CHAPTER 9: INVERTEBRATE CONTROL PROGRAM

This chapter outlines alien invertebrate control actions by the Army natural resource program on Oahu (OANRP). This year's control efforts included the expansion of the number of rare plants receiving slug control, the development of a protocol to prevent accidental exposure of native snails to molluscicide, as well as surveys for, and treatment of invasive ants at several high traffic areas (primarily helicopter landing zones).

9.1 SUMMARY OF SLUG CONTROL ACTIONS JULY 1, 2017 – JUNE 30 2018

Hawaii has no native slugs. Two temperate species are well established at elevations above 1,500 feet: the marsh slug, *Deroceras laeve* and the leopard slug, *Limax maximus*. Slugs can cause dramatic declines in the survival of rare native Hawaiian plants (Joe & Daehler 2008). Slug control with molluscicide (Sluggo) was shown to encourage seedling germination and recruitment for rare plant species (Kawelo *et al*. 2012) in particular those within the Campanulaceae.

This year the number of plant populations protected from slug depredation increased 17% over previous levels and the associated area receiving treatment increased by 14%. The increase was made cost effective by transitioning to a longer lasting slug control product, FerroxxAQ (EPA Reg. No. 67702-49) which, in prior field trials (Joe 2017) was shown to be effective for up to 6 weeks. In contrast, the product we had been using since 2010, Sluggo (EPA Reg. No. 67702-3-34704) required reapplication monthly. This savings is reflected in the total annual staff time spent conducting slug control last year (July 2016-June 2017) compared to time spent this year (July 2017-June 2018). Despite the increase in treated area, the time spent by staff remained flat (Figure 1). In fact, since 2013 staff time has increased 180% while the number of plant species protected has increased 250%.

