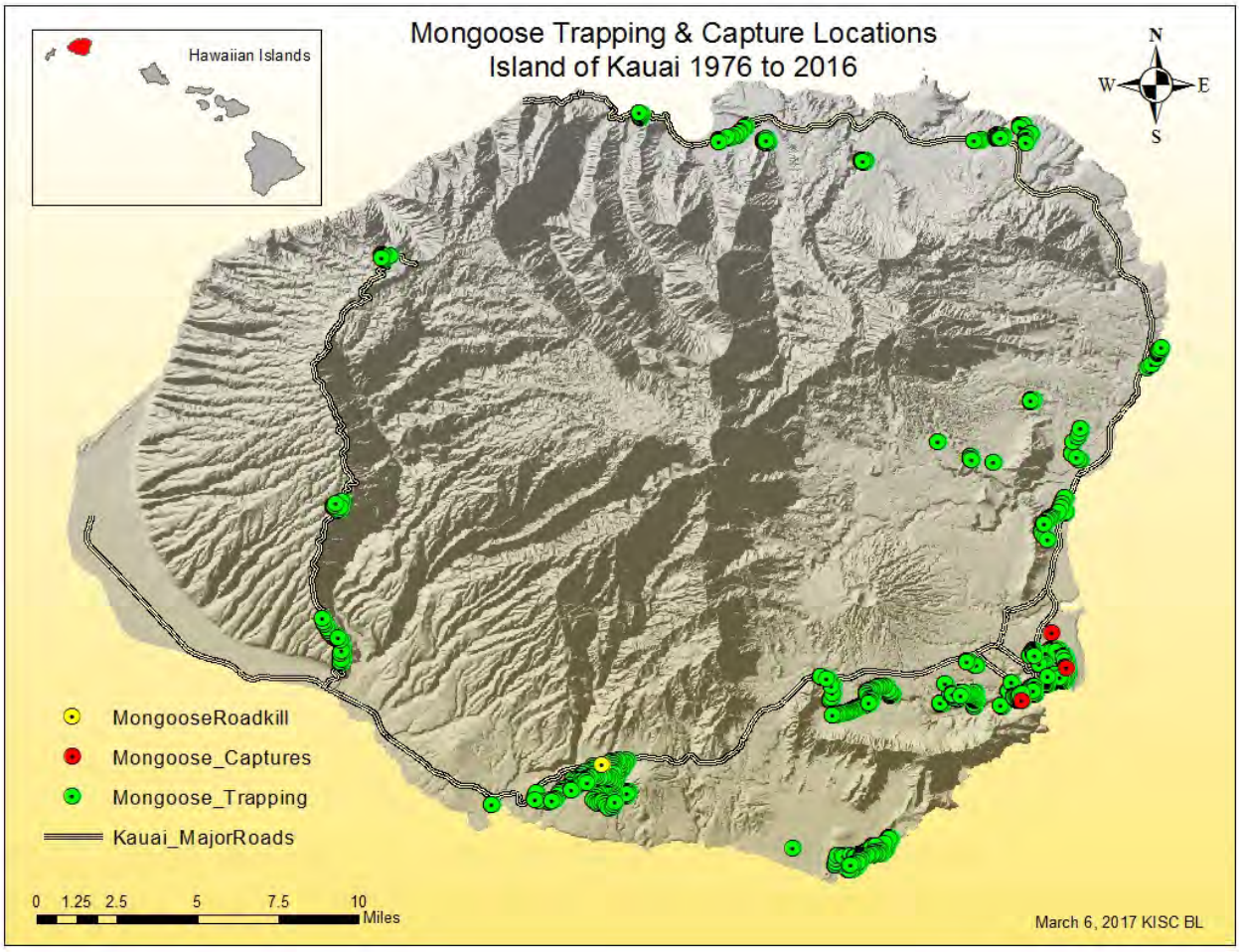
Actions:

- Cooperate with lead agency, HDOA, on coqui monitoring efforts.
- When KISC receives an *E. coqui* report notify HDOA Plant Quarantine Kauai.
- Respond to calls when requested by HDOA.
- Assist HDOA with continued outreach to increase voluntary reporting.

Methods:

- Continue to verify and document locations of *E. coqui* reports on Kauai.
- Control newly discovered individuals to prevent new infestations.
- Hand capture frogs in areas where spraying is not an option, usually done at private residences in single frog cases.
- Chemical control consists of utilizing Citric Acid (16%) foliar spray.
- Spot spray areas only in area where frogs are heard calling.
- Utilize the Pono Endorsement Program to help sustain vigilance.

Mongoose (*Herpestes auropunctatus*)



Map 24 *H. auropunctatus* trapping locations and captures

Background: Intentionally introduced to Hawaii in 1883, the mongoose (*Herpestes auropunctatus*) is now a serious threat to the endemic forest birds, ground nesting shorebirds and sea turtles on all islands except for potentially Kauai and Lanai where it was not introduced. *H. auropunctatus* are diurnal predators and have heavily impacted Hawaii's bird populations, which evolved relatively predator free. The life cycle of *H. auropunctatus* lends to their invasive success; reaching sexual maturity at 10 months of age, *H. auropunctatus* can breed

Photo 29 First live *H. auropunctatus* capture (2012)

2-3 times a year producing up to 9 offspring annually. There have been credible sightings of *H. auropunctatus* on Kauai since the early 1960s with one confirmed road kill in 1976 and two live captures in 2012.

It is likely that *H. auropunctatus* regularly transit to Kauai via shipping containers but they have not been brought here in numbers that would support a reproducing population. Historically some intentional introductions have failed and Will Pitt (Smithsonian) surmises that stray *H. auropunctatus* are susceptible to rat control poisons employed around housing and hotels that encircle Nawiliwili harbor.

