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Pōhakuloa Training Area's Natural Resources Office takes action to preserve the Mauna Kea *pāmakani* during extreme drought

By Tiana Lackey

THE MAUNA KEA *pāmakani* (*Tetramolopium arenarium* ssp. *arenarium*) is a member of the sunflower family that was listed as endangered in 1994. In the wild, these species are now only found at Pōhakuloa Training Area (PTA) on the island of Hawai'i (U.S. Fish & Wildlife Service [USFWS], 2003). The primary threats to this species include: feral ungulates, who eat the plants; competition from invasive plants; and fire. Over the past year, drought has emerged as an additional threat to this and other listed species at PTA.

The National Weather Service recently announced that the 2009-2010 Hawaiian Islands wet season was the driest in the past 30 years, and the National Drought Mitigation Center has ranked Hawai'i as the driest state in the nation (National Weather Service, 2010). On July 19, 2010, the U.S. Department of Agriculture (USDA) designated all four Hawai'i counties as primary natural disaster areas due to losses caused by the continuing drought (USDA Farm Service, 2010). Most of PTA is currently experiencing extreme (D3) or exceptional (D4) drought.

Rainfall between January and July 2010 in Mauna Kea *pāmakani* habitat totaled 1.19 centimeters (0.47 inches), about 3% of the normal annual average. The dry winter has had a serious impact on Mauna Kea *pāmakani* population numbers. The number of individuals dropped from 693 in 2006 to just 27 in June 2010, with the greatest decline (80%) between 2009 and 2010.

PTA Natural Resources Office (NRO) staff deter-

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mined that the viability of the only known population of Mauna Kea *pāmakani* would be unsustainable without taking action.

As a result of the current drought and the rapid increase in mortality of the Mauna Kea *pāmakani*, the PTA NRO decided to initiate an emergency management response. Managers re-prioritized program resources in order to initiate a supplemental watering effort. The goal of the watering effort was to sustain the remaining plants until the onset of normal



Water-stressed Mauna Kea *pāmakani* (left), on the first day of watering. The same plant (right), three months later, showing improved plant vigor. (Photos by Tiana Lackey, left; and Lisa Castle, right, PTA-NRO)

rainfall levels.

Weather data were analyzed to determine the amount of water that would be needed to simulate a meaningful rainfall event. NRO staff determined that approximately ½-gallon of water per plant would be adequate, so drip-irrigation bottles were used to deliver this amount to each plant over four hours.



Drip irrigation bottle used to provide supplemental water to the Mauna Kea *pāmakani*. (Photo by Mona Tatum, PTA-NRO)

Army biologists tracked the following information for each plant: location; plant identification number; vigor; evidence of browse; number of reproductive structures; presence/absence of ants and scale; and percent cover of weeds. Biologists also took pictures

of each plant on a rotational basis to record visible changes in plant vigor.

Plants were initially watered once a week, and after eight weeks, the frequency of the watering was reduced to once every two weeks.

In June, 2010, there were 27 naturally occurring Mauna Kea *pāmakani* at PTA, however only 4% of these plants were healthy, with 96% in poor or moderate health. As of October 6, this population of Mauna Kea *pāmakani* consisted of 8 adults and 4 juveniles. Even though 15 of the 27 plants (or 56%) have died since watering began in June, the health of the remaining plants has dramatically improved. Of the 12 individuals that were alive in October, 92% were healthy and 8% were in moderate health.

Additionally, 58% of the remaining plants had reproductive structures, a hopeful sign for reproduction and a potential contribution to the seed bank.

As supplemental watering for the Mauna Kea *pāmakani* continues, difficult questions have arisen for NRO managers to consider, including:

1) Will supplemental plant watering produce unforeseen or unintended consequences? For example, after four days of supplemental watering, invasive ants and scale (previously unobserved) were found

on 62% of the plants.

2) What potential effects will continued trampling and soil compaction (due to the watering procedures) have on the plants?

3) Significant resources have been allocated to save the few remaining plants, but at what point does this sacrifice become detrimental to other conservation measures at PTA? Disproportionate allocation of limited personnel and financial resources toward one species may have negative consequences for others, especially during extreme climate conditions.

4) How will the NRO staff proceed if ultimately the survival of this species becomes dependant on continued intensive management?