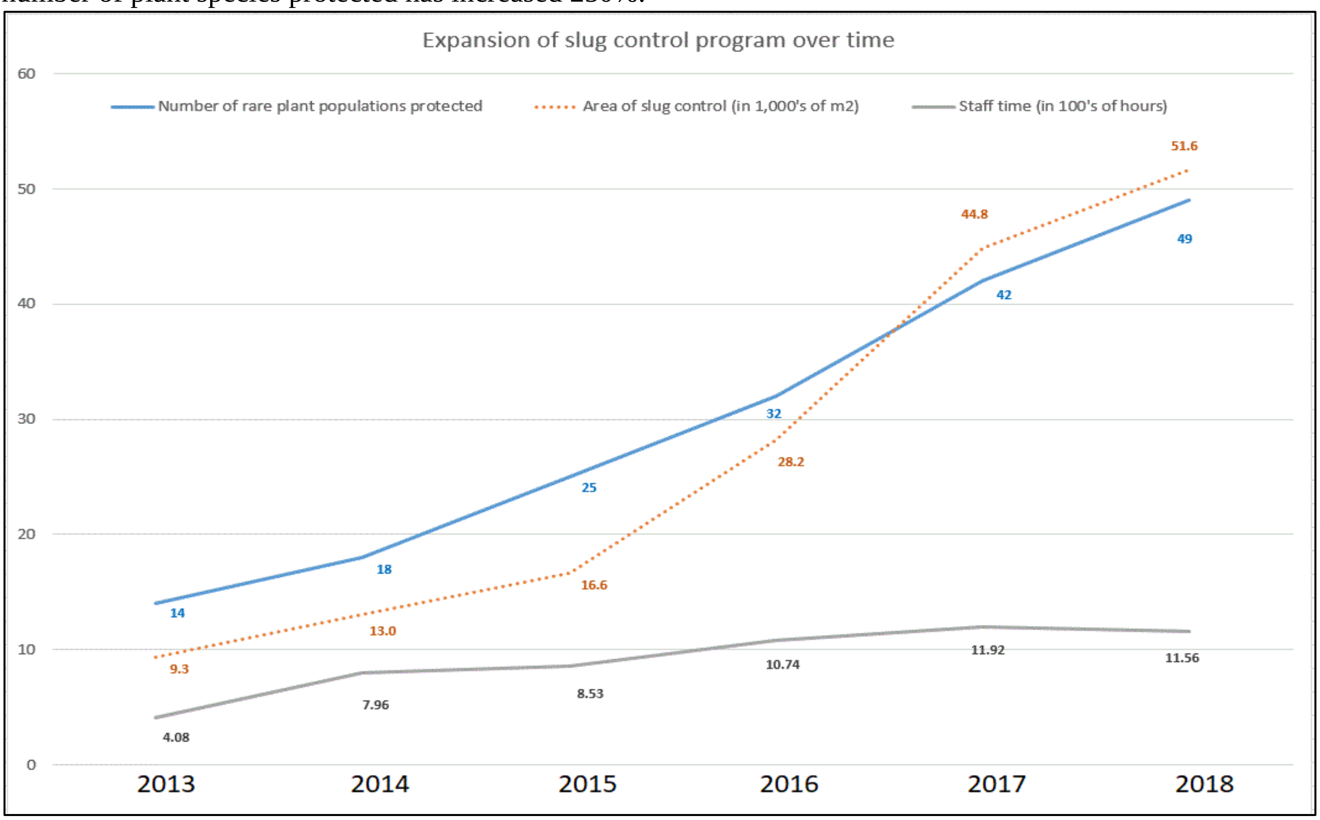

Figure 1. Line graph showing growth of slug program over time and staff effort.

Currently all high priority, vulnerable plant populations are protected from slugs with the exception of seven populations (Table 1) where the presence of rare snails precludes the use of molluscicide and at one plant population in Manuwai where treatment will begin in 2019. Due to its longer field efficacy, FerroxxAQ is the molluscicide used in all of our MUs except for Makaha where the landowner (Board of Water Supply) has approved only the use of Sluggo (Table 2).

At present, 49 rare plant populations spanning a 12.75 acre area receive slug control. Forty six percent of this treated area falls within Pahole MU which accordingly has the highest number of treated plant populations (Table 2).

Table 1. List of rare plant species exempt from slug control due to the presence of native snails

Rare plant species	Population reference code (PRC)	Snail species present	Note
Cyanea superba subsp. *superba*	MMR-H, MMR-G, MAK-A, PAH-A	*Leptachatina* spp., *Achatinella mustelina*	
Cyanea grimesiana subsp. *obatae*	PAH-C, PAK-C	*Achatinella mustelina*	PAK-C has partial slug control
Scheidea obovata	PAH-D	*Achatinella mustelina*	

Table 2. List of rare plant species undergoing slug control. Bold underlined text indicates additions for the year 2017-2018. An Asterisk (*) marks remote plant populations which, due to the difficulty of access, receive slug control at a reduced rate.

MU	Plant species treated (PRC in brackets)	Treatment area (m^2) 2017-2018	Product used/rate of application
Ekahanui	*Cyanea grimesiana* subsp. *obatae* (EKA-C) , *Delissea waianaeensis* (EKA-D), *Schiedea kaalae* (EKA-D)	3,000	FerroxxAQ/6 weeks
Kahanahaiki	*Cyanea superba* subsp. *superba* (MMR-E & MMR-H), *S. nuttallii* (MMR-E), *S. obovata* (MMR-C & MMR-G)	2,300	FerroxxAQ/6 weeks
Kaluaa & Waieli	*Delissea waianaeensis* (KAL-C), *S. kaalae* (KAL-B)	3,500	FerroxxAQ/6 weeks
Lihue	**<u>*Labordia cyrtandrae* (ALA-S), *Phyllostegia hirsuta* (ALA-A)</u>**	2,800	FerroxxAQ/6 weeks
Makaha	*Cyanea longiflora* (MAK-B), *C. grimesiana* subsp. *obatae* (MAK-B), *S. obovata* (MAK-A), *S. nuttallii* (MAK-B)	2,450	Sluggo/4 weeks
Opaeula Lower	*Cyrtandra dentata* (OPA-F)	1,500	FerroxxAQ/12 weeks*

Table 2 (continued).

