

9.0 Strategy for Stabilization of Koolau *Achatinella* species

General Description and Biology

Achatinella species are arboreal and generally nocturnal, preferring cool and humid conditions. During the day, the snails seal themselves against leaf surfaces to avoid drying out. The snails graze on fungi growing on the surfaces of leaves and trunks. *Achatinella* are hermaphroditic though it is unclear whether or not individuals are capable of self-fertilization. All species in the endemic genus bear live young (USFWS 1993).

Taxonomic background: The genus *Achatinella* is endemic to the island of Oahu and the subfamily Achatinellinae is endemic to the Hawaiian Islands. A total of 41 species were recognized by Pilsbry and Cooke in a monograph of the genus (1912-1913). This treatment is still recognized for the most part by the USFWS, although several genetic studies by Holland and Hadfield (2002, 2004) have further elucidated the relationships among species.

Threats: Threats to *Achatinella* species in general are rats (*Rattus rattus*, *R. norvegicus*, and *R. exulans*), predatory snails (*Euglandina rosea*), terrestrial flatworms *Geoplana septemlineata* and *Platydemis manokwari*, and the small terrestrial snail *Oxychilus alliarius*. Lower elevation sites may be under more pressure from *E. rosea* and rats as human disturbed sites may have provide more ingress points for these threats.

Threats in the Action Area: The decline of these species has not been attributed to threats from any Army training maneuvers either direct or indirect. Rather, the decline is likely due the loss of genetic variation caused by genetic drift in the remaining small populations and predation by rats (*Rattus* sp.) and the introduced predatory snail *Euglandina rosea*. Possible threats from Army training to these species' habitat are trampling of host vegetation during foot maneuvers and the introduction of invasive species. However, these threats are currently low or non-existent for the areas where these species occur (Army 2003).

Defining stabilization for *Achatinella* species

The approach to the stabilization of Koolau *Achatinella* species taken in the Oahu Implementation Plan (OIP) is modeled after the plan outlined for *Achatinella mustelina* in the MIP. However, there are several significant differences regarding the management of the Koolau species, such as the threat level, quantity of individuals, type of habitat terrain, and the number of species.

The biology of Oahu tree snails has been studied for several decades in Hawaii. Life history patterns (including low reproductive rates and late age at first reproduction), population dynamics (sometimes including large fluctuations in snail densities), and vulnerability to predation, results in a set of appropriate stabilization actions. Stabilization incorporates two main activities: *in situ* management and maintaining captive breeding populations. Stabilization actions for these species will be initiated when training maneuvers occur along or off trails in the upper reaches of the Kawailoa Training Area (KLOA) and Schofield Barracks East Range (SBER) (Tier 2: see Chapter 5.1: Army Stabilization Priority Tiers) or under Tier 1 actions as a proactive management project that may be done in partnership with other landowners and conservation agencies. Due to the dire need for conservation of the Koolau *Achatinella* species, the Army will pursue partnerships for resource protection prior to the initiation of Tier 2. The Army will not be able to conserve these species without partnerships.

There are a number of challenges in attempting to stabilize populations of *Achatinella*. These include difficulties in controlling alien predators (rats and *Euglandina rosea*), large fluctuations of snails in populations due to natural disasters or predation events, the slow rate of recovery due to life history traits, and the impacts to wild populations from collection of individuals for captive propagation. In locations where habitat is either intact or restorable, and a snail population structure exists that promotes natural recruitment, a population will be managed *in situ* for stability. *In situ* management options range from threat abatement, habitat management, and stimulation of natural regeneration. If there are few individuals, and conditions for habitat rehabilitation are poor, the population might be identified for captive propagation. Captive propagation serves as a means of preserving genetic resources for future reintroduction attempts that will aid in maintaining the populations required to achieve stabilization.

Population Units (PU) designated as manage *in situ* for stability will have the following actions implemented: (1) assess population sizes; (2) assess threat management needs and choose site(s) for predator and ungulate exclosure(s); (3) habitat restoration; (4) manage threats (as appropriate), including areas adjacent to exclosure(s); (5) population monitoring (see Chapter 6 Monitoring and adaptive management), including areas adjacent to exclosure; (6) data management, analysis, reporting; and (7) adaptive management.

Population units and population size

Currently to ensure stabilization, each PU must include 300 or more snails, totaled across age classes. This number was determined largely from empirical observations on the Pahole population of *A. mustelina* (Hadfield and Mountain 1980, Hadfield 1986, Hadfield *et al.* 1993). Without predators, the size of the Pahole population of *A. mustelina* in a 25 square meters (m²) grew from approximately 50 to 300 snails in about 4 years. When predators (rats or the introduced snail *Euglandina rosea*) entered the area, the population diminished rapidly to less than 30 individuals. Recovery from these predation events has been slow, even with active conservation efforts. The stabilization plans for all the *Achatinella* species may be modified using the adaptive management process to ensure that the best science is applied to achieve stabilization of these species.

Management for the Koolau species of *Achatinella* in the action area is modeled after the plan developed for *A. mustelina* in the MIP. Genetic analyses were completed by Holland and Hadfield (2002) which outlined evolutionarily significant units (ESUs) which followed a definite geographical pattern along the Waianae mountain range. The Makua Implementation Team (MIT) utilized these ESUs as populations to manage for stability. This type of genetic analysis has not been completed for other *Achatinella* species. Therefore, the Army designated “geographic units” (GUs) for the Koolau species based on known geographic locations of discrete snail populations until ESUs can be determined for the Koolau species. Currently, a minimum of six population units (PUs) is required for stabilization (USFWS 2003). This requirement and management goals may change based on genetic analyses. For those species that do not currently have six extant GUs, reintroductions within predator proof exclosures will be attempted using captive reared individuals.

Table 9.2 lists the current known population size of each PU, most of which are less than three hundred. Many of the species actually number less than 300 individuals for all populations

combined and several species are represented by less than 6 PUs. As mentioned previously, two management designations are defined to stabilize species: manage for *in situ* stability and collect for captive propagation. Ten *Achatinella* species were included within the Service's 2003 Biological Opinion. The Army has decided to manage all extant populations units of *A. byronii*/*A. decipiens*, *A. lila*, and *A. livida* for stabilization due to the extremely low number of extant populations known. The Army will manage eight PUs for *A. mustelina* to represent the six ESUs; ESUs B and D cover a large geographic area and are represented at two separate manage for stability sites.

There are a few snail species that are considered currently in the action area (AA) but are not known from any extant populations. These species are *A. apexfulva*, *A. bulimoides*, *A. curta*, *A. leucorraphe*, and *A. pulcherrima*. As mentioned in the Taxon Summaries and Stabilization Plans, *A. bulimoides*, has recently been observed on several separate occasions in the summit areas above Punaluu Valley. However, on these occasions all individuals seen (except 2) were collected for captive propagation. These species are discussed in detail in Chapter 9.1. Surveys will be conducted for the remaining species (*A. apexfulva*, *A. bulimoides*, *A. curta*, *A. leucorraphe*, *A. pulcherrima*) within the action area to determine additional management actions. If any *in situ* populations of these species are found stabilization plans will be made with the input of Army natural resources biologists, U.S. Fish and Wildlife Services Biologists, landowners, and field experts.

The main goal of stabilization is to achieve stable and self sustaining populations units of each *Achatinella* species. In order to achieve this goal, *in situ* and *ex situ* management of individuals is necessary. *In situ* management includes: threat control over a broad enough area to enable population expansion, habitat restoration, reintroduction, etc. *Ex situ* management includes: collection for captive propagation, maintenance of captive propagation, genetic analyses, etc. Additionally, the Army must conduct long-term monitoring of populations for trend analyses and to determine the effectiveness of management practices. This may include timed searches, mark-recapture studies, and ground shell plots.

To determine the status of managed field populations, each manage for stability GU will be monitored each year. Data will be included in discussions at the snail working group meetings and in the Army's annual report, which will be used by the OIT to make management recommendations. Monitoring growth of snails (Table 9.1 first row) is necessary only for introduced populations, to assure that the habitat is adequate.

Table 9.1 Monitoring of *Achatinella* population size and population units.

Elements to Monitor	Monitoring Objective	Data collected	Proportion of Population to Monitor	Schedule
# and size of Snails in a PU; recruitment; range expansion	Determine the number of individuals present in each size class; survival rate;	No. of individuals; length, width, operculum orientation; spread to nearby vegetation	All individuals found; use mark-recapture	To be determined by the OIT and
Growth of re-introduced or augmented snails	Determine if site is adequate for growth	Growth per size class; shell length and width	All individuals found	
Genetic variability	Determine if initial variability is maintained	Collect small tissue samples for DNA analyses	All snails \geq 15 mm shell length	

Stabilization Success: Success will be determined as having 300 individuals within a GU and 6 GUs for each species. In addition to a minimum number of snails and population units, healthy populations of *Achatinella* tree snails also must include all size classes in a fairly typical distribution.