Because the presence of *H. auropunctatus* is potentially incipient, KISC has maintained a fulltime mongoose person on staff and recently added a part-time assistant. This program responded to "credible" sightings by monitoring trap/ tracking lines in order to insure proactive action against the establishment of a viable population here. A new strategy was developed in cooperation with KISC and USFWS in 2015. The first step was to hold a summer *H. auropunctatus* summit inviting the public to one day of presentations from local, state and international experts in the field. The summit was followed by a technical planning committee that created new "Standard Operating Procedures" for both assessing the current populations and threshold guidelines and trapping techniques for rapid response. *See Appendix C: Standard Operating Procedures to Conduct an Island-wide Status Assessment and Early Detection Rapid Response (Phillips & Lucey 2015)*

Objective: Ensure *H. auropunctatus* do not become established on Kauai.

Strategy: Evaluate current population status and compose a biosecurity plan.

Actions:

- Initiate an island-wide population assessment.
- Activate new response protocols using three sightings within one week as trigger.
- Write a Kauai specific *H. auropunctatus* biosecurity plan.
- Publish a scientific paper analyzing past sighting events to determine if any pattern exists that would indicate the value of previous sighting protocols.

Methods:

- Send 2-3 staff to USDA wildlife lab for training in small mammal track identification.
- Dedicate two staff to conduct an island-wide tracking tunnel survey to determine if a *H. auropunctatus* population is already established on Kauai.
- This effort is in cooperation with USFWS Pacific Region and adheres to *Standard Operating Procedures to Conduct an Island-wide Status Assessment and Early Detection Rapid Response (Phillips & Lucey 2015).*
- Data collection will follow new iPad IOS platform protocols.

Coffee Berry Borer (*Hypothenemus hampei)*

Photo 31 Outreach poster for CBB

Photo 30 Early detection trap for CBB
(Photo credit CTAHR)

Background: On September 2, 2010, University of Hawaii staff alerted HDOA that Coffee Berry Borers (CBB) had infested *Coffee arabica* in the Kona region of the Big Island. On December 2, 2014, USDA detected CBB on Oahu. A rapid response team was deployed involving CTAHR, HDOA, USDA and coffee farm employees to delimit the infestation.

The rapid spread from Hawaii Island to Oahu illustrated the need to create both an education campaign and a rapid response plan for Kauai. In addition to smaller growers, Kauai Coffee is the largest coffee plantation in the U.S. and cultivates 3.000 acres in mostly continuous fields through which newly arrived beetles would likely spread rapidly. In 2014, KISC partnered with CTAHR to create educational posters and create a plan for a potential invasion of Kauai. CBB spends most of its life inside coffee berries, which they bore into to lay their eggs. This life cycle makes it difficult to chemically or biologically treat the infestation. CTAHR researchers are exploring chemical treatments and maintaining early detection beetle traps at Kauai Coffee.

Objective: Prevent the establishment of CBB on Kauai.

Strategy: Assist CTAHR and HDOA with outreach and rapid response.

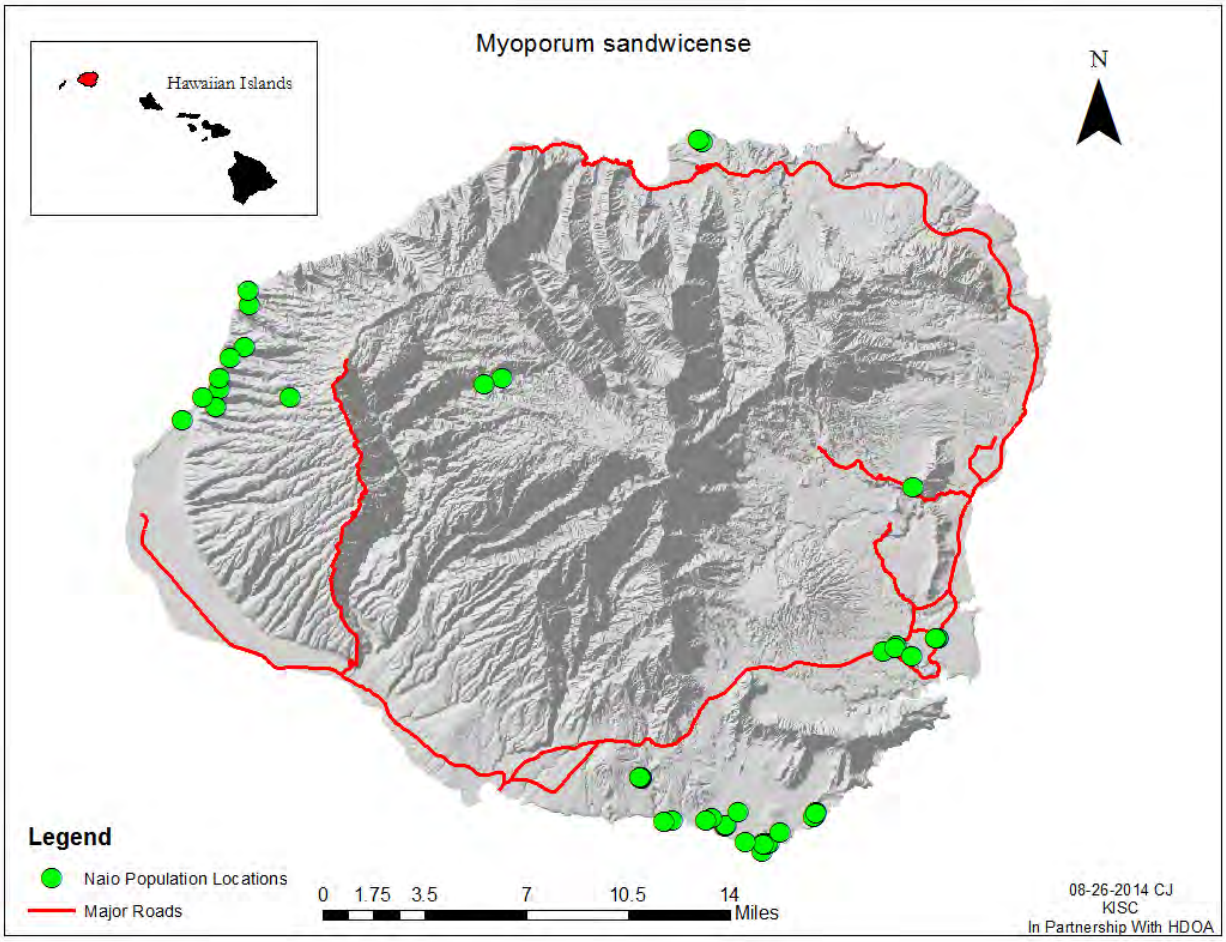
Actions:

- Use CBB outreach materials at KISC events.
- Identify KISC as a component of the rapid response team under incident command protocols.

