Hawaii's Coqui Frog Management, Research and Education Plan

DRAFT

LIST OF TABLES

LIST OF FIGURES

1. EXECUTIVE SUMMARY

A. STATE OBJECTIVE

The coqui frog, *Eleutherodactylus coqui*, can affect native plant and animal species and may alter ecosystem processes in Hawaii's native forests. High densities of the coqui frog have become a serious noise nuisance in residential and tourist areas and are also decreasing property values. Vendor and public concern over purchasing infested nursery material is impacting the floriculture and nursery products industry. In 2006 alone, the State Legislature allocated $2 million for the control of coqui frogs. But State Legislature funding has recently decreased in 2007 to $800,000 for the entire state. The full ecological and economic impact of the frog has yet to be determined, but the severity of the invasion requires the development and implementation of a coordinated management plan. The objective of the Statewide Management Plan for the Coqui Frog is to provide a comprehensive summary of the status of the invasion, outline possible management options, evaluate the costs and consequences of the different management options, and provide recommendations for future action.

The coqui management options under consideration range from "No Action" to "Eradication" from all known locations. Eradication is an option which is highly attractive theoretically, but not so easy in practice (e.g., Hobbs and Humphries 1995; Mack and Lonsdale 2001). Myers and Ware (2002) point out that the opportunity for eradication is often lost by the time the problem is recognized and control projects are considered or actually implemented. This might be the case for the Big Island where the frogs have been present for almost 20 years, but for some of the other main Hawaiian Islands eradication is still possible.

Because it is possible to restrict the movement of organisms between the main islands through quarantine practices, the containment of invasive species that are widely established on one island to protect the remainder of the State can help to limit the damage caused by the invasion. Efforts to contain and quarantine frogs needs joint private and government cooperation in preventing the spread of the coqui on inter-island transportation of materials, such as nursery products and vehicles. This is especially critical for the Big Island which has by far the highest infestation of frogs statewide.

In addition to addressing a suite of options for action, this Plan recognizes that there are significant differences among the Hawaiian Islands in terms of distribution, abundance, rate of spread, control efforts, and level of involvement by government agencies and local communities. For instance, coqui frogs are not known to be present on Lanai, Molokai, or Kahoolawe. Multi-agency efforts since 2000 have reduced the populations on Kauai and Oahu and eradication is feasible with current tools and resources. On Maui, successful control efforts at thirteen population centers have significantly reduced frog densities, but control at one large infestation has been problematic. On the Big Island, island-wide eradication may no longer be feasible, but geographically-defined areas could be contained. These differences as well as level of control are described in the

island-specific sections of the Plan. Where there is uniformity among islands in terms of apparent options, a single summary has been provided.

B. MANAGEMENT GOALS WITH PREFERRED ALTERNATIVES

Statewide

The preferred alternative would be to restrict the spread of frogs into new habitats, eradicate small discrete populations in high-value natural areas, and eradicate frogs from the islands of Oahu and Kauai. These management efforts should be combined with increased public education and outreach for all islands. To reduce the spread of frogs, detection and monitoring activities should increase statewide, quarantine systems should be established that minimize the risk to intrastate and via out-of-state exports, and effective protocols should be enacted for movement of materials among islands. Local communities and businesses who are actively suppressing local coqui populations should be supported. All information on the distribution of frogs and the efficacy of control efforts should be centrally maintained.

For management purposes in the State of Hawaii, incipient populations are generally considered to be five or less vocalizing males heard in one location or in the surrounding area. A naturalized population is generally considered to be five or more vocalizing male coqui heard in one location or in the surrounding area. A naturalized population is declared eradicated if no frogs have been detected for a year from the date the last vocalizing coqui frog was heard, based on surveys conducted periodically post-treatment.

Oahu

The alternative for increased control would ensure that current progress on eradication of all known populations of coqui frogs is maintained as well as ensuring that no new populations become established. Increased public education would result in improved reporting and monitoring that will establish a more effective response to new populations.

Big Island

Even if no additional resources are made available efforts to maintain information on the distribution of coqui and the efficacy of control efforts should be improved. Establishing more effective protocols to prevent spread of frogs inter-island will result in preventing the costs associated with mitigation and control for other Counties. Efforts should be made to eradicate or contain frogs in geographically-defined areas on the Big Island, including outlying populations, high-value natural areas, and sites that would facilitate further distribution. Continuing support to local communities and businesses who are actively suppressing local coqui populations by providing education, training and material support is a priority.

Kauai

The alternative for increased control would ensure that current progress on eradication of all known populations of coqui frogs is maintained as well as ensuring that no new populations become established. Increased public education would result in improved reporting and monitoring that will establish a more effective response to new populations.

Maui

The alternative for increased control would ensure that current progress on eradication at most known smaller population centers of coqui frogs is maintained. Containing the Maliko Gulch population and work toward eventual eradication is preferred but unlikely to succeed with current resource levels. Increased public education would result in improved reporting and subsequently more effective response to new populations. Adding additional inspectors may be possible with the new Hawaii Department of Agriculture's (HDOA) Biosecurity initiative which could provide adequate inspection of incoming plant materials for Molokai and Lanai.

C. RESEARCH GOALS WITH PREFFERED ALTERNATIVES

Control

Current chemical control methods may be used in agriculture, private lands, and natural areas. Additional chemical control methods could be developed to target frogs in natural areas or to be used in quarantine areas for sensitive plants. Current costs of the most utilized chemical, citric acid, is expensive, subsequently finding additional low cost chemicals to control the coqui is desirable. Barriers and hot water methods may be useful in quarantine areas or greenhouses and development of effective methods seems likely. Non-target effects of chemical control should also be evaluated further. State funding should be centralized so duplication of effort and research into unproductive areas is minimized. Hawaii Invasive Species Council's (HISC) process of providing research funds is well established and ensures peer review of research endeavors. Funds provided to HDOA and other entities should follow a similar framework to ensure high quality research.

Effects of Frogs

Increased state funding should be directed to research on the economic and ecological effects of frogs to document the impact and reveal areas of concern. Funding for the effects of control efforts should be a high priority to ensure that goals for each island are being met.

D. EDUCATION AND OUTREACH WITH PREFFERED ALTERNATIVES

Education and Outreach activities should be increased state-wide to present a unified and comprehensive focus on this pest. This will require additional resources to increase participation and awareness. Current levels of resources are inadequate to encourage

reports of new coqui locations, provide responses to calls that do come in or train community members to respond to populations of coqui in their neighborhoods. More could be done to reach the plant industry. The plant industry mailing database has recently been completed and numbers up to 3000 entries statewide. Education for homeowners/residents should continue to use the major media outlets on the island, but to increase the frequency of the messages. Additional materials should be developed and disseminated for all relevant media, including television, newspaper, radio, and internet to educate the public about the magnitude of the coqui frog problem, how to take appropriate action, and the status of detection and control efforts. Public assistance in detecting and reporting frog locations is essential.

The incorporation of the statewide 643-PEST hotline with appropriate follow up is critical. To encourage public cooperation, reports must generate a timely and meaningful response from a central response center. This central response center for inquiries and reports from the public should field and answer questions from the public and take information about new infestations as well as inform reporters about planned activities for the area and how the reporter can help. Developing a response follow-up tracking system and central database will maintain adequate communication among cooperators.

E. FUNDING NEEDS AND SOURCES

Current funding levels are not sufficient to achieve statewide eradication of coqui frogs. Continued control efforts funded by state and federal sources on Kauai and Oahu will result in the likely eradication of all known populations of coqui on those islands. It is unlikely that the current resources available for surveying for coqui and providing outreach to encourage businesses and the public to report new locations of coqui are adequate to ensure the individuals and small populations are detected rapidly enough to eliminate the need for a continuing response capacity. Current state and county funding for Maui County efforts will result in a reduction in the number of populations of coqui frogs but will not fully contain the large population at Maliko Gulch. Current efforts on the Big Island may slow the spread of coqui from some isolated populations but does not address spread from large population centers, the impact of coqui to nurseries and other businesses, most new isolated populations or many of the requests from the public for assistance.

The selective alternatives are needed that would provide for increased survey, detection and outreach efforts on Kauai and Oahu, increased control on Maui and more support for the Big Island communities. Another important element that will reduce future costs is investment in improved inter-island quarantine and interdiction and a stronger investment in research. This would require additional funding higher than the current efforts from local, state and federal funding agencies. Overall, cost estimates are based on current knowledge. Prices may decrease if additional tools or methods are developed or prices may increase due to increased costs. Furthermore, a research funding protocol is necessary to independently reviews applicants for research funds. This would ensure a

more transparent and effective method to allocate research funds to the most qualified applicants.

2. COQUI EFFECTS

A. ECOLOGICAL EFFECTS

Left unchecked, the coqui frog is expected to adversely affect native and endemic invertebrates and change certain ecological processes. At such high densities, this sit-and-wait, generalist predator can possibly consume greater than 400,000 invertebrates a night/ha, based on 55,000 frogs/ha with an average of 7.6 prey items consumed per night per individual (Beard 2007a). This direct consumption has significant potential to reduce Hawai‘i’s invertebrate populations, which make up most of Hawai‘i’s endemic fauna (Eldredge and Miller 1995). One recent diet study in particular has provided evidence that the coqui frog predates on endemic invertebrates. Beard (2007a) suggests that Acarina (mites), Coleoptera (beetles), Collembola (springtails), Diptera (flies) and Gastropoda (snails) are the most vulnerable to predation and that each order comprised more than 1.5% of its total diet in a variety of habitats including nurseries, disturbed habitats, and natural areas.

The coqui frog may contribute to significant increases in nutrient recycling rates in the ecosystem from its excrement, which in turn may increase certain invasive plant growth and increase leaf litter decomposition rates (H. Sin et al., in press). Increased leaf litter decomposition can in turn release additional nutrients for plant use, particularly invasive plants. Invasive plants in Hawai‘i are usually able to utilize certain resources, such as nutrients, more efficiently than native plants (Ostertag and Verville 2002, Pattison et al. 1998). Specifically, in a small-scale enclosure experiment, the presence of the coqui frog reduced herbivory rates, increased certain nutrients in ‘ōhi‘a (*Metrosideros polymorpha*) leaf litter, increased ‘ōhi‘a leaf litter decomposition rates and increased the number of new leaves of strawberry guava (*Psidium cattleianum*) (H. Sin et al., in press). These results are consistent with similar small- and large-scale experiments conducted in the coqui frog’s home range in Puerto Rico (Beard et al. 2003, Beard et al. 2002).

The coqui frog also has been hypothesized to compete with native birds for food, the majority of these birds being insectivorous (Kraus 1999). Some variables to consider when discussing potential competition of native birds and the coqui frog are: overlapping range, habitat, and common prey of these species. Currently, the majority of Hawaiian endemic birds are above 500 m in elevation (Stattersfield et al. 1998) and high densities of frogs are below this elevation (Beard and Pitt 2005, H. Sin, unpublished data). The current status of this condition suggests minimal competition between native birds and coqui frogs. However, there is a strong potential for coqui frogs to naturalize in these higher-elevation areas as they are capable of occurring in all types of habitats from sea level to 1300 m in elevation (H. Sin, unpublished data).

There is also a degree of overlap in common prey items where native birds and coqui frogs co-occur. For example, the coqui frog has the potential to compete for food with such species as the ʻelepaio (*Chasiempis spp*.), the ʻiʻiwi (*Vestiaria coccinea*), and particularly the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) as they share common prey items and elevational range (Beard and Pitt 2005). Conversely, frogs might be a possible food source for native birds, though unlikely due to different activity periods of these groups. Furthermore, research indicates that the coqui frog is an opportunistic feeder foraging upon abundant prey items. This generalist feeding behavior may interrupt key ecosystem processes and reduce the availability of preferred invertebrates for native bird and bat populations.

The coqui frog may also increase populations of native bird predators, such as the black rat (*Rattus rattus*) and the small Indian mongoose (*Herpestes javanicus*), by serving as a food source (Kraus et al. 1999). However, a recent diet study of rodents (*Rattus rattus* and *Rattus exulans*), cane toads (*Bufo marinus*), and the small Indian mongoose (*Herpestes javanicus*) on the Island of Hawaiʻi found that only the small Indian mongoose had consumed coqui frogs (Beard and Pitt 2006). These results are similar to those found in Puerto Rico, which has the same non-native rat, mongoose, and toad species (Beard 2007b). Further research is necessary to determine if coqui frogs are indeed bolstering mongoose populations. The coqui frog may also serve as a food source for other potentially devastating bird predators such as the brown tree snake (*Boiga irregularis*) (Beard and Pitt 2005).

B. ECONOMIC EFFECTS

The coqui frog has adversely affected Hawaiʻi's economy, such as the nursery and real estate industries, due primarily to the volume and consistency of its vocalizations. The mating call of male coqui frogs, which typically begins at sunset and continues throughout the night, can reach sound levels of 80 - 90 decibels (at 0.5 m), exceeding the legislatively-established state health standard of 70 dBA (Hawaiʻi Revised Statutes § 324F-1) (Beard and Pitt 2005). Coqui frog vocalizations have resulted in sleep loss for both residents and tourists, which has decreased accommodation revenues in some areas and has negatively affected real estate markets (Kaiser and Burnett 2006). Hotels have reported complaints of coqui frogs and some visitors report that they have changed, or are planning to change, their travel plans to avoid coqui frogs in the future (W. C. Pitt, USDA-APHIS-WS-NWRC, personal communication). Residents in heavily populated areas report that the introduction of coqui frogs to their community has negatively affected their quality of life and may influence their willingness to live, or continue to live, in impacted areas. Effects on hotels, resorts, and displacement of residents are largely anecdotal and more research is needed to quantify these impacts.

Property owners on the Island of Hawaiʻi have also felt the economic effects of coqui frogs and are currently required to disclose if frogs are present on the property before selling their property or homes, similar to termites; which has resulted in an average of 0.16% loss of real estate value per sale (Kaiser and Burnett 2006). Though this percentage appears small on a per household basis, the total direct damage to property

values for all homes in the State of Hawai‘i is conservatively estimated at $208.8 million (Kaiser and Burnett 2006).

The nursery industry has been particularly affected by the presence of coqui frogs. The State of Hawai‘i has designated the coqui frog as a “pest” and “injurious wildlife” under Hawai‘i Revised Statutes (HRS)141-3 and 124-13, respectively. These laws establish provisions for both cooperative and mandatory control of the coqui frog, and make it illegal to release, transport or export coqui frogs. These requirements have resulted in rejection of nursery goods at ports of entry, lost time in shipping, added labor costs for nurseries, and more stringent preventative/treatment measures for invasions of coqui frogs. Indirect costs to nurseries and plant providers have increased as consumers have become more selective purchasers. Although no citations have been issued to businesses or individuals, the Hawai‘i Department of Agriculture’s website (HDOA) states:

> Any person or organization who intentionally transports, harbors or imports with the intent to propagate, sell, or release the coqui is in violation of State law and may be charged with a class C felony and subject to a minimum fine of $50,000 and a maximum fine of $200,000, plus 3 years in prison. (www.hawaii.gov/hdoa) This is under state statutes 150A-14.

Currently, the HDOA and other public and private entities are working on both mandatory and voluntary “Coqui-Free” certifications for nurseries to minimize the possibility of inadvertent distribution. These programs are also intended to help reassure apprehensive consumers and build confidence that the inadvertent spread of coqui frogs is being limited.