Genetic Analyses

Genetic analyses will be conducted to provide additional insight on the range of genetic diversity and the locations of ESUs within and among the extant populations of 4 species: *A. byronii/decipiens*, *A. lila*, *A. livida*, and *A. sowerbyana*. This type of analysis has proven invaluable to the management of *A. mustelina* for the MIP. It is anticipated that management plans may change slightly based on the results of the genetic analyses. All changes will be approved by both the Army and the U.S. Fish and Wildlife Service.

Genetic samples will be collected from all large populations of *A. sowerbyana*, all populations of *A. livida*, and from at least one large population of *A. lila*. Genetic analyses are not necessary for the immediate management of *A. byronii/decipiens* and *A. lila in situ* as there are so few populations left that all extant occurrences will be managed for stability. Genetic analyses can aid in the determination of ESUs for *A. sowerbyana*, and in the reintroduction of *A. lila* (see individual species stabilization plans). Currently, the researchers with Dr. Hadfield and Dr. Brenden Holland's lab recommend microsatellite analyses in order to determine genetic variation among Koolau *Achatinella* species. Genetic analyses to determine management directions for the Koolau species are included in Tier 1.

Captive Propagation

The goals of the captive-rearing program, described in detail in the appendices, are to ensure against total loss of a species by propagating them *ex situ* and to provide snails that can be used to augment field populations. The captive-rearing program is essential to the stabilization of *Achatinella* species. Overall, a tree snail rearing program greatly adds to the robustness and depth of tree snail field stabilization actions. It should be noted, however, that captive propagation cannot replace the field actions. Ultimately, when field populations are secure from historic, current, and perceived threats the captive propagation program will no longer be needed.

In some locations, the number of individuals has declined to the point where natural regeneration of the populations is unlikely. For these populations, it is vital to collect a limited number of

individuals for rearing in captive propagation to ensure that their genetic diversity is not lost. Living individuals from severely declining populations can be maintained in a captive propagation facility until predator control and plant habitat restoration are advanced to a condition that will support reintroduction.

Field populations used for captive propagation will be selected and prioritized based on genetic data and level of immediate threat of extinction. Initial populations should include 7-10 snails or more if sufficient numbers are present in the wild population to allow for their removal without creating a threat to the wild population. The maximum number of snails collected will be no more than 20% of the known population (USFWS permit guidelines). However, if populations are found to be in imminent danger of complete extirpation or extinction due to predation or other threats, 20-100% of known snails may be collected as a rescue operation (IT recommendation). It is preferable to get an idea of the size of field populations to determine population densities before removing snails to captive facility (i.e. monitoring via described methods). The target size for captive populations is 50 snails of each population unit.

Table 9.2 Geographic Units, ESUs, and number of individuals of *Achatinella* species.

Species name	Geographic Unit	Wild Population Size
<i>Achatinella byronii/decipiens</i>	Total	269
	A: East Range	6
	B: Puu Pauao	16
	C: Poamoho	69
	D: Punaluu Cliffs	3
	E: North Kaukonahua	175
<i>Achatinella lila</i>	Total	95
	A: Poamoho Summit	39
	B: Peahinaia Summit	11
	C: Opaaula-Punaluu Summit	45
<i>Achatinella livida</i>	Total	145
	A: Crispa Rock	60
	B: Northern	2
	C: Radio	83
<i>Achatinella mustelina</i>	Total	950
	ESU A	472
	ESU B1	377
	ESU B2	569
	ESU C	69
	ESU D1	626
	ESU D2	92
	ESU E	462
ESU F	157	
<i>Achatinella sowerbyana</i>	Total	743
	A: Kawainui Ridge	2
	B: Kawaiiki Ridge	3

	C: Opaepala-Helemano	344
	D: Poamoho Summit and Trail	302
	E: Poamoho Pond	90
	F: Poamoho-North Kaukonahua Ridge	2
	G: Lower Peahinaia	40
<i>Achatinella apexfulva</i>	Lab	2
<i>Achatinella bulimoides</i>	Lab (2 additional individuals were observed in the Punaluu area on the last collection trip)	43
<i>Achatinella curta</i>	n/a	0
<i>Achatinella leucorraphe</i>	n/a	0
<i>Achatinella pulcherrima</i>	n/a	0

Table 9.3 Captive populations of OIP *Achatinella* species.

Species name	Population Unit	Captive Population Size (2005)*	Captive Population Size 2008
<i>Achatinella byronii/decipiens</i>	North Kaukonahua, Poamoho	28	30
<i>Achatinella lila</i>	Poamoho Summit	240	544
<i>Achatinella livida</i>	Near radio	78	108
<i>Achatinella mustelina</i>	See OANRP 2007	299	180
<i>Achatinella sowerbyana</i>	Lower Peahinaia, North of summit, KLO-F	41	25
<i>Achatinella apexfulva</i>	Poamoho	12	2
<i>Achatinella bulimoides</i>	Poamoho	5	43

* Numbers from 2005 Draft OIP.

During field collections, habitat variables will be recorded and will include: elevation, vegetation components, and exposure (temperature, humidity, etc.). Shell characteristics of each individual should also be documented, including: color photos, length and width of shells, orientation of operculum, etc.

Laboratory space is limited for captive snail propagation. If a laboratory population remains small or declines in numbers, laboratory conditions will be evaluated to determine and correct the cause of the decline or small population and results will be discussed with the Army and USFWS. Additional snails should come from the same genetic population as the founder snails. To prevent unintentional selection for lab-adapted snails in captive propagation, a proportion of the stocks should be replaced. Prior to taking this management action, the OIP snail committee will meet to evaluate the need for supplementing the captive populations and the distribution of the existing snails in the wild.

Health of captive snails will be tracked by comparing size, fecundity, and mortality of snails in captivity with snails in the wild until other methods for documenting “health” have been determined. If snails in the captive propagation facility show signs of disease, they must immediately be isolated and carefully observed until health appears restored. Specific Captive-Rearing Protocols developed by the Hadfield group at the University of Hawaii are attached (Appendix 2.5 Captive Propagation Protocols for *Achatinella* species).

Augmentation and reintroduction

The purpose of captive propagation is to provide healthy populations of snails for eventual release into the wild, either for augmentation of existing populations or to reintroduce within their historic range where habitat is suitable and threats are controlled. Since several of the *Achatinella* species have less than 6 populations, reintroductions will be necessary in order to achieve stabilization goals.

Specific protocols for an augmentation and reintroduction plan are currently being developed by the Oahu Rare Snail Working Group (see Appendix 2-7 Rare Snail Reintroduction Guidelines). Reintroduction of captive-reared snails into sites currently devoid of *Achatinella* should occur when there are sufficient numbers of individuals in the lab to support a release, reintroduction sites are located within the historic range of the species, genotypes utilized are appropriate for the geographic location considered, habitat conditions are appropriate to support healthy snail population, and predators are absent or controllable. Augmentation of extant, *in situ* managed field populations from laboratory-reared snails will be triggered when threats at a given MU or PU site are considered eliminated or controlled; such as within a protected enclosure or in a predator free environment. If a protected field population is found to be declining, it will be necessary to determine the cause before augmentation is considered. If a species or population is determined by field experts and the OIT to have enough individuals to support a reintroduction/augmentation the Army will pursue the feasibility of this action.

This arena of *Achatinella* conservation has not been conducted on a large scale for conservation purposes other than research (i.e. previous reintroductions have focused on research rather than programmatically determined long-term conservation objectives). Therefore, monitoring will be an essential aspect of this action. In some cases genetic analyses of both captive and wild snails may aid in selecting locations to augment/reintroduce a population.

Success: The success of a reintroduction will be measured by the longevity of released individuals and the growth or decline of the population itself. Appropriate monitoring of individuals over time (prior to release and following) will aid in the determination.

Surveys

Thorough field surveys funded and conducted by the Army have been completed at historic locations for many of the extant and recently extirpated species of *Achatinella* within the action area. Additional field surveys plan to focus on undersurveyed habitat near recent *Achatinella* locations. Surveys of historic and new areas will also provide an indication of where additional reintroduction and augmentation activities can occur. The Army will complete *Achatinella* surveys two days each year for each non-extant species and will survey additional areas for currently known species when time permits.

Threat management

Stabilization also relies upon the identification, control, management, or elimination of threats. Threats currently known to impact *Achatinella* species are: fire, trampling/disturbing native vegetation that snails may be using, introduction of non-native plants, predation by rats and other species of snails, and changes in microclimates from these activities. Introduced predatory flatworms represent just one potential threat that should be monitored to ensure that it does not impact the *Achatinella* species. The threat management plan for *Achatinella* species populations is outlined below and is adapted from the MIP to cover all *Achatinella* species.

Threat- Ungulates: Ungulates destroy native vegetation upon which healthy populations of *Achatinella* depend.

Goal: Ungulate exclusion-elimination. Total eradication of pigs and goats within a management unit is required to protect snail population units. The managed snail population units should be within larger ungulate exclosures and substantial predator exclosures.

