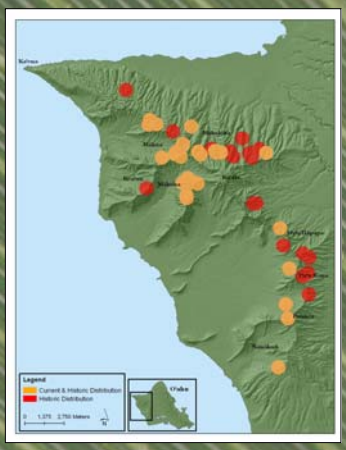
Managing *Flueggea neowawraea* on O‘ahu

O‘ahu Army Natural Resource Program

Joseph Rock considered *Flueggea neowawraea* rare when he first described it in 1913 in The Indigenous Trees of the Hawaiian Islands. His *Neowawraea phyllanthoides* was described from the first four trees found on the southern slopes of Mauna Loa. Since Rock’s description, *F. neowawraea* has been reported from Hawai‘i, Maui, Moloka‘i, Kaua‘i, and the Wai‘anae Mountains of O‘ahu. It was not recognized as a species of *Flueggea* until W. John Hayden’s revision based on analyses of wood anatomy and seed and floral morphology (Hayden 1987.) In the last few years the O‘ahu Army Natural Resources Program (OANRP) has been working with the State of Hawai‘i, Board of Water Supply, and the Navy to stabilize *F. neowawraea* on O‘ahu. In the past few years many of the techniques vital for species recovery have been developed. These include successful vegetative propagation techniques, seed and pollen storage methods, hand-pollinations, reintroduction strategies, and a known life history. All trees on O‘ahu show signs of infestation by the black twig borer *Xylosandrus compactus* and research on control methods has begun.

Less than ten trees are known from the island of Hawai‘i (N. Agorostas *pers. comm.* 2007) five or less are known from Maui (H. Oppenheimer *pers. comm.* 2007) and the species is no longer known from Moloka‘i (Hayden 1987.) There are less than thirty trees known from Kaua‘i (Ken Wood *pers. comm.* 2007) and thirty-six trees are known from the Wai‘anae Mountains of O‘ahu. Compared with populations of other Endangered taxa in Hawai‘i that have declined in the last fifty years, *F. neowawraea* seems to have been in decline across its range when it was first described in 1913.



Of the 36 remaining trees on O‘ahu, seven are male, 14 are female and the sex of 15 trees is still unknown. Nine additional trees have been observed to have died in the last five years. Since there are only three sites on O‘ahu where known male and female trees are within 100 meters of each other, a management strategy to bring all of the known trees into captive propagation has begun.

Flueggea neowawraea grows up to 35m tall, with a trunk up to 2m in diameter. They are often the most massive trees in the forest. Many of the remaining trees are mostly dead, with a strip of live material stretching up to the crown. Some have multiple dead trunks and survive as thickets of basal suckers and no juvenile trees have been observed. The dead trunks last a very long time and can still be found lying in many gulches. These logs show the former distribution of this species on O‘ahu. *Flueggea neowawraea* is dioecious and most known trees on O‘ahu are isolated from each other and often in poor health. Because of this few reproductive pairs are known.

Propagation

The OANRP has been collecting cuttings and air-layers from wild trees since 1999. Material from half (18/36) of the known trees from these collections is now growing at the Pahole Rare Plant Facility. In the past year, the greenhouse stock was used to begin cross-pollination trials in an effort to produce seed. Although many of the plants flowered during the expected season (Oct. - Dec.) many of the cuttings have flowered while rooting and many males flowered when no female plants were flowering. Over the last ten months, pollen was collected from six greenhouse plants. Some pollen was applied right away to available female flowers. The rest was dried to 20% relative humidity and stored frozen. The frozen pollen was later applied to a flowering female plant. Pollen has been held frozen for as long as six months and produced viable seed. On a few occasions male and female plants were flowering at the same time and viable seed was produced without any manipulation. Once viable seed is produced, it can be held frozen until the habitat is ready for reintroduction. Seed storage data shows that fresh mature seed can be stored dried and frozen for five years with no decrease in viability.

Greenhouse plant

Rooted Air-layer from a mature tree

Female flowers

Fruit and seedlings from hand-pollinated greenhouse plants

Male flowers

FEMALES

MALES	Plants	MMR-A-1	LKN-C-2	LEH-C-2	MAK-D-3	
	NAN-A-1		(2:5)* 5 mos. old		(4:4) 5 mos. old	
	HAL-B-1	(1:2) X - fresh pollen	Naturally-X (36 fruit)	(0:1) X - fresh pollen	(2:4) fresh & 3 day old	
	MAK-C-1					Pollen stored
	MAK-D-2			(12:17) 6 mos. old	(10:20) 1day old	Pollen stored
	MA[illegible]					Pollen stored
	LEH-C-3			(129:266) some eaten by birds		Pollen stored
	LEH-A-1					Pollen stored
	LEH-A-3					Pollen stored

Crosses between four females and eight males were tracked to test hand-pollination methods and seed viability.