Methods:

- Display posters and other related outreach materials at public venues.
- Ensure the public and industry is knowledgeable about the risks of CBB to the Kauai coffee industry.
- Maintain maps of Kauai Coffee fields and roads on Panasonic Toughbooks©. In order to direct KISC crews in case of an outbreak.
- Assist the rapid response team under incident command protocols developed by CTAHR if CBB are detected.

Myoporum Thrips (*Klambothrips myopori*)



Map 25 Naio plant locations. NOTE: This is not a map of the Myoporum Thrips, this is a map of the host plant.

Background: *K. myopori* was first discovered in California in 2005 and in Hawaii in 2008 when it attacked the native Naio (*Myoporum sandwicense)* on the Big Island. Genetic analysis revealed that the California and Hawaii populations are closely related to the Tasmanian population. Monitoring sites on Big Island indicate a high mortality ranging from 30-50%

In 2014, DOFAW authored an EDRR Plan for *K. myopori* and worked closely with KISC and the Kauai DOFAW botanist to create a map of known *M. sandwicense* sites across Hawaii. *K. myopori* is not known to be on Kauai, it is only known to be on Big Island.

Photo 32 Naio plant (Photo credit Forest and Kim Starr)

Photo 33 *K. myopori* (Photo credit DLNR)

Photo 34 Curled and galled Naio (Photo credit DLNR)

Photo 35 Beginning of leaf dieback (Photo credit: DLNR)

Objective: Prevent the establishment of *K. myopori* on Kauai.

Strategy: Continue following protocols outlined in EDRR Plan for *K. myopori*

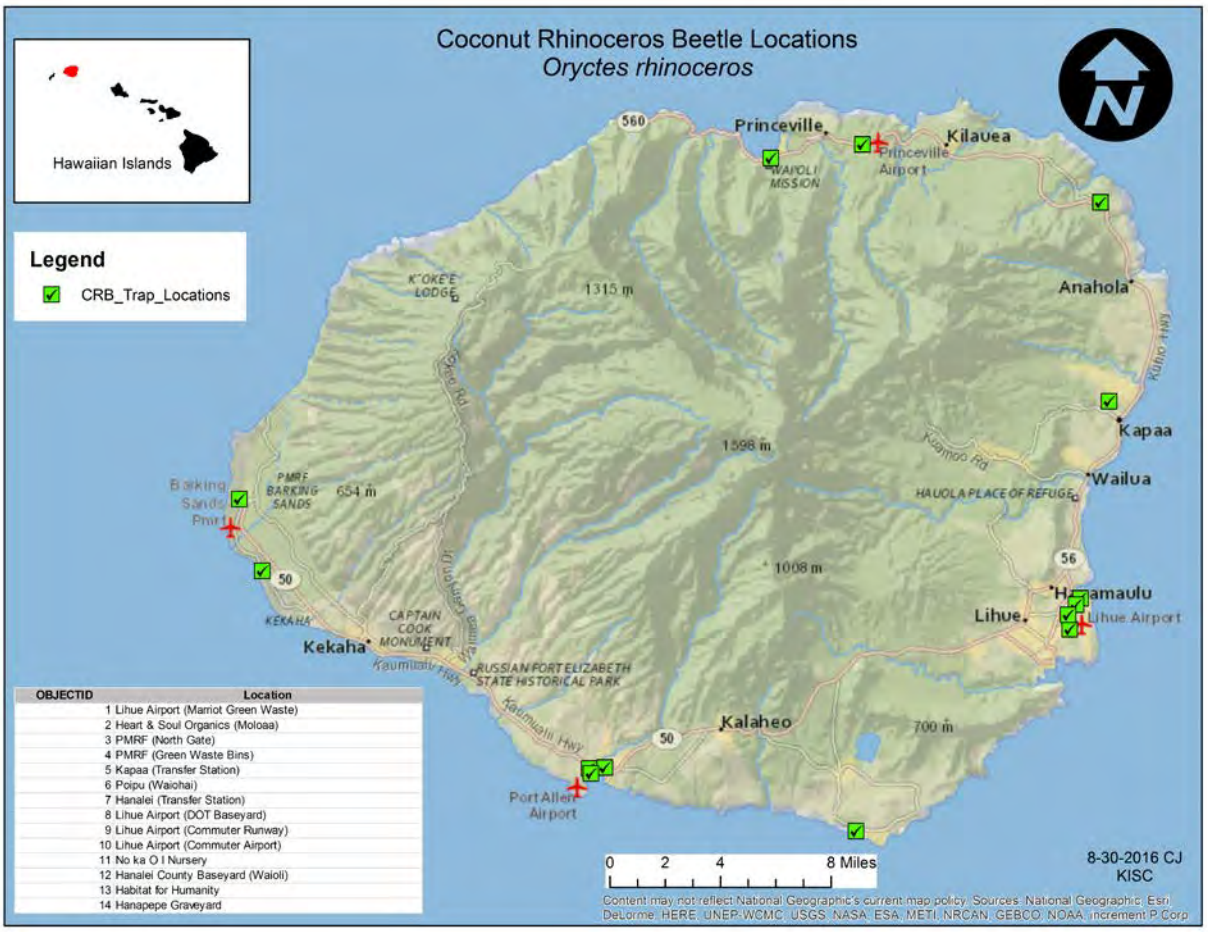
Actions:

- Visit selected monitoring sites quarterly

Methods:

- Check *M. sandwicense* plants for signs of *K. myopori* presence
- Display posters and other related outreach materials at public venues.
- Ensure public and industry is knowledgeable about the risks of *K. myopori*
- Maintain and update maps of Naio locations.
- Assist any rapid response under incident command protocols as directed by DOFAW

Coconut Rhinoceros Beetle (*Oryctes rhinoceros)*



OBJECTID	Location
1	Lihue Airport (Marriot Green Waste)
2	Heart & Soul Organics (Moloaa)
3	PMRF (North Gate)
4	PMRF (Green Waste Bins)
5	Kapaa (Transfer Station)
6	Poipu (Waiohai)
7	Hanalei (Transfer Station)
8	Lihue Airport (DOT Baseyard)
9	Lihue Airport (Commuter Runway)
10	Lihue Airport (Commuter Airport)
11	No ka O I Nursery
12	Hanalei County Baseyard (Waioli)
13	Habitat for Humanity
14	Hanapepe Graveyard

Map 26 CRB trap locations

Background: Coconut rhinoceros beetles (CRB) were first detected on December 23, 2013 at Joint base Pearl Harbor-Hickam on Oahu. There has been a concerted eradication effort by HDOA since the initial detection with a total of 2,741 adults detected on base and 352 adults detected off base. Eggs are typically laid in humid mulch piles, which provide food for growing larvae as they develop through instars into adults. Adults bore into adult palms destroying the apical meristem and can kill the tree. To date, no CRB have been detected on Kauai.

Photo 36 Coconut palms with CRB damage (Photo credit: HDOA)

Objective: Prevent the establishment of CRB on Kauai

Strategy: Maintain CRB detection traps across Kauai at high-risk sites, such as airports, harbors and green waste sites.

Actions:

- Provide assistance to HDOA with KISC crew members to periodically visit CRB traps on an “as needed” basis.
- Assist HDOA with initial rapid response if CRB are detected.

Methods:

- Visit traps with HDOA staff. Help repair traps when needed.
- Crews to continue visual surveys for palm damage when in field.
- Rapid response methods are determined by HDOA.

Miscellaneous Vertebrates

Photo 38 Brown Tree Snake (Photo credit: G, Torr)

Photo 37 Cottontail rabbit (Photo credit: Wikipedia)

Photo 39 Jackson's Chameleon captured on Kauai in 2013

Background: A variety of other alien vertebrates have the potential to become established on Kauai. However these animals, including snakes, lizards, turtles, frogs, exotic birds, and rabbits could possibly be released by pet owners or travel in cargo shipments. Other vertebrate pests, such as bulbuls, Mitred Conures and Jackson Chameleons, may potentially arrive on Kauai from established populations on neighboring islands.

Objectives: Prevent invasive vertebrates from naturalizing on Kauai.

Strategy: Coordinate with HDOA and DLNR to monitor pest reports to increase the likelihood that these species will be prevented from becoming established on Kauai.

Actions:

- Assist HDOA and DLNR in responding to reports of new alien vertebrates.

Methods:

- KISC will continue to monitor invasive and deleterious lists for potential invaders.
- KISC will experiment with a new pilot project assisting Kauai HDOA with RR.

TARGET EVALUATION SPECIES

Rose Ringed Parakeet (*Psittacula krameri*)

Photo 40 RRP eating mango
(Photo credit: Arindam Aditya)

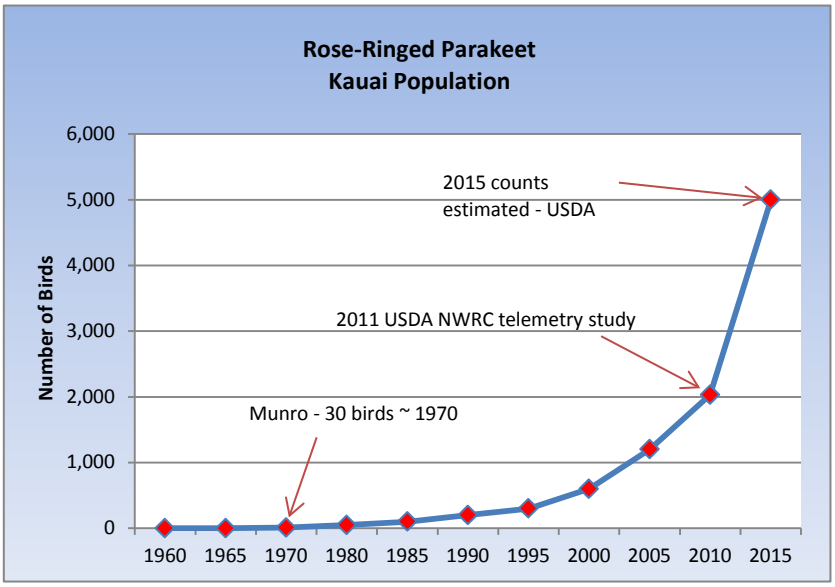


Figure 29 RRP population trends

Background: The rose-ring parakeet (RRP) is listed as one of the most significant agricultural pests of important food crops in the world. It can affect wildlife by transporting invasive seeds, displacing cavity nesters, and potentially spreading disease. On Kauai, the RRP has shown similar population growth to other invasions taking several decades to enter into exponential growth. The birds have been observed consuming longan, lychee, mango, orange, *Luecaena*, *Pritchardia*, and corn seeds causing significant crop losses.

Objective: To control or eradicate the existing rose-ring parakeet on Kauai.

Strategy: Coordinate stakeholders and agencies to determine best methods for deterring, controlling or eliminating the RRP population.

Actions:

- Utilize the existing RRP working group to create public support for a control program.

Methods:

- Create a standardized presentation to share island-wide with community groups. Create outreach materials for display at public events.
- Consolidate public comments regarding RRP depredation and attitudes in a database maintained at CTAHR. Facilitate the RRP working group.
- Coordinate legislative education to direct funding to the USDA National Wildlife Lab in Hilo to conduct a GPS tracking study and experiment with control techniques resulting in an island-wide strategy for Kauai.