3. CURRENT MANAGEMENT PRACTICES

A. CHEMICAL CONTROL

The most widely used chemical methods for controlling coqui frogs are to apply either 16% citric acid or 3% hydrated lime solutions to an infested area. Both chemicals have been shown to be effective toxicants for frogs while also reducing egg hatch rates. However, direct application of solutions onto frogs and eggs are necessary to be effective; thus, several applications may be needed to ensure that all frogs and eggs are eliminated (Beard and Pitt 2005). Historically, laboratory and field studies demonstrated that a 2% caffeine solution was an effective frog toxicant and did not have significant harmful effects on non-target species (Campbell 2001a, b, Pitt and Sin 2004a). However, caffeine is no longer registered for use as a frog toxicant and there are no future plans for registration given extensive testing requirements associated with concerns over potential human health effects. USDA-APHIS-WS-NWRC has also reviewed a long list of additional chemicals, both non-restricted and restricted use, but additional products have yet to emerge that are both lethal and cost-effective.

A 16 % citric acid solution was found to be effective at controlling frogs in laboratory and field settings (Pitt and Sin 2004b, c). Citric acid is classified as a "minimum risk" pesticide and is exempt from requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) 40 CFR 152.25. Subsequently, this product was put to use in the field after it was found to be effective on frogs. Citric acid does not affect most non-target arthropods (Pitt and Sin 2004c). However, citric acid may result in some phytotoxic effects and may not be appropriate for all greenhouse plants (Pitt and Sin 2004d). These potential phytotoxic effects, along with the relatively high cost (~$1.00/gallon), make this product undesirable in some situations. Some variation in the percent of active ingredient and addition of pyrethrins has occurred with citric acid use in an attempt to improve efficacy and minimize phytotoxic effects (Scott Williamson, DLNR, unpubl. data). Recent research, using more precise methodology, has demonstrated that lethal threshold of citric acid solution can be achieved as low as 8% solution with frogs (Doratt and Mautz, unpublished research). As a result USDA/WS and DLNR on the Big Island has been using a 12% solution (1 lb per gallon of water) for treatments and have found this to be effective as well. It is thus recommended to use a lower citric acid solution concentration to reduce operating costs.

On April 26, 2005, a 3% hydrated lime solution was registered for use by HDOA under a Section 18 quarantine exemption from the U.S. Environmental Protection Agency. This registration will expire on April 26, 2008. The 3% hydrated lime solution has proven to be an effective frog toxicant in both laboratory and field settings and has minimal non-target effects on arthropods (Pitt and Doratt 2005). Laboratory tests revealed that higher concentrations of hydrated lime (6%) will be more effective, especially when used as a soil drench. However, the label for hydrated lime currently restricts the concentration to 3%. Hydrated lime may be corrosive and results in white residue on plants and surfaces. As a result, hydrated lime is often not a preferred method in the floriculture industry where slight blemishes on plants make them undesirable. Hydrated lime does have a lower cost (~$0.06/gallon) than citric acid and is often more attractive to homeowners because costs tend to rapidly accumulate when treating large areas. However, there are more safety and environmental concerns with using hydrated lime than with citric acid, such as the caustic effects to skin by hydrated lime exposure.

B. MECHANICAL CONTROL

Several mechanical control techniques have been evaluated for use in quarantine operations, nursery production, and for non-production areas. These techniques include hand-capture, barriers, traps, habitat management, and hot water treatments.

Hot water or vapor heat treatments are an effective method for eliminating frogs and their eggs from potted plants for quarantine. Hot water is applied as a spray at 113 ^{o}F for 3 minutes and 100% mortality may be achieved (A. Hara, unpubl. data, CTAHR, UH). In addition, vapor heat (113 ^{o}F, 90% humidity) was also effective. Hot water treatment of plants also removes other agricultural and environmental invertebrate pests such as aphids, mealybugs, ants, and mollusks with minimal damage to most plants. Orchids and

bromeliads are more sensitive to these heat treatments and this approach may not be preferred (A. Hara, unpubl. data, CTAHR, UH).

Habitat management may reduce the density of frog populations. Frogs densities are typically higher in dense vegetation, often comprised of nonnative plant species. Removing nonnative plants and dense vegetation will likely reduce the number of frogs from a given area (B. Mautz, unpubl. data, UHH).

Capturing individual frogs is effective if only less than a dozen frogs are present and it is possible to remove and find all frogs and follow up to capture animals as they mature from eggs to juveniles to calling males. Only the adult males call and locating all juveniles, females, and egg masses is unlikely.

Several barriers and traps have been developed and tested for frogs in Hawaii. Traps made of bamboo or PVC pipe that provide refugia or nest sites for males have had limited effectiveness in capturing frogs (Sugihara 2000). No locations studied in Hawaii appear to be refugia limited. A trap that contains several calling males was effective at attracting female frogs, but this trap did not capture the frogs and thus frogs had to be hand captured. These traps likely would not be effective in reducing a large population of frogs. However, currently PVC pipe traps using fruit fly attractants are currently being investigated to enhance the traps efficacy (A. Hara, unpubl. data, CTAHR, UH).

Another preventive technique being explored is the use of a coqui barrier or fence. Designed by the HDOA, the fence restricts coqui frog movements from infested areas to frog-free areas. The fence consists of a two- to three-foot high fine insect mesh supported by posts spaced several feet apart. The barrier has a 90° lip at the top that extends approximately one foot toward the infested area. Laboratory tests have demonstrated that a frog can climb up the vertical portion but falls off the horizontal lip due to lack of traction from its toe pads (Kyle Onuma, HDOA, personal communication). Additionally, the height of the fence adequately discourages the frog from jumping over the structure. However, the barrier needs constant maintenance to ensure there is no overhanging vegetation and to ensure the structure remains sound. This technique is more applicable to small areas such as greenhouses rather than larger natural areas.

C. BIOLOGICAL CONTROL

Biological control or the release of organisms to combat the frog likely will have little success and could have many unintended consequences. The history of biological control efforts for vertebrate pests has provided no promise of successful use and there appears to be no prospect for real-time development of useful biological control technology for control of frogs. Unfortunately, the most frequently cited disease organism (such as the irido virus or chytrid fungus) have a low potential for controlling coqui frogs in Hawaii, primarily because viruses and diseases are most effective when applied to small populations of species with low reproductive capacity (Brauer and Castillo-Chavez 2001, Daszak et al. 2003). In large populations, diseases may initially induce temporary

population declines, but subsequently surviving resistant individuals may lead to population levels similar to those prior to treatment. Another important consideration is that most of the major frog diseases infect tadpole stages (Daszak et al. 2003). Because coqui frogs do not have a free-living tadpole stage, they are less likely to be affected. One disease organism that has been implicated in frog population declines worldwide, the chytrid fungus, is already established in coqui frog populations in Hawaii (Beard and O'Neill 2005). Although there are no native frogs in Hawaii, there is a chance that a frog infected with a disease could be transported to other states or countries. Thus, releasing a disease organism may affect frog populations elsewhere and could restrict trade.

The release of a coqui predator has low potential for success in controlling widespread frog populations. Most predators eat more than one prey species and thus an introduced predator may have significant unintended effects on native species. Even an ideal predator that would only prey on coqui frogs, would likely not eradicate coqui frogs. As frogs became rare in the environment, the predator population would likely decrease allowing frogs to increase (Holling 1973, May 1973). The high density of coqui frogs in Puerto Rico reveals that coqui frogs would be very abundant even with many predators, competitors, and parasites. Even if an introduced predator in Hawaii were to reduce the density of coqui to that found in their native range this would be unacceptably high for residents and export businesses. Another possibility is that the predator would reduce the prey population to a low level and then the predators would disappear because some prey would have morphological or behavioral adaptations that would make them less vulnerable to predation. Predators that have caused the extinction of animals are generalists (i.e., eating many species) and have access to all the prey (i.e., no habitat differences or refuges) (Matter and Mannan 2005).

4. CURRENT STATUS AND GOALS

A. STATEWIDE

Current distribution and spread

The distribution of the coqui is explained in further detail in the Statewide Plan in the respective island sections.

Statewide quarantine efforts

On September 27, 2001, the Hawaii Board of Agriculture officially declared the coqui frog an agricultural pest. Act 108 Session Laws of Hawaii 2006 designated coqui frog as a pest, which establishes HDOA's authority to control frogs in the State. Similar to a noxious weed, HDOA can access a coqui- infested property after attempts have been made to contact the owner in instances where allowing the property to remain untreated would frustrate eradication efforts. This authority is not likely to impact most control efforts on the Big Island.

The 2003 Hawaii State Legislature and Governor Linda Lingle approved legislation that established the Hawaii Invasive Species Council (HISC) and calls State agency chairs and department heads to address gaps in Hawaii's invasive species prevention and response measures.

The HISC, under the co-leadership of the Department of Land and Natural Resources (DLNR) Chairman and the Department of Agriculture Chairperson, is comprised of leaders of the following entities:

- Hawaii Department of Business, Economic Development and Tourism
- Hawaii Department of Health
- Hawaii Department of Transportation
- Hawaii Department of Agriculture
- Hawaii Department of Land and Natural Resources
- Hawaii Department of Defense
- Hawaii Department of Consumer Affairs
- University of Hawaii
- Department of Hawaiian Home Lands
- Federal agency representatives
- County Mayors

The first official meeting of the HISC convened on October 29, 2003. HISC members adopted a working committee structure to look at laws, policies, procedures, and needs in the areas of ongoing prevention, early detection/rapid response, ongoing control of widespread pests, and increasing public awareness.

Tasked with a need to look at each agency's organizational and resource shortfalls, HISC recognized the critical need for sustainable funding sources for adequate inspections of incoming goods, the need for early detection and rapid response for priority invasive species, and the need for ongoing control of existing pests.

The main vector for the inter-island transportation of coqui frogs is contaminated nursery products. In January 2007, HDOA tested a prototype hot water container in Honolulu in hopes to treat nursery products in Oahu and on the Big Island. There are future plans by the HDOA to install a hot water treatment facility in Hilo for all outgoing nursery products.

In addition, another vector of frog transportation is vehicles, in which frogs often seek cover and are accidentally transported to other locations. Subsequently, the treatment of vehicles transported inter-island should be a priority as well. HISC is currently coordinating with the proposed inter-island Superferry to treat vehicles with hot water.

Private and government efforts

The efforts to control the coqui from the private and government sectors are various and are explained further in the Statewide Plan for the respective Islands.

Education and Outreach

Education and outreach is explained further in detail in the respective island categories.

Communications and Coordination

Communications and coordination are explained further in detail in the respective island categories.

Funding

Statewide Fiscal Year 2006 – 2007

brackets indicate projections]	Statewide	Hawaii	Maui	Oahu	Kauai
State	**$520,000**	**$1,425,000**	**$166,000**	**$90,000**	**$117,600**
Legislative Appropriation LNR407					
DLNR		$300,000	$100,000	$50,000	$50,000
HDOA	$500,000				
County		$1,000,000			
HISC (est. portion of funding used for coqui) LNR407 trans to LNR402	$20,000	$75,000	$50,000	$30,000	$50,000
DOFAW IS Program (est. portion of funding used for coqui) LNR402		$50,000	$16,000	$10,000	
HDOA					$17,600
Federal	**$0**	**$100,000**	**$0**	**$16,000**	**$0**
USDA - WS		$100,000			
DOD				$16,000	
County		**$300,000**	**$141,000**	**$0**	**$335,000**
County General Funds		$300,000	$141,000		$335,000
Private Spending		**[$1,000,000]**	**[$14,500]**	**[$10,000]**	**$14,000**
Totals	**$4,249,100**	**$2,825,000**	**$321,500**	**$116,000**	**$466,600**

Total money spent on coqui frog control and eradication efforts for 2006 – 2007 exceeds 4 million dollars, which includes efforts by the State, Counties, Federal, and private efforts.

Statewide Management Goals with Alternatives

1. Alternative – No action

Under the "No Action" alternative, coqui frogs will become widely established in residential areas, particularly on the wetter windward sides of islands but also in irrigated areas on the leeward sides. Natural areas will become highly infested, with densities expected to approach or exceed 10,000 frogs per acre. The environmental consequences of "No Action" are expected to include predation of native insects and ecosystem level changes in nutrient cycling. Economic impacts will include reduced property values in infested areas and loss of tourism revenue as visitors choose to stay in areas that do not have coqui frogs. The floriculture and nursery industries are expected to experience reduced revenue from sales to areas that refuse to accept plant material or agricultural products from infested islands. The quality of life will be negatively affected as residents and visitors are unable to prevent the loud mating call of the coqui frog from interfering with their daily lives.

2. Alternative – Current Action

With current efforts, the populations of coqui on Kauai and Oahu will be eradicated and the population at Maliko Gulch on Maui will continue to expand. All other populations on Maui will be controlled with future control efforts being focused on containing the large population at Maliko Gulch. Populations of coqui on the Big Island will continue to expand in the Hilo and Puna districts with increasing effort being required to suppress new outlying populations. Current quarantine efforts will result in the current detection of 2-6 new calling male coqui each year on Kauai, Oahu and Maui resulting in an ongoing need for outreach to enlist the public's help in reporting coqui, as well as the ability to mobilize staff to respond to new calls. Coqui will also continue to be intercepted in exported goods especially nursery goods and cut flowers likely resulting in increased scrutiny of and subsequent destruction of these products or increased quarantine regulation for Hawaii's exports.

3. Alternative – Increased Control

Increased control efforts will expand eradication to the Maliko Gulch population on Maui and will reduce the population growth on the Big Island to expansion form the large windward populations and undetected or untreated new populations established by the movement of materials intra-island. Increased quarantine efforts will reduce but not eliminate the continued detection of new calling male coqui each year on Kauai, Oahu and Maui resulting in an ongoing need for outreach to enlist the public's help in reporting coqui, as well as the ability to mobilize staff to respond to new calls. Hot water treatment will reduce the number of coqui intercepted in exported goods reducing the likelihood of increased restrictions on Hawaii's exports.

4. Alternative – Eradication

Eradication is not currently feasible with existing tools given the extent of coqui populations on the Big Island. Increased research with the goal of developing a more effective and inexpensive control tool would be needed. Complete treatment using heat for all products leaving the Big Island would reduce the number of new calling male coqui each year on Kauai, Oahu and Maui and decrease the likelihood of increased quarantine restrictions on Hawaii's exports.

5. Decision Summary

The alternative of increased control is desirable in that Oahu, Kauai, and perhaps Maui can achieve total eradication. Quarantine issues will remain critical in preventing the movement of frogs from the Big Island to the other islands. Increased public outreach and education is also paramount in monitoring efforts.

B. OAHU

Current Distribution

The first Oahu observation of a coqui frog was made in 1998. Initial control efforts at several infested nurseries and the wildland population in Wahiawa began in 2001. Since, the Coqui Working Group (CWG) was established to address the coqui issues faced by O'ahu. CWG cooperators include the Department of Public Works U.S. Army Environmental, U.S. Fish and Wildlife Service, Coordinating Group on Alien Plant Species (CGAPS), City and County of Oahu, Hawaii Department of Land and Natural Resources – Division of Forestry and Wildlife (DOFAW), Hawaii Department of Agriculture(HDOA) and OISC.

On O'ahu, coqui frogs have been reported from personal residences, nurseries, businesses and hotels. Since 2005, OISC has served as the clearinghouse of all coqui data on Oahu. OISC has created a database and tracking system to capture and record all coqui work performed on Oahu and to track the status of the various populations and single-call sites. Geographically, these reports are scattered throughout the island of O'ahu, with the majority coming from the greater Honolulu area and the Windward side.. From January 2005 – March 2007, there have been confirmed reports of coqui frogs at approximately 46 sites islandwide (Figure 1). Currently, in 2007, there is only one population in a wild land area that is being actively treated and 3 nurseries that have had populations in the past that are regularly monitored to treat any residual individuals. However, it's important to note that as of November 2006 there has not been any observed activity in the wild land population in Wahiawa.