MU	Plant species treated (PRC in brackets)	Treatment area (m^2) 2017-2018	Product used/rate of application
Pahole	*Cyanea longiflora* (PAH-A, PAH-I, PAH-J), C. *grimesiana* subsp. *obatae* (PAH-D), *Delissea waianaeensis* (PAH-C), *Euphorbia herbstii* (PAH-G, PAH-R & PAH-S), *Schiedea kaalae* (PAH-C), *S. nuttallii* (PAH-A, PAH-D, PAH-E,), *S. obovata* (PAH-E),	23,630	FerroxxAQ/6 weeks
Palikea	*Cyanea grimesiana* subsp. *obatae* (PAK-A & PAK-B), *C. superba* subsp. *superba* (PAK-A), *Phyllostegia hirsuta* (PAK-A), ***C. grimesiana* subsp. *obatae* (PAK-C)**	5,097	FerroxxAQ/6 weeks
Upper Kapuna	*Schiedea kaalae* (KAP-A), *Cyanea longiflora* (PIL-B, PIL-C, PIL-E & PIL-F), *S. kaalae* (KAP-A), *S. nuttallii* (PIL-B)	3,427	FerroxxAQ/6 weeks
West Makaleha	*Cyanea longiflora* (LEH-B), *S. obovata* (LEH-A, LEH-C & LEH-B), ***C. grimesiana* subsp. *obatae* (LEH-A &LEH-B)**	2,461	FerroxxAQ/6 weeks
Manuwai	*Delissea waianaeensis* (ANU-A)	1,441	FerroxxAQ/12 weeks*

9.2 Native Snail Incursion into Treatment Area

Native snail monitoring within treatment areas is crucial to prevent accidental exposure to molluscicide. On the Special Local Needs label for Sluggo, the following caution appears: “Do not apply in areas where it may come into contact with known populations of endemic Hawaiian snail species from the following rare families or subfamilies: Amastridae, Achatinellinae and Endodontidae). Bait must not be applied within 20 m of any tree known to harbor endangered Hawaiian tree snails (*Achatinella* spp.).” Accordingly, all areas which currently receive Sluggo have been extensively searched by our rare snail conservation specialist for one day and one night. Though the FerroxxAQ label contains no such stipulation, we nonetheless expect it to have a similarly adverse impact on native snails should they consume the bait. Our commitment to conserving native species led us to adopt these recommendations for the application of FerroxxAQ. Due to these precautions, on four occasions we have discontinued molluscicide application after repeated applications because of the discovery of a rare native snail. Here we describe these discoveries and outline our response.

A thorough daytime and nighttime survey does not guarantee snail detection. Snails can be hidden deep in foliage, move into or out of an area, or occur in such low numbers that an encounter would be improbable. In addition, treated areas are, generally speaking, more pristine and contain greater native plant species cover. This may prove attractive to native snails drawing them in from nearby marginal habitat. Regular, periodic monitoring is necessary to ensure native snails are not present and do not move into areas where they would be exposed to molluscicide. Prior to 2015, *Achatinella mustelina*, (family: Achatinellinae) were found in a treated area in Makaleha West and an unknown *Leptachatina* species (family: Amastridae) inhabited the gulch at Kahanahaiki. At Makaleha West we resumed treatment after moving the snails to better habitat (Joe 2014), while in Kahanahaiki we discontinued treatment indefinitely because the snails were too ubiquitous to translocate. Since that time, *A. mustelina* has been found at two additional sites, one in Palikea (October, 2016) and one in Pahole (March, 2017) (Figure 2). In each of these cases, we discontinued molluscicide treatment immediately and the Rare Snail Conservation Specialist relocated both snails into predator-proof enclosures. We eventually resumed treatment after one daytime and nighttime search yielded no additional snails. Thus, we currently treat three sites where there is a high risk of snail incursion (defined below).

Given that snails may migrate into areas undergoing treatment or be missed during the initial survey, we recommend the following protocol for areas which both receive molluscicide treatment *and* are at 'high risk' for snail occupation (a 'high risk area is one where snails have been found historically or is adjacent to areas where snails are currently found).