Actions to Achieve Goal: Construct OIP MU fences, monitor for signs of ungulate impact to *Achatinella*.

Success: Success will be determined when the fence is constructed and all the ungulates have been removed. Maintaining an ungulate free area will be an ongoing activity where fencing maintenance and periodic monitoring will be considered success milestones.

Threat - Alien plants: Alien plants negatively impact snail habitat by out-competing native vegetation that is used by the snails as host plants. Alien plants may also alter the climatic environment at given sites.

Goal: Over time, manage vegetation to maximize the percentage of appropriate native species without upsetting climatic environment. If possible achieve 75% native vegetation within 50 meters of stabilization PUs and 50% native canopy cover across MUs (see Chapter 5 Threat Assessments).

Actions to Achieve Goal: Habitat restoration will be necessary in some areas to achieve this goal. Understory weed species will be controlled to encourage regeneration of native species and ensure maintenance of climatic environment needed to sustain the population.

Success: Success will be determined via monitoring results for each area. A high percentage of native cover may not be possible in all situations, however, the OIT will determine the level of success restoration activities are having based on monitoring data.

Threat- Rats: Three species of rats are serious predators of native Hawaiian snails. Rats can invade areas unpredictably and rapidly decimate local snail populations.

Goal: Eliminate rat predation threat; the extent of baiting area is site specific.

Actions to Achieve Goal: Construct predator exclosures where possible and maintain with poison baits. Support research and labeling of formulation for aerial dispersal of rat bait.

Predator-exclusion fences have already been constructed by the Hawaii Natural Area Reserves crews on the Makua Military Reservation at Kahanahaiki and in the Pahole Natural Area Reserve. These barriers utilize a design first developed to protect endemic tree snails in French Polynesia. They consist of a rigid wall of corrugated metal roofing laid horizontally with the

lower 15 or more centimeters buried in the earth. A 25 cm shed-like roof extends outward from the top of the fence to cover two barriers against the predatory snail *E. rosea*: a 10 cm trough filled with coarse salt (calcium chloride or sodium chloride) and a two-wire electrical barrier. The wires, energized by a battery that is kept charged by a solar panel, are attached against the wall, one 8 mm above the other. A snail that contacts both wires receives an electric shock, which causes it to drop backward off the wall. The rigid wall of the barrier also serves to deter rats, but this is augmented by abundant placement of toxic rat bait (diphacinone) both inside and outside the barrier. It is important the vegetation be kept cleared from the predator-exclusion barrier so that it cannot provide bridges for predators to reach the interior. It is worthwhile to pursue alternatives in predator enclosure design (materials and construction); however, in doing so, the necessity for vegetation clearing cannot be compromised. Modifications to this design are necessary in the extremely wet and windy environments of the Koolaus. Suggestions to the current design include using recycled plastic construction material and pepper paint as a *E. rosea* deterrent.

Monitoring: The Army will begin monitoring quarterly or biannually and will evaluate whether this is sufficient or too frequent. If an enclosure is in place that prevents rat ingress, need to reevaluate appropriate monitoring method and interval (for rat detection, quarterly visits may be appropriate; for *Euglandina* detection may need monthly visits—see more discussion below). To detect predation, the Army will conduct ground surveys to locate freshly broken shells. Rats typically eat only the larger tree-snail classes (*i.e.*, snails larger than about 12 mm). Typically the larger whorls are broken off, and marks of the rat's teeth can be seen on the shells. Use additional protocols established in the monitoring section (Chapter 6).

Success: Successful control of rats in an area will be determined by monitoring data. It is assumed that rats will pose a continual threat to snail populations as there will be constant pressure of immigration of new individuals from surrounding unmanaged habitats.

Threat - *Euglandina rosea*: The introduced predatory snail *E. rosea* feeds only on other snails and is the major cause of destruction of snail populations at this time.

Goal: Eliminate *E. rosea* predation via predator enclosures where possible and with dog detection teams.

Actions to Achieve Goal:

- Build enclosures around populations selected for stabilization wherever feasible. Ensure contractors adhere to design and plans for the enclosures through close monitoring of progress throughout construction.
- Toxic *E. rosea* baiting may be done much less frequently with a predator enclosure.
- Support research on dog detection of *Euglandina*.
- Support research on molluscicide for use in natural areas, and on other enclosure designs.

Monitoring:

- Managed populations without enclosures:
 1. Determine the area occupied by an *Achatinella* population. Then select a much larger area (recommend a minimum 100 m x 100 m area) around the snail population for monitoring.

2. Monitor *Achatinella* by surveying the ground for evidence of *Euglandina* predation, which is indicated by fresh dead shells of all size classes. When predation is noted, the Army will respond quickly.
3. Some destruction of *Dicranopteris linearis* and other plants is probably necessary while searching for ground shells, but care must be taken to limit disturbance. The Army will measure effectiveness of predator monitoring.
4. The Army will use additional protocols established in the monitoring section (Chapter 6).
5. The Army may determine densities of *E. rosea* in the *Achatinella* areas utilizing dog detection squads.

Success: Success of *Euglandina* control may be difficult to measure. However, populations of *Achatinella* will be monitored for growth and persistence with these control methods.

Threat - *Platydemis manokwari*: This flatworm is a documented predator of tree snails from other Pacific Islands and does occur from low elevations on Oahu to the top of Mount Kaala. The other two species have been found feeding on the tissue of dead Oahu tree snails, but it is not known if these two animals were the cause of death or just opportunistic feeders.

Goal: To detect and eliminate predation on *Achatinella*. Nothing is currently known about control measures for *P. manokwari*, but the electric fence on the predator enclosure may deter this flatworm.

Actions to Achieve Goal: monitoring of *Achatinella* rich areas will hopefully detect this predator if present. Research on the threat of this predator to *Achatinella* is also needed.

Monitoring: Only careful visual searching in leaf litter and under logs and rocks will reveal this flatworm. The Army will conduct searches at the same time as *E. rosea* searches.

Success: Success of detection and elimination of this species will be difficult to measure. However, populations of *Achatinella* will be monitored for growth and persistence with monitoring and research.

Bibliography of demographic papers on Hawaiian tree snails

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9.1 Tier 1 (surveys) *Achatinella apexfulva*, *A. bulimoides*, *A. curta*, *A. leucorraphe*, *A. pulcherrima*

Taxon Summaries and Stabilization Plans

Scientific name: *Achatinella* Pilsbry & Cooke

Hawaiian name: *Pupu Kanioe, Pupu Kuahiwi, Kahuli*

Family: Achatinellidae, subfamily Achatinellinae (Oahu Tree Snails)

Federal status: Listed endangered



Long Term Goals:

- Survey for extant populations a minimum of two days per year for each of the five species.
- Protect any found individuals or populations either *in situ* or via captive propagation.
- Surveys: Tier 1 Priority
- Stabilization: Tier 2 (stabilization plans to be developed on discovery of extant individuals or lab populations large enough to support a reintroduction)

Description and biology: *Achatinella apexfulva* is a species of long-lived tree snail. Adults reach up to 19 mm long and 12.5 mm wide, and have up to 6 whorls. The shells can be either dextral or sinistral. The color scheme begins with yellow at the tip followed by blackish brown to chestnut whorls with some whitish streaks and spiral lines. The lip is salmon colored and moderately thickened with a white columellar fold (USFWS 1993).

Achatinella bulimoides is a species of long-lived tree snail. Adults reach up to 21.3 mm long and 11.8 mm wide, and have up to 6 ¼ whorls. The shells can be either dextral or sinistral. The color scheme is white with a chestnut lip or whitish with chestnut bands and a chestnut lip (USFWS 1993).

Achatinella curta Newcomb is a species of long-lived tree snail. Adults reach up to 21.4 mm long and 10.3 mm wide, and have up to 5 whorls. The shells can be either dextral or sinistral.

The color scheme is polished yellow or chestnut with a plain or with a black sutural band, rarely with two or more on the last whorl (USFWS 1993).

Achatinella leucorraphe Gulick is a species of long-lived tree snail. Adults reach up to 19.0 mm long and 12.0 mm wide, and have up to 6 ½ whorls. The shells can be either dextral or sinistral. The color scheme is gray ornamented with irregularly interrupted dark cinereous streaks and a few indistinct, white, spiral lines (USFWS 1993).

Achatinella pulcherrima Swainson is a species of long-lived tree snail. Adults reach up to 20 mm long and 11.2 mm wide, and have up to 6 whorls. The shells are dextral. The color scheme is white or yellow with none to several broad bands of chestnut (USFWS 1993).

Historical distribution: *Achatinella apexfulva* was known from Poamoho and Peahinaia trails of the Northern Koolau Mountains on Oahu, but have severely declined in the last 30 years (USFWS 1993). This species has only been seen recently along the Poamoho trail (US Army Garrison 2004).