OISC has reviewed all available reports of coqui on the island to assess accuracy, determine current status, and to establish the location of population centers. For purposes of analysis, the term "population" means a physical property (TMK or geographically defined area) that has had five (5) or more calling males.

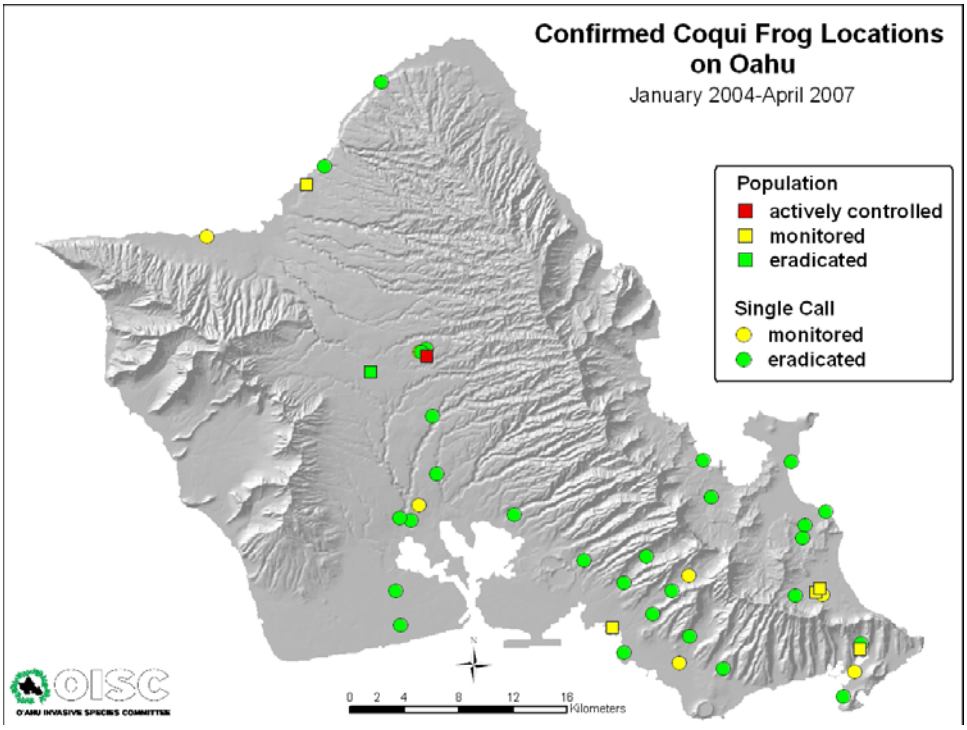

Figure 1. Reported Coqui Frog Locations on Oahu.

Quarantine

HDOA has primary responsibility for inspecting inter-island plant shipments on Oahu as on all other islands.

Private efforts

There have been successful collaborations between the Oahu CWG and local nurseries that either have populations of coqui or are working to prevent becoming infested with coqui. All of the infested nurseries have assisted with coqui eradication efforts to some degree. Home Depot in Iwilei assisted the CWG with habitat modification of its landscaping to eradicate a naturalized population. In addition, a nursery owner in Waimanalo has been very proactive in developing a hot water treatment facility to treat nursery shipments. A portable hot water treatment facility was developed by HDOA. Another nursery in the same community was able to eradicate its coqui population using hand capturing and a novel technique involving attracting coqui to caged males.

Government Efforts

Since 2001, DLNR, HDOA, DPW Army Environmental began preliminary efforts to control coqui frog using hand capture as the primary tool. They systematically responded on a case-by-case basis to reports from the public, serving an early-detection and rapid-response function and hand capturing frogs whenever possible. In 2003, with the hiring of a DOFAW invasive species technician, the CWG was able to increase efforts,

dedicating consistent time and effort specifically toward addressing coqui frog. At this time, the CWG began to work with the individual nurseries that had coqui infestations and sites, such as Home Depot in Iwilei. These nursery coqui populations and one coqui population that had naturalized outside a nursery in Wahiawa were addressed by mechanical means.

OISC got involved in control efforts in 2003. With increased funding in 2005, OISC was able for the first time to secure and allocate the necessary resources towards large scale coqui eradication efforts at Wahiawa and added *Eleutherodactylus coqui* to their target species. In 2005, OISC hired a temporary crew of 3-5 technicians and a field supervisor to systematically treat the Wahiawa population with citric acid night sprays. The treatment seemed to be greatly effective in reducing the population from an estimated 130+ calling male frogs in 2004 to 3-4 at the end of the 2005 calling season. In 2006 and 2007, the nighttime sprays were replaced by a daytime drench that intended to target remaining frogs that were missed by the previous year's nighttime sprays and had retreated to low lying refugia during the day. Since the end of the calling season in November 2006, there has been no observed coqui activity in Wahiawa and monitoring efforts are continuous. By definition, it has been established that a population is considered eradicated from a site after a full year of not hearing coqui.

In addition, in 2005 there were four active nurseries with varying population levels, ranging from a few frogs to several dozen or possibly hundred(s) of calling frogs. As of 2007, of the four, there are only three nurseries that still have frogs that seem to be residual individuals of the original population and are monitored on a regular basis. Two populations at retail stores (store on a military base and Home Depot) have also been eradicated. A protocol for controlling frogs and efforts to assist business owners in receiving NRCS support has been developed. The CWG has been working with the nursery owners to systematically monitor and control all the coqui populations in the nurseries. This will continue until all the nursery populations have been eradicated. Until a systematic treatment plan is developed to treat plants that are shipped inter-island (especially from the Big Island), there is always a risk of reinfestation at any O'ahu nursery that receives plants from the other islands.

OISC and the CWG began a public awareness campaign to increase early detection of coqui on the island by publicizing the coqui call and emphasizing the need to report coqui on Oahu. This included a mailing to all Oahu nurseries and broadcast of Public Service Announcements in 2005.

In 2006, OISC hired a full time vertebrate specialist to coordinate and track all coqui activity island wide. In addition, the specialist is responsible for managing a temporary crew to treat the Wahiawa population using a 400g sprayer to drench the entire infestation area. With ongoing effort, the CWG believe that all of the remaining populations will be reduced to regular monitoring instead of active control efforts by fall of 2008. Coqui management on Oahu is divided into 3 distinct management categories: 1) Wahiawa (the wild land population), 2) nurseries and 3) single calls. Each category has a distinct management strategy.

The Wahiawa infestation covers a 11.7-acre parcel of land, with the majority located on the Schofield Barracks East Range and further extending into surrounding residential neighborhoods. Throughout the parcel, the terrain ranges from residential backyard lots, to overgrown grassy flats, to a deep, dense forested gulch. The area is divided into 5 distinct sections (Figure 2) with several dirt roads that run along its perimeter.

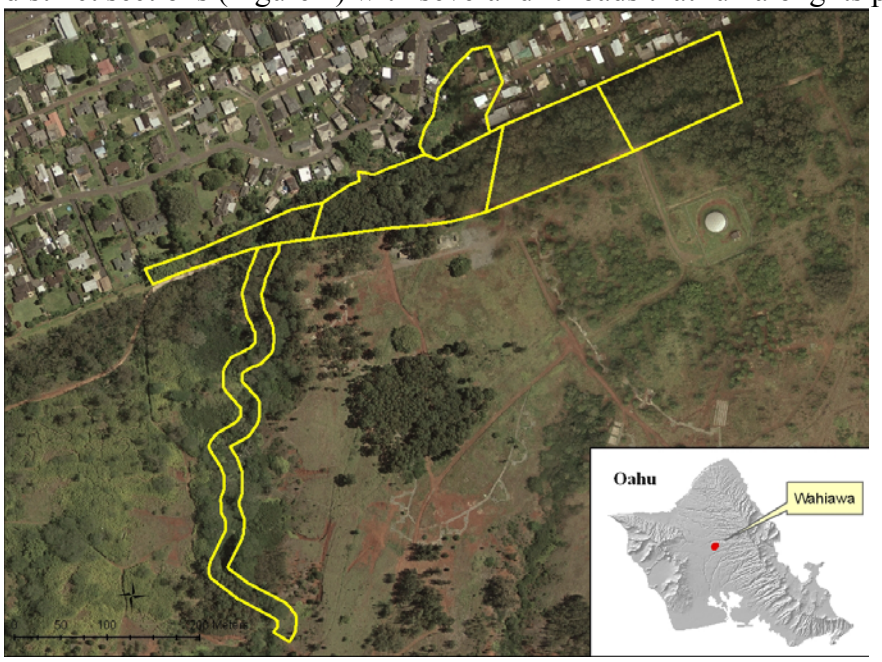

Figure 2. Coqui Frog Treatment Area, Wahiawa, Oahu.

To assist in the implementation of a strategic citric acid drenching for 2006, transects have been cut, clearly labeled and flagged (color coded) through each of the various sections. Efforts have been highly successful and the population will be considered eradicated by November 2008 if there are no observed frogs until then (Figure 3; graph by Robin Yamamoto, CIV USAG HI DPW).

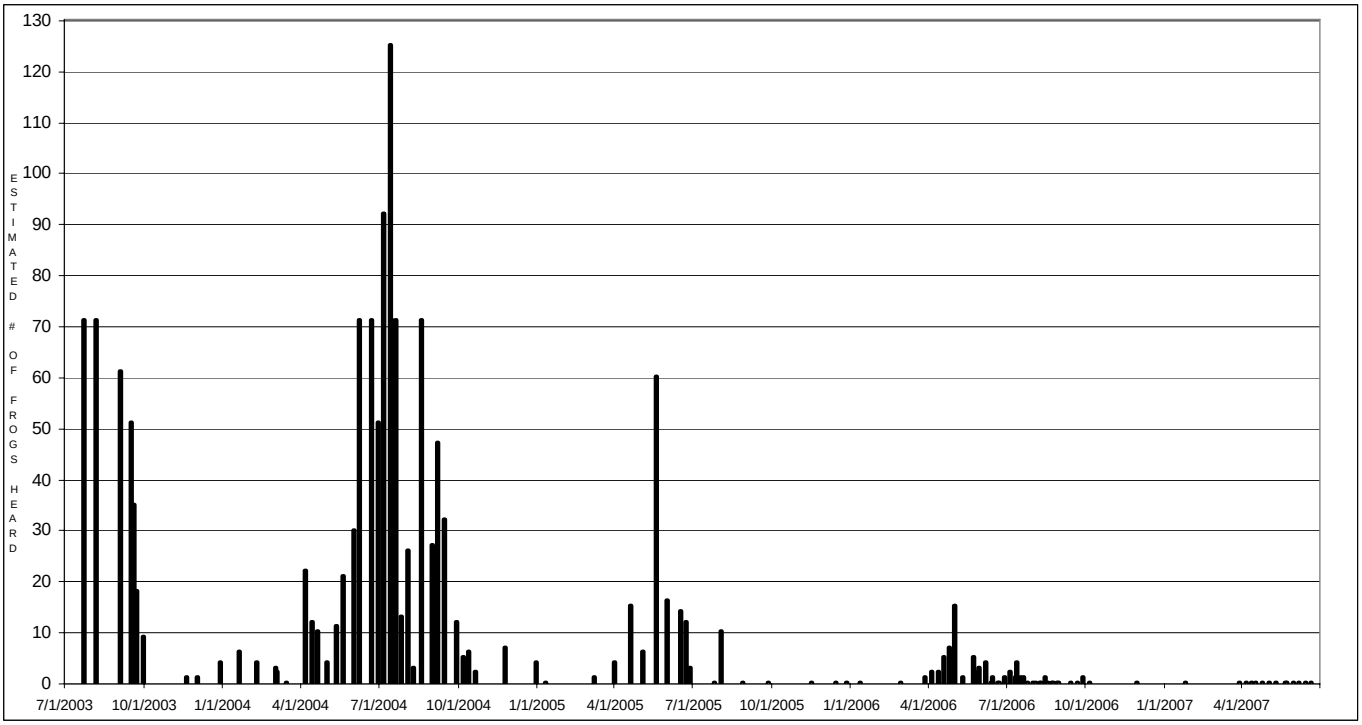

Figure 3. Calling coqui frogs at Wahiawa, Oahu over time.

Oahu – 2006/2007 Control Strategy

In 2006 and 2007, OISC hired a temporary crew of 3 technicians to carry out a strategic daytime citric acid ground drenching of the infested area in Wahiawa. This has been successful and current efforts are focused on monitoring the wild land site and working with nurseries in assisting in their respective control efforts.

Oahu - Nurseries

The nursery industry is the primary vector for coqui transport and re-introduction to Oahu; therefore, the successful management of infested nurseries is critical to eradicating coqui from Oahu and preventing reintroductions. Historically, there have been 5 nurseries and 2 plant stores that have had populations of coqui. The management of the businesses has varied from successful self management to consistent work and oversight from the CWG.

In 2005, a protocol for controlling frogs and efforts to assist business owners in receiving NRCS support was developed. This protocol outlines the steps necessary to successfully treat a nursery using chemical and manual control and the monitoring necessary for successful eradication. The CWG has been working with the remaining nurseries to implement this plan and eradicate the remaining populations.

Oahu - Single Calls / Data tracking

OISC serves as the data clearing house and coordinating entity responsible for tracking all coqui data on Oahu. OISC has developed a coqui database to monitor and track all work on coqui by the CWG and all coqui sites on the island.

Single calling frogs are presumed to have arrived and been transported via commercially sold contaminated plants. The CWG relies on the general public to report calling frogs. The calls are usually routed to the HDOA Pest hotline where they are recorded and screened for credibility. If a site visit is deemed necessary, one of the CWG partners will respond. Calls that are screened over the phone and deemed not to be coqui are not recorded in the database.

Education and Outreach

Current education and outreach efforts on Oahu are conducted by the CWG. The main messages are that coqui continue to be spread across the state, they will cause damage, and to report coqui to the Pest Hotline. Outreach methods included direct community outreach at forums and events, written flyers and news articles, television and radio media. Special interest groups were also targeted. Oahu-based nurseries received mailed information packets on coqui and the sprayer-loan program, and awareness presentations were made to participants of the Pesticide training and certification classes. Radio and television media coverage included public service announcements (PSA's) on local radio stations and local TV stations. Newspaper and newsletter articles appeared, and there were occasional local radio and TV interviews about the issue.

Communication and Coordination

OISC and CGAPS works with the rest of the CWG partners to educate the public about coqui frogs. Door-to-door canvassing, PSA's on the radio and tv, flyers, the internet, neighborhood board meetings and booths at community events are just a few examples of techniques that were employed to convey the message about coqui frogs to the general public.

Funding

The current funding should result in the eradication of frogs on Oahu. Specific funding for control work on Oahu has come from Oahu County and the State of Hawaii. OISC's current funding for work on coqui frogs in 2006 totals approximately $180,000.

Management Goals and Alternatives

1. Alternative – No Action

Under this scenario frogs would be moved around the island and state due to movement of materials, as well as the natural spread of the frogs. This would likely lead to increased economic, ecosystem, and agricultural impacts, as well as effects on the general public. This would also shift the costs associated with control to local businesses and the general public.

2. Alternative – Current Action

OISC believes that the current level of state, county and federal resources being dedicated to coqui frogs (approximately $137,000/year) is at or near adequate levels to eradicate all known populations and respond to new single frog calls as they arise. However, the following caveats apply:

- It is not possible to know with certainty all of the locations where frogs are present and it is likely that there are other population centers as well as sites with individual frogs, including unknown wildland populations. Given current resources, OISC is not able to conduct additional surveys to determine whether other population centers exist.
- Coqui frogs continue to be introduced to Oahu through the nursery trade and spread by plant distributors on the island.

Maintaining the current level of effort will require approximately $175 – $200,000 per year. It is expected that this level will need to be maintained for the next one to two years.