1. If a rare native snail is discovered, discontinue molluscicide application
2. If a subsequent day time and night time search yields no snails, *and* if the discovered snails have been relocated, then molluscicide application may resume
3. For the duration of molluscicide application, areas must be searched for native snails a minimum of once per year (daytime)
4. For two consecutive years following a rare snail find, the areas must be searched annually for at least one night in addition to the annual daytime surveys.

Figure 2. Map showing location of Palikea and Pahole snail finds and locations of predator-proof enclosures

9.3 Invasive Ant Surveys and Management

Background: There are no native ants in Hawaii. Of the approximately 45 species present, all were accidental introductions by humans. The result has been widespread colonization of disturbed and occasionally pristine areas by generalist ants that can utilize a number of resources (Krushelnycky *et al*. 2005). Ants can damage managed resources directly or indirectly. They consume rare native insects directly, as is the case where *Solenopsis papuana* was found to reduce picture wing fly (*Drosophila*) survival by 58% (Krushelnycky *et al.* 2017). Ants affect plants indirectly by reducing pollinators (Sahli *et al.* 2016) and by farming plant pests such as scales and aphids.

Methods: Our program aims for early detection of problem species, delineation of infestations of those species, and when possible, eradication. In order to accomplish this, we have carried out annual standardized surveys since 2004 across areas with a high risk of ant introduction (outhouses, out planting sites, *Drosophila* sites, campgrounds, fence lines, helipads, and roads). Ants in these areas are sampled using baited index cards left out for one hour. Counts of foraging ants at these cards also are used to measure treatment efficacy. Our methodology is outlined in Joe 2010.
Treatment of an ant infestation is only considered when one or all of the following criteria are met:
1. The infestation is <3 acres
2. The ant species present is not widespread in adjacent locations
3. The ant species present is known to harm native species.
4. The site is an area of high traffic where materials are staged prior to transport into a pristine area.

These characteristics were true of the Nike Site high elevation nursery where we eradicated *Anoplolepis gracilipes* or the yellow crazy ant (YCA) in 2011 (Joe 2012) and *Solenopsis geminata* from Peacock Flats campground (Joe 2011). Neither of these species have been detected at those sites in over 5 years. At Pualii MU we control *Pheidole megacephala* (the big headed ant) because the infestation is less than three acres. Only the fourth criteria is true for six areas where we currently conduct regular ant control: Nike Site Landing Zone (LZ), East Baseyard (Wahiawa), West Baseyard (Schofield Barracks), Kaala Road Landing Zone (Culvert 37 LZ, FAA Road), the Waianae Mountains Watershed Baseyard LZ (WMWB LZ) (Palehua) and Kaluaa LZ (Figure 5). Regular ant control is necessary at all sites to prevent transport of ants into pristine areas, however, as adjacent areas remain infested, ants inevitably recolonize over time. These sites as well as other ant sampling locations are shown in Figure 5. Four baits are used in rotation: AmdroPro (EPA Reg. No. 241-322), Provaunt (EPA Reg. No. 100-1487), MaxForce (EPA Reg. No. 432-1262) and Terro PCO (EPA Reg. No. 149-8-64405). Note that Terro is used only around buildings.

Map removed to protect rare resources

Figure 3. Map showing locations of ant control as well as ant sampling sites

Results ant treatment: After failing to control YCA using a variety of insecticides, we were successful at eradicating them at Nike Site and suppressing YCA at WMWB LZ and using Provaunt. At WMWB LZ, we reduced foragers counted at baits 90% on average (Figure 4). Additionally, the number of baits with any ants fell from 89% to 20% post-treatment (Figure 5). Ants did not recover fully from the Provaunt treatment for five months.

