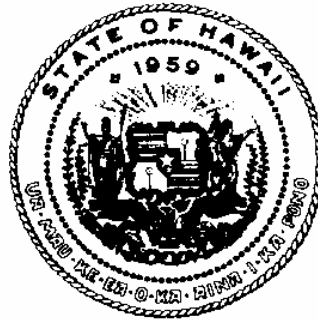


REPORT TO THE TWENTY-FOURTH LEGISLATURE
REGULAR SESSION OF 2007
STATEWIDE EFFORTS TO ERADICATE AND CONTROL
THE COQUI FROG AND FUTURE OUTLOOK



Prepared by

THE STATE OF HAWAII
DEPARTMENT OF AGRICULTURE
PLANT INDUSTRY DIVISION

In response to Act 160, Session Laws of Hawaii 2006

Honolulu, Hawaii
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MAKING AN APPROPRIATION TO ERADICATE AND CONTROL THE COQUI FROG

EXECUTIVE SUMMARY

Act 160, Session Laws of Hawaii 2006, supported statewide control and eradication efforts against the coqui frog by appropriating a budget of \$2 million in funding as part of an overall plan to help State, County, business and community groups in the fight against this invasive species. The purpose of these appropriations is two-fold to:

1. Focus efforts on the Island of Hawaii by providing a total of \$1.8 million to be divided as follows:
 - o \$1 million for a grant to the County of Hawaii,
 - o \$300,000 to the Department of Land and Natural Resources for control and eradication, and
 - o \$500,000 to the Department of Agriculture for control, eradication and research; and
2. Provide an additional \$200,000 toward eradication efforts on other islands with \$100,000 for the Island of Maui, and \$50,000 each for the islands of Kauai and Oahu.

By dedicating a major portion of the coqui frog appropriations to Hawaii County, the legislature has provided a mechanism to reduce the number of infestations on the Big Island, thus decreasing the likelihood of re-infestations to other areas within the State, and at the same time assure the support of Hawaii's agricultural industries and to achieve eradication of the coqui frog on other islands.

BACKGROUND

Description: The coqui frog, *Eleutherodactylus coqui Thomas* (Anura: *Leptodactylidae*) is a small light-brown to dark-colored frog with variable patterns including a light stripe down the middle of its back. Adult frogs measure up to 2 inches in length. This frog species directly develops into a small frog from the egg stage, and as such, does not require a body of water to reproduce. The female lays a clutch of 16-41 eggs on damp moss or leaf litter or other detritus, and the eggs are then brooded by the male who keeps them moist until hatched. Mating pairs of frogs produce a clutch about every 2 ½ weeks, which equates to 26 clutches or approximately 1,400 eggs per female per year. When the froglets hatch in approximately 17-26 days they are less than ½-inch long and become fully mature in about 8 months. Adult frogs have a natural lifespan of 4 to 6 years. The coqui frogs normally remain hidden during the day in leaf litter and emerge at night for feeding and mating. At night the adult males climb into the trees calling "ko-kee" to attract females for mating. Coqui frogs feed primarily on arthropods (insects and spiders), but may also eat snails and smaller frogs.

Natural Distribution: The coqui frog is native to Puerto Rico, but has also been found in the southeastern part of the United States, in parts of Florida, Central America and other Caribbean islands, and most recently in a plant nursery in San Diego, California. It is believed that the frogs first arrived in Hawaii through potted plant material from the mainland or Puerto Rico around 1988.

Problems Posed in Hawaii: The coqui has no natural enemies in Hawaii to keep the population in check, thereby posing a threat to Hawaii's island ecosystem. The warm tropical weather likely promotes breeding to occur all year round. Due to the frog's voracious appetite, this species may put Hawaii's unique insects and spiders at risk. In some areas on the Big Island, populations may exceed 10,000 frogs per acre, consuming more than 50,000 insects per night and may compete with endemic birds and other native fauna that rely on insects for food.

Many levels of indirect and synergistic interactions could occur between the coqui frog and other introduced invasive species. Dense populations of coqui might indirectly affect native birds by serving as a valuable food source for other exotic predators and competitors of native birds, thereby augmenting those populations and putting more pressure on native birds. In addition, a number of nematode parasites have been identified and associated with this invasive species, and it is possible that nematodes or other types of vertebrate parasites could be transported with coqui frogs thereby infecting indigenous fauna.

In addition, the coqui can be a major noise nuisance in Hawaii. The male coqui frog has a loud, two-note whistle to attract females who are not known to vocalize. Calling begins in late afternoon hours and continues throughout the night, often from the canopy of trees above ground level. The noise level of the mating call has been measured at levels up to 80-90 decibels, comparable to the sound produced by a lawnmower. Areas that are infested with coqui have caused restless nights for residents and visitors who are unable to sleep due to the noise produced by the shrieking frogs. In some instances it has also been noted to affect real estate sales on the Island of Hawaii after discovery by prospective homeowners that coqui were present on the property.

Lastly, the coqui have been found to live and lay their eggs in plant materials, which have had an effect on the nursery industry for the intrastate, interstate and foreign export movement of propagative plants. Several market areas for nursery-grown plants from Hawaii have been closed to prevent any further spread of the coqui frogs.