Achatinella bulimoides was last known from the summit area of the Poamoho trail (USFWS 1993).

Achatinella curta was last known from the Paalaa Uka on the ridge South of Opaepala Gulch, and on the Peahinaia and Kawaihoa Trails (USFWS 2003).

Achatinella leucorraphe was last known from the Schofield Waikane Trail (USFWS 2003).

Achatinella pulcherrima was last known from the summit area near the south fork of Opaepala stream and on the Peahinaia trail approximately 1 km (0.6 mi) from the summit trail (USFWS 2003).

Population trends: A single individual of *A. apexfulva* was collected in 2005 by Army natural resources staff, prior to this *A. apexfulva* had not been seen in 2002/2003 (Army Garrison 2003b).

A total of 12 individuals of *A. bulimoides* were seen by Army natural resources staff in 2005-2006. Prior to this *Achatinella bulimoides* had not been seen since 1982 (USFWS 1993).

Achatinella curta, *A. leucorraphe*, and *A. pulcherrima* have not been seen in over 15 years. *A. curta* was last seen in 1990. *A. leucorraphe* was last seen in 1989. *A. pulcherrima* was last seen in 1993.

Current status: The single individual of *A. apexfulva* seen in 2004-2005 by Army natural resource staff along the Poamoho trail was collected for captive propagation. This particular tree has been known to harbor *A. apexfulva* in the past and has been thoroughly searched a few times since 2005 with no snails seen (US Army 2007). Currently there are 2 individuals in captive propagation (Holland pers. comm. 2008).

Ten of the twelve individuals of *A. bulimoides* observed were collected for captive propagation and more individuals are expected to be found in surveys of the surrounding area. Currently there are 43 individuals in captive propagation.

There are currently no known individuals of *Achatinella curta*, *A. leucorraphe*, and *A. pulcherrima* in the wild. Surveys are planned for these species in the last observed sites.

Table 9.4 Current Population Units of *Achatinella apexfulva*.

Location	Population Unit Name	Total Number of Individuals
<i>Ex situ</i>	Poamoho (founders 5 individuals 1994, 2005)	12 (2005)
		2 (2008)

Table 9.5 Current Population Units of *Achatinella bulimoides*.

Location	Population Unit Name	Total Number of Individuals
<i>Ex situ</i>	Poamoho (10 founders, 2005-2006)	7 (2005)
		43 (2008)

Habitat: Currently, *Achatinella apexfulva* is found at lower elevations than other species in the Northern Koolau Mountains, ranging from 1500 ft to 2000 ft elevation. Previous sightings have been in mesic to wet forests on native tree species including Ohia lehua (*Metrosideros polymorpha*) and hame (*Antidesma platyphyllum*).

Achatinella bulimoides was found at the summit and just below the summit on the windward side of the Northern Koolau Mountains. Previous sightings have been in wet forests on native tree species including Ohia lehua (*Metrosideros polymorpha*) and hame (*Antidesma platyphyllum*). Previous sightings of *Achatinella curta*, *A. leucorraphe*, and *A. pulcherrima* have been in mesic and wet forests on native tree species including Ohia lehua (*Metrosideros polymorpha*) and hame (*Antidesma platyphyllum*).

Table 9.6 OIP *Achatinella* Taxa Summary

Species	Last observed in the wild	Army Action Area	Last observed Location	Potential Survey Areas
Inside AA				
<i>Achatinella apexfulva</i>	2005	KLOA	Poamoho Trail	Lower elevations of Poamoho Trail
<i>Achatinella bulimoides</i>	2006	KLOA	Poamoho summit area	Poamoho trail and summit areas including windward summit habitat; Punaluu Cliffs.
<i>Achatinella curta</i>	1990	KLOA	Kawailoa Trail, Peahinaia Trail	Areas between Kawailoa Trail and Peahinaia Trail
<i>Achatinella leucorraphe</i>	1989	SBER	Schofield Waikane Trail	Schofield Barracks East Range and South of Schofield Waikane Trail
<i>Achatinella pulcherrima</i>	1993	KLOA	Opaeula drainage	Opaeula drainage area and Poamoho Summit area

Discussion of Recent Species Survey History

A. apexfulva- this species last seen along the Poamoho trail in 2005. The individual seen was collected for captive propagation.

A. bulimoides- this species was recently rediscovered at the summit of Poamoho trail (2005). A total of 10 individuals were collected on four separate occasions for captive propagation. Two individuals remain in the wild but occur outside Army training areas.

A. curta- recent surveys along the lower elevations of Kawaihoa Trail.

A. leucorraphe- last surveyed along Schofield-Waikane trail at last sighting point.

A. pulcherrima- last surveyed in the upper Opaulea drainages.

Priority Management Actions

The highest priorities for these species are surveying and increasing captive populations of *A. apexfulva* and *A. bulimoides*. Surveys are needed in the areas nearest the last observed site and at historical sites for each species. The Army will survey with 2 people for 2 days for each of the five species each year. These surveys will be done in habitat that is appropriate for these taxa. Because some of the historical habitats overlap for some of these species survey days may cover more than one species. The Army Natural Resources program has conducted numerous and extensive surveys within the action area and has thus far been unsuccessful in locating these species (see survey route maps this section). Many of these routes have been surveyed repeatedly over the past 10 years (e.g. North Kaukonahua area, Poamoho trail, Lower Peahinaia Trail, Kawaihoa Trail, and portions of the Koolau Summit trail). Army natural resources staff conducting the surveys have been trained in rare snail field searching techniques by Dr. Mike Hadfield and his students over the past 10 years.

Increasing the numbers of individuals in captive propagation may be more challenging than field surveys. The Army will consult with the OIT to find ways to assist the UH Tree Snail Lab in propagating these species. Currently, just 2 individuals of *A. apexfulva* and 43 individuals of *A. bulimoides* are in captive propagation.

A. apexfulva- It may not be possible to achieve stability for this species because of the low numbers of individuals available for propagation. Stability *in situ* would have to be reached through the reintroduction of individuals into a predator proof enclosure. The OIT may address plans to build a lower elevation predator proof enclosure when *ex situ* numbers are of sufficient size and vigor. However, this species appears to reproduce more slowly than most *Achatinella* species (Hadfield pers. comm. 2005).

A. bulimoides- This species was recently rediscovered near the summit of the Poamoho trail, in the KLOA action area. Ten individuals were seen and collected for captive propagation on four separate occasions. At the last collection survey date two individuals remained outside of the Army action area. At this time the Army plans to conduct surveys to determine the extent of the population. This species is currently increasing in the captive lab population. If this trend continues and there are enough individuals to support a reintroduction the Army will develop a reintroduction/stabilization plan specific to this species by consulting with the OIT and other partnering conservation organizations.

Map removed, available
upon request

Figure 9.1 Historic distribution of *Achatinella curta* in the Northern Koolau Mountains on Oahu.

Map removed, available
upon request

Figure 9.2 Historical distribution of *Achatinella curta* in the Northern Koolau Mountains on Oahu.

Map removed, available
upon request

Figure 9.3 Historical distribution of *Achatinella leucorraphe* in the Koolau Mountains on Oahu.

Map removed, available
upon request

Figure 9.4 Historical distribution of *Achatinella pulcherrima* in the Koolau Mountains of Oahu.

Map removed, available
upon request

Figure 9.5 Last observed sites for *Achatinella apexfulva* and previous Army snail survey routes in the Northern Koolau Mountains of Oahu.

Map removed, available
upon request

Figure 9.6 Last observed sites for *Achatinella bulimoides* and previous Army snail survey routes in the Northern Koolau Mountains of Oahu.

9.2 Tier 2 *Achatinella byronii/decipiens*: Taxon Summary and Stabilization Plan



Scientific name: *Achatinella byronii/decipiens* Wood

Hawaiian name: *Pupu Kanioe, Pupu Kuahiwi, Kahuli*

Family: Achatinellidae, subfamily Achatinellinae (Oahu Tree Snails)

Federal status: Listed endangered

Long Term Goals:

- Manage extant population units (PUs) and additional reintroduction PUs, up to a total of six PUs within the action area to encompass the known geographical range of the species
- Achieve at least 300 individuals in each PU
- Maintain captive propagation populations of significant PUs
- Control all threats at each managed field location
- **Tier 2** stabilization priority

Description and biology: *Achatinella byronii* and *A. decipiens* are considered by many to be synonymous. Thus far, the Army treats *A. byronii* and *A. decipiens* as the same species. The OIP follows this format in accordance with the Oahu Biological Assessment, the Oahu Biological Opinion, Army natural resource data, and preliminary morphological comparisons by various field experts (U.S. Army 2003; USFWS 2003; OANRP 2004). The two species have been described with very similar morphology both having dark chestnut colored longitudinal striae or stripes. Cooke (1912-1914) considered *A. decipiens* to be a subspecies of *A. byronii*. While the geographical delineation between the two species imposed by Pilsbry, appears to be somewhat arbitrary (Pilsbry and Cooke 1912-1914; OIT 2005). The Army will refer to the entity occurring in the action area as *A. byronii/decipiens* until further clarifications are made by malacological experts.