3. Alternative – Increased Control

Increased control on Oahu should focus on island-wide detection and prevention activities. This would include additional surveys in coqui habitat and increased monies towards education and publicity to increase reporting. More time should be spent surveying the island for coqui frog infestations. Surveys should be conducted at all known nurseries on a periodic basis. This work could be conducted at a cost of approximately $50,000 annually for the next two to three years. The duration of the cost depends on whether adequate prevention steps are achieved.

The continued introduction of coqui frogs from the Big Island must be stopped through prevention. The fact that infected plants continue to arrive is evidence that inspection at ports is not adequate. More HDOA inspectors should be hired to conduct inspections at all ports. Hot water treatment and spraying with citric acid should be mandatory for all plant material coming to Oahu from the Big Island and potentially Maui.

HDOA should be able to provide cost estimates for how many additional inspectors would be needed to adequately inspect materials arriving via the ports. USDA-WS, HDOA or CTAHR should have information on the cost to develop and install hot-water treatment or citric acid spray systems at the ports.

4. Alternative – Eradication

The "Current Action" alternative is nearly what the CWG deems necessary to eradicate coqui from Oahu County. Additional work would include the management plans set out under "Increased Control" and prevention with the assurance of ongoing monitoring and maintenance over the next three to five years. Continued and enhanced public education and involvement will be required.

Table 1. Oahu cost estimates for eradicating coqui frogs

Cost Estimates for Eradicating Coqui Frogs on Oahu: FY07 – FY09

	2007	2008	2009
OISC Vertebrate specialist	$45,000	$50,000	$55,000
Current level of effort – Wahiawa	$100,000	$50,000	$10,000
Current level of effort – Nurseries	$10,000	N/A	N/A
Current level of effort – Single call	N/A	N/A	N/A
DOFAW – Invasive Species Tech *			
Education / Outreach			
PSA (radio)	$15,000	$17,000	$19,000
Print Advertising	$1,000	$1,250	$1,500
Outreach posters, flyers, etc.	500	250	250
Prevention: HDOA Inspectors			
Totals	$177,007	$122,008	$87,009
Grand Total	$386,024		

* DOFAW Invasive Species Technician has to date been dedicated to the coqui project. The cost for this position would need to come from DOFAW. If this changes, the cost per year would increase by $57,000.

5. Decision Summary

The alternative for increased control would ensure that current progress on eradication of all known populations of coqui frogs is maintained as well as ensuring that no new populations become established. Increased public education would result in improved reporting and subsequently more effective response to new populations.

C. BIG ISLAND

Current Distribution and Spread

The estimated infested acreage of coqui frogs in 2006 was 7,000 acres. Currently, in 2007, the acreage has increased to approximately 24,000 acres (Figure 3). While control techniques can be effective certain populations have continued to grow unhindered. Most of East Hawaii is considered infested, including most Hilo, Puna, and outlying areas north of Hilo, where they reach densities over twice as high as in their native range. Small breeding populations have persisted up to 3,000 feet elevation. Isolated detections

have occurred in elevations up to 4,000 feet and were probably transported by vehicles and construction equipment from infested areas. Coqui frogs have also infested sites on the west side, of Hawaii Island, including Kaloko Mauka, Captain Cook, and Manuka State Park. Coqui frogs are not considered eradicable on Hawaii Island but control efforts aim to contain their spread by treating small isolated populations.

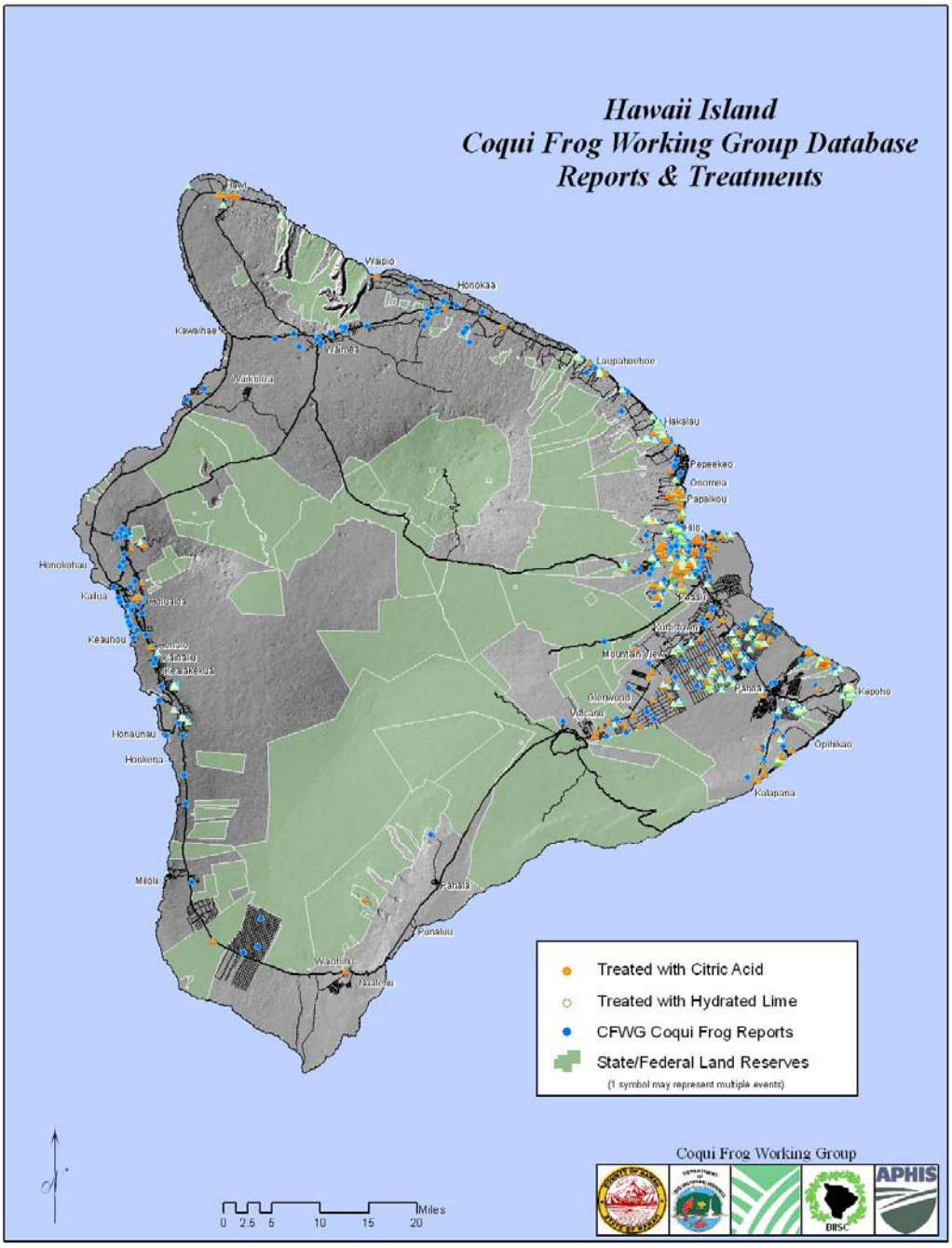

Figure 4. Confirmed coqui frog locations and control sites on the Big Island.

Quarantine

On April 12, 2004, the Mayor of the County of Hawaii declared a state of emergency on the island of Hawaii specifically due to the coqui frog infestation, its threat to human health and welfare, unknown impact to the island's ecosystems and economic welfare of the island. HDOA has primary responsibility for inspecting inter-island plant shipments. There is no current systematic treatment of outgoing nursery products on the Big Island, but the HDOA is planning on installing a hot water treatment plant in Hilo to treat for frogs.

Private efforts

A certification program is currently being pursued by the nursery industry to reduce the spread of frogs. This program, Stop Coqui, is being developed through the Big Island Association of Nurseries.

Hawaii County awarded mini grants to 80 community associations for self help. The mini grants provides up to $5,000 per community group per application in the purchase of chemicals, personal safety equipment, and other expenses. The grant does not allow the purchase of sprayers. It is worthy to note that a lot of control efforts on the Big Island is conducted by these community groups.

Big Island Invasive Species Committee (BIISC) has a Citric Acid Matching Program (CAMP) to help alleviate costs associated with citric acid. Under this program an individual can get up to nine bags of citric acid matched from BIISC. This program cannot be used in conjunction with the County grants as this would consititute "double dipping" of community resources.

Hawaiian Island Economic Development Board (HIEDB) was awarded a $200,000 federal grant in 2005 to work with US Department of Agriculture (USDA) to develop a community-support program to control coqui frogs. HIEDB provides loan sprayers, chemicals and conducts education and outreach.

USDA/WS also has a sprayer loan program previously funded by the County of Hawaii, who also purchased the sprayers, and is currently funded by DLNR. This program has about 30 sprayers ranging from 5 gallon backpack sprayers to larger capacity 400 gallon sprayers that are used by the Big Island communities.

Nanawale O Puna received a government grant. This organization is providing limited quantities of chemicals to the public through a voucher program.

Government efforts

All levels of government are involved in the efforts to control the coqui frog on the Big Island. These entities make up the Big Island's Coqui Frog Working Group (CFWG) and include the County of Hawaii, HDOA, USDA/APHIS/WS, USDA/APHIS/WS/NWRC,

DLNR, UH Hilo, CTAHR, HIEDB and BIISC. The CFWG works on different aspects of the coqui problem on the Big Island and also does collaborative community outreach classes.

The County of Hawaii focuses their control efforts on County lands, such as parks and transfer stations. In 2006 the State Legislature appropriated $1 million to the County in addition to $300,000 from the County's general funds. This funding was used for their control efforts, research support on control and efficacy, and to fund the community grant program and sprayer loan program, which was contracted to USDA/WS (see above section).

HDOA primarily focuses on control assistance with nurseries and plant quarantine. In 2006, the State Legislature appropriated $500,000 to HDOA for coqui control efforts Statewide. Funding is used for the development of hot water treatment facilities in Honolulu and Hilo and a nursery matching program for hot water treatment facilities. These facilities are still in progress of being built and/or utilized. Additionally funds are used for coqui barrier research and a nursery hot water treatment matching program.

USDA/WS was funded by the County of Hawaii in 2006 to operate the sprayer loan program and to conduct community spraying assistance. Funding was from the State Legislature appropriation to the County. They also have a hotline number to document coqui locations and give assistance and advice for homeowners.

In 2006, DLNR/DOFAW on the Big Island was appropriated $300,000 for coqui control efforts. Efforts included control work on state lands, with assisatance from BIISC, with high value natural areas as a priority. IN 2007, DLNR/DOFAW was appropriated $500,000 for coqui control from the State Legislature. Approximately half of this funding was doled out to the following CFWG agencies to further the working group's goals; support was given to HDOA for their coqui barrier demonstration for nurseries, funding was secured for the USDA/WS Sprayer Loan Program for communities and a control crew for DLNR coqui control project, and approximately 440 bags was donated to BIISC's Citric Acid Matching Program for communities. In addition, DLNR/DOFAW, in conjunction with HISC and BIISC manages a CFWG database of all hotline calls and treatment of frogs on the Big Island for more comprehensive data of the coqui frog problem.

UH Hilo conducts research on the efficacy of treatment by examining sound pressure readings pre- and post-treatment. Preliminary results show that once a population reaches a certain density the sound levels plateaus with increasing numbers of frogs. UH Hilo also conducts population density estimates as it relates to vegetation density.

University of Hawaii College of Tropical Agriculture and Human Resources (CTAHR) research ranges widely from testing the efficacy of hot water treatment to frogs to irradiation of frogs for sterilization. Additionally they are testing increasing the efficacy of PVC pipe traps for frogs by placing fruit fly attractants to enhance food availability.

Overall, the cooperators in the CFWG address the control of coqui frogs in its various aspects such that there is little overlap but room for cooperative work. For example, the DLNR, USDA-WS, and County of Hawaii have worked on together on several control projects where there is State/County land bordering communities.

Education and outreach

The CFWG has conducted a number of cooperative education classes for communities island-wide. Class attendees learned about the life cycle of coqui frogs, strategies for control, chemical safety, spraying techniques, large capacity sprayer training, and about the community resources that are available. Additionally, HIEDB, UH-CTAHR, Big Island Invasive Species Committee (BIISC), USDA-WS, and USDA-NWRC are groups involved in educating the public on how to control coqui frogs. General public outreach messages are that coqui will continue to spread and damage the island, new infestations should be reported to the BIISC hotline for mapping, the public needs to take charge of protecting their community, and sprayers and chemicals are available. Outreach methods include a series of legislator-community informational meetings with key officials that were held in all districts, and community event talks, displays and control technique classes.

Targeted outreach included an initial Invasive Species Management Plan specific to the control and eradication of Caribbean tree frogs was developed and presented to the Hawaii Export Nursery Growers. General public outreach was also conducted via newspaper and newsletter articles, and radio and television interviews and programs, and placed advertisement in newspapers.

The resort community has taken an active role in coqui frog prevention, treatment and education. Activities have included anti-coqui meetings for resort managers, mailing meeting notes and best practices to meeting participants and to the Kohala Coast Resort Association, and sending employees to a chemical safety and sprayer class. A number of resorts have requested presentation and educational material support for employees and resort homeowners.

UH- CTAHR is engaged in a nursery education program, assisting nurseries by providing research and information about new innovations to fight the coqui frogs.

HIEDB prepared and sponsored advertising on ESPN and KAPA radio stations to publicize the USDA-WS loan sprayer program, the County mini grant program, and the HIEDB chemical voucher program. Radio programs have highlighted coqui frog issues. A new web site www.stopcoqui.com was launched in February 2006. HIEDB also spearheaded a coqui bounty program for chartered private schools in East Hawaii in October 2007. CTAHR also produced a video that was aired on the public access channel.

Written exposure of coqui frogs has included paid advertisements, brochures and newspaper articles. Paid ad space in a homeowners brochure in the Hawaii Island Journal reached a 20,000 island-wide distribution. Newspaper articles supplied by HIEDB about coqui frog have included articles in the Hawaii Island journal the Hawaii Island Board of Realtors Newsletter, and the Hawaii Tribune-Herald. In addition, the Focus on the Economy published in Hawaii Tribune-Herald and West Hawaii Today carried a column on coqui frogs and a "Homes of the Big Island" March 15-April 15, 2006 issue carried a two-page, four-color coqui control article.

Public relations activities have included educational e-mails and newsletter articles were provided to the Kona-Kohala Chamber of Commerce and the Hawaii Island Chamber of Commerce for distribution to membership. Education booths with coqui related materials were manned at Earth Day, the Horticultural Festival, and the Hilo Jaycees Spring Fest.

A number of pest alert leaflets and brochures were produced by CTAHR and Wildlife Services. A brochure entitled Coqui Frog for Homeowners produced by UH CTAHR is in process of being revised and printed. HIEDB produced laminated instruction manuals to accompany the 400 gallon sprayers in the Community Sprayer Loan Program.

Communications and coordination

On the Big Island, communications have included meetings with local legislators, large landowners and the Chamber of Commerce. Dwight Takamine and Clifford Tsugi led the Big Island House of Representatives in meeting with communities to discuss invasive species and the coqui frog. HIEDB held a meeting with landowners on the Big Island to get them to take action to control frogs on their properties. HIEDB has begun to interface with the Hawaii Island Chamber of Commerce and the Kona-Kohala Chamber of Commerce to open a dialog with the business community on the problems associated with coqui frogs.

Funding

Funds for management of frogs on the Big Island come from County, State, and Federal governments. In 2006 the State Legislature appropriated the County $1 million and DLNR $300,000. In 2007, the State Legislature reduced funding for coqui control on the Big Island to $500,000 to the DLNR. The general public and businesses have also spent significant amounts to control frogs on privately owned properties.