Need for Control in Hawaii: The coqui frog has been found to be quite adaptable to the different ecological zones and elevations within the State and have been found from sea level to the 4,000 feet elevation. In less than 20 years from a presumable single infestation on the Island of Hawaii, the species has spread to over 200 sites on the Big Island. They have been found on Maui (40 or more sites), Oahu (5 sites) and most recently a large site on Kauai. Unchecked they will continue to spread. In their native

Puerto Rico, coqui frogs average 40 mature adults per 20 x 20 m plot compared to >200 in a similar sized plot on the Island of Hawaii. The major reason for this disparity is the lack of predators in Hawaii.

Mode of Spread in Hawaii: Because the coqui frog is nocturnal and remains hidden in vegetation throughout the day, the movement of plant materials has been generally associated with its spread throughout the State. The coqui have been known to travel on propagative ornamentals such as bromeliads, palms, and dracaenas, as well as with the movement of green waste and its associated storage containers. Generally hidden in the leaf whorls of plants or amongst leaf litter in pots, mature adults, including males guarding eggs, can easily be transported as long as sufficient moisture is available.

Even though the coqui frog can be introduced into new areas with the transport of plant materials, other pathways do exist. There have been several reports that coqui frogs have been intentionally transported and released into regions of the Big Island. The coqui can be easily maintained in a 10-gallon aquarium, since their survival rate from the froglet stage to an adult frog is very high. It is conceivable that additional populations can be established by experienced herpetoculturists maintaining populations of frogs at their homes for eventual release into uninfested areas. Although the popularity of the coqui frog in the pet trade is considered low, this is a pathway that warrants some consideration.

Lastly, the transportation system has been associated with the unintentional transfer of coqui frogs due to the movement of pallets, vehicles, boats and trailers from high coqui-populated areas, which have been found to be contaminated with frogs at final point of destination.

Impact on Agriculture in Hawaii: Hawaii's vital floriculture and plant nursery industry is at risk. In 2000, grower sales of Hawaii's flowers and nursery products totaled a record \$83.4 million, a figure that puts Hawaii's sales behind only Florida and California. The coqui frog has jeopardized local plant sales as well as export markets due to imposed quarantine sanctions. Several inter-island shipments of nursery stock have already been rejected due to shipments infested with coqui frogs, and future plant shipments from the infested grower are now subject to mandatory treatments prior to transfer from one island to another. Some Big Island plant producers have voluntarily treated shipments prior to transport even though the coqui do not exist in their area. Residents and other nurseries alike are extremely cautious of buying coqui-infested plants, and potentially moving frogs into their neighborhoods. Currently, because of the presence of coqui frogs in the State, propagative plant materials exported from Hawaii to Guam require an approved treatment and other phytosanitary certification requirements prior to its arrival into the U.S. territory. In the future, other export markets may propose quarantine legislation to exclude plant nursery shipments from Hawaii unless shipments are certified free of coqui frogs or subject to approved treatments, thus further impacting the horticultural industry. Lastly, a number of nematode species have been associated with the coqui, and it may be possible that nematodes or other types of parasites could be transported and infect indigenous fauna.

Distribution in Hawaii: Initially, coqui-infested nurseries were the major source of frog distribution throughout the State. Coqui frogs are now established in much of East Hawaii, along the Hamakua Coast and in pockets of infestation in North and South Kona. With the wide distribution of the frog on the Island of Hawaii, multiple pathways of frog movement now exists on island, from infested potted plants and green waste to vehicles and all manner of materials or supplies where the frog can find refugia, thus being inadvertently moved through the transportation network. The control of this frog species is clearly one of the major challenges for state, county and federal agencies for Hawaii County and its community. In other areas throughout the State, single males have been captured on Molokai and Lanai, but presently no known populations exist on these islands. Coqui frog populations (five or more calling males) are being monitored in three areas on Oahu (on approximately 15 acres of military, State and private properties in Wahiawa, one nursery in Haleiwa, and three nurseries in Waimanalo) and one on Kauai (approximately 15 acres of leased private property in Lawai). Control efforts, with the intent of eradication on these two islands, has been ongoing and require follow-up treatments and extensive monitoring to ensure population decline. On the Island of Maui, as many as a dozen coqui frog populations are known to exist, including a large 125-acre parcel in Maliko Gulch, which is heavily infested. Current control efforts in this area are marginal due to available resources and personnel. The other smaller population sites on Maui have been under treatment pressure with citric acid in hopes of eradicating these populations. Unlike the other island situations, the infestation on the Island of Hawaii is too widespread over a large land mass for eradication at this time, but efforts are underway to reduce the nuisance level of the frog in neighborhoods and in public and resort areas to prevent the spread of frogs to other areas that are not yet infested. Early detection and rapid response is vital in keeping uninfested areas coqui-free. Plant Industry program staff from all branches are involved in efforts with community groups and with other state, federal and county agencies to eradicate the frog from Oahu, Kauai and Maui, and to control and contain the frog on the Island of Hawaii.

