Valley Audubon Center), and 3,700 seeds in seed storage (Lyon Arboretum Seed Storage Facility) (Service 2005b).

Critical Habitat Description A total of 900 ha (2,224 ac) of critical habitat, in five separate units, was designated for *Nototrichium humile* on Oahu and Maui. On Oahu, 502 ha (1,241 ac) of critical habitat was designated in four units on State lands (Kaena State Park, Pahole Natural Area Reserve, and Kuaokala, Mokuleia, and Waianae Kai Forest Reserves), and on private lands. Overall, the four units on Oahu provide habitat to support six populations. On Maui, one unit on State and private lands was designated to provide habitat for one population. To meet recovery goals, a population should be represented by at least 300 mature, reproducing individuals of *N. humile* (68 FR 35950).

The primary constituent elements of critical units on Oahu include cliff faces, gulches, stream banks, or steep slopes in dry or mesic forests often dominated by *Diospyros sandwicensis* or *Sapindus oahuensis*, at elevations between 185 and 806 m (607 and 2,644 ft). In addition, all Oahu units contain one or more of the following associated native plant species: *Abutilon sandwicense, Alyxia oliviformis, Antidesma pulvinatum, Artemisia australis, Bidens cervicata, Canavalia* sp., *Carex wahuensis, Charpentiera* sp., *Dodonaea viscosa, Elaeocarpus bifidus, Erythrina sandwicensis, Eugenia reinwardtiana, Hibiscus* sp., *Melanthera tenuis, Metrosideros polymorpha, Myoporum sandwicense, Myrsine lanaiensis, Nestegis sandwicensis, Peperomia* sp., *Pisonia umbellifera, Pleomele* sp., *Pouteria sandwicensis, Psydrax odorata, Rauvolfia sandwicensis, Reynoldsia sandwicensis, Sicyos* sp., *Stenogyne* sp., *Streblus pendulinus*, or *Syzygium sandwicensis*. The plant community, associated species, and elevations are indicative of important features such as soil moisture, nutrient cycling and availability, temperature ranges, and light levels, which are primary constituent elements of the habitat required for the species' conservation (68 FR 35950).

Threats to the Critical Habitat See the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Environmental Baseline of the Species and Critical Habitat

Status of the Species in the Action Area About 858 individuals, or 68 percent of all known individuals of *Nototrichium humile*, are located within the action area in seven population units (see Table SB 27). Five of these action area population units have exceeded minimum numerical criteria for a stabilization population (at least 25 mature, reproducing individuals). Four population units (including three that have exceeded minimum numerical criteria for a stabilization population) have declined in numbers since 2003, and two population units have more or less maintained their numbers. Only the Punapohaku population unit has increased in numbers since 2004, since it was first discovered. The Kaluakauila population unit is located within the Kaluakauila Management Unit, the Makua population units are located within the Ohikilolo Management Unit, and the Kahanahaiki population unit is located within the Kahanahaiki Management Unit; these three management units are fenced. Survivorship of 18 augmented plants in the Makua population unit is about 83 percent so far (U.S. Army Garrison 2005b). The Kahanahaiki, Keaau, Keawaula, and Punapohaku population units are not located within management units or fences. All action area individuals are located in fire risk zones. About 566 individuals occur in the high fire risk zone, 193 individuals occur in the low fire risk

zone and 139 in the very low risk zone. Thus, *N. humile* in the action area consists of approximately 70 percent of the total remaining individuals of this species and occurs in seven population units, five of which have exceeded minimum numerical criteria for a stabilization population and four (including three of the stabilization population units) of which are declining in numbers, with the majority (44 percent) within the high fire risk zone.

Status of the Critical Habitat in the Action Area The action area contains a total of about 6 ha (16 ac) or slightly more than one percent of the total critical habitat for *Nototrichium humile* on Oahu, or slightly less than one percent of the State-wide total. Critical habitat is located within one unit in the northwestern part of the action area (within the Kaluakauila Management Unit) in an area of high fire risk. This area is part of a critical habitat unit totaling 5 ha (13 ac) that extends beyond the action area and provides habitat for one population of 300 mature, reproducing individuals. There is less than one percent of another 1 ha (3 ac) critical habitat unit that all falls within the action area. This unit is in the very low fire risk zone.

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Nototrichium humile* and its critical habitat in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. *Nototrichium humile* in the action area is especially vulnerable to wildfire resulting from military training activities. Fires have already destroyed or damaged portions of *N. humile* habitat within the action area. The July 2003 prescribed fire, for example, burned about 2.4 ha (6 ac) of *N. humile* critical habitat on State land in the Kaluakauila population unit, and about five plants were destroyed in the Punapohaku population unit. The fire also burned to within 40 m (131 ft) of *N. humile* plants on C-Ridge (U.S. Army Garrison 2003b). About two percent of the total State-wide critical habitat for this species is located in fire risk zones in the action area. Thus, because about 80 percent of all known individuals occur within the action area in zones of high to low fire risk, *N. humile* in the action area has a high background risk of species extinction, and major effort is needed to protect it from existing and any additional threats to its long-term persistence.

Conservation Needs of the Species and Critical Habitat in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) includes *Nototrichium humile* because more than 50 percent of the total remaining individuals are located within the action area. Four population units have been identified for stabilization of *N. humile*: Kaluakauila and Makua (south side) in the action area, and Kaimuhole and Palikea Gulch and Waianae Kai outside the action area. Although there are five stabilization populations which exceed minimum numerical criteria within the action area and two outside the action area, stabilization is not achieved because threats are not controlled and genetic storage goals are not complete. The Army does not expect to augment stabilization population units because of relatively high existing numbers of mature individuals (U.S. Army Garrison 2005b). Post-fire revegetation plans and site-specific fuels modification are needed where this species is located in the action area. About 15 ha (38 ac) of the Ohikilolo Management Unit is not fenced; fence construction for this area is planned for 2011. In the action area, approximately 205 individuals of *N. humile* are in fenced units and 600 individuals are not in fenced units. Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species and Critical Habitat in the Action Area The seven population units in the action area contain approximately 70 percent of the total remaining individuals of *Nototrichium humile*. The Kaluakauila and Makua (south side) population units within the action area are being managed for stabilization as specified by the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). In addition, population units are located within the fenced Kahanahaiki, Kaluakauila, and Ohikilolo Management Units (the Makua south-side population unit is located within the Ohikilolo Management Unit). Goats have been virtually eradicated from Makua in general (U.S. Army Garrison 2005b). The Kaluakauila population unit also is protected by a management unit pig exclosure fence and by grass control within forest patches to minimize the spread of fire. In addition, fuels are controlled along the ridgeline between the management unit and the installation boundary to form a fuelbreak (Service 2004). Genetic storage goals for *N. humile* are under one percent complete, with 48 plants from all 16 population units combined not yet meeting the goals of the Makua Implementation Plan. There are also currently 65 plants growing in the Army nursery (U.S. Army Garrison 2005b). Priority Army greenhouse space for this species is for plants from fire-threatened population units.

Status of the Species – *Peucedanum sandwicense* (Makou)

Species Description *Peucedanum sandwicense*, a short-lived perennial and member of the Apiaceae (parsley) family, is a parsley-scented, sprawling herb. Hollow stems arise from a short, vertical, perennial stem with several fleshy roots. The compound leaves are generally three-parted with stalkless leaflets, each egg- or lance-shaped and toothed. The larger terminal leaflet is usually one- to three-lobed and 7 to 13 cm (2.8 to 5.1 inches) long. The other leaflets have leaf stalks 10 to 50-cm (4 to 20 inches) long or are stalkless. Flowers are clustered in a compound umbel of 10 to 20 flowers. The round petals are white and bent inward at the tips. The flat, dry, oval fruits are 10 to 13 mm (0.4 to 0.5 inches) long and 5 to 8-mm (0.2 to 0.3 inches) wide, splitting in half to release a single flat seed. This species differs from the other Kauai members of the parsley family in having larger fruit and pinnately compound leaves with broad leaflets. This species is the only member of the genus on the Hawaiian Islands (Wagner et al 1999).

Listing Status *Peucedanum sandwicense* was federally listed as threatened on February 25, 1994, and State listed as threatened in Hawaii at the same time. A recovery plan was prepared for this species in September 1995 (Service 1995b). Critical habitat was designated in 2003 on Kauai, Molokai, Maui, and Oahu (68 FR 9115; 68 FR 12982; 68 FR 25934; 68 FR 35950).

Historic and Current Distribution Historically, *Peucedanum sandwicense* is known from Molokai, Maui, and Kauai, and discoveries in 1990 extended the known distribution of this species to Oahu. Currently there are a total of 1,000 to 5,000 individuals in 18 occurrences. On Oahu, there are roughly 100 individuals in four occurrences on State, city, and county lands in Keaau Valley, Puu Kawiwi, Waianae Kai, and Kamaileunu Ridge. One occurrence of 20 to 30 individuals is known from State-owned Keopuka Rock, an islet off the coast of Maui. On Molokai, three occurrences totaling fewer than 30 individuals are found on private and State-owned land in Pelekunu Preserve, Kalaupapa National Historical Park, and Huelo, an islet off the

coast of Molokai. The 10 Kauai occurrences are distributed in Waimea Canyon and along the Na Pali Coast within 2.4 km (1.5 mi) of the ocean (Service 1999b; 68 FR 35950). It is also difficult to assess changes in the abundance *P. sandwicense*. However, the total number of individuals on Oahu appears to be relatively stable from the time the species range-wide abundance was first estimated in 1991. Similarly, the overall number of individuals of this species appears to relatively stable on the other islands where it occurs (Maui, Molokia and Kauai) (Table SB 28).

Table SB 28. Range-wide Distribution *Peucedanum sandwicense.*

Occurrences	**Number of Known Individuals**					
	1991 (1)	**1995** (2)	**1999** (3)	**2003** (4)	**2005** (5)	**2006** (6)
Keaau	--	--	20	--	24	--
Waianae Kai	85	85	79	51	79	16/5‡
Total Population Units on Oahu	1	2	2	4	2	1
Total Individuals on Oahu	**85**	**85**	**99**	**51**	**103**	**21** (16/5)†
Total Population Units State-wide	21	16	16	--	21	--
Total Individuals State-wide	**265-355**	**1000-5000**	**1000-5000**	--	**1153-5163**	--

Shaded occurrences are inside the action area.
‡Mature/immature individuals
†Total (mature/immature)

(1) Listing rule (56 FR 55770)
(2) Waianae and Kauai Recovery Plan (Service 1995a, 1995b)
(3) Makua Endangered Species Mitigation Plan (Service 1999b)
(4) Critical habitat rule (68 FR 35950)
(5) Army re-initiation request (U.S. Army Garrison 2005c)
(6) Army database (U.S. Army Garrison 2006d)

Ecology *Peucedanum sandwicense* grows in cliff habitats from sea level to above 900 m (3,000 ft) and is associated with native species such as *Artemisia australis, Chamaesyce* sp., *Diospyros sandwicensis, Eragrostis variabilis*, and *Metrosideros polymorpha*. Little is known about the life history of *P. sandwicense*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown (Service 1999b).

Threats to the species *Peucedanum sandwicense* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. The primary threats to *P. sandwicense* are habitat degradation and browsing by feral ungulates, trampling by hikers and landslides. Non-native plants compete with *P. sandwicense* for light, space, and nutrients (U.S. Army Garrison 2005c). Based on the fact

there are only a very few individuals remaining on the island of Oahu, *P. sandwicense* has a high background risk of extirpation from the island of Oahu and any additional threats could reduce expectation of its long-term persistence on the island. However, there is only a moderate risk of background extinction for this species State-wide as there are several thousand individuals on Kauai.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Peucedanum sandwicense* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to the limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve stabilization of all existing populations (Service 1999a). Conservation actions required for stabilization are described in the "Stabilization" section of the project description for this opinion. However, *P. sandwicense* is not included as a target taxon for stabilization under the Makua Implementation Plan Addendum. The Army does not actively manage this species in the Makua and Schofield Barracks action areas (Service 2003a). The recovery plan for this species identifies several important conservation actions including fencing, weed control, maintenance of adequate genetic material and outplanting of local genetic material (Service 1995b).

Ongoing Conservation Actions A State-wide strategic plan is being developed by the Hawaii and Pacific Plants Recovery Coordinating Committee that will address the long-term conservation of *Peucedanum sandwicense*. This plan will also include broader landscape actions that are needed for the recovery of this species throughout its range (Hawaii and Pacific Plants Recovery Coordinating Committee 2007). Plants and seeds of *P. sandwicense* are currently held at the following institutions: Harold L. Lyon Arboretum, Pahole Mid-Elevation Rare Plant Facility, and the Waimea Arboretum. The Service is unaware of any other specific conservation actions for this species (Service 1999b; L. Durand, pers. comm. 2004).

Environmental Baseline of the Species

Status of the Species in the Action Area There are approximately 25 individuals *Peucedanum sandwicense* within the Makua action area. However, the exact number is not known because the Army does not actively monitor this species. *Peucedanum sandwicense* is a short-lived perennial herb and fluctuations in abundance are normal. Variation in rainfall along with other abiotic and biotic factors may account for these fluctuations. Furthermore, seeds of *P. sandwicense* may persist in the seed bank and there may be a reoccurrences of this species within the action area when there are more suitable environmental conditions.

Threats to the Species The primary threats to *Peucedanum sandwicense* in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E.

Conservation Needs of the Species and Critical Habitat in the Action Area Pursuant to the guidelines established in the Makua Implementation Plan, *Peucedanum sandwicense* will not be stabilized. There are thousands of individuals outside of the action area. There most robust populations are located on the island of Kauai where there are thought to be between 1,000 and 5,000 individuals of this species. This species will benefit from additional conservation actions

such as fencing, ungulate removal, reduction of non-native plant species, and control of wildfires (Service 1999b).

Ongoing Conservation Actions for the Species There is no species specific conservation action for this species in the action area.