Management Goals and Alternatives

1. Alternative – No Action

Under this scenario, frogs would be moved around the island and state due to movement of materials, as well as the natural spread of the frogs. This would likely lead to an increase of economic, ecosystem, and agricultural impacts, as well as effects on the

general public. This would also shift the costs associated with control to local businesses and the general public.

2. Alternative – Current Action

There is currently one spray crew with USDA-WS that is contracted to conduct DLNR work and one crew with the County of Hawaii. The County crew responds to property owners with incipient populations who are physically unable to spray frogs themselves. The DLNR project focuses on treating frogs in high value natural areas and community support for private landowners adjacent to DLNR lands. BIISC also supplies a field crews to assist control efforts with the DLNR at Manuka State Park and other high value natural areas. None of these crews is able to effectively stop the spread of coqui populations.

Table 2. Big Island costs for current and increased control of coqui frogs.

	FY07	**FY08**	**FY09**
Detection and Control Activities			
Maintain Current level of effort			
--State	$1,000,000	$1,000,000	$1,000,000
--BIISC	$200,000	$200,000	$200,000
--DLNR	$300,000	$300,000	$75,000
--County	$300,000	$300,000	$300,000
--Private	$900,000	$900,000	$900,000
--USDA	$300,000	$300,000	$300,000
Current Level Total	$3,000,000	$3,000,000	$3,000,000
Increased Detection / Control	$6,000,000	$6,000,000	$6,000,000
Education / Outreach	$200,000	$200,000	$200,000

3. Alternative – Increased Control

To increase control efforts, operational funds should be allocated to four entities. USDA would require $4 million, BIISC would require $2 million, NPS would require $250,000, and the County of Hawaii would require $1 million.

Control effort should be directed by a unified command comprised of USDA-WS, HDOA, NPS, BIISC, DLNR and the County of Hawaii. Sites for operational control by USDA-WS or BIISC will be prioritized and selected based on reconnaissance conducted by USDA-NWRC and consultations with cooperating agencies, neighborhood boards, community groups and associations, and industry. The unified command will coordinate

with other state and county officials and interested groups to initiate treatment plans. Operations will be conducted based on ease of access, proximity to sensitive areas, state, county or owner approvals, and available resources. After every operation, USDA-NWRC will evaluate treatment efficacy and determine whether follow-up actions will be needed. As populations are eliminated, resources will be shifted where needed.

USDA, HDOA and CTAHR will work with nursery growers that are known or suspected sites of frog dispersal through the commercial plant trade. Growers would be required, through a quarantine program, to treat infested plant products using available methods to obtain certification that products do not contain coqui frogs.

USDA will work with federal, state and county agencies to control frogs on densely-infested public lands with limited conservation value. The areas occupied will be identified and pesticides applied to stop the spread of the frog. The action may require the clearing of vegetation to provide better access for treatments and will be the responsibility of the appropriate land management agency. After every operation, USDA-NWRC will evaluate potential secondary impacts and determine if actions are needed to improve efficiency and effectiveness of control activities.

4. Alternative – Eradication

Coqui frogs are widespread in East Hawaii covering more than 24,000 acres. Previous large scale spray operations have cost $4,000-10,000 per acre for eradication attempts, this includes multiple treatments. Expanding this cost across the Big Island would require a minimum of $96 million for eradication at this time. This cost would continue to grow if funded over several years as populations expand. However, infestations are located along stream gulches where chemical control methods are currently not permitted. Furthermore, eradication is difficult due to inaccessible terrain and resistance to control from a small portion of the private sector. Thus, eradication attempts can only be applied to local, discrete populations at this time.

5. Decision Summary

Even if no additional resources are made available efforts to maintain information on the distribution of coqui and the efficacy of control efforts should be improved. Establishing more effective protocols to prevent spread of frogs intra-island is critical and will result in preventing the costs associated with mitigation and control for other Counties. Efforts should be made to eradicate or contain frogs in geographically-defined areas on the Big Island, including outlying populations, high-value natural areas, and sites that would facilitate further distribution. Continuing support to local communities and businesses who are actively suppressing local coqui populations by providing education, training and material support is a priority.

C. KAUAI

Current Distribution and Spread

Kauai County currently has only one population of coqui frogs. Located in Lawai next to Aepo Reservoir, the infestation covers approximately 15 acres (Figure 5). Although they were introduced in the year 2000, the frogs were not reported for at least two years. Upon survey, the population was found to be well established in a heavily forested gulch comprised of hau and other weed species. Control work has kept this population from spreading to the surrounding areas. Detection work has also resulted in confirming that coqui were introduced to several other sites as well (Figure 6).

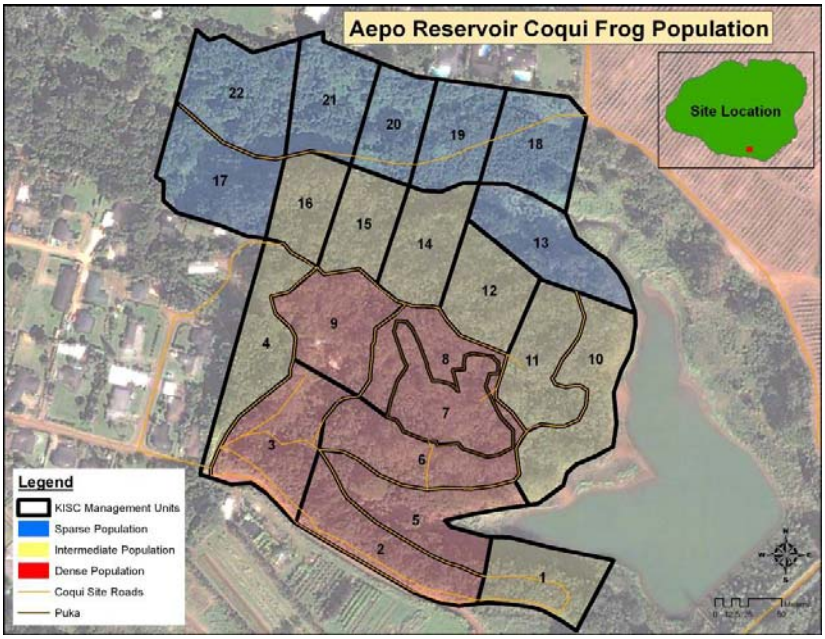

Figure 5. Lawai Reservoir frog population on Kauai.

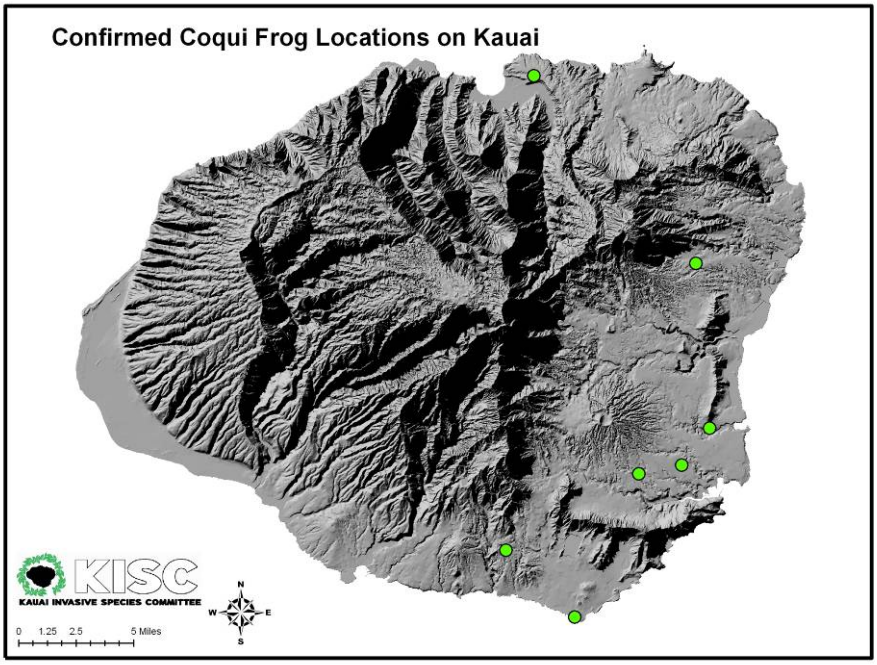

Figure 6. Confirmed coqui frog locations on Kauai.

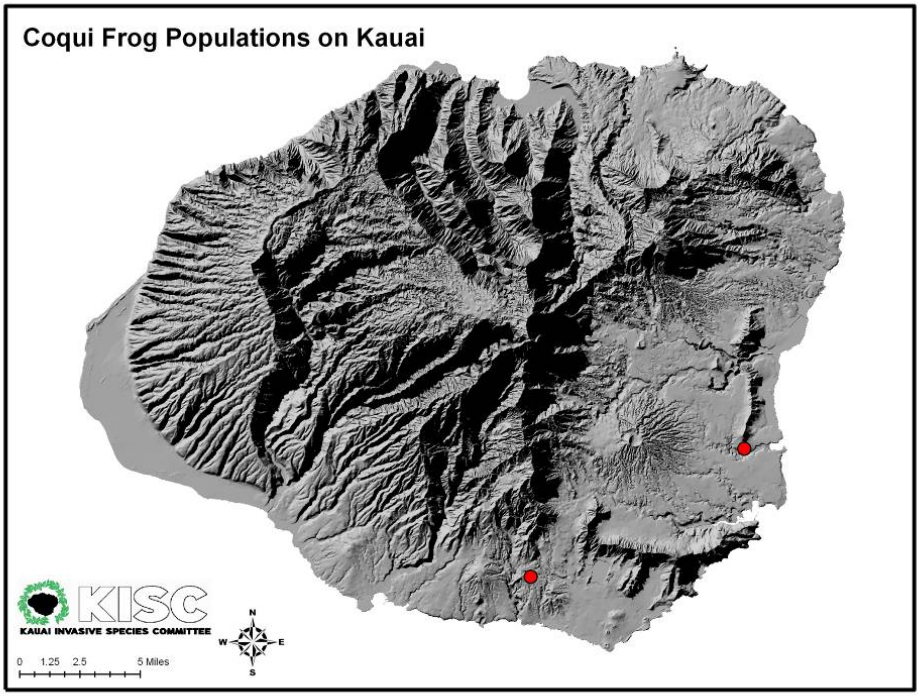

Figure 7. Status of coqui frog control on Kauai.

To date, Kauai has only had one other population (comprised of 7 calling males) reported in Hanamaulu (Figure 7). These frogs arrived on imported plants as juveniles and as they

matured to calling age, were reported by the homeowner. The site was sprayed several times with a resulting eradication of calling frogs.
Coqui continue to be reported by the public and dispatched by Kauai Invasive Species Committee (KISC) personnel. All confirmed frogs were the result of plant importation, not re-location of frogs from the existing site, including an infested shipment of anthuriums from the Big Island. This shipment's destination was the County Fair, but it was sealed and returned to the shipping nursery.

Quarantine

HDOA has primary responsibility for inspecting inter-island plant shipments.

Private efforts

No known private efforts are taking place outside of Kauai's one infestation site. One nursery previously set up a quarantine area with lime dust, but it was dismantled in 2004. This same nursery re-established a quarantine area in 2006 to monitor for calling frogs. This method has proved to be somewhat successful, as they were able to capture several calling male frogs and report it to the shipping nursery on the Big Island.

Government efforts

In 2002, USDA Wildlife Services National Wildlife Research Center (USDA-NWRC) and Wildlife Services Operations began field tests of citric acid on the Lawai frog population and completed EA-funded research.

From 2002 to 2005 control work continued at this site utilizing a partnership between Hawaii Department of Agriculture and Kauai Invasive Species Committee. Continued use of citric acid at 16% was utilized but proved to only contain the heavily infested area due to the density of foliage.

During mid 2005, a strategy meeting was held involving the County of Kauai, HDOA, DOFAW, UH-CTAHR, Federal and private landowners to devise a work-plan to effectively eliminate this infestation. A work plan with a budget was outlined, as well as funding secured. Efforts to utilize existing eradication methods commenced early in November 2005.

Habitat modification with heavy machinery to clear all vegetation 14"diameter and under utilized a track-hoe with a hydro-axe attachment. Access roads were defined using existing, but overgrown, roadways as well as a disused ditch-line. These roads have helped to facilitate ease of pesticide application.

Work continues utilizing chemical application of hydrated lime at 3% as a soil drench and citric acid at 16%.

KISC is the clearinghouse for all Coqui reports and data kept on treatments.

Education and Outreach

KISC utilizes the expertise of their HISC-funded Community Relations and Outreach Specialist. Coqui education and awareness is included in all outreach curriculum and events. Some of the opportunistic venues for outreach include fairs, school visitations, displays, and community groups. Additionally, KISC distributes flyers to the coqui-neighboring community with updates on progress and strategy.

The green industry is a crucial target audience for the island's outreach. The Outreach Specialist meets regularly with the Kauai Landscaping Industry Council (KLIC) to promote awareness, provide the latest coqui information, and facilitate the adoption of voluntary codes of conduct for nursery owners and landscapers. Coqui reporting, tracking of imports and exports, public education, and participation in KISC nighttime nursery surveys are all included as KLIC's roles and responsibilities as suggested in these draft codes.

A HISC-funded grant for airing public service announcements about coqui was implemented during 2005 and in 2007 on local radio stations. Community members were encouraged to report all coqui calls to KISC or the Pest Hotline (643-PEST). KISC receives about 2-4 coqui reports per month. All calls are followed up to determine report validity. As a proportion of all calls, 98% are confirmed greenhouse frogs, 1% are reports of the known infestation, and 1% are confirmed new introductions via plant importation.

Communications and Coordination

Since 2004, the Kauai Invasive Species Committee (KISC) has coordinated all efforts regarding response and control. In the spring of 2005 a Kauai Coqui Working Group was formed to design and initiate a strategic plan for eradication of the Lawai infestation. Working in partnership with HDOA, neighboring landowners, members of the County Council, and private landowners, funding was obtained and work continues at this site.

Reports of coqui calls are received predominately by KISC with others being forwarded from HDOA.

Funding

The majority of the funding for frog management on Kauai comes from state funding to KISC and from the county of Kauai. During FY06, this came to more than $178,000 and FY07 the County of Kauai alone contributed $300,000.

Management Goals and Alternatives

1. Alternative – No Action

This would result in increased frogs around the Island and state due to movement of materials, as well as the natural spread of the frogs. This would likely lead to increased economic, ecosystem, and agricultural impacts, as well as effects on the general public. This would also shift the costs associated with control to local businesses and the general public.

2. Alternative – Current Action

Current funding for Kauai has supported implementation of an action-oriented work plan. Contributions for ground efforts from private landowners, Kauai County, and the State have amounted to over $500,000 during 2006 and 2007. A major portion of this funding was used to contract clearing work to remove foliage and define vehicular access. This funding also has been applied to chemical purchases of hydrated lime and citric acid. Funding at this current level is adequate to continue making meaningful progress with possible eradication.

Coqui frogs continue to be introduced to Kauai through the nursery trade and spread by plant distributors on the island. Unless and until this is stopped, new populations will be created and detection and control efforts will need to be continued indefinitely.

Table 3. Kauai's associated costs to eradicate coqui frogs

Cost Estimates for Eradicating Coqui Frogs on Kauai: FY07 – FY10 (State Fiscal Year)

	FY07	**FY08**	**FY09**	**FY10**
Detection and Control Activities				
Maintain Current level of effort	$300,000	$160,000	$50,000	$50,000
Increased Detection / Surveys	$20,000	$20,000	$10,000	$10,000
Education / Outreach (taken from Mauai)				
Agriculture	$15,000	$15,000	$15,000	$15,000
Homeowners / Residents	$35,000	$35,000	$35,000	$35,000
Prevention: HDOA Inspectors				
Totals	**$370,000**	**$230,000**	**$110,000**	**$110,000**
Grand Total (without Prevention Costs)	**$820,000**			

3. Alternative – Increased Control

Increased control on Kauai should focus on island-wide detection and prevention activities and direct control work should be expanded with additional labor and spraying equipment to control Kauai's one population of frogs.