AQUATIC

In the future KISC is open to the possibility of forming an aquatic invasive species program to assist the DAR with monitoring and response. At this point in time KISC will focus on evaluating the early detection botanist's list of potential targets, including aquatic plants for potential control action. KISC will remain available for DAR in case there is need of an emergency response.

TREATMENT STATEMENT

Target Treatment Methods

KISC field crew uses a handful of different pesticides and application techniques to control invasive plant species on the island. KISC currently has three employees that have been certified by the HDOA to purchase and apply Restricted Use Pesticides (RUP), but we have never used any RUP on any of our targets to date. We strictly adhere to the label of each pesticide in the storage, loading, application and cleanup of all chemicals. All safety precautions, proper application techniques, and Personal Protection Equipment (PPE) requirements are taught to new hires by the Field Crew Supervisor before they are allowed to handle and apply pesticides. Senior crewmembers also reinforce pesticide safety to the rest of the crew before each treatment. Mechanical removal is always considered prior to chemical treatments.

TECHNOLOGY AND DATA STEWARDSHIP

Natural resource management capabilities are improving as detection and data collection technology evolve rapidly. The following technical areas are in various stages of implementation.

Data Collection

Currently track and waypoint data is collected utilizing Garmin© 62s handheld GPS units. Data sheets are filled out on Panasonic Toughbooks©. Waypoints, track lines and data sheets are downloaded by the data technician. Waypoints and the associated information are entered into an Access database. Track lines are buffered depending on survey species to create polygons reflecting area treated and surveyed in acres. Data sheets are archived digitally.

The use of excel Pivot Charts is to track trends by each species in order to evaluate the control progress (seen throughout this document). Trends allow the committee to determine what actions to take including abandonment of targets that no longer appear feasible to eradicate.

Property TMKs will be maintained up-to-date and reviewed annually to locate opportunities for access when landowners change.

Tableau© is a data visualization software that accesses data and displays summary results for work. This allows the public, funders and planners to track the impacts of KISC's work. HISC is now requiring work to be reported by political districts. On Kauai we have three House districts and one Senate district. Tableau can also be utilized as a forecasting tool depending on trend lines.

Figure 30 Tableau is a data display program that provides summary statistics in an easily understandable format.

iPAD/Smart Phone Collection Apps

KISC is initiating an iPad based data entry app for its island-wide mongoose survey. The app is installed on the iPad which will record tracking tunnel locations, sequence and digital photos of tracking cards to review for mongoose tracks. Data is automatically synched in the cloud and downloaded into a database managed by the data technician.

KISC is looking into expanding the use of smartphones in the field. In partnership with NTBG staff, KISC is planning to create databases for all its targets to accept smartphone data collection apps.

Unmanned Aerial Vehicle (UAV)

KISC has begun experimenting with UAV flights at the CTAHR farm to determine the value of aerial reconnaissance for surveying difficult terrain within the *M. calvescens* infestation. There is the possibility of contracting a UAV operator and data processor to assist with setting up the program in winter of 2017.

PUBLIC AWARENESS

KISC is committed to raising public awareness about invasive species, conservation, and building community involvement to address the issue. The community's collaboration and support is crucial to the sustainable success of KISC's efforts. With public awareness, KISC's priority and early detection species will be more likely recognized and reported, resulting in earlier detection of new populations and incipient pests. With community participation, the introduction of new invasive species can be prevented.

Through various avenues, KISC will educate the general public, as well as targeted audiences, on the mission and projects of KISC, the impacts of invasive species, the identification of current priority species, and tangible actions to help.

General Community Education

The cooperation of the community of Kauai is the key factor in preventing and discovering any new populations of KISC's priority target and early detection species. KISC will make all project actions highly visible in order to directly address concerns and facilitate public understanding.

Objective: All Kauai Citizens and Visitors are aware of the threats posed by invasive species.

Strategy: KISC will raise awareness, build participation and partnerships, brand a positive organization image, and connect with the community on a grassroots level with a diverse demographic.

Actions:

- Maintain a living library of pest species in the CTAHR Greenhouse as real examples of pest species
- Maintain plant pressings for educational use
- KISC will present general information about invasive species and specific information about species controlled by KISC at community events and venues with active and/or passive displays. Targeted venues:
    - Earth Day
    - Garden Fair
    - Banana Poka Roundup
    - Agricultural Awareness & Education Day
    - Kauai Farm Bureau Fair
    - Arbor Day
    - Ocean Awareness Day
    - Island libraries
    - Resorts
    - Private businesses

- KISC will maintain and update port signage regarding inter-island movement of pests. Signage locations will include:
    - Lihue Airport
    - Young Brother's
    - Nawiliwili harbor cruise ship disembarking area
    - Additional public and military ports on island
- KISC will utilize various partnerships to promote relevant campaigns/displays. Display examples:
    - Banners for Kauai Fire Department Sparky Van as part of KISC's partnership and Environmental Safety Campaign
    - Traveling Mongoose Display at various public and private venues across the island
    - The idea of planting native over invasive through our partnership with Plant Pono and ongoing Pono Endorsement Program
- KISC will utilize the various forms of media on Kauai to inform a broad-based audience on current projects and invasive species concerns. Targeted media:
    - The Garden Island Newspaper
    - Kauai People
    - KKCR Public Radio
    - Island radio stations
    - KISC website
    - Broad-based press releases
    - Social Media (i.e. Facebook and Instagram)
- KISC will update and maintain a web presence.
    - Update KISC website with programs, opportunities, relevant news, updated species pages, and resources.
    - Monthly blog posts
    - Weekly social media posts: Facebook and Instagram
- Provide unified messages and materials to engage the public and increase invasive species awareness with informational brochures, posters, banners, and pest alerts, and volunteer workdays. Topics for materials will include:
    - General invasive species
    - Current KISC priority targets
    - Early detection species
    - Best Management Practices and resource references (e.g. CTAHR Coqui BMP)
    - HPWRA tool (i.e. www.plantpono.org) & Pono Endorsement Program
    - Non-invasive alternatives and resources
    - Statement that KISC uses Integrated Pest Management (IPM) for control work and does not use RUP's
    - Guardians of the Garden Isle Network

- Provide professional publications to update partners and the public on KISC current and past work. Publications include:
    - Annual newsletter
    - Quarterly updates
    - KISC Blog

    - Species-specific newsletters when appropriate: (e.g. Coqui flyers, false kava hand-outs).
    - Press Releases in local and state news outlets
- To familiarize the public with its name and mission, KISC will distribute logo giveaways.