These guiding ecological and philosophical questions will continue to be discussed by managers. The immediate question of how long to water the plants is the least difficult to answer. Resource managers have installed a rain gauge at the site to help determine when natural rainfall is adequate to reduce or cease supplemental watering. Until enough rainfall data are acquired to make a responsible determination, the dedicated staff at the PTA NRO will continue to devote time and resources to preserving the endangered Mauna Kea *pāmakani*. •

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ACKNOWLEDGEMENTS:

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~Tiana Lackey is a botanical coordinator with CSU-CEMML, working for the PTA Natural Resources Office.

Tiny alien snails put natural resource managers in a salty situation

By Candace Russo

IN LATE 2008, the O'ahu Army Natural Resources Program (OANRP) discovered both their low- and mid-elevation endangered plant nurseries harbored several species of alien snails. *Please see "Alien Snails Found in Plant Nurseries – Can We Keep Them Out of Our Native Forests?" insert following this article for more information and a list of species.*

The OANRP's policy requires all plants be free of pests prior to outplanting back into the wild, so the alien snails discovery presented a challenge.

"We had to decide whether or not we should halt all planned outplanting activities even though initially only some of the plants had snails," said Matt Keir, rare plant program manager for the OANRP. "At that time, we did not have a way to thoroughly check all the plants, so the decision was made to stop all planting and start inspections."

There were no records of any of the alien nursery snails yet in the forest outplanting sites, based on several prior years' snail surveys, and the OANRP—a program responsible for protecting native, endangered species—was not about to introduce a new alien species into the very ecosystems they are working to protect.

The alien snails found in the nurseries could damage native and endangered plants, and may be a threat to native snails, some of which are also endangered. Specifically, the alien snails have the potential to compete with native snails or to provide a food source for carnivorous alien snails such as *Euglandina rosea* or *Oxychilus* spp., which are already a threat in Hawaii's forests because they are known to eat native snails (*please see "Extent of threats posed by non-native garlic snail (Oxychilus alliarius) still unknown" in this EMP issue*).

Although the decision to halt outplanting was not easy, the real challenge was yet to be faced – how to eradicate alien snails from the nursery plants. The first step was to keep any potentially infested outside material from entering the OANRP nurseries.

In 2008, the OANRP was receiving common native plants for restoration use from other local

nurseries. Unfortunately, these plants were later found infested with alien snails prior to entering the OANRP facilities. To solve this part of the problem, the OANRP ceased accepting material from other nurseries.

The next step was to focus on eliminating the problem inside the nurseries. In the beginning, a hot-water plant "shower" was employed, on loan from the Hawai'i Department of Agriculture. Although this method worked on several of the snail species tested (*Zonitoides arboreus* and *Liardetia doliolum*, specifically), it did not work to eliminate *Succinea tenella*. Moreover, seven of the 26 endangered plant species that were tested in the hot water shower did not survive, which was "unacceptable," according to Lauren Weisenberger, propagule management specialist for the OANRP.

Instead, all nursery benches were power-washed, bleached and placed in buckets of salt to prevent movement of new snails onto the benches. Each of the roughly 4,500 plants was then meticulously examined visually (on the plant, on the pot, on the soil surface and in the soil when the plant was removed from the pot) for alien snails and their eggs,



Alien snails (circled in red) hide in the soil of one of the plant pots at the O'ahu Army Natural Resources Program nurseries. (Photo by OANRP staff)

the smallest of which are mere millimeters in length. Plants were grouped by degree of snail infestation, and weekly monitoring ensued. Some plants were even re-potted, removing all soil and replacing with "clean" soil.



Nursery benches are seated in pots filled with salt pellets to prevent new snails from migrating to the plants. (Photos by OANRP staff)

Following several weeks of painstaking snail inspections (called “snailing” by staff), a refined method was developed. Bits of lettuce (a favorite snail food) were placed as bait on the soil surface of each plant and covered with a small pot. Two days later, the relatively simplified task of checking the lettuce baits became the standard task.

Concurrently with these manual control methods, all nursery facilities received the chemical methiocarb as a drench, along with metaldehyde baits, according to recommendations resulting from the work by Hollingsworth & Armstrong, 2003. The horticulture staff also scheduled regular metaldehyde drench treatments for all of the plants.

These sanitation protocols have successfully eradicated all the alien snails except for *Z. arboreus*.

Because *Z. arboreus* remains, the snail-proofing continues. Romaine lettuce, bought in bulk, loads one side of the OANRP baseyard refrigerator. Three days each month, staff continues snailing by examining lettuce baits, placing new baits, and belly-crawling under greenhouse benches to refill salt buckets.

“If a pot on a bench is found to have a snail, the entire bench is checked every other week,” Weisenberger said.