An additional $110,000 is needed to maintain funding levels at $160,000, if county and private funding is not secured. This increased level of support would ensure continued efforts toward eradication and also augment the existing workforce to conduct surveys and treatment, and purchase additional spraying equipment and chemicals. It is expected that this level of funding would need to continue for two years and then could decrease to $50,000 for an additional two years.

Surveys should be conducted at all known nurseries on a periodic basis. This work could be conducted at a cost of approximately $20,000 annually for the next two to three years, providing inter-island movement of the frogs has been halted.

More HDOA inspectors should be hired to conduct inspections at all ports, including the Super Ferry. Hot water treatment and spraying with citric acid should be mandatory for all plant material coming to Kauai from the Big Island.

4. Alternative – Eradication

Eradication of coqui frogs from Kauai will be accomplished through continued implementation of the action plan currently being utilized if funding is secured and readily available. Continued and enhanced public education and involvement will be required.

5. Decision Summary

The alternative for increased control would ensure that current progress on eradication of all known populations of coqui frogs is maintained, as well as, ensuring that no new populations become established. Increased public education would result in improved reporting and subsequently more effective response to new populations.

D. MAUI AND MAUI COUNTY ISLANDS

Current Distribution and Spread

The first Maui observation of a coqui frog was made in 1997. Since that time, Maui Invasive Species Committee (MISC) has recorded 368 reports of coqui frogs scattered across the island (Figure 8). Frogs have been reported from Hana (East Maui), Haiku and Kula (Upcountry), Kahului and Wailuku (Central Maui), Kapalua and Lahaina (West Maui) and Kihei (South Maui). In 2004, MISC estimated that coqui frog infestations covered at least 161 acres.

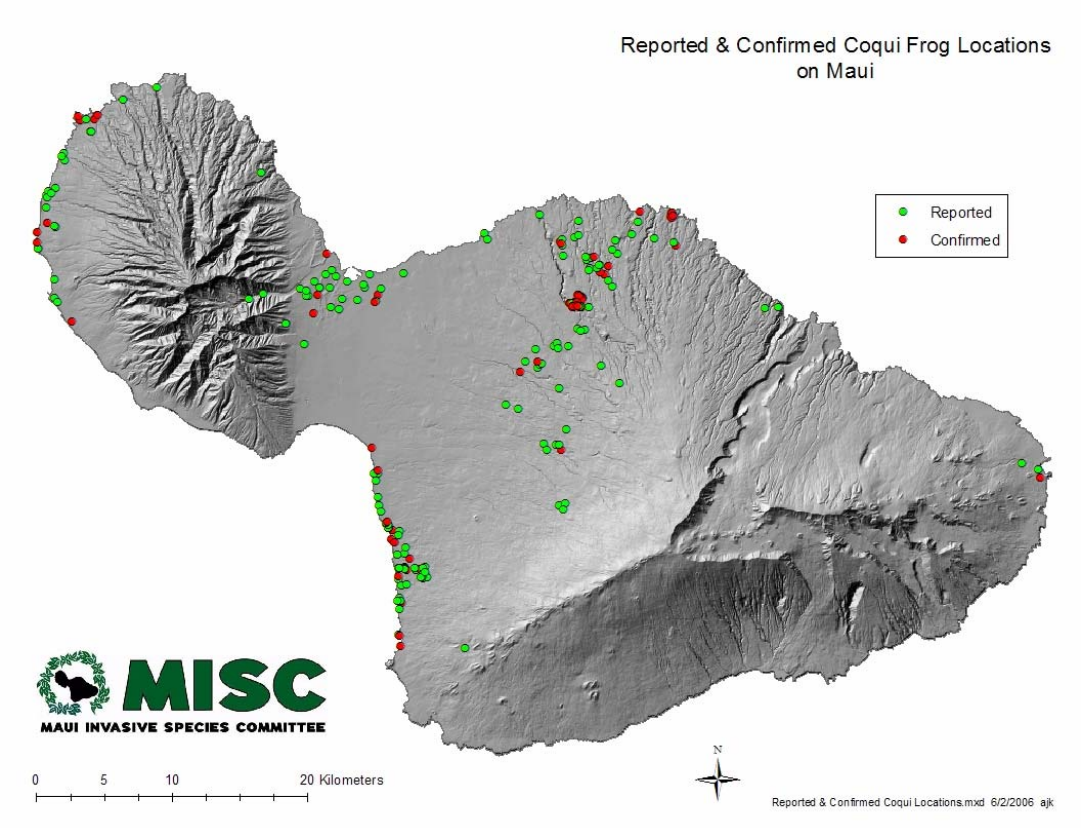

Figure 8. Reported coqui frog locations on Maui.

MISC has reviewed all available reports of coqui frogs on Maui to assess accuracy, determine current status, and to establish the location of population centers. For purposes of analysis, the term "population" means a physical property (TMK) that has had five (5) or more calling males or defined areas, regardless of the number of frogs. Population centers do not include locations where reports were later determined to be false or locations where one or two coqui frogs have been controlled with no repeat occurrence. A total of thirteen (13) naturalized populations have been established on Maui (Figure 9).

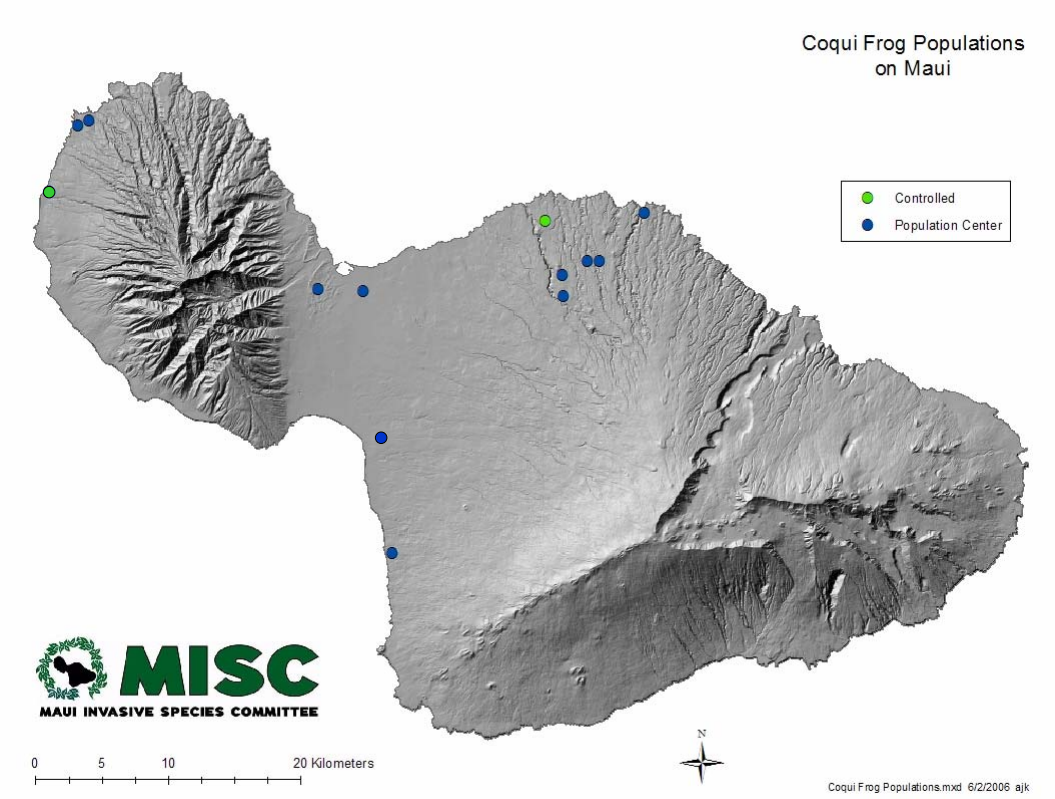

Figure 9. Coqui frog populations on Maui.

The largest population on Maui, which is centered in and adjacent to Maliko Gulch (Haiku), covers an estimated 127 acres. Researchers from the University of Utah who visited infested populations on the Islands of Hawaii and Maui reported that densities in Maliko Gulch rivaled or exceeded any of those encountered on the Big Island. Only minimal control activities have occurred in the 76 acre gulch, or wilderness, portion of this area, with recent efforts successfully reducing coqui numbers on the 51 acre residential rim of the infestation. No concerted or comprehensive effort has been initiated in the wildland portion of the gulch given the high level of resources needed. However, MISC has delimited and maintained the perimeter of the population and developed a comprehensive plan to address the wilderness portion of the infestation if adequate resources are made available.

Molokai

A single male coqui frog was detected in Maunaloa at the Mahana Nursery and controlled on Molokai in 2001. A single male frog was reported on Molokai in June 2007 and apparently controlled. No other coqui frogs have been reported from Molokai.

Lanai

A single vocalizing male was captured on Lanai at the Lodge at Koele in approximately 2003. No other coqui frogs have been reported since then.

Kahoolawe
No coqui frogs have ever been reported from Kahoolawe.

Quarantine

HDOA conducts inspections of inter-island shipments. Maui County does not have a hot-water treatment facility or citric-acid spray equipment at any of the Maui County ports. There are no known plans to install such systems on any of the Maui County islands. Molokai and Lanai do not have HDOA inspectors on island.

Private Efforts

Maui and Molokai
Private efforts to control coqui frogs on Maui have been relatively limited to date. There are two landowners who have worked diligently over the last six years to remove coqui frogs from their properties with varying degrees of success. One of these properties is located at the head of the Maliko Gulch infestation in Haiku and is completely surrounded by a high-density infestation. The other property is located in the Huelo area, but the infestation covers many other properties as well. One nursery in the Haiku/Maliko area sporadically attempted control efforts over the years. Other private landowners in the Haiku/Maliko area have formed a "frog squad." This group initially met regularly and conducted control operations, but has not met since early 2005. Other private efforts to control frogs typically consist of limited sporadic efforts to capture frogs or involve the use of small quantities of citric acid, which MISC packages and provides for distribution.

Government Efforts

Maui and Molokai
Cooperators on Maui have included the following agencies: National Park Service, County of Maui, Hawaii Department of Land and Natural Resources / Department of Forestry and Wildlife, Hawaii Department of Agriculture, County of Maui Department of Water Supply; and the Maui Invasive Species Committee (MISC).

From 2000-2002, MISC responded on a case-by-case basis to reports from the public, serving an early-detection and rapid-response function and hand capturing frogs whenever possible. During 2002, MISC conducted caffeine trials under a short-term Environmental Protection Agency (EPA) experimental permit to determine the feasibility of using caffeine to control coqui frogs. MISC also controlled frogs by hand capturing during this time. The permit for the caffeine spray expired in late 2002.

In 2003, MISC created a position to focus on invasive vertebrate species, including but not limited to coqui frogs. Staff began revisiting previously reported sites to determine whether coqui were still present and started checking new reports to verify infestations.

Given the scope of the problem and inadequate resources at the time to conduct large-scale control work, MISC decided to focus on public involvement for detecting, reporting and controlling coqui frog infestations. MISC produced informational handouts, gave presentations to community and industry groups, and used print and radio media to educate the public. MISC attempted to energize public detection and control efforts through existing community organizations. However, it soon became apparent that the public was not likely to take significant responsibility for controlling frog infestations until after a population had already become well established.

As public awareness about the problem grew, MISC became the primary repository for public reports about coqui frog infestations on the island. Most new sightings are currently reported to MISC. Molokai subcommittee of the Maui Invasive Species Committee (MoMISC) is the primary repository and responding entity for any frog reports on Molokai. Over the last year, HDOA has received only two or three reports of frog locations. At present, nearly all control work is being conducted by MISC. HDOA personnel occasionally respond to reports of single frogs. HDOA personnel assisted with spray operations until 2004.

With increased funding from the State of Hawaii and Maui County, MISC hired a four-person crew to focus on coqui frogs beginning in spring 2005. Control activities include hand capturing frogs, spraying citric acid at infested sites on a systematic four to six-week schedule, and ongoing habitat work. MISC uses two 100-gallon spray rigs, one on loan from HDOA and the other purchased by MISC.

By the beginning of 2006, MISC had eradicated one population center located in Haiku. MISC continues monitoring population centers for nearly twelve months with no repeat occurrence of frogs prior to considering a population eradicated. In 2006, an additional three populations were moved to a "monitor" phase. Sites placed on monitor status continue to be visited on a regular schedule for at least one year after the last vocalizing male has been heard. MISC eradicated one additional population center located in Kaanapali by April, 2007.

Remaining active populations now cover an estimated 142 acres, down from the 2004 estimate of 161 acres. Field observations suggest that frog densities have been significantly reduced at many of the population sites, with the caveat that frogs may be less vocal during the colder winter months. With ongoing effort, MISC believes that the remaining eight populations will be in "monitor" phase by the fall of 2007, with all but the largest following suit. Sites identified as "Revolving Sites" include several plant providers where single frogs are often reported after new shipments arrive from the Big Island. There are two revolving sites on Maui.

Education and Outreach

Maui and Molokai

Current education and outreach efforts in Maui County are being conducted by MISC, MoMISC, HDOA, County of Maui, and the Tri-Isle Resource Conservation & Development Council, Inc, with most activities conducted by MISC. Activities include dissemination of information via flyers and other display information at public community events, presentations to school groups, community and civic associations, government officials and industry groups. Occasional articles have been produced by MISC for publication in newspapers, newsletters, and magazines. Local media exposure has included television and radio broadcasts. MISC has recently initiated a volunteer program involving high school students and community members who will participate in hand-capturing coqui frogs. The HISC-funded, Maui-based coqui-free certification program for participating plant providers also includes a significant public education and outreach component. Consumers will be informed about program through press releases, on MISC's web site and through other advertising mechanisms. It is expected that the program will further enhance public awareness about coqui frogs.

Communications and Coordination

Maui and Molokai
MISC is the central coordinating agency for communications about county-wide activities involving coqui frogs.

Funding

Specific funding for previous control work on Maui has come from the National Park Service, Maui County, and the State of Hawaii. Current funding sources are Maui County and the State of Hawaii. MISC's current annual funding for work on coqui frogs totals approximately $265,000.

Management Goals and Alternatives

1. Alternative – No Action

This would result in increased frogs around the island and state due to movement of materials, as well as the natural spread of the frogs. This would likely lead to increased economic, ecosystem, and agricultural impacts, as well as effects on the general public. This would also shift the costs associated with control to local businesses and the general public.

2. Alternative – Current Action

MISC believes that the current level of state, county and federal resources being dedicated to coqui frogs (approximately $250,000/year) is adequate to continue making meaningful progress at all known Maui sites with the exception of Maliko Gulch. However, the following caveats apply:

- It is not possible to know with certainty all of the locations where frogs are present and it is likely that there are other population centers as well as sites

with individual frogs, including unknown wildland populations. Given current resources, MISC is not able to conduct additional surveys to determine whether other population centers exist.

- Coqui frogs continue to be introduced to Maui through the nursery trade and spread by plant distributors on the island. Unless and until this is stopped, new populations will be created and detection and control efforts will need to be continued indefinitely.

Molokai and Lanai

At the current level of action, detection efforts are not adequate. Neither Molokai nor Lanai has an HDOA inspector stationed on the island. It is expected that eventually, coqui frog populations will become established on these islands unless inspection and detection activities are increased.