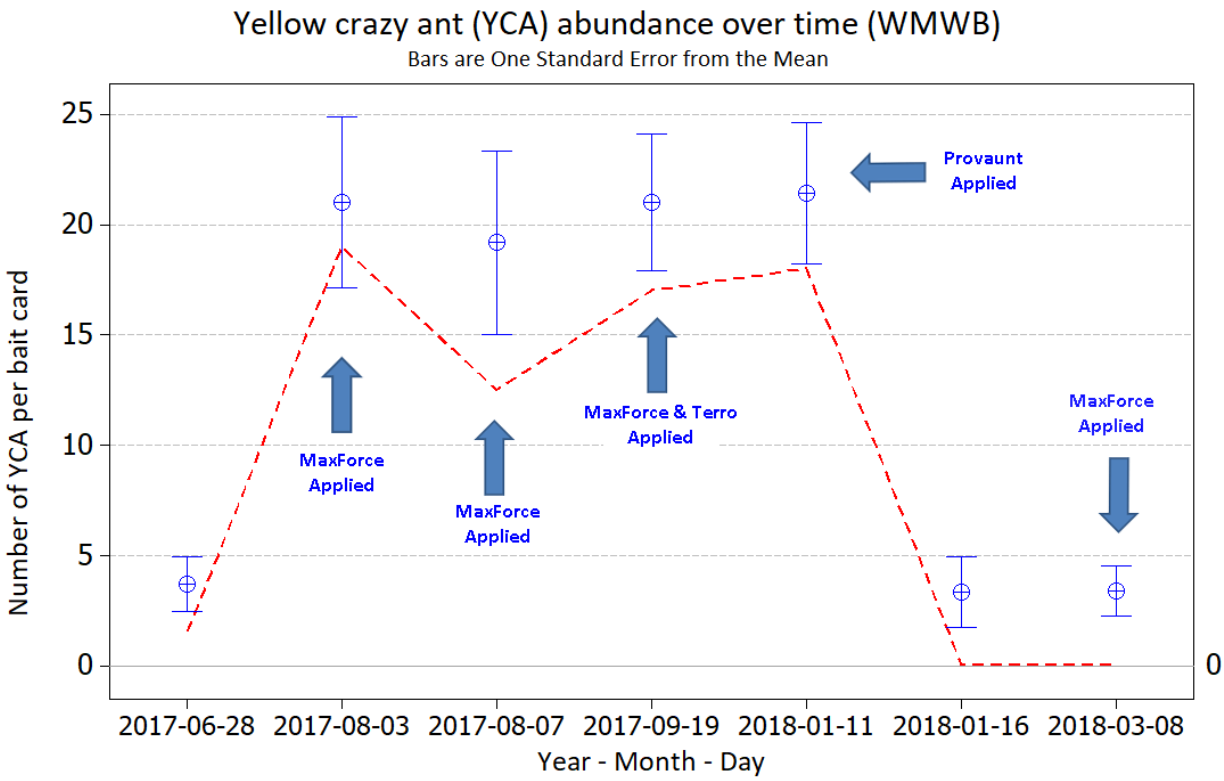

Figure 4. History of YCA treatments at WMWB showing a reduction in ants after Provaunt application. The red dotted line shows the median number of ants at each sampling station (n=53) while the blue circle shows the mean.