“For *Z. arboreus*, the OANRP protocol requires

that all plants must be found snail-free for ten months before they are deemed safe for outplanting” she added.

Today, almost two years after the first snails were discovered as a widespread problem in the OANRP nurseries, the infestation has been contained to only a single bench of plants and a “living collection” (collection of plants kept as a genetic “safety-net,” not to be outplanted) of *Flueggea neowawraea* at the mid-elevation nursery site.

This progress does not mean that OANRP snailing days are over.

“We are assuming (based on observations) that *Z. arboreus* are naturalized at the mid-elevation nursery grounds,” Keir said. “Barriers must be maintained even after the *Flueggea* and the last bench are clean.”



O’ahu Army Natural Resources Program staff place lettuce pieces on the soil surface of endangered plants - covering each piece with a small pot - to bait for alien snails. (Photo by OANRP staff)

To help better understand this situation and further refine their nursery sanitation protocols, the OANRP staff has plans to consult with Dr. Rob Cowie, a research professor at the Pacific Biosciences Research Center of the University of Hawai’i, who specializes in terrestrial and freshwater snails.

As for the common native plants used for restoration, several alternative methods are being explored. Seed collection and sowing of *Bidens torta* were found to work well in forested field sites; a field nursery has been established at the Kahanahāiki forest to grow Koa (*Acacia koa*) on site; and a trial is in

the works to measure the success rate of transplanting common natives from degraded areas, unprotected from damage by wild pigs and goats, into fenced areas.

These alternatives will enable OANRP to continue restoration efforts using common native plants without compromising the endangered species.

“Once inspection and treatment protocols are proven, [the OANRP] will be able to share them with local nurseries so they are able to supply clean plants in the future,” Keir said.

Despite setbacks, strict nursery sanitation protocols have enabled the OANRP to add 3,165 snail-free endangered plants to O’ahu’s native forests over the last two years—and the next season of outplanting is just around the corner. OANRP staff plans to resume its standard schedule for endangered plant reintroductions, confident that no alien snails will be introduced in the process. •

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~Candace Russo is an environmental outreach specialist with RCUH/PCSU, working for the O’ahu Army Natural Resources Program.



O’ahu Army Natural Resources Program’s low-elevation nursery. (Photo by Dietra Myers Tremblay, OANRP)

Alien Snails Found in Plant Nurseries - Can We Keep Them Out of Our Native Forests?



The O'ahu Army Natural Resources Program (OANRP) maintains two endangered plant nurseries where propagules are raised for genetic storage and to be outplanted back into the wild. In 2008, it was discovered that much of the nursery stock are harboring multiple species of alien snails. It has been shown that horticultural facilities act as critical vectors for many alien snail and slug species, highlighting the need for greater awareness about these species (Cowie et al., 2008). The purpose of this informational flyer is threefold: 1) to provide additional information for any agencies/organizations conducting out-plantings in the wild by highlighting the species found in OANRP nurseries; 2) to garner any information that the horticultural, botanical, and conservation community may have regarding quarantine and eradication methods; and 3) to garner any information the horticultural, botanical, and conservation community may have regarding known distribution of these alien snail species in the wild.

Five snails of concern:



Zonitoides arboreus



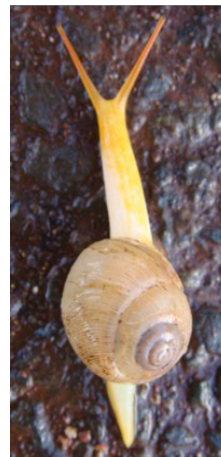
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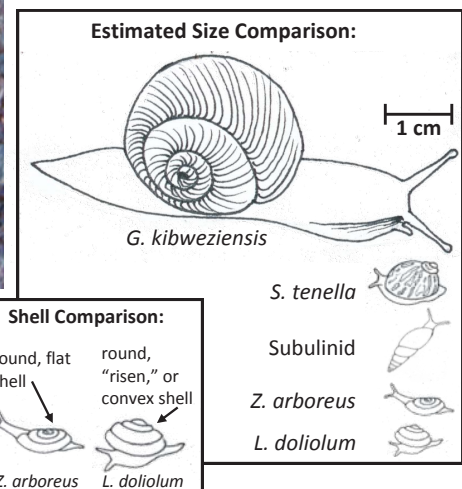
Liardetia doliolum



Succinea tenella



Gonaxis kibweziensis



RISKS associated with accidental forest introduction:

- Competition with native snails for food
- Increased prey for snail predators
- Potential to transmit diseases to native snails (currently little known)
- Possibly affecting plant health (currently little known)

OANRP's current QUARANTINE & ERADICATION methodology:

- Potted plants are routinely baited with lettuce to attract snails, and lettuce and soil below lettuce are examined for snail presence.
- If, following 10 months of visual examination, snails are never found, then plants are cleared for outplanting.
- If snails are found, infected plants are treated with metaldehyde (Hollingsworth & Armstrong, 2003; Hollingsworth pers. comm., 2009).
- Nursery facilities are drenched with metaldehyde, all equipment is power-washed, all stock is kept on benches seated in salt pellets.