EXISTING CONTROL MEASURES AND EFFICACY

CHEMICAL CONTROL

Citric Acid: Commercially available food-grade citric acid can be applied as a foliar spray on infested plants and have been known to control juveniles, adults, and also adversely affect coqui eggs. Citric acid anhydrous can be obtained in 50-pound bags and is sometimes repackaged in five and 10-pound formulations by certain retail stores. It is a common food additive and is considered safe for environmental use by the Environmental Protection Agency (EPA). A formulation of 1.3 pounds of citric acid in 1 gallon of water should be mixed thoroughly to make a 16% citric acid solution, which is recommended to be applied in the early evening or throughout the night when frogs are active and males call, or after a light drizzle when the ground is moist, but not wet. Coqui frogs normally remain hidden during extended dry periods or during heavy rainfall, at which time spray applications may not be effective if there is no direct spray

contact made with the coqui. Since infested areas must be treated thoroughly, exposure to the citric acid spray may damage certain sensitive plants by causing leaf burn or yellowing. To avoid long-term damage to plants and flowers exposed to the citric acid spray, treated materials are rinsed with fresh water about an hour after spraying.

Hydrated Lime: In April 2005 the EPA approved an emergency exemption to allow the use of calcium hydroxide, commonly known as hydrated lime to control coqui frog infestations in Hawaii for a period of three years. The cost of hydrated lime is approximately 10 times less expensive than citric acid, thus making it more cost effective for use by large nursery growers and property owners. The exemption also allows the use of hydrated lime in outdoor nurseries, residential areas, resorts and parks, forest habitats and natural areas. A 97-percent powder formulation of hydrated lime as a dust or a three-percent solution for spraying is allowed under this exemption. Dust applications by commercial growers are specified for agricultural use only on agricultural lands. Additional restrictions include strict avoidance of the product on: 1) food crops; 2) areas recently treated with ammonium-containing fertilizers; 3) areas where children play or congregate; 4) trees; and 5) non-agricultural uses such as around residential dwellings. In order to use hydrated lime for coqui frog control, a State of Hawaii, Department of Agriculture “Applicator Authorization Form” must be completed and submitted to the supplier of the product at time of purchase.

MECHANICAL CONTROL

Hand-Capture: Upon discovery of its location, the coqui frog can be captured by enclosing your hands around the frog very quickly. Since they are not poisonous, the coqui can be safely handled with bare hands with no further risk to the capturer. The use of a short length of clear plastic tubing that is normally used to protect florescent bulbs, and a plastic bag attached on one end, can be used as an effective capture tool. The open end of the tube is placed over the frog with limited detection to allow the coqui to climb up the tube and into the plastic bag.

Exclusion: Habitat modification to some extent may discourage the spread of coqui frogs. The coqui spend their day in the moist underbrush or leaf litter, and at night become active and climb into the tree canopy to perch in moist protected leaf shelters. The reduction of suitable coqui frog habitats such as the removal of dead leaves on plants, the pruning and thinning of shrubs, and the removal of leaf debris to expose bare ground can slow their spread. Since coqui frogs tend to hide in moist leaf litter, the proper disposal of green waste (instead of piling the debris in one area) can reduce the refugia sites for them to thrive in. In drier conditions, they may be attracted to standing or dripping water, therefore minimizing or eliminating water sources will drastically affect their movement. In addition, the modification of areas around properties by clearing the vegetation to ground level to make buffer zones will keep frogs at a distance. The creation of an unfavorable environment for the coqui will likely reduce its spread and establishment in desired areas.

Trap Station: Since the coqui frog requires a refugia site during daylight hours and eggs need to be deposited in protected areas, the use of pvc-pipe “T-traps” or cut bamboo could be employed for use by frogs as potential nesting sites. This method could be used as a passive control or detection/monitoring system for homeowners and plant producers alike. The implementation of these low-maintenance detection devices could be easily checked during daylight hours for the presence of coqui frogs. Another method developed by a nursery grower is to house captured calling males in a screened cage enclosure to attract females to the area. As the caged males call throughout the night, females will be lured to the enclosure, and can then be hand captured. This technique has been quite successful in suppressing smaller-sized populations, however it is very labor intensive because the captured males require constant monitoring to ensure proper hydration and adequate food sources to maintain their vigor to call. Moreover, the amount of time that is needed to check the immediate area for females and then capture the free-roaming animals would be a considerable undertaking.

Thermal Treatment System: The use of hot water has been found to be quite effective in treating cut flowers and potted plants against quarantined insects. This post-harvest method requires subjecting plant materials to water temperatures of 49°C (120°F) for 12 minutes. The University of Hawaii at Hilo built a small-scale facility and conducted several experiments to determine the lowest possible lethal temperature for coqui frogs while at the same time avoiding excessive heat damage to treated plants. It was determined that to effectively eradicate coqui frog in potted plants, it was necessary to shower the plant materials with heated water at a temperature of at least 45°C (113°F) for a duration period of at least 5 minutes. The treatment was effective in killing all life stages including eggs. Although certain plants were susceptible to the treatment, heat damage could be reduced or eliminated if a two minute shower of cold water followed the hot water process. Additional research has also found that the gradual heating of the water applied to the plant materials over an extended period prior to the treatment schedule has reduced damage.