Strategy: KISC will increase support and raise awareness in communities within or in close proximity to work sites and survey areas. KISC will maintain a positive public image with landowners, fostering working relationships to allow access for priority species control.

Actions:

- KISC will develop working relationships with landowners. KISC will keep landowners informed and updated of control work on their land and encouraging their involvement. When appropriate KISC will train landowners in proper control and monitoring methods for owner control.
- KISC will host species-specific community meetings, such as LFA in Kalihiwai, Coqui in Kapahi, and CRB on Westside.
- KISC will distribute printed materials to neighbors of work sites and survey areas, such as *M. calvescens* packets in Wailua and early detection species alerts in neighborhoods within species buffer zones.
- Informational signage installed at long-term public worksites to educate the public on species-specific information and decrease the unwanted spread of targeted species. (e.g. Signage at the LFA infestation site)
- KISC will collaborate with the Department of Land and Natural Resources to educate hikers at trailheads in targeted species infestation areas on invasive species seed dispersal by providing information and a boot scrubbing station. (e.g. Kuilau Trailhead in known *M. calvescens* infestation area).

Strategy: KISC will promote unified statewide outreach efforts to increase public support and awareness of invasive species concerns across the state.

Actions:

- KISC will be an active participant in the HISC Public Outreach Working Group (POWG) and KRODWG meetings and campaigns.
- KISC will assist with the development and implementation of statewide public outreach events (e.g. Hawaii Invasive Species Awareness Week).
- KISC will assist partners with invasive species outreach efforts. For example: assist in design of statewide LFA flyer, assist CTAHR with coffee berry borer awareness campaign, and HDOA with CRB.

Strategy: KISC will promote and encourage invasive species education in schools on Kauai.

Actions:

- KISC will partner with outreach and education specialists across the island to help develop and support environmental education in school aged children on Kauai.
- KISC will develop and implement science-based invasive species projects and activities for school students. Past programs included:
    - LFA survey activity
    - Service Learning Projects for elementary students and high school students
- KISC will participate in career days at various schools across the island.

Guardians of the Garden Isle

Objective: Maintain a community network to encourage and promote environmental stewards on Kauai by raising awareness of invasive species issues and solutions.

Strategy:

KISC will promote and maintain the membership network "Guardians of the Garden Isle." The Guardians of the Garden Isle Network engages residents and visitors on an individual level. It encourages continued awareness, support, and the use of resources needed for invasive species reporting, prevention, and mitigation.

Actions:

- KISC will maintain network with regular updates (emails, posts, and blogs) on relevant invasive species news.
- The Guardian of the Garden Isle Early Detection workshops focus on the impacts of invasive species, early detection species identification, and tangible actions each member can take to mitigate the spread of invasive pests. Examples of tangible actions include reporting target species and gear decontamination. Cleaning gear ensures that invasive seeds and pathogens will not spread across the island. Resources will be provided focusing on HPWRA, non-invasive alternatives, reporting resources, best management practices, and decontamination protocols. Target audiences include:
    - Conservation partners
    - Neighborhood associations
    - Rotary Clubs
    - Chamber of Commerce
    - Kauai Landscaping Industry Council
    - Kauai Visitors Bureau
    - CTAHR Master Gardeners
    - Community clubs and associations
    - Nursery and landscaping professionals
    - Botanical gardens
    - Transportation entities (i.e. Young Brothers, Matson, etc.)
    - Resorts and tour operators

    - Legislators
    - County and State departments
    - Kauai County Farm Bureau
    - Hunter education programs
    - Hikers
    - Large land owners- e.g. Grove Farm
    - Forestry
    - Tropical fruit growers
    - Cut flowers industry
    - Conservation districts
    - Heavy equipment operators and construction companies
    - Cattleman's association
    - Hawaii Floriculture and Nursery Association
    - Concerned citizens
- KISC will provide plant identification workshops in collaboration with NTBG.
- KISC will organize and partner with other organizations to implement cooperative volunteer and education days to remove invasive species. Past volunteer days included:
    - Kawaiele & Mana Plains Wetland Restoration Project – DOFAW/DLNR
    - Makauwahi Cave Reserve
    - Kokee Resource Conservation Project
    - Malama Huleia mangrove cleanup

Pono Endorsement Program

Objective: To prevent the spread of invasive species on Kauai through the nursery and landscaping industry with a community-based voluntary program. *This partnership program was developed in collaboration with CGAPS-Plant Pono.*

Strategy: Encourage the industry to not use invasive plants and to keep target pest species from moving to Kauai on nursery/plant stock through a Pono Endorsement Program. Promote collaboration among government agencies, conservation partners, landscaping and nursery industry, and Kauai consumers.

Actions:

- Implement and maintain a Pono Endorsement Program in partnership with CGAPS-Plant Pono.
- Pono endorsement programs are customized for individual industries. Targeted stakeholders include nurseries, landscapers, landscape architects, hotels, cut flower industry, and growers.
- Program requires the use of the HPWRA with promotion of www.plantpono.org. HPWRA is promoted as a tool for participants to screen their stock for invasiveness.
- Program provides various Best Management Practices resources to the industry.