If you can provide additional information about these snail species, methods for control in the nursery, or have seen them in the wild, please contact: Matt Keir, OANRP Rare Plant Program Manager (matthew.keir@us.army.mil)

References:

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The above flyer was distributed to local horticulturists by the OANRP following discovery of alien snails in their nursery facilities. (Compiled by Matt Keir & Candace Russo, OANRP; updated October, 2010.)

Volunteers lend a hand to help improve Nōi habitat

By Kim Welch

AS I SWITCHED to 4-wheel drive mode to navigate a deeply rutted dirt road in Kahuku Training Area, I was gratified to hear the eager and encouraging comments from the volunteers in the back seat.

"You've got it...we're almost to the top!" shouted one.

"This trip just gets better and better," said another, sounding genuinely happy about the rugged ride.

Yes, these were clearly just the right group of volunteers for today's task.

The O'ahu Army Natural Resources Program (OANRP) regularly leads volunteer trips to support its mission of managing endangered species on Army installations and training areas. However, on September 27, 2010 the volunteer effort was part of a much larger national volunteer movement - National Public Land's Day - engaging more than 170,000 volunteers in hands-on efforts to care for natural resources at more than 2,000 sites across the country.

This particular OANRP volunteer trip aimed to control invasive weeds within the mid-elevation mesic forest of Pahipahi'ālua, in Kahuku Training Area (KTA). Along with three staff from the OANRP, DPW Environmental Division (including the Chief of



Volunteer Josephine Hoh (front) and Candace Russo, an OANRP outreach specialist (back), transplant a native Hawaiian sedge (*Carex wahuensis*) into an area of Pahipahi'ālua forest that was cleared of invasive weeds on September 27, 2010 as part of National Public Lands Day. (Photo by OANRP staff)

the Natural Resources Section, Michelle Mansker), four brave volunteers answered the call for weeding support.

The volunteers were diverse in their professional backgrounds: a botanical gardens manager, a lawyer, a chemist, and a horticulturalist yet, their passion for caring for Hawai'i's native forest brought them together for a day of invasive weed control.

As an added incentive, the day's trip targeted weeds that were encroaching on a population of one of O'ahu's rarest trees: the endangered nōi, or *Eugenia koolauensis*.

Armed with clippers and hand-saws, the group spent several hours clearing a hillside of shoulder-height weeds known as Koster's Curse (*Clidemia*

hirta), presumably named after the man who introduced this highly invasive plant to Hawai'i.

The rewards for this day of hard work were plentiful: the opportunity to experience a day in a remote native forest; a chance to meet new friends; and the satisfaction that comes with help-

Nōi

According to ancient legend, the nōi, (along with the 'ohe, and kauila trees) are said to be possessed by poison gods and are regarded as having mana (power). To tamper with the trees or the wood, especially in places of worship, is to invite serious trouble.

There is the saying....He iki nōi of Paka'alana (*lit. A small nōi of Paka'alana*), which could be used to describe a small but very powerful person.



Michelle Mansker, chief, Natural Resources Section, DPW Environmental, clears the invasive weed Koster's Curse (*Clidemia hirta*) from a steep slope in Pahipahialua forest, KTA, on a National Public Land's Day volunteer trip on September 27, 2010. (Photo by OANRP staff)

ing to restore the critical habitat that an endangered Hawaiian species depends on. An added bonus was the discovery of several endangered *E. koolauensis* seedlings, growing beneath the invasive weeds that were cleared away.

We ended the day by planting 30 native Hawaiian plants into the weeded area (transplanted from a high impact area along a footpath), in hopes that one day, this small hillside in Pahipahi'ālua would be reclaimed as native forest.