BIOLOGICAL CONTROL

To date there are no known biocontrol agents in Hawaii that specifically prey on the coqui as a food source. It has been reported that free-foraging chickens have been observed taking coqui while searching for arthropods and other invertebrate prey, however this is considered an incidental take. The Chytrid fungus, a serious pathogen of amphibians in many parts of the world, is present in Hawaii and has been found in coqui populations, but the frogs tested positive for the fungus showed no apparent pathological affects as a consequence of the fungus. This may change over time as the fungus possibly adapts to the increasingly high population densities of the frog in Hawaii. This is entirely speculative, however, and could very well never materialize as spores of the fungus are water borne, and the coqui frog has no life stage requiring free standing water (unlike most amphibians, the coqui has no tadpole stage). In its native range, there are snakes, lizards and large-carnivorous spiders that forage on coqui, but none of these species currently exist in Hawaii and would not be considered as a reliable biocontrol agent since they may pose additional ecological harm if introduced.

INVOLVED ORGANIZATIONS AND ROLES

Coqui Frog Working Group (Hawaii County)

A partnership made up of federal, state and county agencies, universities and related non-government organizations, as well as private industry working collaboratively to secure resources, research tools and applications that can be implemented to eradicate and control the coqui frog.

Department of Agriculture

Plant Quarantine Branch - Responsible for inspection and enforcement of state quarantine laws, regulations and policies concerning plants, non-domestic animals and microorganisms. Maintains daily operational function of a statewide phone number (643-PEST) to log calls, verify the report information, coordinate a response to confirm the presence of the coqui frog and provide technical assistance.

Plant Pest Control Branch – Responsible for coordinating research and development to broaden control methodology including the use of alternative chemical and mechanical means.

Pesticides Branch – Obtains EPA approval for use of chemicals, provides technical resources as well as training in the proper use of the chemicals according to label.

Department of Land and Natural Resources

Division of Forestry and Wildlife (DOFAW) - The largest land management entity in the State of Hawaii with direct responsibility for over 800,000 acres of state trust lands. Its responsibilities include statewide watershed and endangered species protection, forest and wild land fire management, hunting, conservation research and management, forestry, natural area reserve system, recreation and public information and involvement. Coqui frog research and management falls under the invasive species program of conservation research and management. DOFAW cooperates with other organizations listed and are in partnership with non-government organizations in an effort to control the spread of invasive species throughout the state.

Hawaii Invasive Species Council

A government body placed within the Department of Land and Natural Resources for administrative purposes to maintain a broad overview of invasive species problems in the State through consultation and coordination with appropriate State agencies on invasive species issues and to help identify potential private and federal funding availability for control and eradication efforts. Presently, the council is co-chaired by the chairperson of the Department of Land and Natural Resources and the chairperson from the Department of Agriculture.

University of Hawaii

College of Tropical Agriculture and Human Resources – Provides on-going research on the development and implementation of non-chemical control methods such as the use of a hot water shower system to treat plant materials, physical barriers to exclude coqui incursions into pre-defined areas, traps to attract and contain frogs as alternate refugia sites, and sterilization to suppress reproductive capabilities to suppress coqui frog populations.

Invasive Species Committees

Kauai Invasive Species Committee – A partnership of government, private and non-profit organizations, and concerned individuals working to prevent, control or eliminate targeted invasive plant and animal species in order to preserve Kauai's native biodiversity and minimize adverse ecological, economic and social impacts.

Oahu Invasive Species Committee – A partnership of government, private and non-profit organizations united to reduce populations of targeted invasive species on the island of Oahu by eradicating incipient invasive species, and stopping established invasive species from spreading further. The group is concerned with all non-native invasive species threatening agriculture, watersheds, native ecosystems, tourism, industry, human health, or the quality of life on Oahu.

Molokai Invasive Species Committee – A subcommittee of the Maui Invasive Species Committee, and a partnership of government, private and non-profit organizations with a mission to prevent new pest species from becoming established on Molokai. The focus is to prevent and control incipient pest infestations through local communication, coordination and planning. This group is concerned with invasive plant and animal species that threaten native ecosystems, agriculture, industry, human health, or the quality of life on Molokai. It has collaborated with the Maui Invasive Species Committee on issues such as setting pest prevention priorities, measuring progress, and funding.

Maui Invasive Species Committee – A partnership fighting to protect Maui County from invasive plants and animals that threaten the environment, economy, and quality of life. It works to prevent invasive species from becoming established on Maui, controls invasive species on private and public property, and educates people about invasive species and how to protect Maui.

Big Island Invasive Species Committee – A partnership of private citizens, community organizations, businesses, land owners, and government agencies united to address invasive species issues on the Island of Hawaii. Specific goals include eradication or containment of *Miconia calvescens*, utilizing "rapid response teams" to eradicate other newly-established pests and preventing new invasive

species from becoming established. The group is concerned with all non-native invasive pests threatening agriculture, native ecosystems, industry, human health or the quality of life within Hawaii County.

U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), Wildlife Services, and National Wildlife Research Center

APHIS is responsible for protecting and promoting U.S. agricultural health, administering the Animal Welfare Act, and carrying out wildlife damage management activities. As part of this responsibility, APHIS is working to develop environmentally sound strategies to manage coqui and greenhouse frog populations in an effort to protect Hawaii's natural resources and preserve the islands' inherent tranquility. The APHIS National Wildlife Research Center Hawaii field station in Hilo is cooperating with the State Department of Agriculture and the University of Hawaii College of Tropical Agriculture and Human Resources, in order to develop new methods of control by providing a variety of control options that will meet the needs of homeowners, resorts, nurseries, land managers, and others. The APHIS Wildlife Services provides resources and personnel to communities affected by frog populations with coordinating the loan sprayer program, and providing dedicated spray crews and evaluators to assess the efficacy of spray applications.