Kahoolawe

No current actions are being taken to ensure that plant materials, supplies or equipment being transported to Kahoolawe are free from coqui frogs. The likelihood that incoming plant materials contain frogs or frog eggs is considered very low because plants come from a grower on Maui with a high awareness of environmental issues (Ho'olawa Farms) or from Molokai, where coqui frogs are not known to be present. Water tanks come from Hawaii Island, but deployment is limited to the base area, where detection of any frogs would be likely.

3. Alternative – Increased Control

Maui

More time should be spent surveying the island for coqui frog infestations, especially in perimeter areas around known infestations. Surveys should be conducted at all known nurseries on a periodic basis. This work could be conducted at a cost of approximately $50,000 annually for the next two to three years. The duration of the cost depends on whether work on Maliko Gulch commences and on whether adequate prevention steps are achieved. The continued introduction of coqui frogs from the Big Island must be stopped. The fact that infected plants continue to arrive is evidence that inspection at ports is not adequate. More HDOA inspectors should be hired to conduct inspections at all ports. Hot water treatment and spraying with citric acid should be mandatory for all plant material coming to any Maui island from the Big Island.

MISC has determined that different management strategies should be used for different areas of the Maliko Gulch infestation using three smaller management zones (Figure 10). Concurrently, aggressive management within the Maliko Rim area should follow current management practices being used at other sites on Maui.

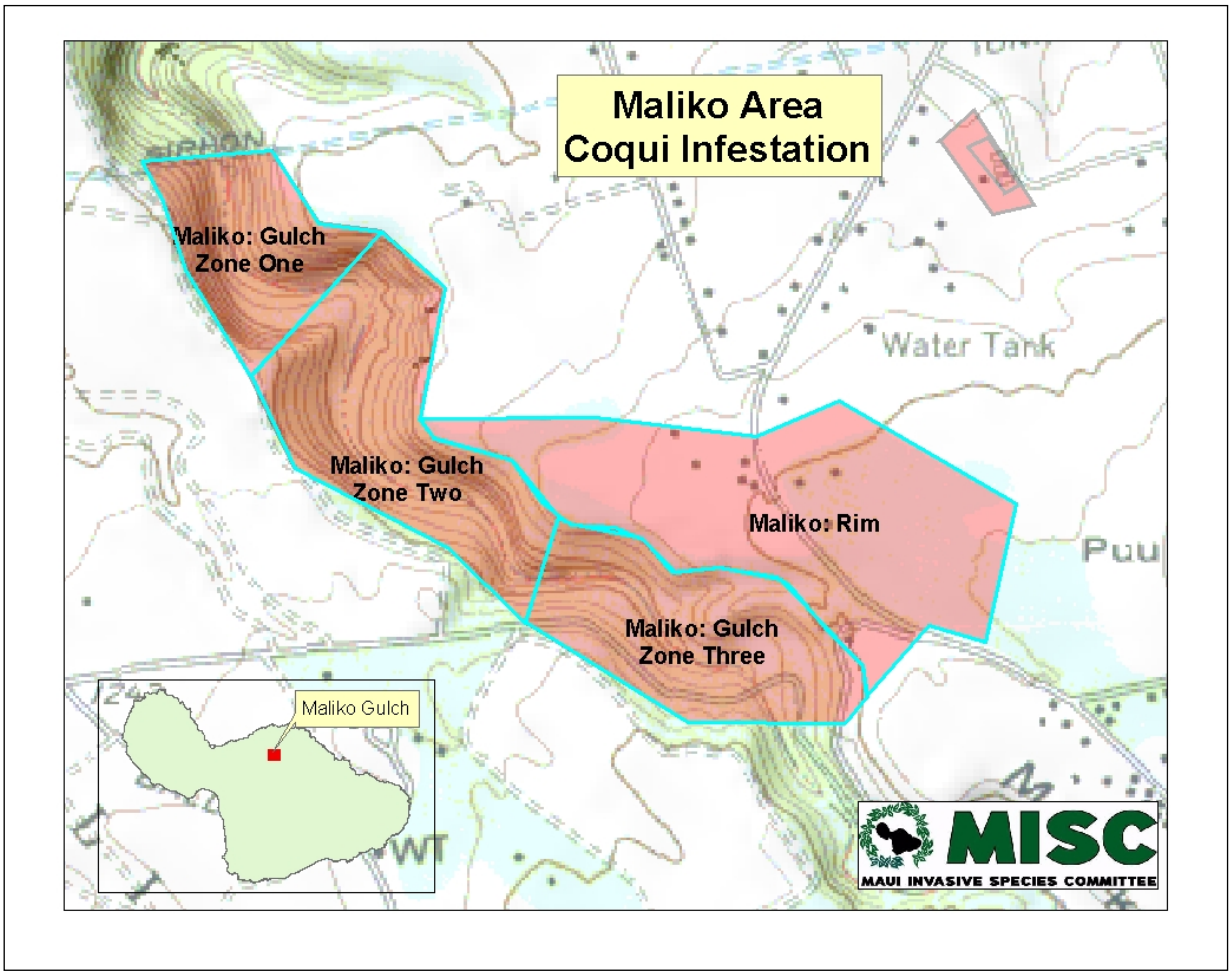

Figure 10. Maliko Gulch coqui frog infestation

MISC recommends establishing and using an irrigation spray system for portions of Zone One and all of Zone Two, and conducting spray operations within Zone Three using large hoses and spray rigs. Additional details on the proposed management approaches for the Maliko Gulch area are available upon request. MISC estimates that the cost to work on the entire Maliko Gulch infestation would be approximately $750,000 for the first year. Costs for the second year should be substantially less. These estimates assume that some of the resources currently devoted to working at other population centers would become available to assist with work on Maliko Gulch during the second year. Funding at lower levels will lengthen the amount of time needed for control and most likely increase the overall cost.

Molokai, Lanai and Kahoolawe

Increased efforts for Molokai, Lanai and Kahoolawe islands should focus on prevention. Increased inspection at all ports of entry is needed for Molokai and Lanai. For Molokai, adding an HDOA inspector would greatly enhance the likelihood of detecting coqui frogs before they get established. Detection surveys in potential habitat on Kahoolawe should

be conducted with the full involvement of the Kahoolawe Island Reserve Commission and Protect Kahoolawe Ohana.

4. Alternative – Eradication

Maui

Eradication of coqui frogs from Maui will require implementing the management plans set out under "Increased Control" with the assurance of ongoing monitoring and maintenance over the next three to five years. Continued and enhanced public education and involvement will be required. It is estimated that the cost to achieve eradication on Maui will be approximately $1,100,000 for the first year and $725,000 for the next two years, not including costs for additional HDOA inspectors. After that, costs should decrease to approximately $200,000 for another two years.

Table 4. Maui's associated costs in eradicating the coqui frog

Cost Estimates for Eradicating Coqui Frogs on Maui: FY09 – FY13 (State Fiscal Year)

	FY09	**FY10**	**FY11**	**FY12**	**FY13**
Detection and Control Activities					
Maintain Current level of effort	$250,000	$250,000	$250,000	$100,000	$100,000
Maliko Gulch	$750,000	$375,000	$375,000		
Increased Detection / Surveys	$50,000	$50,000	$50,000	$50,000	$50,000
Education / Outreach					
Agriculture	$15,000	$15,000	$15,000	$15,000	$15,000
Homeowners / Residents	$35,000	$35,000	$35,000	$35,000	$35,000
Prevention: HDOA Inspectors					
Totals	**$1,100,000**	**$725,000**	**$725,000**	**$200,000**	**$200,000**
Grand Total (without Prevention Costs)	**$2,950,000**				

Molokai, Lanai, and Kahoolawe

Eradication is not relevant for islands where coqui frogs are not presently established.

5. Decision Summary

The alternative for increased control would ensure that current progress on eradication at most known smaller population centers of coqui frogs is maintained. Containing the Maliko Gulch population and work toward eventual eradication is preferred but unlikely

to succeed with current resource levels. Increased public education would result in improved reporting and subsequently more effective response to new populations. Adding additional inspectors may be possible with the new HDOA Biosecurity initiative which could provide adequate inspection of incoming plant materials for Molokai and Lanai.

5. RESEARCH GOALS

A. CONTROL

1. Alternative – Current Action

Current control methods have been successful in eradicating frogs in limited areas. These control methods are not appropriate for all applications, such as for use with sensitive plant material. Reduction in funding for research would potentially reduce the number of new tools developed but would not stop research from occurring because funding comes from several non-state sources.

Research funding for the current action may require additional state funding if non-state sources disappear or are reduced. Currently, HDOA has funded research on various control methods, including chemical and non-chemical control. The County of Hawaii has spent $200,000 developing and evaluating control methods.

2. Alternative – Increased Research

Increased research would likely result in chemical and mechanical methods to manage frog populations. Funding for control efforts has been primarily from the State and more recently the County of Hawaii. Increased funding would speed the development of tools and may yield more effective methods.

3. Decision Summary

Current chemical control methods may be used in agriculture, private lands, and natural areas. Additional chemical control methods could be developed to target frogs in natural areas or to be used in quarantine areas for sensitive plants. Barriers and hot water methods may be useful in quarantine areas or greenhouses and development of effective methods seems likely. State funding should be centralized with HISC so duplication of effort and research into unproductive areas is minimized. HISC's process of providing research funds is well established and ensures peer review of research endeavors. Since funding was reduced from $4,000,000 in 2005 and to $2,000,000 in 2006 and to $700,000 in 2007 it is not clear if there will be continued support for the HISC research program. Funds provided to HDOA and other entities should follow a similar framework to ensure high quality research.

B. ECOLOGICAL AND ECONOMICAL EFFECTS

1. Alternative – Current Action

The majority of funding for research on the ecological effects of coqui frogs has come from National Science Foundation, US Fish and Wildlife Service (USFWS), state funds through HISC, and the County of Hawaii. A reduction in state funding would not significantly limit current research endeavors. Many of the primary ecological effects of frogs will be revealed under research currently underway. However, long-term effects may go undetected. Effects of control efforts are currently being funded through the County of Hawaii and state funding may be required if the County does not continue funding this research. Very little research has been conducted on the economic effects of frogs on the nursery and tourism industries.

2. Alternative – Increased Research

Increased research may reveal unknown effects of the frogs on the native ecosystems and may further detail the effects already documented. The effects of current control efforts on plants and animals will be documented with current funding and increased state funding would be necessary to detail the effects of future control efforts. The economic effect of frogs on agriculture, tourism, and human health has been little studied. Economic research could provide a detailed picture of current and potential economic effects.

3. Decision Summary

Increased state funding should be directed to research on the economic effects of frogs to document the impact and reveal areas of concern. Funding for the effects of control efforts should be a high priority to ensure that goals for each island are being met.

6. EDUCATION AND OUTREACH GOALS

1. Alternative – No Action

According to the CGAPS statewide awareness survey, titled "Baseline awareness of and attitudes toward invasive species in Hawaii," conducted with 501 residents in August 2004, 66% of Oahu residents, 92% of Big Island residents, 58% of Kauai residents and 67% of Maui County residents "have heard of" coqui frogs.

Without advertising the problem of coqui and the Pest Hotline, coqui will surely spread and establish additional populations on Oahu, Kauai and Maui, and may become established on Molokai. An additional benefit to public education is in gaining access to private property.

On the Big Island, most people have heard of the coqui, but not everyone understands how they can be controlled and where resources exist to assist people in controlling the

frogs. If all outreach on this issue is stopped, communities will not know whom to turn to for advice or assistance with sprayers, chemicals or techniques.

2. Alternative - Current Action

On the Big Island HIEDB has $180,000 budgeted to publications and outreach UH-CTAHR has $50,000 budgeted, and a new outreach specialist for BIISC is budgeted for part-time outreach about coqui (in addition to other duties). HIEDB is operating with a grant from the Pacific International Center for High Technology Research (PICHTR). UH-CTAHR is operating with a grant from the County of Hawaii. Furthermore, the CFWG routinely conducts community outreach meeting island-wide. Community education and outreach will continue at the above described level, until funds are exhausted.

At this stage, Big Island communities are providing most of the manpower in the fight against coqui frogs. Community education is focused on: making people aware of resources to assist them, engaging new people in the fight, eliminating incipient populations, safe use of chemicals and effective strategies. If community education did not exist people would not know where to get money, sprayers, chemicals or technical support. Misuse of chemicals and sprayers occurs regularly and education is on-going to minimize this. The community needs to know safe and effective ways to kill and capture frogs.

Current levels of action regarding education and outreach are helpful, but not adequate. OISC's funding for radio and television PSAs are based on available soft funds and not need, thus falls short of what is necessary.

On Maui, information about coqui frogs are typically incorporated into MISC's overall outreach and education program, as opposed to being a central component. Occasionally, specific presentations or articles focus on the coqui frog. A large part of MISC's education / outreach happens when members of the public call to report a frog location or during active control work on private property. Maintaining education and outreach at the current level means that some members of the public will not realize that they have coqui frogs or understand why the frogs are a problem. Without adequate public awareness, members of the floriculture and nursery industries will be less willing to participate in control activities and frogs will continue to be spread across Maui County. The cost to maintain current levels of education and outreach activities are included in the overall cost of frog operations for Maui County.

3. Alternative - Increased Education and Outreach

Education and Outreach activities should be implemented **state-wide** to present a unified and comprehensive focus on this pest.

Agriculture

At least two statewide mailings to landscape and nursery businesses should occur each year to ensure that the businesses primarily related to the spread of coqui know about the problem, the Pest Hotline, and the resources available to them if they have infested areas. The plant industry mailing database is under construction and numbers about 800 businesses statewide.

On the Big Island, a major initiative of the Coqui Frog Working Group at this time is a program called "Stop Coqui Hawaii", a collaborative effort to educate consumers by promoting plant vendors that follow coqui free protocols. Stop Coqui Hawaii is aimed at nurseries and retail plant vendors and the goal is to provide a standard set of protocols for them to follow which will increase the chances of their plants being coqui free. The consumer can also be confident that they are buying from a nursery that is diligent. The public education (nurseries and consumers) portion of this proposal is estimated at $50,000.

In general, MISC has encountered a high degree of cooperation among members of the nursery industry. Increased education and outreach efforts should focus on working with the affected industries. MISC has begun working to create and implement a voluntary coqui-free certification program for local nurseries and plant providers. This will provide participating growers and plant providers with an incentive to become and stay coqui-free, while providing information to the public about where to purchase coqui-free nursery material. Maintaining this program once implemented and further expanding its reach should be considered a high priority. This program is expected to involve a high degree of direct contact with the nursery industry and requires funding a position at approximately 25% FTE. Personnel costs, along with purchase of marketing materials and supplies are expected to run approximately $15,000 per year.

Resorts/Tourism

The primary push for coqui education in the Resorts/Tourism sector needs to be among the resorts and resort communities. This effort has being with the South-Kohala Anti-Coqui meeting, but there is much more to be done. An educational program that can be taken "door to door" for resort employees and resort homeowners should focus on preventing the importing of frogs in nursery plants, coqui frog identification, procedure for reporting a frog and eradication. Distributing printed materials to resort community residents and their landscapers is also crucial. Estimated budget for this effort is $25,000.

Targeting part-time residents and tourists with messages about coqui frogs is important because many of the traditional education and outreach activities might not reach these members of the public, who could provide valuable information about coqui frog locations. A cooperative program with resorts that choose to advertise as coqui-free also could be developed.