- Program provides plant lists to encourage the discontinued sale of targeted invasive species that are having an impact on Kauai.
- Encourage participant collaboration with KISC for pest (e.g. LFA and coqui) surveys as well as botanical early detection surveys (survey plant inventory for targeted species and other species of interest).
- Encourage partnership between the participant and the KISC botanist by providing plant identification resources.
- Program will promote the businesses that are following recommendations to reduce the spread of invasive species. Promotions include website, social media, event displays, mentions in every KISC presentation, as well as radio and newspaper advertisements when funding is available.
- Provide workshops for participant employees regarding early detection identification, HPWRA, non-invasive alternatives, reporting resources, resources for plant identification, proper BMPs and decontamination protocols.
- Incorporate common invasive plant education into KISC outreach programs by illustrating examples of widespread species impacting Kauai.

PARTNERSHIP PROJECTS

KISC's mission is to work collaboratively and in partnership with other entities on Kauai focusing on invasive species prevention, control and eradication. By continuing to build a broader foundation on which to not only unite invasive species efforts but to also draw from available expertise, KISC will be able to increase capacity with limited funding for targeted species control.

Past partnership projects include *P. juliflora* removal at PMRF, clearing of invasive species at NTBG Allerton and McBryde Gardens and Limahuli Preserve, assisting with weed removal and clearing for a fence-line with Waipa Foundation, a Nene relocation project with DLNR's DOFAW, building and helping to install forest bird nesting boxes with the KFBRP, assisting USFWS Hanalei National Wildlife Refuge with the control of avian botulism, helping Makauwahi Cave Reserve with invasive control, controlling invasive species and out planting natives at Kawaiele & Mana Plains Wetland Restoration Project, clearing mangroves on Huleia stream with Malama Huleia, and clearing *Salvinia molesta* from the Kilauea River.

KISC will continue to utilize a variety of on-island partners to enhance its mission of building community interest and participation. Partnering with various groups and agencies in a variety of ways also helps to increase in-kind contributions that are needed to match funding. Awareness as to the threats and effects of invasive species can be fostered in partnerships in both marine and terrestrial ecosystems.

CTAHR Partnership

KISC works cooperatively with CTAHR employees and has its base yard located at the CTAHR Kauai Agriculture Research Center. Cooperative projects include supporting grant proposals for mutually beneficial research projects and active participation with CTAHR staff as in the case of *M. calvescens* control through Herbicide Ballistic Technology (HBT) and CBB Rapid response guided by farm administrator Dr. Messing. As a resident of the farm KISC maintains shade house space to conduct invasive species germination trials and maintenance of a living invasive species collection for educational purposes. KISC also provides personnel to help setup of both the CTAHR farm day and farm bureau public events as well as upkeep of the KISC facility including tending of a native garden. In addition, KISC holds a plot agreement with CTAHR to maintain one of the most diverse awa (*Piper methysticum*) collections on the islands. Seedlings generated from this plot are sold during National Arbor day and serve to educate the Kauai community on the differences between traditional awa and false kava, one of KISC's targets. KISC also maintains a native garden near the farm entrance.