Our sincere thanks goes out to all volunteers who help OANRP protect O'ahu's remaining native forest treasures. •

Small isolated populations of *Eugenia koolauensis*, or nioi, were discovered in the KTA area in 1993 by the Hawai'i Heritage Program. Since then, OANRP staff and volunteers have worked to control both invasive and incipient weed species around these populations. In addition, in 2006 OANRP staff constructed fences around the known *E. koolauensis* populations to protect the young saplings and seedlings from wild pig damage.

Currently, the greatest threat to this endangered tree is a non-native plant pathogen, *Puccinia psidii* rust, which has had devastating effects on the remaining populations of *E. koolauensis*. OANRP staff plans to initiate a three-pronged approach for controlling the *P. psidii* on the KTA *E. koolauensis*, including: (1) the removal of alien tree species that serve as hosts for *P. psidii*, particularly those upwind of *E. koolauensis*; (2) propagating *E. koolauensis* from cuttings taken from trees showing lowest disease incidence; and (3) with permission from the Hawai'i Department Agriculture, begin field-testing fungicides, if proven effective and not phytotoxic to *E. koolauensis*.



Eugenia koolauensis
(Photo by OANRP staff)

~Kim Welch is an environmental outreach specialist with RCUH/PCSU, working for the O'ahu Army Natural Resources Program.

Extent of threats posed by non-native garlic snail (*Oxychilus alliarius*) still unknown

By Stephanie Joe & Candace Russo

Invasive Species Memo...

Name: *Oxychilus alliarius*, a.k.a. "Garlic Snail" (a non-native, predatory snail)

Current location in Hawai'i: All main Hawaiian Islands – Kaua'i, O'ahu, Moloka'i, Lāna'i, Maui, Hawai'i

Native to: Europe (there are no native *Oxychilus* species in Hawai'i)

Diet: Predatory/Scavenger – may eat plant material, but prefers and actively preys on other snails.

ALTHOUGH THE NON-NATIVE garlic snail (*Oxychilus alliarius*) was first recorded on the Hawaiian Islands in 1937 (Cowie, 1997), the effects of its predatory behavior on native Pacific Island land snails has yet to be quantified.

This snail's shell (less than 1 cm) is shiny and smooth with a red-brown coloration. The body is black-blue and smells like garlic when disturbed. Scientists know that *O. alliarius* is found over a wide range of elevations, from as low as about 1,300 ft, up to almost 5,000 ft, and that it can be found on all the main Hawaiian Islands. However, detailed information about *O. alliarius* and their effects on native land snails, including endangered tree snails, is lacking.

There is some evidence that the diet of *O. alliarius* in a laboratory setting is restricted to prey smaller than the endangered tree snails (*Achatinella* spp.) found on O'ahu, <3 mm shell size (Meyer and Cowie, in press). However, University of Hawai'i researcher Dr. N. Yeung has observed *O. alliarius* consuming larger prey in the field, such as rare native snails in the genus *Auriculella*.

The vast majority of Pacific Island land snails are small, with either adult or juvenile stages of <3 mm in shell length. This, combined with the information collected from field observations, indicates that *O. alliarius* is a potential threat to many of Hawai'i's native land snails, including members of several families such as Succineidae, Achatinellidae (specifically

Tornatellides spp. and *Auriculella* spp.), and Helicari-
onidae (specifically *Philonesia* spp. and *Kaala* spp.).

On O‘ahu, *O. alliarius* have been found at Mt.
Ka‘ala (4,000 ft. elevation), which is also home to
many of the aforementioned native snails and the
endangered k‘ahuli (*Achatinella mustelina*).



Oxychilus alliarius feeding on a 7 mm *Auriculella* snail
from Mt. Ka‘ala. (Photo courtesy of Patrick Curry &
Jaynee Kim)

If you are hiking at this elevation on O‘ahu keep
an eye out for *O. alliarius*, but beware, there are
other native land snails, *Kaala subrutila* and *Philone-
sia* spp., that look very similar to *O. alliarius*! All of
these small (adults are approx. 1 cm) snails share a
similar round, flattened shell akin to the shape of a
cinnamon bun.

A few distinguishing features may help with
identification: *K. subrutila* is found only at Ka‘ala, and
nowhere else in the world, so if you’re not at Ka‘ala,
you likely won’t see this snail; *Philonesia* spp. are not
restricted to Ka‘ala; *K. subrutila* and *Philonesia* spp.
both have bright yellow speckles on their shells and
O. alliarius do not; also, the soft-bodied “head” of *O.
alliarius* has a bluish-black color to it – this area on
K. subrutila and *Philonesia* is brown to grey in color.
Because these features are subtle, it can be difficult
for the layperson to rely on visual clues alone for an
accurate identification.