Achatinella byronii/decipiens is a species of long-lived tree snail. Adults reach up to 20.5 mm long and 11.0 mm wide, and have up to 6 to 6.5 whorls. The shells can be either dextral or sinistral. The USFWS described *A. byronii* as having green and yellow bands with chestnut and a pinkish gray tip and *A. decipiens* as yellow with white transverse bands or white with yellow transverse bands. Both taxa were described as having moderate longitudinal ridges or striae (USFWS 1993).

Known distribution: *Achatinella byronii/decipiens* is known from approximately five locations in the wild: Schofield Waikane trail, North Kaukonahua stream drainage, Puu Kaaumakua, West of Puu Pauao, and along the Punaluu Cliffs of the Koolau Summit Trail.

Population trends: *Achatinella byronii/decipiens* is the second most abundant species in the Koolau Mountains. However, this species is still considerably scarce as there are less than 300 individuals remaining in the wild. The populations are clumped and nearby areas of similar habitat are devoid of snails.

Current status: Currently, there are five populations of *A. byronii/decipiens* totaling approximately 269 individuals. Approximately 97% of extant individuals are found within the action areas of KLOA and SBER. Additionally, there are 30 individuals in captive propagation at this time.

Habitat: *Achatinella byronii/decipiens* is generally found in native wet Ohia forest at or just below the summit of the Koolau Mountains from 605 to 770 m. Native trees and shrubs include hame (*Antidesma platyphyllum*), olapa (*Cheirodendron* spp.), aiea (*Ilex anomala*), and ohia lehua (*Metrosideros polymorpha*).

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina

Achatinella byronii / decipiens**GU: A East Range**

SBE-A	Manage for stability	0	2006-06-28	0	0	0	0	No	No	No	No
Middle Waikakalaua-South Kaukonahua dividing ridge											
SBE-B	Manage for stability	1	2001-02-28	1	0	0	0	No	No	No	No
South Kaukonahua stream											
SBE-C	Manage for stability	1	2001-02-28	1	0	0	0	No	No	No	No
East Waikakalaua-South Kaukonahua dividing ridge											
SBE-D	Manage for stability	1	2002-05-01	1	0	0	0	No	No	No	No
West Waikakalaua-South Kaukonahua dividing ridge											
SBE-E	Manage for stability	3	1997-09-25	1	1	1	0	No	No	No	No
North branch of South Kaukonahua											
GU Total:		6		4	1	1	0				

GU: B Puu Pauao

KLO-D	Manage for stability	16	2006-08-22	15	1	0	0	No	No	No	No
Puu Pauao											
GU Total:		16		15	1	0	0				

GU: C Poamoho

KLO-A	Manage for stability	0	2004-12-01	0	0	0	0	No	No	No	No
South of Poamoho Trail											
KLO-B	Manage for stability	23	2006-04-18	18	3	2	0	No	No	No	No
Poamoho Cabin											
KLO-C	Manage for stability	1	2001-06-13	0	0	0	1	No	No	No	No
South of Poamoho Cabin											
KLO-F	Manage for stability	45	2006-04-19	42	3	0	0	No	No	Yes	No
North of Poamoho Trail											
KLO-G	Manage for stability	0	2007-08-31	0	0	0	0	No	No	No	No
Poamoho trail 1800 ft at A. apexfulva site											
GU Total:		69		60	6	2	1				

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
GU: D Punaluu cliffs											
KLO-H	Manage for stability	2	2006-05-04	2	0	0	0	No	No	No	No
Windward cliffs opposite Peahinaia summit LZ											
KLO-I	Manage for stability	1	2007-04-02	0	1	0	0	No	No	No	No
East of 290											
GU Total:		3		2	1	0	0				
GU: E North Kaukonahua											
KLO-E	Manage for stability	175	2002-08-21	120	40	15	0	No	No	No	No
North Kaukonahua											
GU Total:		175		120	40	15	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>15 mm
Medium	7-15 mm
Small	<7 mm

Table shows the number of snails, size classes, and threats to the snails in the ESU sites. Yes = threat is being controlled; In some cases the threat may be present but not actively preying on *Achatinella*.

Map removed, available
upon request

Figure 9.7 Current and historical distribution of *Achatinella byronii/decipiens* Koolau Mountains, Oahu.

Discussion of Management Designations

All known geographic units will be managed for stability.

Captive Propagation Information

This species has been in captive propagation for approximately 11 years. The numbers of individuals in this population have fluctuated and may benefit from the introduction of new wild individuals. All captive propagation populations will be founded by at least 7-10 individuals whenever possible. The minimum goal of each *ex situ* representation of wild stock is to reach 50 individuals (Makua Implementation Team, 2003).

The UH Snail Lab has one population of this species, comprised of 30 individuals, represented with mixed individuals from the Schofield-Waikāne Trail below KLO-E. This lab population was started in 1997. Additional lab populations are needed from all other GUs. The number of individuals in captive propagation populations should be sufficient in number to allow reintroductions before attempts are made to reintroduce the species.

Table 9.7. Captive propagation data for *Achatinella byronii/decipiens*.

Species	Year	# juv	# sub	# adult	# Individuals
<i>A. byronii/decipiens</i>	2007	5	14	9	28
	2008	6	17	7	30

Management Notes

The main priorities for the management of *Achatinella byronii/decipiens* include surveys and mark recapture studies to determine the extent of the GUs, collection of individuals to establish captive propagation populations for all extant GUs, and the construction of ungulate proof fenced exclosures around the MUs. Currently there are not 6 extant GUs for stabilization. The Army will discuss meeting stabilization goals with the OIT each year following monitoring and surveys.

The Army has not conducted extensive surveys for this species in recent years. The total numbers of individuals reported here is greater than reported in the past, however, this is due more to the use of the database in keeping track of the most accurate counts rather than the most recent population visits (i.e. in some cases the Army has searched more thoroughly). This database allows us to track the ‘manage for stability’ populations and the level of threat control currently being conducted at these sites.

The database shows that approximately 250 *A. byronii/decipiens* occur within proposed or existing MUs. The Poamoho GU-C is partially protected within a rat baiting grid that is restocked every six weeks along the Poamoho summit. This population contains approximately 45 individuals.

Monitoring: GUs are currently monitored for signs of rat predation via ground shell plots. When signs of predation are observed rat baiting will be initiated. Management will consist of securing sites from feral pigs, maintaining habitat and collection of individuals for captive propagation from each GU managed for stability.

The **East Range GU-A** will be managed within the South Kaukonahua MU. The **Puu Pauao GU-B** occurs along a west facing ridge extending from the summit. The **Poamoho GU-C** occurs along the summit of the Koolau Mountains where the Poamoho trail meets the summit. This GU will be managed in 2 separate management units: Poamoho and Poamoho Pond. The **Punaluu Cliffs GU-D** has not been well monitored for population size or threats. The **North Kaukonahua GU-E** is the largest population of this species and occurs approximately 1 mile below the summit along a North facing ridge of the Schofield Waikane trail.

Table 9.8 Priority Management Actions for *Achatinella byronii/decipiens*

Geographic Unit	Specific Management Actions	Partners/Concerns	Timeline
East Range (South Kaukonahua MU) GU A	<ul style="list-style-type: none"> • Surveys to determine extent of PU • Collect individuals for captive propagation • Construct South Kaukonahua II MU • Set up rat bait station grid • Construct predator proof enclosure 	<ul style="list-style-type: none"> • MU in SBE, Army owned land • MU needs an EA 	<ul style="list-style-type: none"> • construct S. Kaukonahua I MU, OIP yr 6; 2013
Puu Pauao GU B	<ul style="list-style-type: none"> • Survey to determine the extent of PU • Collect individuals for captive propagation • Construct MU • Set up rat bait station grid • Construct predator proof enclosure 	<ul style="list-style-type: none"> • MU in State Forest Reserve (proposed NAR), need license agreement with the State. • MU needs an EA 	<ul style="list-style-type: none"> • Construct Poamoho III MU, OIP yr 9; 2016
Poamoho GU C	<ul style="list-style-type: none"> • Survey to determine extent of PU • Collect individuals for captive propagation • Construct Poamoho I & II MUs • Set up rat bait station grid • Construct predator proof enclosure 	<ul style="list-style-type: none"> • MU in State Forest Reserve (proposed NAR) • MU needs an EA 	<ul style="list-style-type: none"> • construct Poamoho I MU, OIP yr 8; 2015 • construct Poamoho II MU; OIP yr 9 2016
Punaluu Cliffs GU D	<ul style="list-style-type: none"> • Surveys to determine extent of PU • Collect individuals for captive propagation • Set up rat bait station grid • Determine if a predator proof enclosure is feasible (steep cliffs) 	<ul style="list-style-type: none"> • Kamehameha Schools land, needs a license agreement prior to surveys 	<ul style="list-style-type: none"> • begin surveys once agreement with landowner is in place; est. 2008
North Kaukonahua GU E	<ul style="list-style-type: none"> • Survey to determine extent of PU • Collect individuals to bolster captive propagation population numbers • Construct North Kaukonahua MU • Monitor for rat predation • Set up rat bait station grid • Construct predator proof enclosure 	<ul style="list-style-type: none"> • MU in State Forest Reserve (Proposed NAR) • MU needs an EA 	<ul style="list-style-type: none"> • construct N. Kaukonahua MU, OIP yr 7; 2014