BUDGET

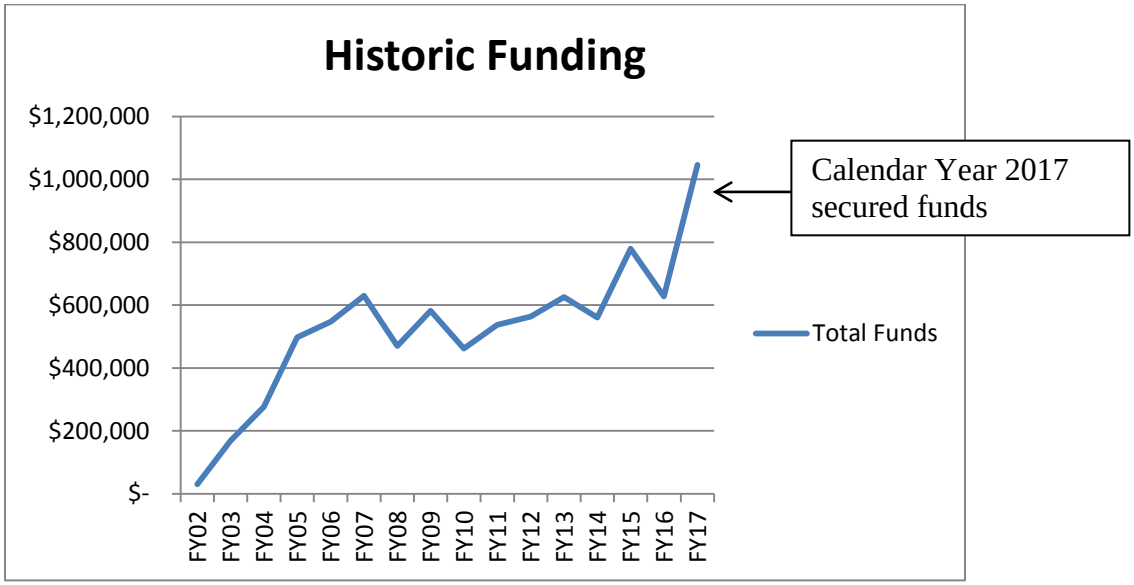


Figure 32 KISC annual allocated funds

KISC Program Funding History

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18
Total State	$ -	$ 68,000	$ 75,000	$ 293,000	$ 395,400	$ 202,000	$ 383,609	$ 385,100	$ 192,500	$ 253,608	$ 347,860	$ 377,541	$ 394,663	$ 623,450	$ 412,026	$ 699,013	
HISC				$ 220,000	$ 277,200	$ 150,000	$ 262,522	$ 375,100	$ 90,000	$ 109,800	$ 297,860	$ 233,078	$ 314,663	$ 570,000	$ 412,026	$ 604,513	
DOFAW G		$ 65,000	$ 45,000	$ 40,000	$ 68,200	$ 2,000		$ 10,000		$ 83,584	$ 50,000	$ 84,463	$ 50,000				
DOFAW Coqui					$ 50,000	$ 50,000	$ 91,087										
DOFAW/NAP		$ 3,000	$ 30,000	$ 33,000													
SLDF							$ 30,000		$ 102,500	$ 60,224		$ 60,000					
WPPG													$ 30,000			$ 50,000	
HTA																$ 14,500	
SNIPP														$ 53,450		$ 30,000	
Non-HISC State	$ -	$ 68,000	$ 75,000	$ 73,000	$ 118,200	$ 52,000	$ 121,087	$ 10,000	$ 102,500	$ 143,808	$ 50,000	$ 144,463	$ 80,000	$ 53,450	$ -	$ 94,500	
Total Federal	$ 30,000	$ 70,000	$ 196,045	$ 199,000	$ 86,000	$ 98,000	$ 85,721	$ 196,695	$ 208,838	$ 283,499	$ 165,084	$ 173,326	$ 106,000	$ 106,000	$ 166,000	$ 307,626	
Federal - USFWS	$ 10,000	$ 25,000	$ 136,045	$ 139,000	$ 12,000		$ 5,000	$ 109,343	$ 53,938	$ 50,000	$ 50,000	$ 70,000	$ 10,000	$ 10,000	$ 10,000	$ 146,626	
Federal - USFS		$ 45,000	$ 60,000	$ 60,000	$ 59,000	$ 98,000	$ 80,721	$ 87,352	$ 154,900	$ 233,499	$ 99,084	$ 80,000	$ 75,000	$ 75,000	$ 110,000	$ 55,000	
Federal - NPS																	
Federal - NRCS	$ 20,000																
Federal - NAVFAC											$ 16,000	$ 23,326			$ 25,000		
Federal - HIARNG													$ 21,000	$ 21,000	$ 21,000	$ 47,000	
Federal - NFWF					$ 15,000											$ 59,000	
Total Private	$ -	$ 25,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Hawaii Community Foundation		$ 25,000															
County	$ -	$ 5,000	$ 5,000	$ 5,000	$ 66,000	$ 330,000	$ -	$ -	$ 60,000	$ -	$ 50,000	$ 75,000	$ 60,000	$ 50,000	$ 50,000	$ 40,000	
Total Funds	$ 30,000	$ 168,000	$ 276,045	$ 497,000	$ 547,400	$ 630,000	$ 469,330	$ 581,795	$ 461,338	$ 537,107	$ 562,944	$ 625,867	$ 560,663	$ 779,450	$ 628,026	$ 1,046,139	

Figure 33 KISC historical budget

EVALUATION

It is imperative that KISC evaluates itself to determine if its programs are effective. With the diverse knowledge base of the committee, KISC can benefit significantly from the committee's input. The KISC Manager, with assistance from staff members, is responsible for follow-up evaluations and reporting results to the KISC committee regularly at quarterly KISC meetings. At an annual all-day workshop KISC will re-evaluate the objectives and reform the goals for the next year's action plan. The executive committee's goal is to make its decisions by consensus.

The KISC Manager and staff are responsible for documentation of all KISC activities, monetary expenditures, and accomplishments in terms of areas surveyed/treated and plants removed/treated. Maps of known locations of all target species (including annotation with population structure, fertility and history of control efforts) are being kept and updated as new reports come in. Special attention is given to all populations of target species, which appear to have fruited and/or have persisting seed banks. Short-term and long-term control operations are aimed at exhausting the seed banks established by previously controlled plants. Careful GPS data, along with data archiving and mapping of all other information gathered, is evaluated to generate an effective schedule for continued follow-up retreatments.

By using adaptive management regarding methods of control and a reevaluation of objectives, KISC can better balance control efforts with committed funding. Prioritization of identification and eradication of incipient species as well as broadening the base of community support will be key for quickly responding to the next invasion that is sure to arrive.

ACKNOWLEDGEMENTS

This document was written and edited by the following KISC staff: Kelsey Brock, Cleve Javier, Ray Kahaunaele, Tiffani Keanini, Bill Lucey, Rachel Smith and KISC Chair, Adam Williams

Photo Credits

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Uncredited Plant Photos: Mugs Kaneholani

References

Enserink, M. (1999). Biological Invaders Sweep In. Science, 285(5435), 1834-1836. doi: 10.1126/science.285.5435.1834

Kraus, Fred, David C. Duffy. (2010). A successful model from Hawaii for rapid response to invasive species. Journal for Nature Conservation 18:135-14.

Mehta, S. V., Haight, R. G., Homans, F. R., Polasky, S., & Venette, R. C. (2007). Optimal detection and control strategies for invasive species management. Ecological Economics, 61(2), 237-245.

Null, William. (2006). Little fire ant *Wasmannia auropunctata*: It's presence on Kauai. Report to USFWS Pacific Region.

Phillips, Reese & Lucey, William. (2015) Kauai Mongoose Standard Operating Procedures to Conduct an Island-wide Status Assessment and Early Detection Rapid Response. Report to USFWS Pacific Region.

Rago, Fiamma & Sugano, Dean. Can't see the forest for the (albizia) trees: an invasive species update. Honolulu, HI: Legislative Reference Bureau, December 2015. 1. Introduced organisms – Administrative agencies – Hawaii – United States. KFH421.5 L35 A25 15-3

Vorsino, Adam. E. et al. (2014). Modeling Hawaiian ecosystem degradation due to invasive plants under current and future climates. http://dx.doi.org/10.1371/journal.pone.0095427

Wetterer, J.K. and Porter, S.D. (2003). The little fire ant, Wasmannia auropunctata: distribution, impact, and control. Sociobiology 42:1–41.

Kauai Invasive Species Committee - Strategic Action Plan

Recommendation and Approval Statement

The Kauai Invasive Species Executive Committee hereby approves this document that sets the guidelines for early detection and rapid response of invasive species on the Island of Kauai from January 2017 through December 2022.

Approved By: _____

Chair

Approved By: _____

Chair-Elect

Approved By: _____

Past-Chair

Approved on: _____

Date