Status of the Species and Critical Habitat – *Phyllostegia kaalaensis* (No Common Name)

Species Description *Phyllostegia kaalaensis* is a short-lived perennial herbaceous plant in the Lamiaceae (mint family). It has long stems extending from the base of the plant with oppositely arranged leaves 5 to 13 cm (2.0 to 5.1 in) long. Inflorescences are borne at the stem tips on stalks with nodes of 3 to 6 white, tubular, slightly fragrant flowers. Each segment of the black, four-segmented fruits contains a single seed surrounded by fleshy pulp (Wagner et al 1999; Makua Implementation Team 2003).

Listing Status *Phyllostegia kaalaensis* was federally listed as endangered on October 10, 1996 (61 FR 53089), and was State listed as endangered at the same time. This species was included in recovery plans for Oahu plants (Service 1998a). Critical habitat was designated for *P. kaalaensis* on Oahu on June 17, 2003 (68 FR 35950). *Phyllostegia kaalaensis* was accepted as a species distinct from the more common, closely related *P. glabra* in the 1990s (Wagner et al 1999).

Historic and Current Distribution *Phyllostegia kaalaensis* is endemic to the Waianae Mountains of Oahu, where it has been known only since the 1970s. When the species was listed in 1996, five occurrences totaling less than 50 individuals were known (61 FR 53089). Available survey data indicate that *P. kaalaensis* has been extirpated in the wild since the late 1990s. The causes for its extirpation are unknown. The Waianae Kai population unit, for example, was first discovered in 1993 at about 30 plants, all of which had disappeared by 2004. Currently, there is one existing population unit with only two augmented immature plants located on State land in the Keawapilau to Pahole population unit (Table SB 29) (U.S. Army Garrison 2006c). This population unit is being established at two reintroduction sites using greenhouse-propagated stock, and is far from reaching minimum numerical stabilization criterion (defined as 50 mature, reproducing individuals per population unit). Moreover, these reintroductions have not been very successful, with very low survival rates. Demographic data for this species indicate reproduction in this species is probably primarily through vegetative cloning, as most of the previously known, naturally occurring plants occurred in dense patches far away from any other plants of the species. In addition, cuttings were salvaged from the Keawapilau to Pahole, Palikea Gulch, and Waianae Kai population units and are now being maintained as *ex situ* living collections. The Keawapilau to Pahole population unit and Palikea Gulch population unit are located within the Makua action area and the Schofield Barracks Military Reservation action area, respectively, where they are at zones of very low risk to training-related wildfire. Thus, *P. kaalaensis* is characterized by one reintroduced population unit containing only two augmented immature individuals.

Table SB 29. Range-wide Distribution of *Phyllostegia kaalaensis.*

Population Units	Numbers of Known individuals

	1996 (1)	**1998** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Kapuna*	--	--	2	0/0[‡] [0/20][§]	0/0 [0/19]	0/0 [0/2]
Keawapilau*	--	--	2			
Pahole*	--	--	10-15			
Ekahanui	--	3	0	0	0	0
Makaha*	0	0	0	0	0	0
Manuwai*	0	0	0	0	0	0
Palikea Gulch	--	1	10	0	0	0
Waianae Kai	--	30	8	0	0	0
Total Individuals	**<50**	**40**	**32-37**	**20** (0/0)[†] [0/20]	**19** (0/0) [0/19]	**2** (0/0) [0/2]

Shaded population units are inside the action area.
*Stabilization population units
[‡]Total mature/immature individuals
[†]Total (mature/immature)
[§][augmented and or reintroduced]

(1) Listing rule (61 FR 53089)
(2) Recovery Plan (Service 1998a)
(3) Makua Implementation Plan (Makua Implementation Team 2003)
(4) MIP Addendum (U.S. Army Garrison 2005a)
(5) 2005 status update (U.S. Army Garrison 2005b)
(6) 2006 status update (U.S. Army Garrison 2006c)

Ecology *Phyllostegia kaalaensis* typically was found in mesic to dry-mesic areas in gulch bottoms and upper gulch slopes at elevations of 490 to 760 m (1,610 to 2,500 ft). It occurred most commonly in forests dominated by the native trees *Diospyros sandwicensis* and/or *Sapindus oahuensis*, or in forests containing a mix of several tree species, under forest canopy and in sunny openings. Flowering and fruiting occur from January to June. The flowers are presumably pollinated by moths, and the fleshy black fruits are characteristic of seed dispersal by fruit-eating birds (Makua Implementation Team 2003). The branches of *Phyllostegia kaalaensis* often touch ground and take root to produce a separate plant, and reproduction in this species may be primarily through vegetative means. The longevity of *Phyllostegia kaalaensis* individuals is unknown but is probably less than 10 years as with other perennial herbaceous plants; however, vegetative clones have the potential to live indefinitely (Makua Implementation Team 2003). Other demographic information for *Phyllostegia kaalaensis* in the wild is unknown, including number of seeds produced, age at sexual maturity, survivorship to sexual maturity, number of years in reproductive condition, survivorship during reproductive life, pollination and seed dispersal in the wild, and specific environmental requirements.

Threats *Phyllostegia kaalaensis* was listed as endangered because of major, ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section, and are tabulated in Appendix E. Outplants of *P. kaalaensis* in rocky gulch slopes and bottoms are vulnerable to trampling damage because of its extensive underground rhizome growth.

Occurrences of *Phyllostegia kaalaensis* are also particularly vulnerable to extirpation from naturally occurring events such as rockslides and/or reduced reproductive vigor due to small population size and limited distribution (56 FR 55770, 68 FR 35950, Service 1998a). Because the plants known in 2003 represent a small number of genetically unique clones, inbreeding depression could potentially occur in *P. kaalaensis* populations. Reductions in population size could result in expression of inbreeding depression among progeny, for example in reduced reproductive vigor, with potentially deleterious consequences for the long-term persistence of this species. The science of conservation biology has documented a general pattern of population collapse for a wide range of plant and animal species (Dennis et al 1991; Schemske et al 1994; Morris et al 1999; Menges 2000). According to this pattern, *P. kaalaensis* in the wild already is in a phase of "quasi-extinction" with numbers that have declined to the point where demographic stochasticity alone can result in extirpation. Thus, *P. kaalaensis* has a very high background risk of species extinction and any additional threats could eliminate expectation of its long-term persistence.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Phyllostegia kaalaensis* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve stabilization of all existing populations (Service 1998a). At least 50 mature, reproducing individuals are needed per population unit to attain stability for short-lived perennials. The Keawapilau to Pahole population unit is only partially fenced. This population unit needs augmentation and reintroduction, and reintroductions are needed in the Makaha and Manuwai population units that represent all available genetic stock. Research is needed to test a variety of outplanting techniques and site characteristics. If indications of inbreeding depression are observed, controlled experiments should be conducted by mixing different stocks. Extirpated sites also should be monitored periodically for regeneration. Reintroductions for establishment of this and other population units cannot proceed until fences are built for the Upper Kapuna, Manuwai, and Makaha Management Units. The Makaha Management Unit and part of the Upper Kapuna Management Unit are scheduled for fence construction in 2007 or shortly thereafter.

Ongoing Conservation Actions Since listing, the Makua Implementation Team (2003) has developed stabilization protocols for *Phyllostegia kaalaensis*, which are incorporated in the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). Only the Pahole portion of the Keawapilau to Pahole population unit is fenced and partially weeded. *Phyllostegia kaalaensis* can be successfully propagated from cuttings. However, this species has the lowest survival rate for any taxon the Army has outplanted so far (maximum 32 percent) (U.S. Army Garrison 2005b). In 2005, *P. kaalaensis* was represented in *ex situ* collections that included 723 apical and lateral vegetative buds in micropropagation (Harold L. Lyon Arboretum), 104 cuttings in a nursery (Harold L. Lyon Arboretum), and three seedlings in a nursery (Harold L. Lyon Arboretum) (Service 2005b). Very little seed was ever collected and no seed has ever been tested for storage and most storage is with cuttings from now-extinct occurrences in the Keawapilau to Pahole, Palikea Gulch, and Wiaiane Kai population units (U.S. Army Garrison 2005b).

Critical Habitat Description A total of 843 ha (2,082 ac) of critical habitat in six separate units was designated for *Phyllostegia kaalaensis* on Oahu. Critical habitat was designated on State lands (Mokuleia and Waianae Kai Forest Reserves, and Pahole and Mt. Kaala Natural Area Reserves) and private land (Honouliuli Preserve). Three units each provide habitat for one population, two units combined provide habitat for one population, and one unit provides habitat for six populations. To meet recovery goals, a population should be represented by at least 300 mature, reproducing individuals of *P. kaalaensis* (68 FR 35950).

The primary constituent elements of critical habitat include gulch slopes or bottoms or almost vertical rock faces in mesic forest or *Sapindus oahuensis* forest at elevations between 248 and 878 m (813 and 2,880 ft). In addition, all units contain one or more of the following associated native plant species: *Antidesma platyphyllum, Claoxylon sandwicense, Diplazium sandwichianum, Freycinetia arborea, Hibiscus* sp., *Myrsine lanaiensis, M. lessertiana, Neraudia melastomifolia, Pipturus albida, Pouteria sandwicensis, Psychotria hathewayi, Streblus pendulinus,* or *Urera glabra*. The plant community, associated species, and elevations are indicative of important features such as soil moisture, nutrient cycling and availability, temperature ranges, and light levels which are primary constituent elements of the habitat required for the species' conservation.

Threats to the Critical Habitat See introduction to "Status and Environmental Baseline of the Species and Critical Habitat" section.

Environmental Baseline of the Species and Critical Habitat

Status of the Species in the Action Area Only two immature individuals of *Phyllostegia kaalaensis*, representing all of the known individuals of this species, are located within the action area, on State land in the Keawapilau to Pahole population unit (see Table SB 29). Plants in the Pahole portion of the population unit were last observed in 2000, in a fenced area protected from pigs. These last plants may have been extirpated due to drought-induced invasion of non-native invasive weeds. Survivorship rates in the Pahole and Keawapilau portions of the population unit have been very low. Immature individuals were outplanted in a wide variety of sites, from deeply shaded to sunny exposed areas; so far, the healthiest plants are those in sunny openings. *Phyllostegia kaalaensis* plants in the action area are located in areas at risk of training-related wildfire. Both remaining individuals occur in the very low fire risk zone. Thus, *P. kaalaensis* in the action area is characterized by one population unit of two reintroduced immature plants that comprise 100 percent of all remaining individuals, and are located in a zone at very low risk of training-related wildfire.

Status of Critical Habitat in the Action Area The action area contains a total of 107 ha (263 ac), or 13 percent of the total critical habitat for *Phyllostegia kaalaensis*. Designated critical habitat is located within two units in the northeastern portion of the action area. These critical habitat areas are portions of two larger critical habitat units that combined form 646 ha (1,596 ac) and extend outside the action area boundary to provide habitat for 6 populations of *P. kaalaensis*. Critical habitat for this species in the action area occurs in areas at risk of training-related wildfire, with 8.1 ha (19.9 ac) located in the low fire risk zone and 98.4 ha (243.1 ac) in the very low fire risk zone. It is estimated that more than half of the critical habitat occurs in areas with predominantly non-native plant cover (K. Kawelo, pers. comm. 2004; Service 2004a).

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Phyllostegia kaalaensis* and its critical habitat in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section, and are tabulated in Appendix E. About 13 percent of critical habitat for this species is located in areas at low and very low risks of training-related wildfire. Thus, because there are only two known remaining individuals within the action area, *Phyllostegia kaalaensis* in the action area area has a very high background risk of species extinction and any additional threats could eliminate the expectation of its long-term persistence.

Conservation Needs of the Species and Critical Habitat in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) includes *Phyllostegia kaalaensis* because no population units meeting numerical criteria for stabilization exist outside the action area. Three population units have been identified for stabilization of *P. kaalaensis*: Keawapilau to Pahole in the action area, and Makaha and Manuwai outside the action area. The Kapuna and Keawapilau portions of the Keawapilau to Pahole population unit are not fenced. Post-fire revegetation plans and site-specific fuel modification are needed where individuals and critical habitat are located in the action area. Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species and Critical Habitat in the Action Area The Keawapilau to Pahole population unit, which contains all *in situ* individuals of *Phyllostegia kaalaensis*, is being managed as specified in the Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). These individuals are located in the action area within the fenced Pahole Management Unit. A total of about 237.7 ha (587.0 ac) of critical habitat for this species is located within management units both within and outside of the action area (East Makaleha, Ekahanui, Kahanahaiki, Kaimuhole, Makaha, Manuwai, Pahole, Upper Kapuna, West Makaleha). About 98.0 ha (242.0 ac) of the total critical habitat that is within management units is located inside the action area (Kahanahaiki, Pahole, Upper Kapuna, West Makaleha). As of 2005, genetic storage goals were about four percent complete, with six plants towards the goals outlined in the Makua Implementation Plan. In addition, there were six plants growing in the Army nursery (U.S. Army Garrison 2005b).

Status of the Species and Critical Habitat – *Plantago princeps* var. *princeps* (Ale, Laukahi kuahiwi)

Species Description *Plantago princeps* is a short-lived woody perennial of the Plantaginaceae (plantain) family. It is a shrub at least 1 m (3.3 ft) tall that is single-stemmed or sparingly branched at the base. The leathery, oblong leaves are up to 20 cm (7.8 in) long and clustered at the branch tips. The stem tips usually bear several erect inflorescences, each of which consists of a single stem of small, densely arranged flowers on the upper portion. The small capsules contain three to four black seeds that are 1.5 to 2.1 mm (0.06 to 0.08 in) long. Seed surfaces are covered by a sticky mucilaginous membrane (Wagner et al 1999; Makua Implementation Team 2003).

There are four varieties of *Plantago princeps*: var. *anomala* (Kauai), var. *laxiflora* (Molokai, Maui, and Hawaii), var. *longibracteata* (Kauai and Koolau Mountains of Oahu), and var. *princeps* (Waianae and Koolau Mountains of Oahu). All are woody shrubs except *P. princeps* var. *longibracteata*, which is herbaceous. In addition to geographic distribution, these varieties are distinguished by the amount of pubescence on stems, leaves, and flowers; size and venation of leaves; and orientation of flowers.