9.3 Tier 2: *Achatinella lila*

Taxon Summary and Stabilization Plan



Scientific name: *Achatinella lila* Pilsbry

Hawaiian name: *Pupu Kanioe, Pupu Kuahiwi, Kahuli*

Family: Achatinellidae, subfamily Achatinellinae (Oahu Tree Snails)

Federal status: Listed endangered

Long Term Goals:

- Manage extant population units (PUs) and additional reintroduction PUs, up to a total of six PUs within the action area to encompass the known geographical range of the species
- Achieve at least 300 individuals in each PU to be managed for stability.
- Maintain captive propagation populations from each of the three PUs being managed for stability.
- Control all threats at each managed field location.
- **Tier 2** stabilization priority

Description and biology: *Achatinella lila* is a species of long-lived tree snail. Adults can reach up to 17.0 mm in length and 11.0 mm diameter and have up to 5 ½ whorls. The shells coil in the sinistral direction. The color pattern is generally whorls of yellow or green on a chestnut background with a sienna brown to whitish tip.

Known distribution: *Achatinella lila* was historically known from along the summit of the central to northern Koolau Mountains. See Figure 9.8

Population trends: Few populations of *Achatinella lila* are known and some have just a few individuals. Approximately 95 individuals total are known in the wild. Rat predation has not been documented from any of the known sites. However, nearby snail sites of other species have been observed in decline. Therefore, these populations are highly vulnerable to rapid decline.

Current status: Three geographic units (GUs) are known from the KLOA action area; Poamoho Summit GU-A, Peahinaia Summit GU-B, and Opaepala-Punaluu Summit GU-C. Currently, there are 544 individuals in captive propagation (Holland pers. comm. 2008), see table 9.6 below. The Army is currently conducting rat control at two sites, within GU-A and B. This appears to be the most successful species in captive propagation; therefore this species is a good candidate for an

experimental reintroduction within an area with sufficient threat control (see Appendix 2-7; Rare snail reintroduction guidelines).

Habitat: *Achatinella lila* is known from native Ohia wet forest along the summit areas of the Northern Koolau Mountains from 2520 to 2770 ft. Native trees and shrubs include hame (*Antidesma platyphyllum*), olapa (*Cheirodendron* spp.), aiea (*Ilex anomala*), and ohia lehua (*Metrosideros polymorpha*).

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella lila											
GU: A Poamoho Summit											
KLO-A South of Poamoho Trail	Manage for stability	5	2000-09-25	5	0	0	0	No	No	No	No
KLO-B North of Poamoho Trail	Manage for stability	34	2004-12-01	29	2	3	0	No	No	Yes	No
GU Total:		39		34	2	3	0				
GU: B Peahinaia Summit											
KLO-C Peahinaia Summit	Manage for stability	2	2006-05-03	1	1	0	0	Yes	Yes	Yes	No
KLO-F Below Peahinaia Summit on windward side	Manage for stability	9	2006-05-04	8	1	0	0	No	No	No	No
GU Total:		11		9	2	0	0				
GU: C Opaepala-Punaluu Summit											
KLO-D Notch Site, Opaepala Fence	Manage for stability	3	2005-05-03	1	1	1	0	No	No	No	No
KLO-E Windward side below Sanpur outplanting	Manage for stability	42	2006-05-03	32	8	2	0	No	No	No	No
GU Total:		45		33	9	3	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>15 mm
Medium	7-15 mm
Small	<7 mm

Table shows the number of snails, size classes, and threats to the snails in the ESU sites. Yes = threat is being controlled; In some cases the threat may be present but not actively preying on *Achatinella*.

Map removed, available
upon request

Figure 9.8 Current and historic distribution of *Achatinella lila* in the Koolau Mountains of Oahu.

Discussion of Management Designations

All known occurrences of *Achatinella lila* will be managed for stability. A total of six manage for stability GUs with 300 individuals each will need to be managed. Reintroductions will have to be made to attain this.

Captive Propagation Information

This species has been in propagation since 1997. However, all lab individuals of *A. lila* at this time are descendants of the initial adult population collected from near the Poamoho trail summit (Hadfield, 2005). This is by far the most successfully propagated species of *Achatinella* in the Koolau Mountains. Due to the high numbers of individuals represented *ex situ* this species is the best candidate for an experimental wild reintroduction within a protected area. However, before a reintroduction/augmentation to the Opaepala summit area can be done, modifications to the predator proof enclosure design are needed.

Prior to the reintroduction, the UH Snail Lab would like to compare the level of genetic variation of lab populations versus the wild populations and the degree of similarity within and among the lab and wild populations. Genetic samples from all the populations are being collected to facilitate this comparison. This information will aid the development of a reintroduction plan for this species. The Army recently helped to organize a reintroduction protocol, to be utilized by any conservation agency, in anticipation of a reintroduction of either *A. mustelina* or *A. lila* (see Appendix 2-7: Rare Snail Reintroduction Protocol).

Table 9.9 Captive propagation data for *Achatinella lila*.

Species	Year	# juv	# sub	# adult	# Individuals
<i>A. lila</i>	2007	215	246	8	470
	2008	151	372	21	544

Management Notes

Poamoho GU-A was recently known to have extant individuals both north and south of the Poamoho trail. However, in recent thorough surveys no individuals south of the trail were seen. More surveys are needed in the area. The **Peahinaia summit GU-B** occurs along the Opaepala/Helemano MU fenceline and the majority of individuals known are within the ungulate enclosure. The Army is conducting rat control at a portion of this site. The **Opaepala-Punaluu summit GU-C** was likely once contiguous with the individuals known in the Peahinaia Summit (GU-B). However, at this time the two populations are not known to overlap. More surveys are needed to determine the extent of this GU as more individuals have been observed on the windward side of the summit outside of the Opaepala/Helemano MU.

The target number of six GUs of this species, each with 300 individuals, will likely only be reached via reintroductions within predator free areas. An experimental predator proof tree snail enclosure is proposed for this species within an existing ungulate fence. Management for stability will consist of securing sites from feral pigs, maintaining habitat, and collecting of individuals from all populations for captive propagation.

Table 9.10 Priority Management Actions for *Achatinella lila*

Geographic Unit	Specific Management Actions	Partners/Concerns	Timeline
Poamoho Summit GU A	<ul style="list-style-type: none"> • Construct Poamoho MU • Continue rat bait grid restocking for North Poamoho PU • Construct predator proof enclosure • Conduct reintroductions as feasible 	<ul style="list-style-type: none"> • MU in State Forest Reserve (proposed NAR) • MU needs an EA 	<ul style="list-style-type: none"> • construct Poamoho I MU (Tier 1), OIP yr 8; 2015
Peahinaia Summit GU B	<ul style="list-style-type: none"> • Construct predator proof enclosure at summit LZ area, reintroduce snails • Continue rat bait grid restocking • Collect for captive propagation 	<ul style="list-style-type: none"> • MU fence completed 	<ul style="list-style-type: none"> • OIP Tier 2, YR1
Opaepala-Punaluu Summit GU C	<ul style="list-style-type: none"> • Survey/ determine if additional ungulate fencing is necessary • Construct predator proof enclosure • Collect for captive propagation 	<ul style="list-style-type: none"> • MU fence completed 	<ul style="list-style-type: none"> • OIP Tier 2, YR1

9.4 Tier 2: *Achatinella livida*

Taxon Summary and Stabilization Plan



Scientific name: *Achatinella livida* Swainson

Hawaiian name: *Pupu Kanioe, Pupu Kuahiwi, Kahuli*

Family: Achatinellidae, subfamily Achatinellinae (Oahu Tree Snails)

Federal status: Listed endangered

Long Term Goals:

- Manage extant population units (PUs) and additional reintroduction PUs, up to a total of six PUs within the action area to encompass the historical geographical range of the species
- Achieve at least 300 individuals in each PU
- Maintain captive propagation populations from each extant PU
- Control all threats at each managed field location
- **Tier 2** stabilization priority

Description and biology: *Achatinella livida* is a small long-lived tree snail. Adults can reach up to 17 mm in length and 9.0 mm diameter and have up to 6 whorls. The colors generally are livid brown to livid purple that gradually change to white at the tip. The shell suture is marked with a line of deep orange brown (USFWS 1993).

Known distribution: *Achatinella livida* was historically known from middle to upper elevations in the central to northern Koolau Mountains.