Invasive species, no matter the size, have the
potential to affect Hawai‘i’s native species, many of

which are already very rare, as is the case for most
of Hawai‘i’s native land snails. Because of this, the
O‘ahu Army Natural Resources Program (OANRP)
is responding to the need for further research on
O. alliarius. An upcoming project, funded by the
OANRP and conducted by Dr. Norine Yeung from the
University of Hawai‘i, will investigate the extent of *O.
alliarius* spread, population densities and the effects
on native species. •

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~Stephanie Joe is a research
specialist with RCUH/PCSU,
working for the O‘ahu Army
Natural Resources Program.

~Candace Russo is an environ-
mental outreach specialist
with RCUH/PCSU, working
for the O‘ahu Army Natural
Resources Program.



Collage of native *Achatinella* tree snails.
(Photos and arrangement by Jamie Tanino, OANRP)



Staff Spotlight

...because it's always nice to put a face with a name!

O'ahu Army Natural Resources Program's
Rare Snail Conservation Specialist

Vince "Snail Man" Costello



Vince Costello has been with the OANRP since the program began, in 1995. He is currently the Rare Snail Conservation Specialist, working with all OANRP staff, local researchers and partner organizations to protect endangered tree snails on Army land. Vince spends many nights on camping trips in the Ko'olau and Wai'anae mountains searching for snails by flashlight (they are active at night and their shells reflect light, making them easier to spot). Several of Vince's current projects include: establishing a new snail enclosure for a population of *Achatinella mustelina* critically threatened by the carnivorous snail, *Euglandina rosea*; conducting population counts using capture-mark-recapture techniques; and coordinating an effort to use snail-sniffing dogs to help natural resource managers locate *Euglandina* in areas where endangered kähuli (*Achatinella* spp.) snails are found.

PHOTOS: 1. Searching for *Euglandina* used to train the dogs.

2. *A. bulimoides* 3. Conducting snail counts at Palikea.

4. *A. lilia* 5 & 6. Searching for snails. 7. *A. livida*

8. *A. mustelina* 9. *A. sowerbyana* 10. *A. byronii*

11. Accessing remote mountain areas, prime habitat for endangered tree snails, often involves a helicopter and miles of hiking.

'Tis the Season...

A U T U M N

As the days of Autumn unfold, the appearance of creamy white inflorescences on the endangered *Cyanea superba* subsp. *superba*, or Hāhā, highlight isolated shady gulches along the Wai'anāe Range.

Reaching heights up to six meters, these blooming native lobelias are a sight to behold. Resembling an exquisite chandelier, each plant sends out numerous flowering pendants, dangling beneath the shelter of glossy green oblong leaves.

The flowers, clustered at the end of each pendent, curve inward. Scientists believe that *C. superba* (as well as many of Hawai'i's lobelia) may have co-evolved with native honeycreeper birds, with beaks perfectly shaped to fit the curvature of the flowers.



Cyanea superba ssp. *superba* (Photo by OANRP staff)

Hāhā

VOLUNTEER *Opportunities*

DECEMBER

EVENT: Kahanahāiki volunteer service trip

DATE: Tuesday, December 14

PURPOSE: Invasive weed control & plant monitoring

TERRAIN: Some steep slopes, moderate difficulty

For more information about
O'ahu Army Natural Resources Program
volunteer opportunities, or to be added to our
monthly e-mail posting of all public events,
please contact

Kim Welch or Candace Russo:

kmwelch@hawaii.edu

candace.r.russo@us.army.mil

EMP *Bulletin*

Editors

Candace Russo and Kim Welch
Environmental Outreach Specialists
O'ahu Army Natural Resources Program
RCUH / PCSU
Directorate of Public Works
U.S. Army Garrison - Hawai'i
Schofield Barracks, HI 96857-5013

candace.r.russo@us.army.mil
kmwelch@hawaii.edu

The success of this newsletter depends on article contributions from the staff of the O'ahu Army Natural Resources Program, O'ahu Army Cultural Resources Program, PTA Army Natural Resources Program, and PTA Army Cultural Resources Program. Mahalo to all staff who have contributed to this issue.

*If you wish to contribute an article or have an idea for an article you'd like featured in the next Ecosystem Management Program Bulletin, please feel free to contact us! The deadline to submit articles for the next issue is **December 15, 2010**.*



Robert Eastwood
Director of Public Works
U.S. Army Garrison - Hawai'i