Listing Status *Plantago princeps* was federally listed as endangered on November 10, 1994 (59 FR 56333), and was State listed as endangered at the same time. This species is included in the recovery plan for multi-island plants (Service 1999a). Critical habitat was designated for *P. princeps* on Oahu on June 17, 2003 (68 FR 35950); on Kauai on February 27, 2003 (68 FR 9116); on Molokai on March 18, 2003 (68 FR 12982); and on Maui on May 14, 2003 (68 FR 25934). All varieties are included in the listed taxon.

Historic and Current Distribution *Plantago princeps* is a species endemic to the Hawaiian Islands. Historically, *Plantago princeps* was found on Kauai, Oahu, Molokai, Maui, and Hawaii (where it no longer exists). The two varieties that historically occurred on Oahu are var. *princeps* and var. *longibracteata*. Survey data indicate *P. princeps* var. *princeps*, a woody variety, is currently the only variety extant on Oahu. *Plantago princeps* var. *princeps* has been recorded from three general areas on Oahu, including the leeward Waianae Mountains, windward Waianae Mountains, and southeastern Koolau Mountains (Kalihi, Nuuanu, and Manoa valleys). *Plantago princeps* var. *princeps* was rediscovered in 1987 in the North Branch of North Palawai Gulch; before then, the species had not been seen in the Waianae Mountains since the 1800s. Similarly, the species had not been seen in the Koolau Mountains for over 50 years until this variety was rediscovered in 2001 at Waiawa, near the Koolau summit ridge. Currently, most of the known *P. princeps* var. *princeps* population units are scattered throughout the leeward and windward sides of the Waianae Mountains. *Plantago princeps* var. *longibracteata*, the herbaceous variety, historically was known from Kauai and the Koolau Mountains of Oahu. This variety still occurs on Kauai but is now extirpated from Oahu.

Since listing, available survey data indicate the State-wide total number of individuals of *Plantago princeps* (including all four varieties) appears to be stable or possibly increasing, though this increase could be due to more diligent survey efforts (Table SB 30). When the species was listed in 1994, all four varieties totaled 300 to 1,200 individuals State-wide (59 FR 56333); currently, there are 354 individuals on Oahu and an unknown number State-wide (Hawaii Biodiversity and Mapping Program 2005). When the species was listed, there were five occurrences totaling about 20 individuals on Oahu. *Plantago princeps* var. *princeps* is currently known from nine population units totaling 354 individuals on Oahu, located on Federal, State, and private lands (68 FR 35950). Because all currently known population units of this species were discovered relatively recently, trends in abundance and distribution are difficult to determine. A rapid decline from 20 to 5 individuals of *P. princeps* var. *princeps* was documented in the North Palawai population unit over 1987 to 2003, attributed to competition with daisy fleabane (*Erigeron karvinskianus*), a highly invasive non-native plant (Makua Implementation Team 2003). Trends in abundance and distribution on Oahu indicate that *P. princeps* var. *princeps* has increased since 2003, from eight population units totaling up to 253 individuals to nine population units totaling 354 individuals. None of the currently known population units contains more than fifty mature, reproducing individuals (the minimum number

required for stabilized populations as defined in the Makua Implementation Plan) (Makua Implementation Team 2003; U.S. Army Garrison 2005b). *Plantago princeps* var. *princeps* is present in both the Makua and Schofield Barracks action areas in the Ohikilolo, Pahole, and North Mokiakea population units, in areas at risk from training-related wildfire (Service 2003a).

Demographic data for this species indicates most of the population units of wild *Plantago princeps* var. *princeps* are recruiting successfully (U.S. Army Garrison 2005b). Three Oahu population units have increased in numbers since 2003, three have decreased, and three have remained more or less the same. However, increases in two of the population units are due to refinement of age classes and discovery of additional individuals as a result of more consistent monitoring efforts, not a significant change in numbers or distribution (U.S. Army Garrison 2005b). Thus, *P. princeps* var. *princeps* is characterized by nine population units, each of which contain fewer than fifty mature, reproducing individuals and an overall trend in abundance on Oahu that appears to be increasing but is due in part to increased monitoring efforts.

Table SB 30. Range-wide Distribution of *Plantago princeps* var. *princeps.*

Population Units	**Number of Known Individuals**					
	1994 (1)	**1999** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Ohikilolo*	--	--	14	22/0	22/12	12/14
Pahole	--	--	12	2/2	3/13	2/14
Ekahanui*	--	--	16/7[‡]	33/50	34/88	34/86
Halona	--	--	50-100	50-100	10/28	10/28
Konahuanui/ Kaneohe (Koolau)*	--	--	--	40/5	40/5	40/5
North Mohiakea/Puu Kalena (SBWR)	--	--	70	20/3	15/5	10/13
North Palawai (north branch)	--	--	7	2/2	1/1	--
North Palawai (south branch)	--	--	25	0	--	1/1
Nuuanu	--	--	--	1/0	1/0	1/0
Waiawa (Koolau)*	--	--	40/2	16/17	16/67	16/67
Total Population Units Oahu (2 varieties)	5	7	8	9	10	9
Total Individuals Oahu (2 varieties)	**20+**	**150-250**	**253-303** (234-284/19)[†]	**265-315** (186-236/79)	**361** (142/219)	**354** (126/228)
Total Population Units State-wide (all 4 varieties)	18	29	27	--	20	490-1962[(7)]
Total Individuals State-wide (all 4 varieties)	**300-1200**	**640-1750**	**795-973**	--	**844-2316**	**844-2316**

Shaded population units are inside the action area.

* Stabilization population units
SBMR = Schofield Barracks Military Reservation, West Range.
‡Total mature/immature individuals
†Total (mature/immature)

(1) Listing rule (59 FR 56333)
(2) Recovery plan (Service 1999a)
(3) Makua Implementation Plan (Makua Implementation Team 2003) and critical habitat rules (68 FR 9116; 68 FR 12982; 68 FR 25934; 68 FR 35950)
(4) MIP Addendum and 2004 status report (U.S. Army Garrison 2005a, 2004)
(5) 2005 status update (U.S. Army Garrison 2005b); Hawaii Biodiversity and Mapping Program 2005; M. Bruegmann, USFWS, pers. comm. (2006)
(6) 2006 status update (U.S. Army Garrison 2006c)
(7) S. Ching, pers. comm. (2007)

Ecology *Plantago princeps* var. *princeps* occurs in two different habitat types, at elevations of 480 to 1,100 m (1,580 to 3,600 ft) (Service 1999a). In the Waianae Mountains, this variety is found on cliff faces, ledges, and bases, in mesic vegetation consisting predominantly of native grasses, sedges, herbs, and shrubs. Historical occurrences in the southeastern Koolau Mountains also were found in mesic cliff habitats. In contrast, the Waiawa population unit occurs on a streamside embankment in wet, rainforest habitat close to the Koolau summit ridge, an area with the highest precipitation on Oahu (Service 2003a). *Plantago princeps* var. *princeps* appears to produce flowers and fruits throughout the year (Wagner et al 1999), with increased fruiting in the spring (U.S. Army Garrison 2005b). The sticky seeds may have once been dispersed by now-extinct species of flightless birds (Carlquist 1980; Makua Implementation Team 2003). Plant longevity probably is similar to that of other small, semi-woody shrubs that live less than 10 years (i.e., short-lived perennials) (Makua Implementation Team 2003). Other demographic information for *P. princeps* var. *princeps* in the wild is unknown, including number of seeds produced, age at sexual maturity, survivorship to sexual maturity, number of years in reproductive condition, survivorship during reproductive life, timing of reproductive output, pollination and seed dispersal, vegetative reproduction and specific environmental requirements.

Threats to the Species *Plantago princeps* var. *princeps* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. Because this species prefers cliff habitat, ungulate and weed threats are relatively low (U.S. Army Garrison 2005b). Rat predation on fleshy stems and leaves is a problem in the North Palawai and Ekahanui population units (in Honouliuli Preserve), and may have caused the near disappearance of the North Palawai population units (U.S. Army Garrison 2005b). Fire is a threat to population units in Army action areas (Ohikilolo, Pahole, and North Mohiakea) and to areas vulnerable to non-military related fire. For example, fire burned native vegetation in parts of the Ekahanui Management Unit and near the Halona population unit during summer 2005 (U.S. Army Garrison 2005b). In addition, occurrences of *P. princeps* var. *princeps* are vulnerable to extirpation from naturally occurring events such as rockslides and/or reduced reproductive vigor due to small population size and limited distribution (59 FR 56333; 68 FR 35950; Service 1999a). Thus, *P. princeps* var. *princeps* has a high background risk of species extinction, and any additional threats could reduce expectation of its long-term persistence.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Plantago princeps* var. *princeps* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve stabilization of all existing populations (Service 1999a). The Army has noted that a re-evaluation of stabilization population units may be needed to account for the recently discovered population unit on the Kaneohe side of Puu Konahuanui (currently the largest population unit at 45 total individuals) (U.S. Army Garrison 2005b). A pig-proof fence is needed for the Ekahanui population unit and is planned for 2007. A fence is also needed for the Waiawa population unit and is planned as part of the Army's Oahu Implementation Plan (U.S. Army Garrison 2005b).

Ongoing Conservation Actions The Makua Implementation Team (2003) has developed stabilization protocols for *Plantago princeps* var. *princeps*, which are incorporated in the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). The Ohikilolo, Pahole, and Ehakanui population units are fenced and protected by cliffs and steep terrain. In addition, about 271 individuals (77 percent of all remaining individuals on Oahu) of this species occur in five management units where they will benefit from population unit and/or ecosystem-level protection. The management units include Palikea and Waiawa, which are not fenced; and Ekahanui, Ohikilolo, and Pahole, which are fenced. The Nature Conservancy of Hawaii's long-range management plan for Honouliuli Preserve includes management actions to control non-native plants, feral ungulates, and fire, and to recover rare species and restore native habitats; this plan will benefit *P. princeps* in the Ekahanui and Palawai population units within the preserve. This species is also included in the Army's stabilization plan for species impacted by military training at other areas on Oahu associated with Schofield Barracks Military Reservation (Service 2003a).

Seed collection from this taxon is difficult because it inhabits inaccessible cliffs. Plants fruit year-round, with peak production in the spring, and germination rate of fresh seed is about 60 percent. Cuttings can be successfully propagated, but the plants do not survive well in the greenhouse (U.S. Army Garrison 2005b). *Plantago princeps* is represented in *ex situ* collections, including four cuttings in a nursery (Army Environmental Division, Oahu), 81 plants in a nursery (Haleakala National Park), 39 ungerminated seeds in a nursery (Harold L. Lyon Arboretum), and 5,900 seeds in seed storage (Lyon Arboretum Seed Storage Facility) (Service 2005b).

Critical Habitat Description A total of 2,632 ha (6,504 ac) in 12 separate units on four islands was designated as critical habitat for *Plantago princeps*, including 1,418 ha (3,504 ac) in five units on Oahu (68 FR 35950). Critical habitat on Oahu was designated on Federal (Oahu Forest National Wildlife Refuge), State (Ewa, Mokuleia, and Waiahole Forest Reserves and Pahole Natural Area Reserve), and private lands (including Honouliuli Preserve). The 12 critical habitat units State-wide provide habitat to support nine populations, and the five critical habitat units on Oahu provide habitat for three populations. To meet recovery goals, a population should be represented by at least 300 mature, reproducing individuals of *P. princeps* (68 FR 35950).

On Oahu, the primary constituent elements for three critical habitat units in the Waianae Mountains include slopes or ledges in *Metrosideros polymorpha* lowland mesic forests or shrublands at elevations between 110 and 1,064 m (361 and 3,490 ft). In addition, all units

contain one or more of the following associated native plant species: *Artemisia australis*, *Bidens* sp., *Chamaesyce* sp., *Dubautia plantaginea, Eragrostis* sp., *Lysimachia* sp., *Pilea peploides,* or *Viola* sp. The primary constituent elements for the two critical habitat units in the Koolau Mountains include sides of waterfalls or wet rock faces at elevations between 211 and 885 m (692 and 2,903 ft) that contain one or more of the following associated native plant species: *Bidens* sp., *Coprosma granadensis*, *Eugenia* sp., *Lobelia gaudichaudii, Metrosideros rugosa,* or *Scaevola glabra*. The plant community, associated species, and elevations are indicative of important features such as soil moisture, nutrient cycling and availability, temperature ranges, and light levels, which are primary constituent elements of the habitat required for the species' conservation.

Threats to the Critical Habitat See the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Environmental Baseline of the Species and Critical Habitat

Status of the Species in the Action Area About 42 individuals, or 12 percent of all known individuals of Plantago princeps var. princeps on Oahu, are located within the action area in the Ohikilolo and Pahole population units (see table above) (U.S. Army Garrison 2005b). These action area individuals represent 12 percent of the total State-wide population. None of the population units exceeds 50 mature reproducing individuals (the minimum number required for a stabilized population). Overall, the total known number of individuals of this taxon in the action area has increased from 26 in 2003 to 42 individuals in 2006, but most of that increase is due to discovery of additional plants in the Ohikilolo population unit (U.S. Army Garrison 2005b). Currently, about 67 percent of the action area individuals are immature plants, compared to less than eight percent immature individuals in 2004. The Ohikilolo and Pahole population units within the action area are located in fire risk zones; however, all known individuals occur in the low fire risk zone. These individuals at risk of fire in the action area represent about 12 percent of the taxon's total known number of individuals on Oahu and about one percent of the species' State-wide total. Thus, *P. princeps* var. *princeps* in the action area is characterized by two population units which do not meet the numerical criteria for a stabilization population unit and represent about 12 percent of the taxon's total number of individuals on Oahu. The total number of known individuals has increased primarily due to new discoveries from refined monitoring efforts.