Population trends: Populations of *Achatinella livida* are clumped and widely spaced. Nearby areas of similar habitat are either devoid of snails or single individuals have been seen.

Current status: Currently, approximately 148 individuals are known from 3 populations in the Kawailoa training area. There are 108 individuals in captive propagation at this time (Holland pers. comm. 2008).

Habitat: *Achatinella livida* is known from native Ohia wet forest along the summit areas of the Koolau Mountains from 2320 to 2560 ft. Native trees and shrubs include *Antidesma platyphyllum*, *Cheirodendron* spp., *Ilex anomala*, and *Metrosideros polymorpha*.

2008-09-24

Page 1 of 1

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella livida											
GU: A Crispa Rock											
KLO-A	Manage for stability	60	2004-07-21	38	15	7	0	No	No	Yes	No
Crispa Rock											
GU Total:		60		38	15	7	0				
GU: B Northern											
KLO-B	Manage for stability	5	2008-02-26	2	1	2	0	No	No	Yes	No
Northern											
GU Total:		5		2	1	2	0				
GU: C Radio											
KLO-C	Manage for stability	77	2004-07-20	40	21	16	0	No	No	Yes	No
Radio											
PAP-A	Manage for stability	6	2006-06-24	6	0	0	0	No	No	No	No
Windward side of radio											
GU Total:		83		46	21	16	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>15 mm
Medium	7-15 mm
Small	<7 mm

Table shows the number of snails, size classes, and threats to the snails in the ESU sites. Yes = threat is being controlled; In some cases the threat may be present but not actively preying on *Achatinella*.

Map removed, available
upon request

Figure 9.9 Current and historic distribution of *Achatinella livida* in the Koolau Mountains of Oahu.

Discussion of Management Designations

All known occurrences of *A. livida* will be managed for stability. A total of six manage for stability GUs with 300 individuals each will need to be managed. Reintroductions will have to be made to attain this.

Captive Propagation Information

Achatinella livida has been in captive propagation since 1997. There are currently 4 subpopulations totaling approximately 108 individuals. However, all captive individuals are descendents of the initial adult population from Radio GU-C. All captive propagation populations will be founded by at least 7-10 individuals whenever possible (Makua Implementation Team, 2003). The minimum goal of each *ex situ* representation of wild stock is to reach 50 individuals (Makua Implementation Team, 2003).

The Army will consider starting additional lab populations for the other two extant populations, Crispa (KLO-A) and Northern (KLO-B).

Table 9.11 Captive propagation data for *Achatinella livida*.

Species	Year	# juv	# sub	# adult	# Individuals
<i>A. livida</i>	2005	50	66	6	122
	2008	28	75	5	108

Management Notes

There are currently three extant GUs of this species; Northern GU-B, Crispa Rock GU-A, and Radio GU-C. The Army has been monitoring and baiting for rats at the sites for the past 9 years. The Army will continue to restock baiting grids twice per quarter (weather permitting) at each site in the coming year. Each baiting grid will be reevaluated and expanded if necessary. A priority for all three extant GUs is a thorough monitoring for number of individuals that includes night searches. Management for stability will consist of securing all three wild sites from feral pigs, construction of six predator proof exclosures, maintaining habitat through weed control and the collection of individuals for captive propagation.

Northern GU-B is the least populous GU with just five snails observed in early 2008. Once a thorough search is conducted at this site the Army and the OIT will determine how many individuals should be brought into the lab to secure the population from extinction. This site will be protected within the Koloa MU.

Crispa Rock GU-A contains has not been thoroughly monitored for a total number of individuals since 2004 and no individuals from this GU are represented in captive propagation. A ground shell plot was installed in 2006. The ground shell plot has not revealed any rat predated shells or high numbers of fresh dead individuals although a live *Euglandina rosea* was found. This plot will be re-read annually. This site will be protected within the Kawaiiki subunit I MU (Tier 2).

Radio GU-C is the largest in numbers of individuals, however a thorough monitoring has not been conducted since 2004. Monitoring and possible adjustment of the rat control grid are top priorities for this GU.

Genetics: Preliminary genetics research comparing sequences from CO1 (the same gene used to delineate ESUs in *A. mustelina*) revealed that individuals sampled within populations of *A. sowerbyana*, near the Opaepa MU, contained *A. livida* haplotypes. This data is interesting because to date no *A. livida* have been known from this area and all snails sampled had dextral chirality, which is characteristic of *A. sowerbyana* in this area. However, more research needs to be conducted before any conclusions are made. The Army is working with the UH Tree Snail Lab to provide samples for more genetic analyses.

Table 9.12 Priority Management Actions for *Achatinella livida*

Geographic Unit	Specific Management Actions	Partners/Concerns	Timeline
Crispa Rock GU A	<ul style="list-style-type: none"> • Survey and determine numbers of individuals • Construct Kaipapau II MU • Continue rat baiting • Collect for captive propagation • Construct predator proof enclosure 	<ul style="list-style-type: none"> • Need license agreement with landowner, Kamehameha Schools • MU needs an EA 	<ul style="list-style-type: none"> • construct Kawaiiki I MU, OIP yr 10; 2017 (Tier 2)
Northern GU B	<ul style="list-style-type: none"> • Survey and determine numbers of individuals • Collect for captive propagation • Construct Koloa MU • Continue rat baiting • Collect for captive propagation • Construct predator proof enclosure 	<ul style="list-style-type: none"> • Need license agreement with landowner, Hawaii Reserves Inc. • MU needs an EA 	<ul style="list-style-type: none"> • Construct Koloa MU, OIP yr 4; 2011 • (Tier 1)
Radio GU C	<ul style="list-style-type: none"> • Survey and determine numbers of individuals • Collect for captive propagation • Construct Kaipapau III • Continue rat baiting • Collect for captive propagation • Construct predator proof enclosure 	<ul style="list-style-type: none"> • Need license agreement with landowner, Kamehameha Schools • MU needs an EA 	<ul style="list-style-type: none"> • construct Kawaiiki II MU, OIP yr 10; 2017 (Tier 2)

9.5 Tier 2 *Achatinella sowerbyana*

Taxon Summary and Stabilization Plan



Scientific name: *Achatinella sowerbyana* Pfeiffer

Hawaiian name: *Pupu Kanioe, Pupu Kuahiwi, Kahuli*

Family: Achatinellidae, subfamily Achatinellinae (Oahu Tree Snails)

Federal status: Listed endangered

Long Term Goals:

- Manage extant population units (PUs) and additional reintroduction PUs, up to a total of six PUs within the action area to encompass the historical geographical range of the species
- Achieve at least 300 individuals in each PU to be managed for stability.
- Maintain captive propagation populations from each PU being managed for stability
- Control all threats at each managed field location.
- **Tier 2** stabilization priority

Description and biology: *Achatinella sowerbyana* is a small long-lived tree snail. The shells can be either dextral or sinistral. Adults can reach up to 18.0 mm in length and 9.0 mm diameter and have up to 6 whorls. The whorls are slightly convex. The shell colors are generally glossy tawny buff and streaked with darker shades (USFWS 1993).

Known distribution: *Achatinella sowerbyana* is currently known from middle to upper elevations in the central to northern Koolau Mountains. Historically it was also known from lower elevations.

Population trends: Populations of *Achatinella sowerbyana* appear to be sparse and scattered. Nearby areas of similar habitat are either devoid of snails or single individuals have been seen.

Current status: *Achatinella sowerbyana* is the most abundant *Achatinella* species in the Koolau Mountains. Currently, there are 46 individuals in captive propagation (Holland pers. comm. 2008).

Habitat: *Achatinella sowerbyana* is known from native Ohia wet forest along the summit areas of the Koolau Mountains from 1780 to 2760 ft. Native host trees and shrubs include *Antidesma platyphyllum*, *Cheirodendron* spp., *Ilex anomala*, and *Metrosideros polymorpha*.