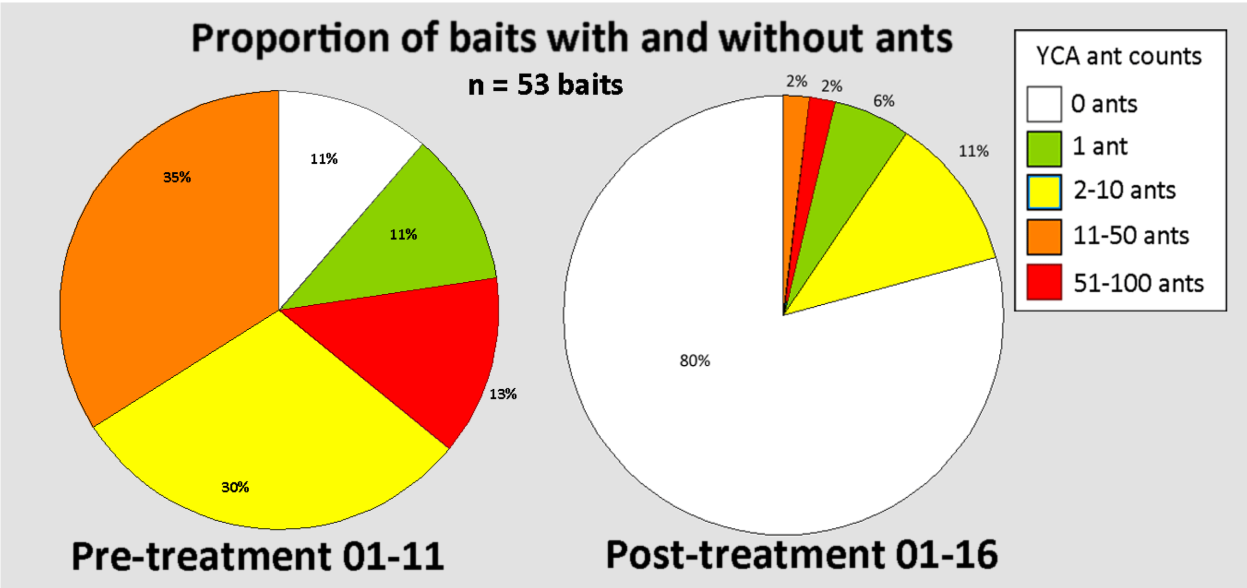

Figure 5. Proportion of bait stations with and without ants pre and post treatment at WMWB LZ

Results ant surveys: Annual ant surveys took place across 12 MUs (Figure 3). Ants both presently and historically recorded at 12 MUs are shown in Table 3. We consider any species discovered over the past three years as being present since multiple ant surveys are needed to confirm a given species is, in fact, absent. A species is considered eradicated if treatment takes place and the target is not detected for five years. Species that are among the 100 worst invaders globally are highlighted in red (Invasive Species Specialist Group [ISSG] 2018). These are defined as “recognized globally as a major threat to biodiversity (the collected wealth of the world's species of plants, animals and other organisms) as well as to agriculture and other human interests.”

It is clear from Table 3 that ants are ubiquitous throughout most of the MUs sampled. Of the 14 MUs surveyed, 12 or 86% are known to have ants. Though not included here because it was discovered outside of the reporting period, the thief ant (*Solenopsis papuana*) *is* present in Opaeula Lower bringing the number up to 93%. The thief ant (a threat to *Drosophila*) is also most commonly encountered ant (Table 4). AmdroPro is known to be effective against the thief ant, however, as it is an insecticide, when used to mitigate threats to *Drosophila*, it may have unintended impacts. Research is currently underway to determine its effect on non-target insects (P. Krushelnycky *pers. comm*.). Currently we do not apply insecticides where there are endangered *Drosophila*. This precludes treatment at Puu Hapapa, Opaeula Lower and Palikea. Treatment for the big-headed ant can and will take place in 2019 at Ohikilolo and at Upper Kapuna. There are no approved insecticides safe to use near water so ants at Makaha cannot be treated at this time. Staff are instructed to be vigilant about inspecting gear at the Makaha trailhead (*i.e.* not setting food or backpacks on the ground) so as not to transport *Anoplolepis gracilipes* to higher elevations.

Table 3. Table showing recent and historical ant occurrence in 13 Management Units (MUs). Species in red are considered a high threat by ISSG (2018)