Status of the Critical Habitat in the Action Area The action area contains a total of 62 ha (153 ac), or two percent, of the total State-wide critical habitat for *Plantago princeps*. Critical habitat is located on State land in the northeastern portion of the action area, in two critical habitat units. These units total 15 ha (37 ac) and 53 ha (130 ac), respectively, and together extend beyond the action area to provide habitat to support one population of 300 mature, reproducing individuals. The entire acreage for both of these critical habitat units occurs in the low fire risk zones of the action area. State-wide, slightly more than one percent of critical habitat for this species on Oahu, Kauai, Maui, and Hawaii is located in an area at risk from training-related wildfire, with none located in the high fire risk zone. It is estimated that almost all critical habitat is in areas of greater than 50 percent native plant cover (K. Kawelo, pers. comm. 2004).

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Plantago princeps* var. *princeps* and its critical habitat in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. Although only 12 percent or less of all known individuals of this taxon on Oahu occurs within the action area, *P. princeps* var. *princeps* in the action area has a high background risk of species extinction and requires ongoing stabilization management to ensure its long-term persistence.

Conservation Needs of the Species and Critical Habitat in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrsion 2005a) includes *Plantago princeps* var. *princeps* because the no population units meeting minimum numerical criteria for a stabilization population exist outside the action area. Stabilization goals to improve the status of *P. princeps* var. *princeps* include management to attain three population units, each with a minimum of 300 mature, reproducing individuals. Three population units have been identified for stabilization of *P. princeps var. princeps*: Ohikilolo, Ekahanui, and Waiawa. Augmentation of the Ohikilolo and Pahole population units is needed as soon as propagation and outplanting techiques are refined; the Army has not outplanted this taxon yet because of difficult access at field sites (U.S. Army Garrison 2005b). Post-fire revegetation plans and site-specific fuels modification are needed for the Ohikilolo, Pahole, Upper Kapuna, and West Makaleha Management Units, which either contain individuals or portions of critical habitat. The 42 individuals of this species occurring in the action area are in fenced management units and this species will thus benefit from ungulate exclusion. There are no plans to fence the small portion of the Upper Kapuna Management Unit that coincides with critical habitat. Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species and Critical Habitat in the Action Area The Ohikilolo population unit is being managed as specified by the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). Within the action area, the Ohikilolo and Pahole Management Units are proposed to be fenced starting in 2007 and completed by 2015 thus controlling ungulates. Weed management will be an ongoing strategy to control invasive species. A major part of the Ohikilolo Management Unit is protected by a boundary ridgeline fence, and goats have been virtually eradicated from Makua (U.S. Army Garrison 2005b). Genetic storage goals are nine percent complete, with 41 plants from all nine population units combined meeting the goals outlined in the Makua Implementation Plan, and there are 10 plants growing in the Army nursery (U.S. Army Garrison 2005b).

Status of the Species – *Pritchardia kaalae* (Loulu)

Species Description *Pritchardia kaalae* is a long-lived palm of the Arecaceae (palm) family. The tree grows to 5 m (16.4 ft) tall, with a single erect trunk surmounted by a cluster of fan-shaped fronds. The inflorescences are as long as the frond tips and often extend well beyond them, and consist of flowers in one or more clusters. *Pritchardia* species usually, if not always, have perfect flowers (with both male and female reproductive parts), and *P. kaalae* is probably self-compatible. The round, fleshy fruits are about 2 cm (0.8 in) in diameter and much smaller than fruits of other *Pritchardia* species (Wagner et al 1999; Makua Implementation Team 2003).

Listing Status *Pritchardia kaalae* was federally listed as endangered on October 10, 1996 (61 FR 53089), and was State listed as endangered at the same time. This species is included in the recovery plan for Oahu plants (Service 1998a). Critical habitat has not been designated for this species.

Historic and Current Distribution *Pritchardia kaalae* is a species endemic to the Hawaiian Islands and to the island of Oahu. Trends in distribution indicate that *P. kaalae* historically was found only in the northern Waianae Mountains of Oahu. In contrast to other *Pritchardia* species in Hawaii, no evidence indicates that the distribution of *P. kaalae* has been influenced by the actions of native Hawaiians (Makua Implementation Team 2003). When the species was listed in 1996, there were five occurrences totaling approximately 130 individuals. Since listing, the total number of individuals has increased to about 911 plants (see table below). However, 85 percent of these are immature plants and 15 percent are mature plants; there are only 137 mature trees range-wide (U.S. Army Garrison 2005b). Two of the five currently known population units have exceeded minimum thresholds for a stabilization population (defined as at least 25 mature, reproducing individuals per population unit for long-lived perennials) (Makua Implementation Team 2003; U.S. Army Garrison 2005b). Population units of *P. kaalae* are located on Federal and State lands (U.S. Army Garrison 2005b) (Table SB 31).

Demographic data indicate the number of mature trees has been slowly decreasing as older trees die and few immature plants are available to take their place (Makua Implementation Team 2003). Since consistent monitoring for this species began at Makua about 10 years ago, little or no recruitment has been observed in wild population units due to goat and rat predation and uprooting by pigs (U.S. Army Garrison 2005b). The Ohikilolo population unit is the only one with documented seedlings (410 immature individuals including seedlings). With protection and management, many seedlings are appearing, and rat control should result in significant increases in recruitment rates (Makua Implementation Team 2003). In addition, *Pritchardia kaalae* is easy to grow from seed and outplantings have been extremely successful (U.S. Army Garrison 2005b). Nonetheless, both augmented and naturally occurring seedlings and immature plants grow very slowly and do not become reproductive for decades. Plants in the Ohikilolo population units are located in zones at low risk from training-related wildfire. Thus, *P. kaalae* is characterized by five population units, two of which exceed minimum numeric criteria for stabilization, low numbers of mature trees and an overall abundance that is increasing through augmentation and enhanced survival of seedlings and immature plants associated with habitat management.

Table SB 31. Range-wide Distribution of *Pritchardia kaalae.*

Population Units	Number of Known Individuals					
	1996 (1)	**1998** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Ohikilolo*	--	--	65/100‡	72/3 [0/308]§	75/221 [0/274]	75/410 [0/284]
Ohikilolo East & West Makaleha*	--	--	--	0 [0/75]	0 [0/32]	0/0 [0/72]
Makaha	--	--	1/0	1/0	4/0	4/0
Makaleha to Manuwai*	--	--	138/3	39/3	50/2	54/3
Waianae Kai	--	--	7/2	7/2	4/5	4/5
Total Individuals	**130**	**130**	**316** (211/105)†	**510** (119/8) [0/383]	**667** (133/228) [0/306]	**911** (137/418) [0/356]

Shaded population units are inside the action area.
*Stabilization population units
‡Total mature/immature individuals
†Total (mature/immature)
§[augmented and or reintroduced]

(1) Listing rule (61 FR 53089)
(2) Recovery plan (Service 1998a)
(3) Makua Implementation Plan (Makua Implementation Team 2003)
(4) MIP Addendum and 2004 status report (U.S. Army Garrison 2005a, 2004)
(5) 2005 status update (U.S. Army Garrison 2005b)
(6) 2006 status update (U.S. Army Garrison 2006c)

Ecology *Pritchardia kaalae* occurs in the mesic zone on moderately steep slopes to very steep cliffs at elevations of 450 to 980 m (1,476 to 3,215 ft) (Wagner et al 1999; Makua Implementation Team 2003). Many *P. kaalae* plants at lower elevations are found in forests dominated by *Diospyros sandwicensis* or *Metrosideros* species; at higher elevations, they are found in the upper, wetter zone of mesic forest dominated by *Metrosideros tremuloides*. The common habitat of *P. kaalae* is steep, open cliffs vegetated with grasses and sedges, shrubs, and small trees (Makua Implementation Team 2003). Recent studies of fossil pollen and charcoal deposits on Oahu indicate that *Pritchardia* constituted a major element of lowland vegetation when Polynesians first settled in Hawaii. Fruit predation by the Polynesian rat brought by early Polynesian settlers appears to have caused a collapse of these *Pritchardia* populations. The *Pritchardia* species of this largely vanished lowland vegetation have not been identified, but *P. kaalae* possibly may have extended from the Waianae Mountains into the lowland populations that were decimated by rats (Makua Implementation Team 2003). Seeds of the related species *P. remota* can survive in the soil for "a significant period of time" (U.S. Army Garrison 2005b). The longevity of *P. kaalae* has not been documented but is presumed to be many decades (Makua Implementation Team 2003). Other demographic information for *P. kaalae* in the wild is unknown, including growth rate, number of seeds produced, age at sexual maturity, survivorship to sexual maturity, number of years in reproductive condition, survivorship during reproductive life, timing of reproductive output, pollination and seed dispersal in the wild, vegetative reproduction in the wild, and specific environmental requirements.

Threats to the Species *Pritchardia kaalae* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. *Pritchardia kaalae* is particularly vulnerable to seedling predation by goats and fruit predation by rats (Makua Implementation Team 2003; U.S. Army Garrison 2005b). This species may also be vulnerable to lethal yellowing, a palm disease prevalent in many tropical and subtropical zones worldwide. Hawaiian *Pritchardia* species planted in Florida as ornamentals are extremely susceptible to this fatal, incurable disease. Lethal yellowing is caused by a "mycoplasma-like organism" transmitted by a sap-sucking plant hopper, *Myndus crudus*, which has not yet been found in Hawaii (Murakami 1999). Nonetheless, lethal yellowing disease remains a potential serious threat to *P. kaalae* on Oahu. Thus, *P. kaalae* has a high background risk of species extinction due to low numbers and serious threats from non-native predators and disease, and any additional threats could reduce expectation of its long-term persistence.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Pritchardia kaalae* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve stabilization of all existing populations (Service 1998a).

Ongoing Conservation Actions The Makua Implementation Team (2003) has developed stabilization protocols for *Pritchardia kaalae*, which are incorporated in the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). The Ohikilolo and Makaleha to Manuwai population units have met minimum numerical criteria for a stabilization population, but threats are not fully controlled and genetic storage is not complete. The Ohikilolo East and West Makaleha population unit within the action area is being established by reintroduction. In addition, about 898 individuals (98 percent of all remaining individuals) of this species occur in four management units where they will benefit from population unit and/or ecosystem-level protection. The management units include Manuwai, East Makaleha, and West Makaleha, which are not fenced; and Ohikilolo, which is fenced.

Germination from seed is a reliable propagation technique for *Pritchardia kaalae*, particularly using excised embryos (50 percent germination). Reintroductions in the wild have been successful, but seedlings grow very slowly; survival of two-year-old outplants is about 89 percent (U.S. Army Garrison 2005b). *Pritchardia kaalae* is represented in *ex situ* collections including 172 embryos in micropropagation (Harold L. Lyon Arboretum), 193 mature fruit in storage or awaiting processing at a nursery (Army Environmental Division, Oahu), seven plants in a botanical garden (Waimea Valley Audubon Center), and 12 ungerminated seeds in a nursery (Harold L. Lyon Arboretum) (Service 2005b).

Environmental Baseline of the Species

Status of the Species in the Action Area About 841 individuals, or 92 percent of all known individuals of *Pritchardia kaalae*, are located within the action area in the Ohikilolo, and Ohikilolo East and West Makaleha population units (see table above). However, only 75 of

these individuals in the action area are mature trees, which represent about 55 percent of the total 137 mature trees that exist range-wide. The Ohikilolo population unit has currently exceeded the minimum numerical criteria for a stabilization population (defined as 25 mature individuals per population unit) and includes both naturally occurring and reintroduced plants. The Ohikilolo East and West Makaleha population unit consists entirely of 72 augmented immature plants that have been outplanted in fenced areas since 2002. Currently, about 91 percent of the action area individuals are immature plants. Overall, action area numbers of *P. kaalae* have increased since 2003, from 165 (including 65 mature trees) to 841 (including 75 mature trees) (U.S. Army Garrison 2005b; Army database 2006). All *P. kaalae* plants in the action area are at risk from training-related wildfire; however, all individuals of this species found in the action area are located in the low or very low fire risk zones. These individuals at risk of fire in the action area represent about 92 percent of the species' total range-wide numbers.

The Ohikilolo population unit is located within the Ohikilolo Management Unit, where vegetation consists of native dry cliff communities, ridgetop mesic native shrubland dominated in some areas by *Dodonaea* and *Metrosideros* species, and areas of *Pritchardia kaalae* lowland mesic forest, a rare natural community (U.S. Army Garrison 2005a). The Ohikilolo East and West Makaleha population unit is located in parts of the Ohikilolo, East Makaleha, and West Makaleha Management Units. Vegetation in the East Makaleha Management Unit consists of dry-mesic to wet native forest and shrubland, and alien-dominated dry-mesic to wet-mesic shrubland and forest (U.S. Army Garrison 2005a). Vegetation in the West Makaleha Management Unit consists primarily of mixed alien-dominated mesic forest and native-dominated forest and shrubland, with areas of Oahu diverse lowland mesic forest, a rare natural community. At lower elevations, vegetation in the West Makaleha Management Unit consists of seasonally dry, alien-dominated forest and shrubland (U.S. Army Garrison 2005a). Two hundred seventy five (30 percent of the individuals range-wide) both mature and immature individuals of *P. kaalae* are within fenced management units in the action and will therefore benefit from ungulate exclosure. Thus, *P. kaalae* in the action area is characterized by one population unit containing 92 percent of all remaining individuals and 55 percent of all mature individuals, which is increasing due to habitat management and augmentation, and another population unit that is being established through reintroduction.

Threats to the Species in the Action Area The primary threats to *Pritchardia kaalae* in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. Thus, because 92 percent of all known individuals and 55 percent of all mature trees occur within the action area, *P. kaalae* in the action area has a high background risk of species extinction; any additional threats could eliminate the expectation of its long-term persistence.