COQUI FROG EFFORTS AND INITIATIVES

The movement of any commodity infested with a pest is prohibited unless treated under Section 4-72-4(b), Hawaii Administrative Rules, which states:

“A commodity infested with any pest defined in section 150A-2, Hawaii Revised Statutes, shall not be transported between the islands unless it has been treated with an appropriate pesticide that exterminates the pest. The chief may, however, authorize the transportation of an untreated infested commodity to an island where the pest is known to be established.”

Under Hawaii Revised Statutes section 150A-2, a “pest” is defined as any animal, insect, disease agent or other organism in any stage of development that is detrimental or potentially harmful to agriculture or horticulture, or animal or public health, or natural resources including native biota, or has an adverse effect on the environment as designated by the Board of Agriculture.

On September 27, 2001, the Board of Agriculture designated the coqui frog (*Eleutherodactylus coqui*) as a “pest” as defined under section 150A-2, HRS. This provided the department with the ability to mandate the treatment of coqui-infested materials. To enforce these provisions, nurseries and shippers are required to present plant materials for inspection prior to interisland movement. Nurseries under the department's export certification program that have been issued a certification stamp for self-certification, which attest that plants are free of the burrowing nematode and other

pests of quarantine concern to mainland states, also have the privilege to use that certification (i.e., “stamp”) for the shipment of plants between islands. Nurseries that are infested with the coqui frog and/or whose plant shipments have been found to be infested with the frog are required to treat plants with citric acid in the presence of a Plant Quarantine Inspector prior to any interisland shipment of plants. Nurseries that are not participating in the export certification program must present plants for inspection and/or treatment for all shipments that have been found with the coqui. However, procedures need to be further tightened to minimize the spread of the coqui frog from infested areas.

After meeting with plant growers and nurseries on the islands of Hawaii and Oahu to discuss the coqui frog problem affecting the nursery industry, it was realized that more effective quarantine measures need to be addressed and that coqui frogs have continued to move in plant shipments from infested areas to other parts of the State, and even in some cases within island areas.

Commercial plant growers and nurseries located in high risk coqui areas are in need of keeping perimeter and growing areas free of coqui frogs through reliable chemical treatments, improved sanitation practices, and the use of barrier technologies. The development of additional chemical controls and application techniques will go a long way in maximizing treatment efforts. The implementation of improved sanitation practices such as the removal and proper disposal of debris and discarded materials that serve as refugia sites for the coqui frog should prevent the future recruitment of coqui frogs into plant growing areas. Additionally, the research development of a fine-mesh screen system and the use of electrical barriers may also provide additional exclusion capabilities.

COLLABORATION AT ALL LEVELS

On-going broad ranging discussions have been held with state, county and federal agencies, and non-government and community organizations on the continued development of strategies for the control of the coqui frog, in particular on the Island of Hawaii where the frog is most wide spread. These discussions through the Coqui Frog Working Group seek to maximize control efforts with the resources and personnel currently available to state, county and federal agencies. The targeted goals were to minimize the nuisance level of the frog in communities and public areas and to prevent the further spread of the frog to non-infested communities. The overall general plan takes into consideration the need for:

- Close coordination
- Shared resources
- Program evaluations, i.e., quality assurance / quality control
- Methodology development, including barriers (physical and electrical), sound monitoring

- New product development, i.e., field trials to test efficacy of pesticide products, and alternative methods of application to increase efficiency of treatment and control
- Data management
- New Program initiatives, i.e., a “Stop Coqui Hawaii Program”, which regains consumer confidence with the purchase of plants from participating businesses at all levels (grower, distributor and retailer)
- Research to seek biological control options for the frog
- Continued support of early detection and rapid response
- Realistic and achievable goals
 - Safe and affordable control for targeted areas
 - Most effective and least costly chemicals
 - Most efficient methods of application
 - Lowest risk to applicators and environment
 - Support at all appropriate levels to keep communities free of the frog that want controls in place and are organized to participate in these programs
 - Sustainable support systems
 - State, County and Federal agencies with adequate resources to support community efforts
 - Program planning support to address needs as they arise
 - Infrastructure to support community and commercial initiatives
- Effective nursery programs to minimize quarantine risk to exporting nurseries
 - Control programs sanctioned by the Hawaii Export Nursery Growers Association
 - Certification programs under State Plant Quarantine Rules (Chapter 72 and 73)

Meetings were held on the islands of Kauai, Maui and Hawaii with the various federal, state and county agencies, and commercial and private organizations to review current and future coqui frog control programs in their respective counties. The developed strategy from the participating counties was looked at from the perspective of an incident command system. It was also realized from these discussions that each individual island has its own unique issues, and the success of control and/or eradication of frog populations were dependent on a unified statewide response. At a minimum the following broad categories needed to be standardized and coordinated:

- Clear and concise objectives and priorities with degrees of achievable outcomes and successes
- Develop an organization (to the extent possible) to provide operational, logistical and financial structure to implement efforts
- Use sound methodology and a systematic approach (to the extent possible) for public awareness and outreach
- Review and revise policy, legal issues (authorities, regulations, etc.) and procedures
- Information sharing across all jurisdictions and participants
- Continue research and development

In Hawaii County funding initiatives have been extended to 79 different community groups with over 87 mini-grants issued (of up to \$5,000 maximum) from the county to address coqui frog infestations within their neighborhoods. The program was established by the County of Hawaii to empower the communities to collaborate with others in utilizing available tools to control the coqui frog throughout Hawaii Island. These funding supports were mainly used to purchase approved chemicals, personal protective equipment required for chemical preparation and application, and also included reimbursements for mileage costs incurred while transporting sprayers and other pre-approved incidentals. In support of this initiative, a sprayer loan program was established to maximize equipment availability and at the same time minimize capital costs to communities that spray citric acid and/or hydrated lime for frog control. Gas-powered sprayers of various tank sizes ranging from 100 to 400 gallons have been purchased and are available at no charge to communities and businesses, which are housed, managed and maintained by APHIS Wildlife Services.

STATEWIDE MANAGEMENT STRATEGIES

Over the past 15 years the issues surrounding the coqui frog issue in Hawaii, which has intensified tremendously and crosses all boundaries, has affected private individuals, groups, organizations and businesses. In addition, government at all levels (county, state and federal) as well as private and public landowners are not immune to the problem. To sum it up, the coqui frog is a statewide problem!

The strategy for each county will depend upon several factors:

- Number of established populations
- Size of individual areas that have the established population
- Topography and the use of the area that has the established population, i.e., residence, nursery, resort, parks, roadside, transfer station, etc.
- Expanse of the established population island-wide

Kauai County: ERADICATION – To date the Island of Kauai has only one known established population of the coqui frog, which is located on a 15-acre parcel of leased private property in Lawai, Kauai. Both the lessee and property landowner have been cooperative with eradication efforts thus far, with neighboring communities supportive to a certain extent. Proper notification has always been a key issue with the Lawai homeowners due to the night time spray operations and related disruption. Initially, the USDA Wildlife Services launched an extensive spray program and greatly reduced the number of coqui frogs in the area; however without follow-up treatments and little habitat modification the frogs soon regained large numbers. The Kauai Invasive Species Committee in conjunction with other state partners has worked collaboratively on the problem as well. The perimeter boundaries of the coqui population has been defined and efforts are on-going to continue habitat modification with the removal of the vegetative under story to reduce the number of suitable refugia sites where frogs can hide during the day and lay eggs after mating. A series of citric acid spray treatments at two to three week intervals are recommended to first reduce the number of mature

reproductive frogs, and then affecting the newly hatched juveniles and immature coqui. On-going weekly monitoring and surveillance of treated areas during the prime breeding season and then curtailed to bimonthly visits during cooler months are required over a one year period. After a one year period wherein no males are heard calling, the site may be deemed eradicated, however periodic surveillance and/or follow-up treatments of the Lawai site should be performed. Additional funding and resources are needed to ensure that eradication is achievable.

Honolulu County: ERADICATION – There is approximately 11 acres in Wahiawa Heights on central Oahu that house a coqui frog population, which is comprised of East Range military lands, state lands and local private residences. The Oahu Invasive Species Committee (OISC), in conjunction with federal and state partners, had divided the parcels into different segments and developed a comprehensive citric acid spray program to treat the area. The results of this concerted and collaborative effort are now being realized. On-going surveillance has been conducted with no males reported throughout the winter months, however with advent of spring and warmer temperatures monitoring efforts would need to be increased to ensure efficacy.

Besides the central Oahu population, the department, with help of OISC, has been monitoring a plant nursery in Haleiwa for coqui frogs. Although the nursery continues to bring in plants (oftentimes treated with citric acid) from East Hawaii, individual frogs are occasionally found during monitoring visits and hand captured, but no re-establishment of a coqui population at this north shore nursery has been realized.

Two other plant nurseries in the Waimanalo area have experienced coqui frog infestations and have been working to rid their premises of the invasive species. Leilani Nursery in particular has constructed a hot shower box that can accommodate commercial plant shipments. The affected greenhouse and plants were sprayed with either citric acid or hydrated lime applications and general sanitation of the surrounding area was instituted to prevent refugia sites for the frogs. In addition, plants were also subjected to the thermal treatment chamber on site, which proved to be very successful. The second Waimanalo nursery has undergone a series of citric acid applications with marginal success and monitoring efforts with OISC and state partners have been on-going. The use of the hot shower box at Leilani Nursery has also been used by the other grower to treat coqui infested palms.

Recently, the department confirmed another established coqui population at a landscaping company, but this time in Kamilonui Valley in Hawaii Kai. A meeting was held with the site manager and a plan of action was developed in response to this latest infestation, which is approximately one acre in size. Plants of value to the grower will be transported via a sealed container to Leilani Nursery for the required thermal treatment and then allowed to be staged at another site after treatment. While this is being done department personnel will steam sterilize the transport container to ensure that any hitchhiking frogs would be destroyed to prevent re-infestation of the treated plants. This operation is expected to last for two days and will provide additional room for spray equipment and team members to apply a series of three citric acid treatments

over a sixty day period. All costs for chemicals, water and equipment maintenance will be borne by the landscaping company. Further monitoring of business accounts by the department will be conducted to ensure no other coqui populations. Continued efforts by state, federal, county and non-government collaborators including dedicated funding and resources will need to be assured to achieve eradication on Oahu.