Management Unit (MU)	Current species (detected within the last 3 years)	Species detected prior to Jan. 2015
Ekahanui	*Solenopsis papuana*	*Plagiolepis alluaudi*, *Technomyrmex albipes*
Kaluaa (Trailhead & Puu Hapapa)	*Pheidole megacephala*, *Plagiolepis alluaudi*, *Solenopsis papuana*	*Pheidole fervens*, *Technomyrmex albipes*
Kaala (Boardwalk & Campsite)	*Cardiocondyla kagutsuchi*, *C. venustula*, *Plagiolepis alluaudi*, *Solenopsis papuana*, *Tetramorium simillimum*	*Cardiocondyla minutior*, *C. wroughtoni*, *Ochetellus glaber*
Kahanahaiki (Snail Enclosure & Fenceline)	*Ochetellus glaber*, *Pheidole megacephala*, *Plagiolepis alluaudi*, *Solenopsis papuana*	*Anoplolepis gracilipes*, *Cardiocondyla emeryi*, *C. kagutsuchi*, *C. obscurior*, *C. venustula*, *C. wroughtoni*, *Leptogenys falcigera*, *Solenopsis geminata*
Koloa	No ants	
Opaeula Lower	No ants	
Makaha (Trailhead & Kumaipo LZ)	*Anoplolepis gracilipes**, *Solenopsis papuana*	*Technomyrmex albipes*
Ohikilolo	*Pheidole megacephala*, *Plagiolepis alluaudi*, *Solenopsis papuana*	*Anoplolepis gracilipes*, *Ochetellus glaber*
Pahole (Snail Enclosure)	*Ochetellus glaber*, *Plagiolepis alluaudi*, *Paratrechina bourbonica*, *P. vaga*, *Technomyrmex albipes*, *Tetramorium bicarinatum*, *Tet. simillimum*, *Solenopsis papuana*	*Anoplolepis gracilipes*, *Leptogenys falcigera*, *Cardiocondyla emeryi*, *C. obscurior*, *Solenopsis geminata*
Palikea (Snail Enclosures, Fenceline & Maunakapu)	*Cardiocondyla kagutsuchi*, *Pheidole megacephala*, *Solenopsis papuana*	*Cardiocondyla venustula*
Pualii North	*Pheidole megacephala, Solenopsis papuana*	
Kapuna Upper (Trailhead & Cabin)	*Pheidole megacephala*, *Solenopsis papuana*	

*Only present at the parking lot, not in the forested area

Table 4. Ant species occurrence (not including species that occur in only 1-2 Units) by number of Management Units 2004-2018

Species	Number of MUs with species	Proportion of MUs sampled, positive for species
Solenopsis papuana	10	71%
Plagiolepis alluaudi	8	57%
Anoplolepis gracilipes	7	50%
Pheidole megacephala	7	50%
Ochetellus glaber	6	42%
Technomyrmex albipes	4	28%
Leptogenys falcigera	3	21%

Results *Wasmannia auropunctata* surveys: Since its first record on Oahu in December 2013, we have surveyed areas on base (Schofield Baracks and Wheeler Army Airfield) as well as pesticide and soil providers to prevent *Wasmannia auropunctata* (the Little Fire Ant or LFA) from establishment. No LFA was detected during any of these surveys (Table 5).

Table 5. Table showing LFA survey details July 2017-June 2018

Location	Date surveyed	Ants detected
BEI Chemicals and Fertilizers 311 Pacific St # B, Honolulu	July 27, 2017	No ants
New housing area on junction of Lyman and Iolani Road, Schofield Barracks	July 27, 2017	*Anoplolepis gracilipes, Pheidole megacephala*
Garden store PX, 903 Cadet Sheridan Road, Schofield Barracks	July 27, 2017	*Pheidole megacephala*

9.4 Rapid Ohia Death Detection

Rapid Ohia Death (ROD) is a disease caused by two fungal pathogens. *Ceratocystis lukuohia* and *Ceratocystis huliohia*. Both of these fungal pathogens kill ohia, (*Metrosideros polymorpha*) Hawaii's most abundant native tree. Both fungi are widespread on the Big Island and *C. huliohia* was found on Kauai in early 2018. It threatens to establish on Oahu. Following recommended decontamination guidelines (CTAHR 2018), we took samples from three ailing trees in Makaha and sent them to USDA in Hilo for testing. All tested negative for the disease. We assist the Oahu Invasive Species Committee to conduct aerial surveys for ROD twice yearly on Schofield Barracks West Range. We remain vigilant to the threat ROD poses and our staff have been briefed on the signs and symptoms of ROD.

9.5 Coconut Rhinoceros Beetle (CRB) Detection and Trapping

CRB was first detected on Oahu in December 2013. Adults attacks palms, agave, sugarcane, banana and pineapple (USDA 2018). It is therefore a threat to agriculture and to the endangered palm *Pritchardia kaalae*. OANRP currently maintains 18 CRB traps spread throughout Wheeler, Schofield and Wahiawa, with a single trap at Dillingham (Figure 6). These are placed near palms and at mulch sites and are checked once every two weeks. Lures are replaced every two months. We have maintained these traps since February 2014. No CRB have been detected at any traps during these period. All information is relayed to HDOA and integrated into CRB distribution maps on Oahu.