Conservation Needs of the Species in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrsion 2005a) includes *Pritchardia kaalae* because there are only two population units exceeding minimum numerical criteria for a stabilization population, including only one outside the action area. Three population units are identified for stabilization of *P. kaalae*: Ohikilolo and Ohikilolo East and West Makaleha in the action area, and Makaleha to Manuwai outside the action area. The Ohikilolo population unit within the action area has exceeded minimum numerical criteria for a stabilization population, although threats are not fully controlled and genetic storage is not complete. The Ohikilolo East and West Makaleha

population unit is being established by reintroduction and will be managed for stabilization, but will not contain mature trees for many years. The East Makaleha and West Makaleha Management Units are not fenced, and ungulates and weeds are minimally controlled; fence construction is planned for 2008 and 2009, respectively (U.S. Army Garrison 2005b). Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species in the Action Area The Ohikilolo, and Ohikilolo East and West Makaleha, population units within the action area are being managed for stabilization as specified by the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). In addition, this species occurs in the East Makaleha, Ohikilolo, and West Makaleha Management Units within the action area. A major part of the Ohikilolo Management Unit is protected by a boundary ridgeline fence, goats have been virtually eradicated from Makua, and weeds and rats are controlled in some *P. kaalae* occurrences (U.S. Army Garrison 2005b). The other management units are not fenced. Genetic storage goals are about 13 percent complete, with 27 plants from all four population units combined meeting the goals outlined in the Makua Implementation Plan, and there are also 30 plants growing in the Army nursery (U.S. Army Garrison 2005b).

Status of the Species and Critical Habitat – *Sanicula mariversa* (No Common Name)

Species Description *Sanicula mariversa* is a perennial herbaceous plant in the Apiaceae (parsley family). Basal leaves arise from a thick underground storage root, and are up to 23-cm (9 in) wide with three to five lobes. The yellow flowers are borne in masses on stems up to 0.7 m (2.3 ft) tall. Some of the flowers are perfect (with both male and female reproductive parts) and others have only staminoid (male) parts. The egg-shaped fruits are 4 to 6 mm (about 0.2 in) long and covered with hooked bristles (Wagner et al 1999; Makua Implementation Team 2003).

Listing Status *Sanicula mariversa* was federally listed as endangered on October 29, 1991 (56 FR 55770), and was State listed as endangered at the same time. This species is included in recovery plans for Waianae plants (Service 1995a) and Oahu plants (Service 1998a). Critical habitat for this species was designated on June 17, 2003 (68 FR 35950).

Historic and Current Distribution *Sanicula* is a genus endemic to the Hawaiian Islands. Historic data indicate *Sanicula mariversa* occurred in the central Waianae Mountains of Oahu (68 FR 35950). This species was first discovered in the 1970s, on Ohikilolo Ridge, and nothing is known of its past distribution and abundance (Makua Implementation Team 2003). When the species was listed, only two occurrences totaling less than 200 individuals were known. Currently, *S. mariversa* occurs in four population units totaling approximately 224 individuals, none of which is stable (Table SB 32). These population units are found on Federal, State, and city/county lands (68 FR 35950).

Currently demographic data is insufficient to detect trends in *Sanicula mariversa*. Since listing, consistent surveys have been conducted for only two locations. These surveys have shown that annual counts do not necessarily reflect numerical individual trends or the number of mature and

immature individuals persisting. *Sanicula mariversa* is a perennial herb that is dormant during the summer. In addition, individual plants do not emerge each year and take many years to mature making detection in the field challenging. Mature plants flower inconsistently and appear to die after flowering once. Environmental conditions, such as large seed production years or favorable germination conditions may influence age at maturity and the length of dormancy periods. All these characteristics result in unpredictable population fluctuations from year to year (U.S. Army Garrison 2005b). Plants in the Keaau and Ohikilolo population units are located in low and very low risk zones for training-related wildfire. Thus, due to low numbers, lack of population units meeting stabilization numeric criteria, and insufficient knowledge of ecological influences on population dynamics, demographic data for *S. mariversa* are insufficient to determine whether the species is sustaining its numbers or declining.

Table SB 32. Range-wide distribution of *Sanicula mariversa.*

Population Units	Numbers of known individuals					
	1991 (1)	**1995-1998** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Keaau*	--	--	16/125‡	7/100	14/69	14/114
Ohikilolo*	--	--	34/109	1/62 [0/19]§	0/51	0/52
Kamaileunu*	--	--	26	13/22	3/16	4/36
Puu Kawiwi	--	--	2	0/32	0/36	0/4
Total Individuals	**< 200**	**75**	**312** (78/234)†	**256** (21/216) [0/19]	**189** (17/172)	**224** (18/206)

Shaded population units are inside the action area.
*Stabilization population units
‡Total mature/immature individuals
†Total (mature/immature)
§[augmented and or reintroduction]

(1) Listing rule (56 FR 55770)
(2) Recovery plans (Service 1995a, 1998a)
(3) Makua Implementation Plan (Makua Implementation Team 2003)
(4) MIP Addendum and 2004 status report (U.S. Army Garrison 2005a, 2004)
(5) 2005 status report (U.S. Army Garrison 2005b)
(6) 2006 status update (U.S. Army Garrison 2006c)

Ecology *Sanicula mariversa* occurs on dry, well-drained slopes at elevations of about 750 m (2,461 ft), usually on north-facing slopes just below the ridgeline or on exposed ridge crests. Most of the known plants grow in deep soil, although two plants were found at Puu Kawiwi in the cracks of a nearly vertical rock face (Makua Implementation Team 2003). Leaves and stems die back to the storage root usually in May, and the plants are dormant during the dry summer months until new growth emerges usually in October or November. Flowering occurs from February through May, with fruits maturing a few months later. The massed inflorescences suggest pollination by insects, and bristles on the fruit suggest dispersal by birds. Because *S. mariversa* is an herbaceous species, its longevity probably is similar to that of other small plants that live less than 10 years (i.e., short-lived perennials) (Makua Implementation Team 2003).

Other demographic information for *S. mariversa* in the wild is unknown, including longevity, dormancy cycles, number of seeds produced, age at sexual maturity, survivorship to sexual maturity, pollination and seed dispersal, vegetative reproduction and specific environmental requirements.

Threats to the Species *Sanicula mariversa* was listed as endangered because of major, ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section, and are tabulated in Appendix E. *Sanicula mariversa* also is threatened by trampling by hunters and hikers on Keaau Ridge, and potentially by fence maintenance activities on Ohikilolo Ridge (Makua Implementation Team 2003). Population units of *S. mariversa* are especially vulnerable to extirpation from naturally occurring events such as landslides and/or reduced reproductive vigor due to small population size and limited distribution (56 FR 55770; 68 FR 35950; Service 1995a; Service 1998a). The science of conservation biology has documented a general pattern of population collapse for a wide range of plant and animal species (Dennis et al 1991; Schemske et al 1994; Morris et al 1999; Menges 2000). According to this pattern, *S. mariversa* already is in a phase of "quasi-extinction" with numbers that have declined to the point where demographic stochasticity alone can result in extirpation. Thus, *S. mariversa* has a very high background risk of species extinction and additional threats could eliminate expectation of its long-term persistence.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Sanicula mariversa* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve stabilization of all existing populations (Service 1995a, 1998a). The numerical criterion for stabilization of short-lived perennials is generally defined as three population units each consisting of 50 mature, reproducing individuals. Owing to infrequent, inconsistent flowering and significant population fluctuations from year to year, this standard was increased for *S. mariversa* to 100 mature, reproducing individuals per population unit. Other particular needs for the conservation of *S. mariversa* include research on seasonal life cycle, dormancy, and seed bank influences, and development of an effective monitoring program to determine whether stabilization criteria should be revised. For example, a five-year average of plants at various stages of maturation may be a more suitable goal for this species than annual counts of observed individuals. In addition, refinement of genetic storage goals require better data on seed dormancy, and propagation techniques must be developed (U.S. Army Garrison 2005b).

Ongoing Conservation Actions The Makua Implementation Team (2003) has developed stabilization protocols for *Sanicula mariversa*, which are incorporated in the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). In addition, individuals of this species occur in three management units where they will benefit from population unit and/or ecosystem-level protection. The management units include Kamaileunu, and Keaau and Makaha, which are not fenced; and Ohikilolo, which is fenced.

Germination trials with fresh *Sanicula mariversa* seed have been unsuccessful, and research is needed to determine dormancy constraints and appropriate propagation and outplanting

techniques. In the wild, plants reintroduced in the Ohikilolo population unit have not been seen since 2003, and seed-sowing trials in 1999 resulted in only one germinated plant (U.S. Army Garrison 2005b). In 2005, *ex situ* collections for this species included 11 ungerminated seeds in a nursery (Harold L. Lyon Arboretum) and 11,000 seeds in seed storage (Lyon Arboretum Seed Storage Facility) (Service 2005b).

Critical Habitat Description A total of 93 ha (230 ac) of critical habitat in six separate units was designated for *Sanicula mariversa* on State lands (Makua, Keaau, and Waianae Kai Forest Reserves and Mt. Kaala Natural Area Reserve) and on private lands (Honouliuli Preserve) on Oahu. One unit provides habitat for two populations and five units together provide habitat for four populations. To meet recovery goals, a population should be represented by at least 300 mature, reproducing individuals of *S. mariversa* (68 FR 35950).

The primary constituent elements of critical habitat include dry, well-drained, slopes or rock faces in mesic shrublands or open grassy areas at elevations between 475 and 1,025 m (1,558 and 3,362 ft). In addition, all units contain one or more of the following associated native plant species: *Bidens torta*, *Carex meyenii*, *Doryopteris* sp., *Eragrostis* sp., *Metrosideros polymorpha*, or *Metrosideros tremuloides*. The plant community, associated species, and elevations are indicative of important features such as soil moisture, nutrient cycling and availability, temperature ranges, and light levels which are primary constituent elements of the habitat required for the species' conservation (68 FR 35950).

Threats to the Critical Habitat See introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Habitat degradation by goats and trampling by humans on or near trails are particular threats in some *S. mariversa* critical habitat units (68 FR 35950).

Environmental Baseline of the Species and Critical Habitat

Status of the Species in the Action Area About 80 percent of all known individuals of *Sanicula mariversa* are located within the action area, in the Ohikilolo and Keaau population units (see Table SB 32). These population units have been monitored since 1995 and 1999, respectively. Neither population unit is currently meeting stabilization numerical criteria (defined as 100 mature individuals). The number of individuals in both population units varies significantly from year to year, ranging from 12 individuals in 1998 to 138 in 2002 in Ohikilolo, and from 11 in 2001 to 107 in 2004 in Keaau. In addition, 19 immature plants were reintroduced to the Ohikilolo population unit in 2001 but have since disappeared (U.S. Army Garrison 2005b). The Army does not plan any future reintroductions or augmentations of *S. mariversa* until more is known about its dormancy cycle. All individuals in the Ohikilolo and Keaau population units are at low and very low risk of training-related wildfire. About 52 individuals occur in the low fire risk zone and 128 individuals in the very low fire risk zone. These population units are located within an extremely dry part of the action area that is buffered somewhat from fire by a strip of thick forest and by sparsely vegetated cliffs (U.S. Army Garrison 2005a). The Ohikilolo population unit is located within the Ohikilolo Management Unit on Makua, which occurs along the steep wall of Makua valley. The Keaau population unit is located within the Keaau and Makaha Management Unit on the saddle ridge between the Keaau and Makaha valleys. Thus, the species is characterized by low numbers of individuals, lack of population units meeting

minimum numerical criteria for stabilization, location of 80 percent of the individuals within fire risk zones.

Status of the Critical Habitat in the Action Area A total of 10.0 ha (24.8 ac), or 11 percent, of the total critical habitat for *Sanicula mariversa* is found within two critical habitat units in the action area. These two critical habitat units are located on State land in the south-central part of the action area, and together provide potential habitat to support one population of 300 mature, reproducing individuals. Critical habitat for this species in the action area is located in an area at risk of training-related wildfire, with 0.3 ha (0.8 ac) in the low fire risk zone and 9.7 ha (24.0 ac) in the very low fire risk zone. It is estimated that slightly more than half of the critical habitat within the action area is found in an area with less than 50 percent native plant cover (K. Kawelo, pers. comm. 2004; Service 2004a).

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Sanicula mariversa* and its critical habitat in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section, and are tabulated in Appendix E. *Sanicula mariversa* in the action area is especially vulnerable to wildfire from military training activities. Feral goats have been substantially reduced in the Ohikilolo population unit, but not in the Keaau population unit. In addition to browsing and trampling, goat activity also has resulted in substantial erosion in parts of the Keaau population unit. About 11 percent of the total critical habitat designated for this species is located in the low and very low fire risk zones. Thus, because about 80 percent of all known individuals occur within the action area in zones of low to very low fire risk, *S. mariversa* in the action area has a very high background risk of species extinction and any additional threats could eliminate the expectation of its long-term persistence.

Conservation Needs of the Species and Critical Habitat in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) includes *Sanicula mariversa* because more than 50 percent of all known individuals occur within the action area, and no population units meeting minimum numerical criteria for stabilization exist outside the action area. Three population units have been identified for stabilization of *S. mariversa*, only one of which is located outside of the action area: Keaau-and-Ohikilolo within the action area and Kamaileunu outside the action area. Furthermore, because of its low numbers, this species is considered particularly at risk from project-related impacts and is included in Army plans for expedited stabilization. Management designations may need to be revised to ensure that two population units are stabilized outside the action area. In addition, post-fire revegetation plans and site-specific fuel modification are needed where this species is located in the action area. About 15 ha (38 ac) of the Ohikilolo Management Unit is not fenced; fence construction for this area is planned for 2011. The critical habitat adjacent to the Ohikilolo Management Unit will not be fenced, but it is located in very steep terrain that limits ungulate and human access (Service 2004a). The Keaau and Makaha Management Unit will be fenced in 2009, and is in need of goat and invasive weed control; there are no plans to fence the Kamaileunu Management Unit. Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species and Critical Habitat in the Action Area Two population units containing 80 percent of the total remaining individuals are being managed for stabilization as specified by the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). In addition, this species occurs in two management units in the action area, Ohikilolo, which is fenced, and Keaau-and-Makaha, which is not fenced. A major part of the Ohikilolo Management Unit is protected by a boundary ridgeline fence, goats have been virtually eradicated from Makua, and invasive weeds are controlled around *S. mariversa* sites. A total of about 19.6 ha (48.4 ac) of critical habitat for this species is located within management units both within and outside of the action area (Ekahanui, Kamaileunu, Keaau and Makaha, Manuwai, Ohikilolo). About 2.4 ha (6.0 ac) of the total critical habitat that is within management units is located inside the action area (Keaau and Makaha, Ohikilolo). In 2005, genetic storage goals were 42 percent complete, with 84 plants from all four population units combined towards meeting the goals of the Makua Implementation Plan; there were no plants growing in the Army nursery (U.S. Army Garrison 2005b).