Black Twig Borer Research

photos by H.C. Kuo

Native to Asia, the black twig borer *Xylosandrus compactus* did not become widely distributed in Hawai'i until 1960, nearly 30 years after its initial arrival in plant material from Singapore. *X. compactus* depends upon on an ambrosia fungus, farmed in galleries bored into the vascular tissue of the host plant, for its development. The life cycle of *X. compactus* is such that damage to the host plant arises as a result of multiple activities: 1. the hole bored by the beetle upon entry 2. the formation of a gallery in which eggs are laid, and, according to some researchers (N. Dudley, Hawai'i Agriculture Research Center (HARC) *pers. comm.*) 3. disease-causing strains of the *Fusarium* fungus, which is inoculated into the new host plant by a gravid female. Upon reaching maturity, the female *X. compactus* leaves her parental gallery, having already mated with a male sibling, the majority of which die in place, never to emerge. On average, eight eggs are produced by the female at one time. These hatch within seven days, after which, larvae feed on fungus until they pupate and reach maturity. Another two weeks will elapse before these recently pupated females will leave the galley, at which time they will depart via the single hole bored by their mother (Hara 1979).

Because *X. compactus* resides primarily within the plant pith, chemical control options are limited. Greenhouse collections of *F. neowawraea* are treated with Merit®, a systemic insecticide applied as a root drench. The numbers of entry holes on greenhouse plants differ little from those recorded from untreated, outplanted trees. This suggested treatment with Merit® did not deter *X. compactus* females from nesting and egg laying attempts. Closer inspection of 10 entry holes, however, yielded only three active galleries among the greenhouse individuals compared to eight among the outplanted population.

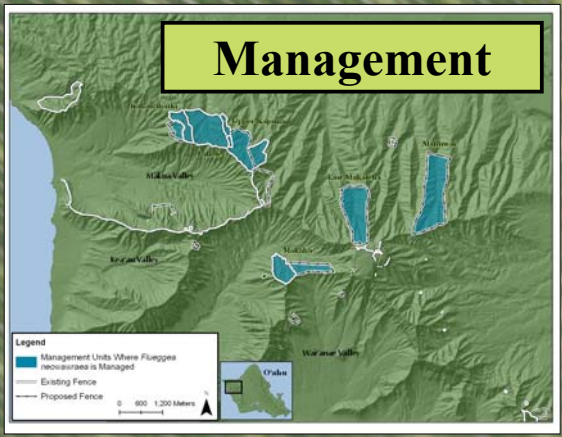
Having found systemic insecticides cumbersome to deploy, slow to act and expensive, with only questionable efficacy, OANRP staff sought out alternatives. In previous work, Dudley and Gillette demonstrated ethanol effectively attracted *X. compactus* (Gillette *et al*., *in prep*), presumably because it mimics the odor of rotting wood. In an effort to monitor *X. compactus* we used counts of *X. compactus* attracted to ethanol-baited traps as an indicator of relative population size.

Ethanol-baited trap

In order to quantify damage to *F. neowawraea*, OANRP staff, using white latex paint, marked all existing holes on outplanted *F. neowawraea* and started recording new holes on a weekly basis. Counts of new entry holes accumulated over time by individual *F. neowawraea* provide data on the frequency of *X. compactus* attack. Preliminary results show trees accumulate one new entry hole per 2.4 inches of bole length every nine days.

In the coming year, the OANRP will deploy ethanol-baited traps in the two reintroduction sites with *F. neowawraea*. Treatment and control plots will be established within the planting and the number of new entry holes will be counted on each tree once a week. If it is determined that the ethanol-baited traps treatment did reduce the number of new holes, this may be a less labor-intensive method to control damage by *X. compactus.*

Management



Flueggea neowawraea is one of 50 plant species included in detailed stabilization plans developed to guide conservation work to mitigate for potential training impacts at Mākua Military Reservation (MMR) and Schofield Barracks Military Reservation (SBMR.) Our goal is to have four population units that each have 25 mature trees. Each site must also have many younger trees in order to sustain 25 mature trees.

Frani Okamoto & a tree at LCC

Reintroductions in gulch bottom

Stabilizing *F. neowawraea* will require fencing over 1,230 acres of habitat in four different population units across the center of its distribution. Reintroduction sites will be prepared with weed and ungulate control. Over the next several years, a living collection in greenhouses and in inter-situ sites will be used to produce seed through natural and hand-pollinations. The four reintroductions will each be established with at least 50 saplings grown from these greenhouse and inter-situ crosses.

Reintroduction and planting trials have begun with saplings grown from seed in 2003. Inter-situ sites at Leeward Community College and Waimea Botanical Garden were planted to determine methods for establishing a living collection in an orchard-like setting. Reintroduction into native habitat has also begun. Initial selection of reintroduction sites was based on locations of nearby wild trees. The first site was on a gulch slope under a mixed canopy. The second reintroduction was planted into a gulch bottom after the canopy trees were removed. Although the sites are close, the two sites performed very differently. The trees in the gulch bottom grew as much as two meters in two years, while the trees on the slope actually declined in height as they could not outpace BTB damage. Based on this small trial, future reintroductions are planned for gulch bottom sites.

Pahole greenhouse collection

In the coming years, the OANRP will continue to work to establish cuttings or air-layers from the remaining trees, store pollen from male trees in the greenhouse, use the frozen pollen to cross with as many different combinations as possible, store the seed until sites are ready and grow it out and reintroduce into gulch bottoms in four units. In addition, we will continue to target the sites that have had viable seed in the wild and storage data on pollen and seeds will be reviewed to ensure no collections are lost. This work has been encouraging for the OANRP and perhaps for other long-lived species we work with. In addition, the stock developed through this process could be used for other island programs that work with *F. neowawraea*.

Literature Cited:

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