MISC also has experienced a high degree of cooperation at resorts or other hotels, but has not attempted to reach tourists or part-time residents as a separate component of public

outreach efforts. No doubt, some contact does occur at public events and fairs, where information about coqui frogs is always prevalent. Additionally, public television and radio broadcasts reach some tourists. However, targeting part-time residents and tourists with messages about coqui frogs is important because many of the traditional education and outreach activities might not reach these members of the public, who could provide valuable information about coqui frog locations. On Kauai, KISC has not interacted much with resorts and hotels due to the fact that there are no coqui populations in these locations but will incorporate prevention messages in future outreach efforts.

Homeowners/Residents

Education for homeowners/residents should continue to use the major media outlets on the island, but to increase the frequency of the messages. Current limited budgets allowing for four radio ads/day and three newspaper advertisements in a year are not sufficient to maintain awareness of coqui control. An enhanced education and outreach plan includes:

- Weekly advertisements in West Hawaii Today and Hawaii Tribune Herald, Twice Monthly in Hawaii Island Journal.
- Increased frequency of existing radio contracts and expansion to other stations.
- Television PSAs on Oceanic Time Warner stations.
- Anti-coqui Posters
- Banners
- Refrigerator Magnets
- A Big Island-wide "get out for coqui" day would draw public attention to the issue.

Estimated budget for this is $125,000.

The general public is the best tool for detection of the coqui frog which is critical for Maui, Kauai and the City and County of Honolulu. Increased exposure is critical to educate the public to report coqui locations. Media such as radio and TV are the most effective, but other tools such as stickers, handouts and posters can supplement and remind the public to report coqui. OISC estimates that the cost for radio PSAs that would run for the three months of the calling season would be approximately $15,000. Increasing awareness is vital island-wide to not only report any additional arrivals, but to also educate the public as to the economical, ecological, and cultural impacts of this pest. Residential infestations pose increased obstacles for eradication including access issues. By educating the public, resistance to eradication may be avoided. Activities and materials should be state-wide and uniform.

Specific proposed activities designed to increase education and outreach for homeowners and residents include development and broadcast of relevant media, and direct contact with community groups, industry participants, and the public. MISC estimates that a one-half time position dedicated to education and outreach activities related to coqui frog infestations is needed.

Media Products & Curriculum Materials
Additional materials should be developed and disseminated for all relevant media, including television, newspaper, radio, and internet to educate the public about the magnitude of the coqui frog problem, how to take appropriate action, and the status of detection and control efforts. Coqui frog webpages should be developed and maintained on each ISC website and information should be contributed as needed to other websites devoted to coqui frog information. Television and radio public service announcements should be developed and aired four to six times per year and could be augmented with radio interviews two to four times per year. Printed media should include articles for local newspapers, industry newsletters, and magazines, including follow-up activities. Activities, displays or handouts could be developed for existing nature centers or public display areas. Education inserts for utility bills would be a good conduit for information about coqui frogs. A video for community groups and schools could be developed and disseminated as well as age-appropriate curriculum materials for elementary, high school and college levels.

Community and Service Groups
Community associations and service groups are a good resource for educating the public about coqui frogs. Presentations should be developed for organizations such as homeowner associations, condominium associations, community associations, service groups and clubs. Presentations specifically tailored for certain industry groups should also be developed to generate and maintain cooperation in coqui frog detection and control activities. Appropriate industry groups might include hotels, resorts, condominium owners, nurseries growers and retailers, landscape professionals, and utility workers (phone, electrical, water, gas, cable).

General Public
Public assistance in detecting and reporting frog locations is essential. The incorporation of the statewide 643-PEST hotline with appropriate follow up is critical. To encourage public cooperation, reports must generate a timely and meaningful response from a central response center. This central response center for inquiries and reports from the public should field and answer questions from the public and take information about new infestations as well as inform reporters about planned activities for the area and how the reporter can help. Developing a response follow-up tracking system and central database will maintain adequate communication among cooperators.

APPENDIX A: Protocol for monitoring/treatment efficacy of coqui frogs

Following standardized protocols for monitoring sites after treating coqui frogs is essential in assuring data quality and accuracy. This would decrease confusion and biases commonly associated with multiple methods in assessing presence/absence and densities of frogs. Currently, the most accurate method to determine density (# of frogs per unit of area, ± error) of coqui frogs is mark-recapture methods (Woolbright 2005). This includes at least 4 nights of mark-recapture of frogs in 20 x 20 meter plots and statistical analysis. This is a time consuming procedure that might not be desirable for sites with low frog densities over large areas (> than 20 x 20 meters) or agencies that cannot expend the associated labor costs. Thus this protocol comprises methods to assess presence/absence and general density indexes of frogs. Furthermore, the term "population" of frogs would include at least 5 calling males, this number was determined with consensus between the ISCs, DLNR, UDSA/WS, and UHH.

The use of tape recorders, sound dB data loggers, and similar sound recording instruments, though useful, can be problematic in assessing frog numbers and treatment efficacy for a number of reasons, especially if it is exclusively used. First, these instruments would record the reproductive calls without giving an accurate depiction of the location of the sound. Second, the sounds represent just the mature calling males without indications to the presence and numbers of females and juveniles, though general numbers maybe extrapolated as discussed further. In addition, the time it would take to review and decipher the sound data can be spent with observers on site gathering more accurate data. However, there is continuing research and development for efficacy of treatment using sound dB readings (William Mautz, Francis Benevides Jr., and Miyako Warrington, *unpublished data*). Preliminarily, it appears that once a population reaches a certain density that dB is constant though the population continues to grow. In addition, data logging sound equipment might be insightful only for presence and absence and perhaps a general index of frogs which is discussed later.

Given that mark-recapture methods and sound recording instruments might not be desirable the next most accurate methods would be divided into two basic searches **audio and line transects**.

In addition, before surveying an area for frogs certain environmental conditions must be ideal for this amphibian to be considered active. Specifically, temperature (at least 17°C) (Miyak Warrington and William Mautz, *unpublished data*), high relative humidity (generally > 60%), and time after a rain event (preferably 1-2 nights after) are desirable environmental conditions. In drier locations (leeward side of islands) time after a rain event might be the most important factor since coqui frogs forage and are more active on wet vegetation(Stewart and Woolbright 1996).

Audio Method

This method allows the observer to quickly assess frog populations in a given area. Roughly there is a 1:1 sex ratio for coqui frogs, at birth, and on average in Puerto Rico the ratio for pre-adults to adults 5.3:1 (Stewart and Woolbright 1996). For example, if an

observer is to hear about 10 frogs it is assumed that the population in that area would be around ***roughly*** 106 frogs (10 x 2 x 5.3). Caution must be taken in using these estimates as frog densities would be site dependent; these estimates would only occur in sites where the frogs have been actively breeding for a long enough period of time to be established.

To determine location of calling males rough estimates can be applied (i.e., one frog calling at 48° from the ohia tree at 30 meters), especially in rugged and inaccessible terrain. But these "rough estimates" can be fine tuned using observer calibrations and GPS/GIS. Observers can calibrate their distance-to-frog estimate by going to the frog location and walking away from the frog at several distances and then measuring those distances, and then repeating until the observer is comfortable with their distance-to-frog estimate. Once the observer is comfortable with their estimates a waypoint can be collected using a GPS and then a compass bearing and distance to the frog would give a more accurate depiction of the frog location using GIS software, such as ArcView. When using a compass make sure that proper declination is set, currently for Hawaii it is ~10° E. Ideally, several readings would give a more precise location of the frog, since a triangulation can then be extrapolated.

An "index" of calling males can be as follows:

- "Low" = 1-5 frogs (5 frogs being a population)
- "Medium" = 5-50 frogs
- "High" ≥ 50 frogs (after 50 frogs it difficult to determine numbers of calling males due to blending of sounds into a chorus)
- This index can also be used in combination of visually confirmed frogs.

Line Transect Method

Line transect are also helpful in determining frog presence due to visual discoveries of juveniles and females in areas where there are no calling males. In conducting a line transect an observer would walk slowly (1 km/hr) and visually inspect all vegetation at different angles for frogs. A 1-2 meter band on either side of the transect (depending on vegetation) should be investigated. In the case a calling male cannot be found but is within the treatment band the observer can note calling male is located. Calling males outside the transect should also be noted using the above techniques. Time and distance are both factors in the line transect method. An observer can walk however long it takes to walk "x" meters or walk whatever distance it would take to walk "x" minutes. Timed searches are preferable to distance searches as this would make the coordination of multiple observers easier.

Conclusion

Overall using the combination of both audio and line transects would be the most effective method in determining frog presence/absence and general population indexes, given the disuse of mark-recapture and sound equipment. In addition a site should not be considered completed eradicated until at least one year since the last frog was observed, since coqui frogs reach sexual maturity at about 316 days (Stewart and Woolbright 1996).

Stewart, M. M., and L. L. Woolbright. 1996. Amphibians. Pages 273-320 *in* D. P. Reagan and R. B. Waide, editors. The food web of a tropical rain forest. University of Chicago Press, Chicago, Illinois, USA.

Woolbright, L. L. 2005. A plot-based system of collecting population information on terrestrial breeding frogs. Herpetological Review **36**:139-142.

7. CONTRIBUTORS

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8. COMMENTS

A. GOVERNMENT

HISC
HDOA
USFWS
USDA
Legislature
Universities

B. BUSINESS

Plant Growers and Wholesale
Retail Outlets
Shippers (Young Brothers, Airlines, Fed EX)

C. PUBLIC

Homeowners
Resorts
Special Interest Groups

Literature Cited:

Beard K. H. 2007a. Diet of the invasive frog, *Eleutherodactylus coqui*, in Hawaii. Copeia(2):281-291.

Beard K. H. 2007b. Coqui Frogs as Predators and Prey in Hawai‘i. Newsletter of the Maui Invasive Species Committee. Spring 2007:6-7.

Beard, K.H., K.A.Vogt and A. Kulmatiski. 2002. Top-down effects of a terrestrial frog on nutrient dynamics. Oecologia **133:** 583–593.

Beard, K.H., A.K. Eschtruth, K. A. Vogt, D.J. Vogt, and F. N. Scatena. 2003 The effects of the frog Eleutherodactylus coqui on invertebrates and ecosystem processes at two scales in the Luquillo Experimental Forest, Puerto Rico. Journal of Tropical Ecology 19: 607–617.

Beard, K. H., and E. M. O'Neill. 2005. Infection of an invasive frog Eleutherodactylus coqui by the chytrid fungus Batrachochytrium dendrobatidis in Hawaii. Biological Conservation 126: 591–595

Beard, K. H., and W. C. Pitt. 2005. Potential consequences of the coqui frog invasion in Hawaii. Diversity and Distributions. 11:427-433.

Beard, K. H., and W. C. Pitt. 2006. Potential predators of an invasive frog (Eleutherodactylus coqui) in Hawaii rain forests. Journal of Tropical Ecology 22: 1-3.

Brauer, F. and C. Castillo-Chavez. 2003. Mathematical models in population biology and epidemiology. Texts in applied Mathematics. Springer Verlag, New York. 416 pp.

Campbell, E. W. 2001a. Dermal toxicity of selected agricultural pesticides, pharmaceutical products, and household chemicals to introduced Eleutherodactylus frogs. Report submitted to the Maui Invasive Species Committee and the Hawaii Department of Land and Natural Resources.

Campbell, E. W. 2001b. Field efficacy trials of the directed spray application of caffeine solutions for controlling introduced Eleutherodactylus frog in floriculture and nursery crops in Hawaii. Report submitted to the Hawaii Department of Agriculture and the USDI - Fish and Wildlife Service.

Campbell, E. W., III, and F. Kraus. 2002. Neotropical frogs in Hawaii: status and management options for an unusual introduced pest. Pages 316-318 *in* R. M. Timm and R. H. Schmitz, editors. Proceedings of the 20th Vertebrate Pest Conference. University of California, Davis.

Daszak, P., A. A. Cunningham, and A. D. Hyatt. 2003. Infectious disease and amphibian population declines. Diversity and Distributions 9:141-150.

Hobbs, R. J., and L. F. Huenneke. 1992. Disturbance, diversity, and invasion: implications for conservation. Conservation Biology 6:324-337.

Hobbs, R. J., and S. E. Humphries. 1995. An Integrated Approach to the Ecology and Management of Plant Invasions. Conservation Biology. 9:761-770.

Holling, C. S. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics 4:1-23.

Kaiser B. A., and K. Burnett. 2006. Economic Impacts of *E. coqui* Frogs in Hawaii. Interdisciplinary Environmental Review 8(2):1-11.

Kraus, F., E.W. Campbell, A. Allison, and T. Pratt. 1999. Eleutherodactylus frog introductions to Hawaii. Herpetological Review 30(1): 21-25.

Kraus, F. and E.W. Campbell. 2002. Human-mediated escalation of a formerly eradicable problem: the invasion of Caribbean tree frogs in the Hawaiian Islands. Biological Invasions 4: 327-332.

Ohashi, T. 2004. Final environmental assessment: Caribbean tree frog control in the state of Hawaii. USDA/APHIS/WS, Volcano, Hawaii.

Ostertag R., and J. H. Verville. 2002. Fertilization with nitrogen and phosphorus increases abundance of non-native species in Hawaiian montane forests. Plant Ecology 162:77-90.

Mark, R. N. and W. M. Lonsdale 2001. Humans as global plant dispersers: Getting more than we bargained for. Bioscience 51: 95-102.

Matter, W. J. and R. W. Mannan. 2005. How do prey persist? Journal of Wildlife Management 69(4): 1315-1320.

Myers, J.H. and Ware, J. 2002. Setting priorities for the biological control of weeds: What to do and how to do it. In: Proceedings, Hawaii Biological Control Workshop. Technical Report # 129. Denslow, J.E., Hight, S.D. and Smith, C.W. (eds) Honolulu: Pacific Cooperative Studies Unit, University of Hawaii. Pp. 62-74.

May, R. M. 1973. Stability and complexity in model ecosystems. Princeton University Press, NJ.

Pitt, W. C., and H. Sin. 2004a. Invertebrate non-target hazard assessment of caffeine application for control of Eleutherodactylus frogs. USDA, APHIS, WS, NWRC. Hilo, HI, 11 pp.

Pitt, W. C., and H. Sin. 2004b. Dermal toxicity of citric acid based pesticides to introduced Eleutherodactylus frogs in Hawaii. USDA, APHIS, WS, NWRC. Hilo, HI, 8 pp.

Pitt, W. C., and H. Sin. 2004c Field efficacy and invertebrate non-target hazard assessment of citric acid spray application for control of Eleutherodactylus frogs in Hawaii. USDA, APHIS, WS, NWRC. Hilo, HI, 13 pp.

Pitt, W.C. and H. Sin. 2004d Testing citric acid use on plants. Landscape Hawaii July/August 5/12.

Pitt, W. C., and R. E. Doratt. 2005. Efficacy of hydrated lime on Eleutherodactylus coqui and an operational field-application assessment on the effects on non-target invertebrate organisms. USDA, APHIS, WS, NWRC. Hilo, HI, 24 pp.

Sin H., K. H. Beard, and W.C. Pitt. 2007. An invasive frog, *Eleutherodactylus coqui*, increases new leaf production and leaf litter decomposition rates through nutrient cycling in Hawaii. Biological Invasions *in press*.

Stattersfield A.J., M. J. Crosby, A. J. Long, and D. C. Wege. 1998. Endemic bird areas of the world: priorities for biodiversity conservation. Cambridge: BirdLife International.

Sugihara, R. T. 2000. Coqui trap study summary. USDA, APHIS, WS, NWRC. Hilo, HI, 2 pp.

Woolbright, L. L., A. H. Hara, C. M. Jacobsen, W. J. Mautz, and F. L. Benevides, Jr. 2006. Population densities of the Puerto Rican Coqui, Eleutherodactylus coqui (Anura: Leptodactylidae) in newly invaded Hawaii and in native Puerto Rico. Journal of Herpetology 40: 122-126.