Maui County: ERADICATION / CONTAINMENT – The Maui Invasive Species Committee (MISC) has been monitoring coqui frog reports on the Valley Island and determined that there are a total of twelve naturalized populations on Maui. The largest coqui population on Maui is centered in the Maliko Gulch area in Haiku, which consists of steep terrain and hard to access areas bordered by private properties that are either within or on the fringe of the established population. A clear perimeter boundary needs to be maintained to contain the coqui population within the high density area of the gulch, thus preventing the further spread of this invasive species. The smaller outlying properties need to be addressed with the institution of a comprehensive spray program that consists of a series of chemical applications to reduce or eliminate coqui populations. Due to limited funding at this time and the high level of resources needed for implementation, no great effort has been expended thus far in Maliko Gulch, however MISC has developed a comprehensive strategic plan to address the infestation should funding and resources become available. Priorities have been focused on manageable areas, which require extensive follow-up monitoring surveillance to ensure efficacy. Continued support for MISC and other state partners is critical to the containment and eradication efforts on the Island of Maui.

Molokai / Lanai: PREVENTION – The islands of Lanai and Molokai must prevent the incursion of coqui frogs through continued outreach activities with the general public and port of entry workers to be on the look out for high-risk commodities that may be harboring invasive species like the coqui frog. The Molokai Maui Invasive Species Committee (MoMISC) and other partners have been a critical component in galvanizing the community through public outreach. Presently, there is no Hawaii Department of Agriculture presence on these islands, therefore additional funding should be made available to MoMISC for the shortfall on Molokai and to other state partners for assistance on Lanai Island.

Hawaii: CONTAINMENT – Although the County of Hawaii has the greatest number of established populations of coqui frogs within the State, control efforts can be implemented in certain areas of Hawaii island. The establishment of the Coqui Frog Working Group has brought together all levels of government, university, non-government and private organizations under a collaborative partnership to find ways to combat the coqui frog. The long-term incident action plan established by this effort focused on the following three critical components:

- Eradication and control of coqui frog populations;
- Chemical and biological control research to be utilized as an effective control method; and
- Public education and outreach into affected communities.

County and USDA Wildlife Services personnel performed island-wide spray operations on a daily basis to service communities with the greatest need, while providing much needed technical support and training for communities that organized their own spray crews. Control efforts were also focused at various distribution points, such as transfer waste stations, county parks and other public locations with the potential for the unintentional transfer of coqui frogs that may be associated with these movements. Wherever possible, isolated incipient infestations were also targeted to further prevent the establishment of a much larger coqui frog population on Hawaii Island. Continued funding support and resources are critical in reducing the number of populations on the island of Hawaii, thus further reducing the spread of the coqui frog on island as well as to other areas within the State.

To reduce the risk of coqui frog movement in plants materials, a Stop Coqui Hawaii program was developed to promote the distribution and sale of plant materials free of coqui frog at all levels: grower, distributor and retailer. The program was initiated by a Kohala community organization with funding support from the County of Hawaii and subsequently developed through a coalition established in partnership with the department, Hawaii County, the Big Island Economic Development Board (BIEDB), nursery growers and retailers. Growers, distributors and retailers that can meet the conditions of the program by offering plants that are free of the coqui frog will be listed in websites, newsletters and printed advertisements. The promotional campaign will give these companies a marketing advantage within the community in the sale of their product, and will ultimately regain consumer confidence in the purchase of Hawaii-grown plants.

FUTURE DEPARTMENT GOALS

Reliable treatment methods, both chemical and mechanical, must be developed and implemented to further reduce the spread of coqui frogs to other areas within the State. Treatment facilities are needed to disinfect infested plant materials prior to movement off-site, whether these materials are shipped to other islands that have little or no populations currently established, or exported out-of-state to other destinations. Shipments of plants transported from an infested area to an uninfested area within the same island need to be properly addressed as well to contain coqui frog populations. To this end, a thermal treatment system is nearing completion in Honolulu, Oahu at the State Plant Quarantine Office located at 1849 Auiki Street. This treatment unit was designed and constructed to handle commercial-sized shipments on a daily basis to fulfill present and future quarantine requirements for interisland as well as export shipments. A second facility is proposed for construction in Hilo at or near the Hilo Airport, with additional treatment chambers going on-line in Kona, Kahului, Maui, and Lihue, Kauai by late 2007. These units can be utilized both as a pre- and post-entry treatment of plants moving from coqui infested areas. An alternate plan is currently under discussion with the County of Hawaii and Hawaii Export Nursery Grower's

Association to establish a cost sharing program for the construction of a number of treatment facilities in East Hawaii to service the plant industry in a more cost efficient manner than could be provided by a single location situated in Hilo.