Status of the Species and Critical Habitat – *Schiedea hookeri* (No Common Name)

Species Description *Schiedea hookeri* is a relatively long-lived perennial of the Caryophyllaceae (pink) family. It is a sprawling or clumped sub-shrub (stems woody at the base) with stems 0.3 to 0.5 m (1 to 1.6 ft) long that curve slightly upward or lie close to the ground in matted clumps. The narrow, oppositely arranged leaves are 3 to 8 cm (1.2 to 3.2 in) long and 0.4 to 1.5-cm (0.2 to 0.6 in) wide. The small, perfect flowers (with both male and female reproductive parts) have no petals and are borne in open, branched clusters that are hairy and somewhat sticky. The fruit is a capsule about 3 mm (0.1 in) long (Wagner et al 1999).

Listing Status *Schiedea hookeri* was federally listed as endangered on October 10, 1996 (61 FR 53108), and was State listed as endangered at the same time. A recovery plan for multi-island plants included this species (Service 1999a), and critical habitat was designated on June 17, 2003 (68 FR 35950). The genus *Schiedea* (including species formerly classified as *Alsinidendron*) has the highest proportion of endangered taxa in Hawaii (Wagner et al 2005), with 19 of 35 taxa (54 percent) listed as endangered and three identified as candidates for listing (Service 2006a).

Historic and Current Distribution *Schiedea* is a genus endemic to the Hawaiian Islands. Trends in distribution indicate range restriction in *Schiedea hookeri*, which historically occurred in the Waianae Mountains of Oahu and perhaps occurred on Maui (although the single fragmentary collection from East Maui may represent another species) (61 FR 53108). Currently, this species occurs only in the Waianae Mountains. When the species was listed in 1996, 11 occurrences totaling 220 to 330 individuals were known. Currently, 18 occurrences totaling about 420 individuals are known on Federal, State, city/county, and private lands (Table SB 33) (68 FR 35950). Current numbers include 128 individuals within the Makua action area and 5 individuals within the Schofield Barracks Military Reservation action area (Service 2003a; U.S. Army Garrison 2006c). Trends in numbers and distribution are difficult to discern, however, owing to inconsistent identification of occurrences and monitoring efforts. No range-wide surveys have been conducted for this species. According to the most recent information available, four of the 18 population units have reached stabilization population minimum numerical criteria (defined as at least 50 mature, reproducing individuals); three of these

stabilization populations are located outside the action area (Service 1999a; U.S. Army Garrison 2006c). No recent information is available on trends in reproduction in the wild, and there is no evidence of reproduction from seed under field conditions (Service 1999a). Plants in the Kahanahaiki, Kaluakauila, Keaau, Ohikilolo, and North Mohiakea occurrences are located in zones at risk from training-related wildfire. Thus, *S. hookeri* is characterized by apparently increasing trends in numbers and reaching minimal numeric criteria for a stabilization population in four of the 18 existing occurrences.

Table SB 33. Range-wide Distsribution of *Schiedea hookeri*.

Population Units	**Number of Known Individuals**			
	1996 (1)	**2003** (2)	**2005** (3)	**2006** (4)
Kahanahaiki	--	--	20	20
Kaluakauila	--	6-10	52	52/0/40‡
Keaau	--	--	12	12
Ohikilolo	--	--	4	4
Lower Kaala Natural Area Reserve	--	--	37	50
Kalena-Kaala Ridge	--	--	--	--
Kaluaa to Ekahanui	--	60	110	2
Kamaileunu Ridge	--	11	--	--
Kolekole/Puu Hapapa	--	10	--	--
Makaha/Makaha-Waianae Kai Ridge	--	40	--	--
Makua/Makaha Ridge	--	4	5	17
North Mohiakea (SBWR)	--	5	--	--
North Waieli	--	--	3	3
Palikea Gulch	--	10	--	20
Puu Kaua	--	55	50	50
Waianae Kai/ Waianae Kai Ridge	--	63	94-144	150
Total Individuals	**220-330**	**333-383**	**387-437**	**420**^
Other Locations				82

Shaded occurrences are inside the action area; numbers include total individuals.
SBWR = Schofield Barracks West Range.
‡Total mature/immature/seedling individuals
^Totals from Army database

(1) Listing rule (61 FR 53108), recovery plan (Service 1999a)
(2) Critical habitat rule (68 FR 35950), Oahu Biological Opinion (Service 2003a)
(3) Army re-initiation request (U.S. Army Garrison 2005c)
(4) Army database (U.S. Army Garrison 2006d)

Ecology *Schiedea hookeri* occurs in the understory of diverse mesic or dry lowland forests typically dominated by *Metrosideros polymorpha* or *Diospyros* species, at elevations ranging between 350 and 900 m (1,148 and 2,953 ft) (61 FR 53108; 68 FR 35950; Wagner et al 1999). It usually grows on slopes, cliffs and cliff bases, rock walls, and ledges. *Schiedea hookeri* is an

outcrossing species probably pollinated by insects. Mature fruits have been observed in June and August, but seed dispersal mechanisms are unknown. This species varies considerably throughout its range in potential for vegetative (clonal) growth and spread. Upright plants at one site, for example, show little clonal potential, whereas decumbent plants at another site exhibit clonal growth by nodal rooting (68 FR 35950; Service 1999a). Plant longevity is probably similar to that of other small, semi-woody shrubs that live less than 10 years (i.e., short-lived perennials). Other demographic information for *S. hookeri* in the wild is unknown, including phenology, number of seeds produced, age at sexual maturity, survivorship to sexual maturity, number of years in reproductive condition, survivorship during reproductive life, timing of reproductive output, pollination and seed dispersal, vegetative reproduction and specific environmental requirements.

Threats to the Species *Schiedea hookeri* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. *Schiedea hookeri* is particularly vulnerable to predation by non-native slugs and snails (61 FR 53108). Seedlings from other *Schiedea* species that occur in mesic or wet sites are apparently consumed by these alien invertebrates. One study noted, for example, that seedling mortality for the related species *S. obovata* doubled when exposed to slug herbivory (U.S. Army Garrison 2005b). *Schiedea* species that occur in dry areas, however, produce abundant seedlings following winter rains, perhaps because drier sites have fewer non-native invertebrate herbivores (Service 1999a). *Schiedea hookeri* also may suffer from a lack of pollinators (Service 1999a). Wildfire ignited by military training activities is a threat to this species in the Makua and Schofield Barracks action areas.

Occurrences of *Schiedea hookeri* are probably not as vulnerable as other endangered *Schiedea* species to extirpation from naturally occurring events and/or reduced reproductive vigor due to small population size and limited distribution. Nonetheless, a series of self-pollination experiments that included within-occurrence crosses and crosses among occurrences demonstrated that *S. hookeri* shows moderately strong inbreeding depression. Reductions in population size could result in expression of inbreeding depression among progeny, such as reduced reproductive vigor, with potentially deleterious consequences for the long-term persistence of this species (68 FR 35950). Thus, owing to minimum numeric criteria being reached in four occurrences, *S. hookeri* has a moderate background risk of species extinction, and protection from existing and additional threats is needed to ensure its long-term persistence.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Schiedea hookeri* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve stabilization of all existing populations (Service 1999a). Conservation actions required for stabilization are described in the "Stabilization" section of the project description for this opinion. However, *S. hookeri* is not included as a target taxon for stabilization under the Makua Implementation Plan Addendum. The Army does not actively manage this species in the Makua or Schofield Barracks action areas (Service 2003a). Research on slug control in forest settings is needed to find ways to reduce invertebrate threats to *S. hookeri* and associated native plants.

Ongoing Conservation Actions No information is available on conservation management for *Schiedea hookeri* since it was listed as endangered. However, about 128 individuals (30 percent of all remaining individuals) of this species occur action area in management units where they will benefit from population unit and/or ecosystem-level protection. The management units include Keaau and Kahanahaiki, which are not fenced; and Kaluakauila and Ohikilolo, which are fenced. The Nature Conservancy of Hawaii's long-range management plan for Honouliuli Preserve includes management actions to control non-native plants, feral ungulates, and fire, and to recover rare species and restore native habitats; this plan will benefit any *S. hookeri* within the preserve. This species is represented in *ex situ* collections that include nine cuttings in a nursery (Harold L. Lyon Arboretum) and 30 plants in a botanical garden (Waimea Valley Audubon Center) (Service 2005b).

Critical Habitat Description A total of 1,102 ha (2,724 ac) of critical habitat was designated in seven separate units for *Schiedea hookeri* on Oahu. Critical habitat was designated on State lands (Kaena Point State Park, Kuaokala, Mokuleia, and Waianae Kai Forest Reserves; and Pahole and Kaala Natural Area Reserves), Federal lands (Lualualei Naval Reservation), and private lands (Honouliuli Preserve). These seven critical habitat units provide habitat for eight populations. To meet recovery goals, a population should be represented by at least 300 mature, reproducing individuals of *S. hookeri* (68 FR 35950).

The primary constituent elements of critical habitat include slopes, cliffs or cliff bases, rock walls, or ledges in diverse mesic or dry lowland forest often dominated by *Metrosideros polymorpha*, *Diospyros sandwicensis*, or *D. hillebrandii*; at elevations between 238 and 978 m (781 and 3,208 ft). In addition, all units contain one or more of the following associated native plant species: *Acacia koa*, *Alyxia oliviformis*, *Antidesma pulvinatum*, *Artemisia australis*, *Bidens torta*, *Carex meyenii*, *Carex wahuensis*, *Charpentiera tomentosa*, *Dodonaea viscosa*, *Elaeocarpus bifidus*, *Eragrostis grandis*, *Hibiscus* sp., *Leptecophylla tameiameiae*, *Melanthera tenuis*, *Pisonia sandwicensis*, *Pouteria sandwicensis*, *Psydrax odorata*, *Sida fallax*, or *Stenogyne* sp. The plant community, associated species, and elevations are indicative of important features such as soil moisture, nutrient cycling and availability, temperature ranges, and light levels, which are primary constituent elements of the habitat required for the species' conservation (68 FR 35950).

Threats to the Critical Habitat See the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Environmental Baseline of the Species and Critical Habitat

Status of the Species in the Action Area The four occurrences of *Schiedea hookeri* in the action area total about 128 individuals or about 30 percent of the species' range-wide distribution (U.S. Army Garrison 2006c) (see Table SB 33). Only the Kaluakauila occurrence is exceeding minimum numerical criteria for a stabilization population at 52 mature individuals. This occurrence is within a fenced ungulate exclosure; the other three action area occurrences are not fenced, and none of the action area occurrences are actively managed by the Army. *Schiedea hookeri* plants in the action area are located in areas at risk from training-related wildfire. About 92 individuals occur in the high fire risk zone, 20 individuals in the low fire risk zone and 6 in the very low fire risk zone. These individuals in fire risk zones represent about 31 percent of the

species' total range-wide numbers; about 25 percent of the species' total range-wide numbers are located in the high fire risk zone. The Kaluakauila occurrence (52 individuals) is located within a zone of high fire risk, in an extremely dry area (U.S. Army Garrison 2005a). Thus, *S. hookeri* in the action area is characterized by one occurrence at minimum numeric levels to be categorized as a stabilization population unit that comprises 30 percent of all remaining individuals, most of which are located within high to very low fire risk zones, and by three occurrences with low numbers not reaching minimum numerical stabilization criteria and unknown trend.

Status of the Critical Habitat in the Action Area The action area contains a total of 30 ha (75ac) or three percent of the total critical habitat for *Schiedea hookeri*. Designated critical habitat is located within one unit in the northeastern portion of the action area. About three percent of critical habitat for this subspecies is located in an area at risk of training-related wildfire, with 6 ha (14 ac) located in the high fire risk zone and approximately 25 ha (61 ac) are in the very low fire risk zone. It is estimated that the critical habitat is located in an area with up to 75 percent native plant cover (K. Kawelo, pers. comm. 2004).

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Schiedea hookeri* and its critical habitat in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. This species is particularly threatened by competition with non-native weeds and by fire. The July 2003 prescribed fire at Makua burned within 20 m (66 ft) of *S. hookeri* plants in the Kaluakauila Management Unit, and burned approximately 2.4 ha (6 ac) of *S. hookeri* critical habitat (U.S. Army Garrison 2003b). About two percent of the total critical habitat designated for this species is at risk from training-related wildfire in the action area, with less than one percent located in the high fire risk zone. In addition, only 31 percent of all known individuals occur within the action area. Thus, *S. hookeri* in the action area has a moderate background risk of species extinction, and any additional threats are unlikely to eliminate the expectation of its long-term persistence.

Conservation Needs of the Species and Critical Habitat in the Action Area *Schiedea hookeri* non stabilization species by the Army because less than 50 percent of all remaining individuals are located within the action area, and there are three stabilization population units outside the action area. A post-fire revegetation plan and site-specific fuels modification plan are needed where *S. hookeri* is present in the action area. Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species and Critical Habitat in the Action Area No conservation actions are currently being implemented for *Schiedea hookeri* in the action area. However, this species benefits from ecosystem-level management in the fenced Kaluakauila and Ohikilolo Management Units, where non-native ungulates and weeds are controlled. In addition, fuels modification along the Kaluakauila ridgeline reduces the risk of fire in the management unit (K. Kawelo, pers. comm. 2004).