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina

Achatinella sowerbyana

GU: A	Kawainui Ridge										
KLO-Q Pinch ridge	Manage for stability	2	2001-09-05	2	0	0	0	No	No	No	No
KLO-R Freckled-Toothed Ridge	Manage for stability	0	2007-05-15	0	0	0	0	No	No	No	No
GU Total:		2		2	0	0	0				
GU: B	Kawaiiki Ridge										
KLO-K Bloody finger	Manage for stability	2	2007-05-17	1	1	0	0	No	No	No	No
KLO-P Ptelid gulch upstream from the Ptelid	Manage for stability	1	1997-08-06	1	0	0	0	No	No	No	No
GU Total:		3		2	1	0	0				

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
GU: C Opaëula-Helemano											
KLO-BB	Manage for stability	3	2004-07-21	2	0	1	0	Yes	Yes	No	No
Below Peahināla trail in Helemano											
KLO-CC	Manage for stability	1	2004-07-21	0	1	0	0	Yes	No	No	No
Helemano southwest of KLO-12 transect											
KLO-D	Manage for stability	6	1997-09-04	0	0	0	6	Yes	Yes	Yes	No
Peahināla Summit											
KLO-DD	Manage for stability	1	2004-07-21	0	1	0	0	Yes	No	No	No
Helemano southwest of KLO-12 transect, middle site.											
KLO-E	Manage for stability	1	1998-05-28	0	0	0	1	Yes	Yes	No	No
Cyrvir, photopoint pole pe'ahināla trail											
KLO-EE	Manage for stability	1	2004-07-21	0	1	0	0	Yes	No	No	No
Helemano southwest of KLO 12 transect, eastern site.											
KLO-F	Manage for stability	5	2006-07-18	2	3	0	0	Yes	No	No	No
Pe'ahināla trail pulcherrima like snails											
KLO-G	Manage for stability	1	2006-05-03	0	1	0	0	Yes	No	No	No
South ridge of Helemano fenceline											
KLO-H	Manage for stability	2	1997-06-06	1	0	1	0	Yes	Yes	No	No
Ilex spot near palm grass site at sta 260 KLO-12											
KLO-HH	Manage for stability	5	2004-12-01	4	1	0	0	Yes	Yes	No	No
West Helemano, below Palm grass site											
KLO-I	Manage for stability	1	2003-08-27	1	0	0	0	Yes	Yes	No	No
Above goose wing											
KLO-II	Manage for stability	1	2004-12-01	1	0	0	0	Yes	No	No	No
West Helemano, above stream 30m, below large flat ridge											
KLO-J	Manage for stability	232	2007-09-18	60	142	30	0	Yes	Yes	Yes	No
Hypalon											
KLO-JJ	Manage for stability	6	2006-03-22	2	2	2	0	Yes	No	No	No
South Helemano fenceline											
KLO-KK	Manage for stability	2	2006-05-02	1	0	1	0	Yes	Yes	No	No
Second ridge off Peahināla trail											
KLO-L	Manage for stability	30	2005-12-08	20	5	5	0	Yes	Yes	Yes	No
Sta 250 on summit trail along Pe'ahināla fence											

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
KLO-LL East of 290	Manage for stability	3	2007-04-02	3	0	0	0	No	No	No	No
KLO-M Shaka	Manage for stability	15	2007-05-16	10	4	1	0	Yes	Yes	Yes	No
KLO-N Lizard-back ridge	Manage for stability	1	2005-01-05	1	0	0	0	Yes	Yes	Yes	No
KLO-O Close to shelter just above waterfall in Opaeula fence	Manage for stability	3	2002-01-01	3	0	0	0	Yes	Yes	Yes	No
KLO-U Rich Ridge	Manage for stability	22	1997-12-11	0	0	0	22	No	No	No	No
KLO-Y KST and Shelter ridge junction	Manage for stability	1	2001-10-18	1	0	0	0	No	No	No	No
KLO-Z Peahinaia south side of goose-head ridge	Manage for stability	1	2003-08-27	0	0	0	1	Yes	Yes	No	No
GU Total:		344		112	161	41	30				
GU: D Poamoho Summit & Trail											
KLO-C North of Poamoho Summit	Manage for stability	177	2007-09-18	49	90	38	0	No	No	Yes	No
KLO-FF South of Poamoho Summit	Manage for stability	19	2003-03-18	0	0	0	19	No	No	No	No
KLO-GG Poamoho trail upper 1/3	Manage for stability	106	2003-02-17	80	15	1	0	No	No	No	No
GU Total:		302		139	105	39	19				
GU: E Poamoho Pond											
KLO-A Poamoho Pond	Manage for stability	90	2004-12-02	59	19	12	0	No	No	No	No
GU Total:		90		59	19	12	0				
GU: F Poamoho-North Kaukonahua Ridge											
KLO-AA Little Italy	Manage for stability	2	2004-05-19	2	0	0	0	No	No	No	No
GU Total:		2		2	0	0	0				

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
GU: G Lower Peahinaia											
KLO-S Puu Roberto	Manage for stability	35	2000-10-25	0	0	0	35	No	No	No	No
KLO-T Near Frog Pond	Manage for stability	0	1996-08-31	0	0	0	0	No	No	No	No
KLO-V Lower Peahinaia trail Hesarb site	Manage for stability	5	1999-12-13	0	0	0	5	No	No	No	No
GU Total:		40		0	0	0	40				

Size Class Definitions

<u>SizeClass</u>	<u>DefSizeClass</u>
Large	>15 mm
Medium	7-15 mm
Small	<7 mm

Table shows the number of snails, size classes, and threats to the snails in the ESU sites. Yes = threat is being controlled; In some cases the threat may be present but not actively preying on *Achatinella*.

Map removed, available
upon request

Figure 9.10 Current and historic distribution of *Achatinella sowerbyana* in the Koolau Mountains of Oahu.

Discussion of Management designations

Until genetic analyses are completed the Army has designated all extant GUs as manage for stability. However, GUs A, B, and F consist of just 2 or 3 individuals and may not be managed for stability if no other individuals are found in those areas. The GUs with the largest number of individuals will be proposed to be managed for stability. Many of the populations, 87% of known wild individuals, will be protected from habitat degradation by feral pigs.

Captive Propagation Information

Currently, there are 25 individuals in captive propagation. All PUs managed for stability will have a captive breeding population founded from at least 7 to 10 individuals. The minimum goal of each *ex situ* representation of wild stock is to reach 50 individuals.

Table 9.13 Captive propagation data for *Achatinella sowerbyana*.

Species (GU represented)	Year	# juv	# sub	# adult	# Individuals
<i>A. sowerbyana</i>	2004	12	23	12	47
	2007	4	14	3	21
	2008	8	14	3	25

Management Notes

All GUs need surveying to determine the extent of individuals and the threats present. Management will consist of securing sites from feral pigs, maintaining habitat via weed control and collecting of individuals from discrete populations for captive propagation. It may be difficult to set up a rat bait grid for many of the PUs, as the known individuals are spread over a large area. Genetic analyses will help to provide insight for management and reintroductions.

The **Kawainui Ridge GU-A**, **Kawaiiki Ridge GU-B**, and **Poamoho-North Kaukonahua Ridge GU-F** are designated as manage for stability but may be dropped due to their low numbers of individuals or difficult access due to the remote nature of sites and the distance between recently known individuals.

The **Opaepala-Helemano GU-C** is the largest with recent capture-mark-recapture studies estimating greater than 400 individuals at a single site within the GU (UH PhD Candidate Kevin Hall pers. com, 2008). The Army conducts rat control at several sites within this GU, all within the Opaepala/Helemano MU.

The **Poamoho summit trail GU-D** is the second largest known GU though recent surveys of known sites along the upper Poamoho trail have seen a large decline (Joel Lau pers. com. 2008). The Army plans to conduct surveys in this area and establish a rat control program in the area. There was a large population (90 ind.) of *A. sowerbyana* observed at **Poamoho Pond GU-E** in 2004, though recent surveys have not been conducted.

There were also a large number of individuals observed at **Lower Peahinaia GU-G**. However, this GU has not been surveyed in many years. Surveys for extant individuals in GU-G and E are high priorities for the conservation of this species.

Table 9.14 Priority Management Actions for *Achatinella sowerbyana*

Geographic Unit	Specific Management Actions	Partners/Concerns	Timeline
Opaeuia – Helemano GU C	<ul style="list-style-type: none"> • Surveys and mark recapture studies to determine the extent of the PU • Collect individuals for captive propagation • Construct predator proof enclosure 	<ul style="list-style-type: none"> • Opaeuia/Helemano fence complete 	<ul style="list-style-type: none"> • Surveys and mark recapture ongoing
Poamoho Summit and Trail GU D	<ul style="list-style-type: none"> • Surveys to determine the extent of the PU • Collect additional individuals for captive propagation • Construct Poamoho MU • Construct predator proof enclosure 	<ul style="list-style-type: none"> • On both Kamehameha schools and State Forest Reserves Land (proposed NAR) • MU needs an EA 	<ul style="list-style-type: none"> • construct Poamoho I MU, OIP yr 8; 2015 (Tier 1)
Poamoho Pond (Kaukonahua- Punaluu) GU E	<ul style="list-style-type: none"> • Surveys to determine the extent of the PU • Collect individuals for captive propagation • Construct Poamoho Pond MU 	<ul style="list-style-type: none"> • On State Forest Reserves Land (proposed NAR) • MU needs an EA 	<ul style="list-style-type: none"> • construct Poamoho II MU, OIP year 9; 2016 (Tier 2)
Lower Peahinaia GU G	<ul style="list-style-type: none"> • Surveys to determine the extent of the PU • Construct Lower Peahinaia MU 	<ul style="list-style-type: none"> • Need license agreement with landowner, Kamehameha Schools • MU needs an EA 	<ul style="list-style-type: none"> • construct Lower Peahinaia MU, MIP year 8; 2011