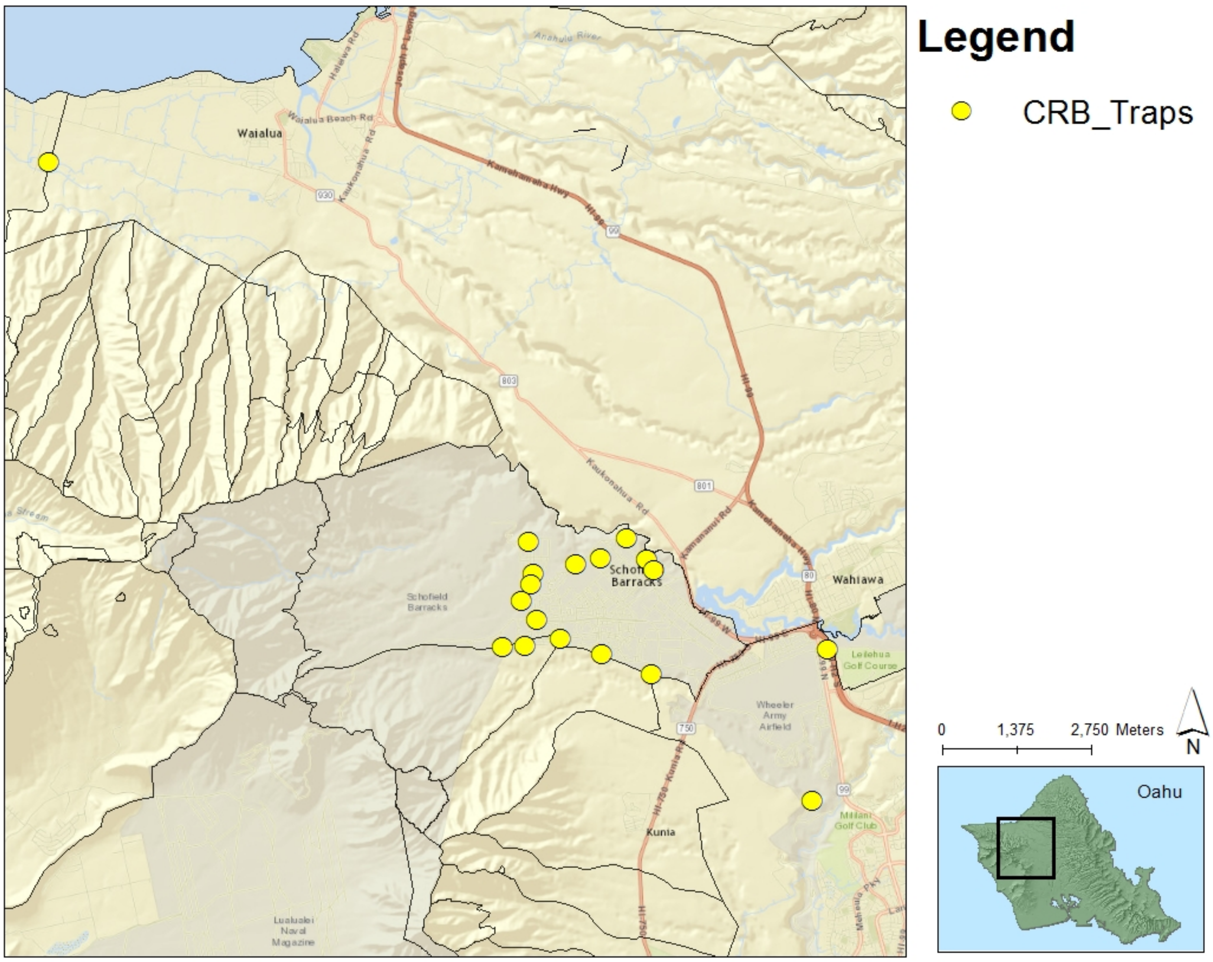

Figure 6. Map of CRB traps maintained by our program

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