Status of the Species – *Schiedea kaalae* (No Common Name)

Species Description *Schiedea kaalae* is a short-lived perennial of the Caryophyllaceae (pink) family. It has a short woody caudex (perennial stem at the ground surface) less than 20 cm (8 in) tall, with short branches that trail along the ground and end in rosettes of thick, oppositely arranged leaves. The small, perfect flowers (with both male and female reproductive parts) are borne in open, branched clusters up to 40 cm (15.6 in) long. The fruit is a small capsule filled with tiny, dark seeds (Wagner et al 1999; Makua Implementation Team 2003).

Listing Status *Schiedea kaalae* was federally listed as endangered on October 29, 1991 (56 FR 55770), and was State listed as endangered at the same time. This species is included in recovery plans for Waianae plants (Service 1995a) and Oahu plants (Service 1998a). Critical habitat for *S. kaalae* was designated on June 17, 2003 (68 FR 35950). The genus *Schiedea* (including species formerly classified as *Alsinidendron*) has the highest proportion of endangered taxa in Hawaii (Wagner et al 2005), with 19 of 35 taxa (54 percent) listed as endangered and three identified as candidates for listing (Service 2006a).

Historic and Current Distribution *Schiedea* is a genus endemic to the Hawaiian Islands. Historic data indicate *Schiedea kaalae* was known from the north-central and south-central Waianae Mountains and the northern Koolau Mountains of Oahu. When listed in 1991, there were five occurrences in the Waianae Mountains and two occurrences in the Koolau Mountains that together totaled less than 100 individuals (56 FR 55770). In 2003, eight population units totaling 24 to 25 individuals indicated a steady decline for this species (Makua Implementation Team 2003). The latest information available indicates an increasing in detection due to more diligent survey effort and augmentation, with 10 population units totaling 235 individuals located on Federal, State, and private lands (68 FR 35950) (Table SB 34). Of these, 62 individuals are naturally occurring and 173 are augmentations from greenhouse-propagated stock. A new population unit was recently discovered at Kahana, and additional individuals were discovered at the Makua population unit (U.S. Army Garrison 2005b). None of the population units have reached the numeric targets for stabilization (defined as 50 mature individuals for short-lived perennials).

Demographic information in the wild is unknown, as *Schiedea kaalae* seedlings and immature plants are seldom seen, especially in Waianae population units. The apparent lack of recruitment is probably due to seedling predation by non-native slugs and snails (Makua Implementation Team 2003; U.S. Army Garrison 2004a, 2005b). The Nature Conservancy of Hawaii has propagated and outplanted *S. kaalae* from seed and cuttings, but no seedlings have been observed at those outplanting sites (U.S. Army Garrison 2004a). No information is available on the survival rate of immature outplantings. Individuals of this species are at risk from training-related wildfire in the Makua and Schofield Barracks Military Reservation action areas. Thus, *S. kaalae* is characterized by extremely low numbers that are increasing only by augmentation and occasional discovery of new occurrences.

Table SB 34. Range-wide Distribution of *Schiedea kaalae*.

Population Units	Number of Known Individuals					
	1991 (1)	**1995-1998** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Pahole*	--	--	3	1/0[‡]	2/0	0/3 [19/0]
Huliwai	--	--	1-2	0	0	0
Kahana (Koolau)*	--	--	--	11/0	5/2	5/2
Kaluaa and Waieli*	--	--	--	--	0/0 [40/25]	0/0 [72/44]
Kaipapau	--	--	--	2/0	0	0
Maakua (Koolau)*	--	--	4	4/0	16/0	16/0
Makaua (Koolau)	--	--	2	2/0	1/1	1/0 [0/1]
Mohiakea (SBMR)	--	--	1	1/0	1/0	1/0
North Kaluaa	--	--	2	0/0 [0/53][§]	0	0
North Palawai	--	--	1	1/0	1/0	1/0
South Ekahanui* (North and South)	--	--	10	5/0 [0/75]	14/0 [0/46]	14/0 [56/0]
Total Individuals	<100	13	24-25	**155** (27/0)[†] [0/128]	**154** (40/3) [40/71]	**235** (38/5) [147/45]

Shaded population units are inside the action area.
SBMR = Schofield Barracks Military Reservation.
[‡]Total mature/immature individuals
*Stabilization population units
[†]Total (mature/immature)
[§][augmented and or reintroduced]

(1) Listing rule (56 FR 55770)
(2) Recovery plans (Service 1995a, 1998a)
(3) Makua Implementation Plan (Makua Implementation Team 2003), Oahu Biological Opinion (Service 2003a)
(4) MIP Addendum and 2004 status report (U.S. Army Garrison 2005a, 2004)
(5) 2005 status update (U.S. Army Garrison 2005b), T. Takahama (Hawaii Division of Forestry and Wildlife, pers. comm. 2006)
(6) 2006 status update (U.S. Army Garrison 2006c)

Ecology *Schiedea kaalae* in the Waianae Mountains is consistently found on steep slopes and shaded sites in the understory of diverse mesic forest and wet forest, usually in gulch bottoms or low to mid gulch slopes, at elevations between 210 to 790 m (689-2,592 ft). It often grows on slopes with sparse groundcover and occasionally in cracks in rock embankments. In the Koolau Mountains, *S. kaalae* occurs in gulch bottoms and on lower gulch slopes within mesic to wet habitats, some of which are constantly wet from seeping water. Plants can grow on gentle to moderate slopes, steep rock embankments, and nearly vertical cliffs (56 FR 55770; Makua Implementation Team 2003). Where *S. kaalae* occurs in the same drainages as its relatives *S. hookeri, S. nuttallii, S. obovata,* and *S. pentandra,* it is usually found in the drier areas. *Schiedea kaalae* flowers from March through June. Cultivated plants are capable of self-pollination, but *S.*

kaalae is an outcrossing species that requires pollinators, probably insects, for fruit production (Wagner et al 2005). In the field, biologists have observed a non-native syrphid fly visiting the plants (Makua Implementation Team 2003). Plant longevity probably is similar to that of other small, semi-woody shrubs that live less than 10 years (i.e., short-lived perennials) (Makua Implementation Team 2003). Other demographic information on *S. kaalae* in the wild is unknown, including number of seeds produced, age at sexual maturity, survivorship to sexual maturity, number of years in reproductive condition, survivorship during reproductive life, timing of reproductive output, pollination and seed dispersal, vegetative reproduction and specific environmental requirements.

Threats to the Species *Schiedea kaalae* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. *Schiedea kaalae* is particularly vulnerable to predation by non-native slugs and snails. One study noted, for example, that seedling mortality for the related species *S. obovata* doubled when exposed to slug herbivory (U.S. Army Garrison 2005b). In addition to the very low risk of training-related wildfire from military activities at Makua, one individual of *S. kaalae* is exposed to the risk of training-related wildfire at Mohiakea Gulch in the Schofield Barracks Military Reservation action area (Service 2003a).

Most importantly, occurrences of *Schiedea kaalae* are vulnerable to extirpation from naturally occurring events and/or reduced reproductive vigor due to small population size and limited distribution (56 FR 55770; 68 FR 35950; Service 1995a, 1998a). In addition, *S. kaalae* and the related species *S. nuttallii* and *S. pentandra* are characterized by low isozyme variability and inbreeding due to small population size (Wagner et al 2005). Reductions in population size could result in expression of inbreeding depression among progeny, for example in reduced reproductive vigor, with potentially deleterious consequences for the long-term persistence of this species. However, low levels of genetic diversity in *S. kaalae* populations may not be detrimental to the species as plants from populations that appear to have undergone repeated self-fertilization are vigorous in cultivation (Makua Implementation Team 2003). Nonetheless, the science of conservation biology has documented a general pattern of population collapse for a wide range of plant and animal species (Dennis et al 1991; Schemske et al 1994; Morris et al 1999; Menges 2000). According to this pattern, *S. kaalae* already is in a phase of "quasi-extinction," with numbers that have declined to the point where demographic stochasticity alone can result in extirpation. Thus, *S. kaalae* has a very high background risk of species extinction, and any additional threats could eliminate expectation of its long-term persistence.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Schiedea kaalae* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve stabilization of all existing populations (Service 1995a, 1998a). The three population units identified for stabilization of *S. kaalae* are all located on State or private lands. The Army proposes to manage an additional two population units for stabilization at Maakua and Kahana, in the Koolau Mountains (U.S. Army Garrison 2005b). Research on slug control in forest settings is needed to find ways to reduce invertebrate threats to *S. kaalae* and associated native plants.

Ongoing Conservation Actions The Makua Implementation Team (2003) has developed stabilization protocols for *Schiedea kaalae*, which are incorporated in the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). Population units of *S. kaalae* are fenced in the Pahole, South Ekahanui, Kaluaa and Waieli, Makuaa, Mohiakea, and North Palawai population units; weeds are partially controlled only in the Mohiakea, North Palawai, and Kahana population units (U.S. Army Garrison 2005b). In addition, this species occurs in three management units where it will benefit from population unit and/or ecosystem-level protection. The management units include Lower Kahana, which is not fenced; and Ekahanui and Pahole, which are fenced. The South Ekahanui population unit is augmented by The Nature Conservancy of Hawaii. The Nature Conservancy of Hawaii's long-range management plan for Honouliuli Preserve includes management actions to control non-native plants, feral ungulates, and fire, and to recover rare species and restore native habitats, including the South Ekahanui population unit of *S. kaalae*. Seeds and cuttings have been taken from the recently discovered plants in the Kahana population unit for propagation and augmentation (U.S. Army Garrison 2005b).

Obtaining sufficient seed for genetic storage of *Schiedea kaalae* is difficult because plants do not produce much seed at one time. This species can be propagated from both seed and cuttings. Germination rates of fresh seeds vary from less than 15 percent to 75 percent (U.S. Army Garrison 2005b). The Nature Conservancy of Hawaii has propagated this species successfully from seed in the greenhouse, and has reintroduced plants to three sites in Honouliuli Preserve. Survivorship of these outplants appears good, but they have not yet produced any seedlings (U.S. Army Garrison 2005b). This species is represented in several *ex situ* collections, including one apical vegetative bud in micropropagation (Harold L. Lyon Arboretum), 23 cuttings in a nursery (Harold L. Lyon Arboretum), 17 plants in a nursery (Harold L. Lyon Arboretum), nine plants in a botanical garden (Waimea Valley Audubon Center), 598 ungerminated seeds in a nursery (Harold L. Lyon Arboretum), 6,000 seeds in seed storage (Lyon Arboretum Seed Storage Facility), and 193 seedlings in a nursery (Harold L. Lyon Arboretum) (Service 2005b).

Critical Habitat Description A total of 1,103 ha (2,726 ac) in six separate units was designated as critical habitat for *Schiedea kaalae* on Oahu. Critical habitat was designated on State lands (Pahole Natural Area Reserve, Mokuleia, Hanuula, and Kaipapau Forest Reserves, and Sacred Falls and Kahana Valley State Parks) and private lands (Honouliuli Preserve and others). These critical habitat units provide habitat for 10 populations. To meet recovery goals, a population should be represented by at least 300 mature, reproducing individuals of *S. kaalae* (68 FR 35950).

The primary constituent elements of critical habitat include steep slopes, cliffs, stream banks, or deep shade in diverse mesic or wet forests at elevations between 64 and 904 m (210 and 2,965 ft). In addition, all units contain one or more of the following associated native plant species: *Alyxia oliviformis, Boehmeria grandis, Charpentiera* sp., *Claoxylon sandwicense, Cyrtandra calpidicarpa, Cyrtandra laxiflora, Diospyros hillebrandii, Diplazium arnottii, Diplazium sandwichianum, Dryopteris unidentata, Freycinetia arborea, Hedyotis acuminata, Nothocestrum longifolium, Pipturus albidus, Pisonia sandwicensis, Pisonia umbellifera, Pouteria sandwicensis, Psychotria hathewayi, Selaginella arbuscula*, or *Xylosma hawaiiense*. The plant community, associated species, and elevations are a barometer for such things as soil moisture, nutrient cycling and availability, temperature ranges, and light levels, which are included as

primary constituent elements of the habitat required for the conservation of this species (68 FR 35950).

Threats to the Critical Habitat See the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Environmental Baseline of the Species and Critical Habitat

Status of the Species in the Action Area The action area includes 22 (19 mature, 3 immature) *Schiedea kaalae* plants in the Pahole population unit or about nine percent of the species' total range-wide numbers (see Table SB 34). In 2003, there were three individuals in this population unit (Makua Implementation Team 2003; U.S. Army Garrison 2005b). The 22 plants are within the fenced Pahole Management Unit where ungulates, but not invasive weeds, are controlled by the Hawaii Division of Forestry and Wildlife (U.S. Army Garrison 2004a). This part of the Pahole Natural Area Reserve is in a zone of very low fire risk. Thus, *S. kaalae* in the action area is characterized by one population unit that has increased in number to 22 individuals or about nine percent of all remaining individuals of this species.

Status of the Critical Habitat in the Action Area The action area contains a total of 150 ha (372 ac) or 14 percent of the total critical habitat designated for *Schiedea kaalae* on Oahu and in the state. Critical habitat is located on State land (Pahole Natural Area Reserve) in the northeastern part of the action area. This critical habitat is part of a total 425 ha (1,051 ac) critical habitat unit that extends beyond the action area and provides habitat for two populations of 300 mature, reproducing individuals each. About 14 percent of critical habitat for this species is located in an area at risk from training-related wildfire, with almost no critical habitat located in the high fire risk zone. Approximately 0.0 ha (trace <0.1 ac.) are in the high fire risk zone, 7.4 ha (18.2 ac) are in the low fire risk zone and 143.1 ha (353.6 ac) are in the very low fire risk zone. It is estimated that almost half of the critical habitat in the action area contains less than 50 percent native plant cover (K. Kawelo, pers. comm. 2004).