Alternative chemical applications are also needed for large area wide control programs. Citric acid and hydrated lime are contact toxicants with little to no residual toxicity for the frog after sprays have been applied and later dried. As a result, multiple rounds of application are required in a complex habitat where frogs are hidden in the canopy of trees and in thick underbrush. Gaining access to areas for treatments has been in large part the problem with both chemicals due to the limited reach of spray treatment as a liquid application. Alternative application methods will be tested in fiscal year 2007 in an effort to improve the efficiency of treatment programs.

With the department's existing staff of five Plant Quarantine Inspectors and a single Plant Pest Technician in Hilo, preventing the spread of coqui frog in propagative plant materials have proven to be challenging and difficult. With the commitment of funding support from the 2006 Legislature, additional staff positions were designated to Hawaii County. Given the importance of the Island of Hawaii and in particular to the East Hawaii horticultural plant industry, the HDOA Hilo office will be increased from 6 staff positions to 22 positions by mid-term of fiscal year 2007 (from six to fourteen inspectors; and from one to eight technician positions). The new positions will focus on working with Big Island plant growers to develop a comprehensive coqui frog plan that reduces the likelihood of coqui frog movement generally associated with plant materials. In addition, these staff members will provide a greater presence when witnessing the treatment of infested plant materials moving from one island to another.

The department has received preliminary approval to amend regulations that the Plant Quarantine Branch administers to prevent the movement of coqui frogs associated with plant shipments. The proposed revisions are currently being reviewed by legal counsel and will be readied for the public hearing process under Hawaii Revised Statutes Chapter 91 rulemaking requirements.

REALIZED COSTS

The Hawaii Invasive Species Council estimates that to date approximately \$4 million has been allocated (state, county, federal and private sector) to control the coqui frog in the State of Hawaii. In 2006, \$2 million was allocated by the State Legislature for coqui frog control and eradication efforts: \$1 million was awarded to the County of Hawaii; and \$500,000 each was awarded to the Department of Agriculture and the Department of Land and Natural Resources (DLNR). Funds earmarked for DLNR were to be used to protect high value conservation lands from frog infestation.

The department and the County of Hawaii have joined forces for the use of these allocated funds to support priority control and research and development programs. The following projects will have funding priority:

- USDA, Wildlife Service Contract for treatment services
- Community grants
- County staff and spray crew (salaries and benefits)
- Stop Coqui Hawaii program
- Research contracts to the UH-CTAHR/HDOA for education and barrier technology development
- Safety supplies and other operating expenses
- Chemical purchases and related supplies
- UH-Hilo, non-target species impacts and studies on biology of frog
- USDA-National Wildlife Research Center (NWRC) contract for quality assurance and control evaluations
- USDA-NWRC studies on non-target impacts, such as the Hawaiian hoary bat
- Cost sharing program for heat treatment chambers with nursery growers
- Power sprayers for key nursery areas and agricultural lands to reduce risk of coqui encroachment

Funding for the above priority programs are being negotiated and reviewed for allocation at this time.

OVERALL SUMMARY:

As noted earlier, the coqui frog has established populations on four islands, Oahu, Kauai, Maui and the Island of Hawaii. The infestations on Oahu and Kauai are sufficiently isolated and contained such that eradication of the known breeding populations is the targeted goal. Perhaps 12 known breeding populations exist on Maui, and all but one has been targeted for eradication (a site in Maliko Gulch covering an area of 125 acres is too large to tackle at this time, and is being monitored with only limited peripheral treatment to minimize the risk of further spread pending commitment of additional funding). For the Island of Hawaii, the frog is too widely established over too large a land mass for eradication at this time. At the same time, community initiatives are underway to minimize the nuisance level of the frog and to eliminate new infestations in areas not previously infested with the frog.

The costs for containment and control are high and continued support of eradication efforts is needed for all islands. The cost of eradication of one population in Lawai on the Island of Kauai was recently considered by the Kauai County Council. The 15 acre parcel, which has been under intense control pressure for the past three years, may take another year to be fully eradicated. The Kauai Invasive Species Committee provided a reasonable estimate of control/eradication costs to achieve coqui eradication in 2007, which was requested and approved by the Kauai Council at \$290,000 for the

Lawai site. The eradication efforts at Maliko Gulch on Maui will be a far greater cost over a three year period, potentially in the millions of dollars to achieve some measurable success.

For the Island of Hawaii, the immediate need is a solid plan of action for the control of the coqui frog. This plan has been formulated by a Coqui Frog Working group, which is made up of state, county and federal agencies, and community organizations with the technical support and help of the University of Hawaii-College of Tropical Agriculture and Human Resources and UH-Hilo, Department of Biology. The effort is a work in progress to provide relief to communities and to protect communities not yet infested with the coqui frog through the most efficient and cost effective control methods that can be developed at minimal cost and risk to the environment.

From the statewide perspective, what happens on the Island of Hawaii is key to the long term status of the coqui frog in the State of Hawaii. A strong community based control program on Hawaii Island is needed so that the coqui frog will gain the priority to assure that this invasive species does not become entrenched elsewhere in the state. The cost to sustain these programs on each of the islands and in particular the community-based programs on the Island of Hawaii has not been fully assessed. For the Island of Hawaii the existing control programs and the expansion of these containment and control programs require sustained and dedicated funding.

Only through continued collaborative efforts will we turn the tide against the coqui frog.