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Schiedea kaalae* and its critical habitat in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. The greatest limiting factor to the stabilization of *S. kaalae* is slug predation of seedlings (U.S. Army Garrison 2005b). The action area critical habitat represents about 14 percent of total critical habitat at risk from training-related fire, with none in the high fire risk zone. Although the species as a whole is extremely at risk, the 22 plants in the very low fire risk zone of the action area represent only about nine percent of the species' range-wide distribution. Thus, *S. kaalae* in the action area has a relatively low background risk of species extinction, and any additional threats are unlikely to affect the species' long-term persistence outside the action area.

Conservation Needs of the Species and Critical Habitat in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) includes *Schiedea kaalae* because no population units exceeding minimum criteria for stabilization exist outside the action area (Makua Implementation Team 2003). Three population units have been identified for stabilization of *S. kaalae*: Pahole within the action area, and North Kaluaa and South Ekahanui

outside the action area. In addition, the Army has proposed two additional, backup population units for stabilization: Kahana and Maakua in the Koolau Mountains outside the action area. Army Natural Resources Staff have not seen the *S. kaalae* plant in the Pahole population unit within the action area and long-term access issues with the Hawaii Division of Forestry and Wildlife are unclear (U.S. Army Garrison 2005b). Post-fire revegetation plans and site-specific fuels modification are needed where individuals and critical habitat are located in the action area. Slug control research is needed to find ways to reduce threats to *S. kaalae* in the action area. Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species in the Action Area The Pahole population unit is located within the fenced Pahole Management Unit, and is being managed for stabilization as specified by the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). About 10 percent of the mature individuals of this species in the action area are within a fenced portion of the Pahole Management Unit. In general, sufficient collections for genetic storage have been difficult to achieve as plants produce few seeds at a time. Genetic storage goals are two percent complete, with 21 plants from all nine population units combined towards fulfilling the goals outlined in the Makua Implementation Plan. There are also 15 plants growing in the Army nursery (U.S. Army Garrison 2005b).

Status of the Species and Critical Habitat – *Schiedea nuttallii* (No Common Name)

Species Description *Schiedea nuttallii* is a short-lived perennial of the Caryophyllaceae (pink family). It is an erect subshrub (stems woody at the base) up to 1.5 m (4.9 ft) tall with purple-tinged, oppositely-arranged leaves 5 to 13 cm (2.0 to 5.1 in) long. The small, perfect flowers (with both male and female reproductive parts) are borne in terminal clusters 20 to 25 cm (7.8 to 9.8 in) long. The tiny hard, black seeds are contained within small papery capsules 2.5 to 3.5 mm (0.1 to 0.14 in) long (Wagner et al 1999; Makua Implementation Team 2003).

Listing Status *Schiedea nuttallii* was federally listed as endangered on October 10, 1996 (61 FR 53108), and was State listed as endangered at the same time. A recovery plan for multi-island plants included the listed taxon, then classified as comprised of plants from Kauai, Oahu, Molokai, and Maui (Service 1999a). Critical habitat for the listed taxon was designated for Oahu on June 17, 2003 (68 FR 35950); for Molokai on March 18, 2003 (68 FR 12982); and for Kauai on February 27, 2003 (68 FR 9115). The genus *Schiedea* (including species formerly classified as *Alsinidendron*) has the highest proportion of endangered taxa in Hawaii (Wagner et al 2005), with 19 of 35 taxa (54 percent) listed as endangered and three identified as candidates for listing (Service 2006a).

Previous Biological Opinions for military training at Makua cover Oahu occurrences of the listed taxon, and the Makua Implementation Plan covers the Waianae "subspecies" (Makua Implementation Team 2003). When listed, *Schiedea nuttallii* was considered to include historical occurrences on Kauai, Oahu, Molokai, and Maui, with occurrences still existing on Kauai and Oahu (61 FR 53108). The Makua Implementation Plan noted the species' taxonomy was under revision, and likely would be reclassified as two subspecies, with the Oahu and Maui

plants as the subspecies *nuttallii* and newly discovered plants on Molokai as a new subspecies (Makua Implementation Team 2003). However, the recently revised taxonomy of the genus *Schiedea* treats *S. nuttallii* as a full species comprised of Oahu, Molokai (recently extirpated), and Maui (historic) occurrences (Wagner et al 2005). The Kauai occurrence formerly considered as *S. nuttallii* is now recognized as two species endemic to Kauai, *S. perlmanii* and *S. kauaiensis*. The recently discovered occurrence on Molokai is recognized as a new species, *S. laui*. This Biological Opinion considers *S. nuttallii* as defined by Wagner et al (2005), i.e., as comprised of currently existing occurrences on Oahu. The status of this newly classified species is identical to that of Oahu occurrences of the federally listed taxon.

Historic and Current Distribution *Schiedea* is a genus endemic to the Hawaiian Islands. Historic data indicate considerable range restriction in *Schiedea nuttallii*, which was one of the most widely distributed species in the genus with documented occurrences on Oahu, Molokai (recently extirpated), and West Maui (historical) (Wagner et al 2005). On Oahu, *S. nuttallii* was recorded from scattered occurrences throughout the Waianae Mountains and the southeastern Koolau Mountains. The species is now restricted to the northern Waianae Mountains; plants in the southern Waianae Mountains have not been seen since the late 1970s (Makua Implementation Team 2003). Plants are located on Federal and State lands (68 FR 35950). The Ekahanui Gulch occurrence at the privately owned Honouliuli Preserve, which was noted when the species was listed, has not been seen since 1978 (Service 1999a).

Consistent monitoring survey data for this species are available only since 2003, when *Schiedea nuttallii* was characterized as "clearly declining" with 50 total individuals in three population units (Makua Implementation Team 2003). Currently, this species consists of only two known population units totaling 94 individuals (Table SB 35). The Kahanahaiki portion of the Kahanahaiki to Pahole population unit is located on Makua. The Pahole portion of the Kahanahaiki to Pahole population unit and the Kapuna-Keawapilau Ridge population unit are located in Pahole Natural Area Reserve. The Kahanahaiki to Pahole population unit currently contains 80 mature individuals, and may meet the numerical criterion for stability (defined as 50 mature, reproducing individuals for short-lived perennials). This population unit increased from about 48 total individuals in 2003 to 91 total individuals in 2006, primarily owing to Army augmentation efforts (Makua Implementation Team 2003, U.S. Army Garrison 2006d). About 50 percent of all currently existing individuals are augmentations from greenhouse-propagated stock, including about 52 percent of all mature individuals and 36 percent of all immature individuals. The Kahanahaiki to Pahole population unit is located within low to very low zones at risk from training-related wildfire.

Demographic data in the Kahanahaiki to Pahole population unit include limited recruitment. However, both augmented and naturally occurring immature plants are attacked by invertebrates and are not vigorous (U.S. Army Garrison 2004a, 2005b). Although total numbers have increased from 60 to 94 since 2003, the total number of naturally occurring individuals in the Kapuna-Keawapilau Ridge population unit has remained at only three individuals. Thus, *Schiedea nuttallii* is characterized by low numbers of known individuals with only two existing population units, including one that has met minimum numerical criteria for stabilization but is being sustained primarily through augmentation.

Table SB 35. Range-wide distribution of *Schiedea nuttallii.*

Population Units	Numbers of Known Individuals					
	1996 (1)	**1999** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Kahanahaiki*	--	28	21/12	31/8[‡]	23/8	37/7
Pahole*	2	20-50	14-15	[13/5][§]	[35/10]	[43/4]
Kapuna-Keawapilau Ridge*	--	--	2/1	3/0	3/0	3/0
Ekahanui Gulch	--	2	--	--	--	--
Makaha*	--	--	--	0	0	0
Total Individuals	**25**	**50-80**	**50-51**	**60** (34/8) [13/5]	**79** (26/8) [35/10]	**94** (40/7) [43/4]

Shaded population units are inside the action area.
*Stabilization population units
[‡]Total mature/immature individuals
[†]Total (mature/immature)
[§][augmented and or reintroduced]

(1) Listing rule (61 FR 53115)
(2) Recovery Plan (Service 1999a)
(3) Makua Implementation Plan (Makua Implementation Team 2003)
(4) MIP Addendum and 2004 status report (U.S. Army Garrison 2005a, 2004)
(5) 2005 status update (U.S. Army Garrison 2005b)
(6) 2006 status update (U.S. Army Garrison 2006c)

Ecology *Schiedea nuttallii* occurs in the understory of diverse mesic forest at elevations between 400 and 730 m (1,312 and 2,395 ft). It typically grows on steep rock walls and forested slopes of north-facing gulches in *Acacia koa-Metrosideros polymorpha* lowland mesic forest and *Metrosideros polymorpha-Dodonaea viscosa* forest (68 FR 35950). Flowers and fruits are abundant in the wet season and less so throughout the year. *Schiedea nutttallii* is an outcrossing species that requires pollinators, probably insects, for fruit production (Wagner et al 2005). Plant longevity probably is similar to that of other small, semi-woody shrubs that live less than 10 years (i.e., short-lived perennials) (Makua Implementation Team 2003). Other demographic information for *S. nuttallii* in the wild is unknown, including longevity, number of seeds produced, age at sexual maturity, survivorship to sexual maturity, number of years in reproductive condition, survivorship during reproductive life, timing of reproductive output, pollination and seed dispersal in the wild, vegetative reproduction in the wild, and specific environmental requirements.

Threats to the Species *Schiedea nuttallii* was listed as endangered because of major, ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section, and are tabulated in Appendix E. *Schiedea nuttallii* is particularly vulnerable to predation by non-native slugs and snails. Seedlings have been observed in wild populations, but recruitment is reduced because of these alien invertebrates. Augmented *S. nuttallii* individuals seem to survive the initial outplanting transition but are subsequently weakened by invertebrate injury (Makua Implementation Team 2003). One study noted, for example, that seedling mortality for the

related species *S. obovata* doubled when exposed to slug herbivory (U.S. Army Garrison 2005b). This species also may be threatened by the black twig borer *Xylosandrus compactus*, which causes slight to severe defoliation and reduced plant vigor that may kill branches or the entire plant (68 FR 35950; U.S. Army Garrison 2004a). Black twig borer predation would be of particular concern for *S. nuttallii* because no control methods are available that do not also harm native scolytid beetles. Regarding fire vulnerability, *S. nuttalli* is a small, understory herbaceous plant less than 1.5 m (4.9 ft) tall with stems that are woody only at the base. Whether *S. nuttallii* resprouts or regenerates from buried seeds after fire is unknown, but it is probably similar to most native Hawaiian plants in lack of resistance or tolerance to fire.

Most importantly, occurrences of *Schiedea nuttallii* are vulnerable to extirpation from naturally occurring events such as landslides and/or reduced reproductive vigor due to small population size and limited distribution (61 FR 53108; 68 FR 35950; Service 1999a). In addition, *S. nuttallii* and the related species *S. kaalae* and *S. pentandra* are characterized by low isozyme variability and inbreeding due to small population size (Wagner et al 2005). Reductions in population size could result in expression of inbreeding depression among progeny, for example in reduced reproductive vigor, with potentially deleterious consequences for the long-term persistence of this species. The science of conservation biology has documented a general pattern of population collapse for a wide range of plant and animal species (Dennis et al 1991; Schemske et al 1994; Morris et al 1999; Menges 2000). According to this pattern, *S. nuttallii* already is in a phase of "quasi-extinction" with numbers that have declined to the point where demographic stochasticity alone can result in extirpation. Thus, *S. nuttallii* has a very high background risk of species extinction and any additional threats could eliminate expectation of its long-term persistence.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Schiedea nuttallii* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve stabilization of all existing populations (Service 1999a). Research on slug control in forest settings is needed to find ways to reduce invertebrate threats to *S. nuttallii* and associated native plants.

Ongoing Conservation Actions The Makua Implementation Team (2003) has developed stabilization protocols for *Schiedea nuttallii*, which are incorporated in the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). The Army has been augmenting occurrences in the Kahanahaiki and Pahole population unit since 2003. In addition, this species is located in occurrences over three management units where it will benefit from population unit and/or ecosystem-level protection. The management units include Upper Kapuna, which is not fenced; and Kahanahaiki and Pahole, which are fenced.

Schiedea nuttallii has been successfully propagated by tissue culture from seed, and from cuttings. The germination rate of fresh seed is about 50 percent, and the success rate of cuttings is 10 to 50 percent. Seed can be stored with little or no decrease in viability, but germination trials have not yet been conducted because so few plants are available to provide material (U.S. Army Garrison 2005b). Both remaining population units, Kahanahaiki to Pahole and Kapuna-Keawapilau Ridge, are represented in *ex situ* collections (U.S. Army Garrison 2005b). In 2005,

these *ex situ* collections included 108 cuttings in nurseries (Army Environmental Division,Oahu, and Harold L. Lyon Arboretum), 54 ungerminated seeds in a nursery (Harold L. Lyon Arboretum), 1,300 seeds in seed storage (Lyon Arboretum Seed Storage Facility), and 20 seedlings in a nursery (Harold L. Lyon Arboretum) (Service 2005b).

Critical Habitat Description A total of 1,256 ha (3,103 ac) of critical habitat, in six separate units on three islands, was designated for *Schiedea nuttallii*, including 709 ha (1,753 ac) in three units on Oahu. Critical habitat on Oahu was designated on State lands (Mokuleia Forest Reserve, and Pahole and Kaala NATURAL AREA RESERVEs) and on private lands (Honouliuli Preserve) (68 FR 35950). The three critical habitat units on Oahu provide habitat to support six populations. To meet recovery goals, a population should be represented by at least 300 mature, reproducing individuals of *S. nuttallii* (68 FR 35950).

The primary constituent elements of critical habitat on Oahu include rock walls, forested slopes, or steep walls in *Acacia koa-Metrosideros polymorpha* lowland mesic forest or *Metrosideros polymorpha-Dodonaea viscosa* forest at elevations between 408 and 1,072 m (1,338 and 3,516 ft). In addition, all units contain one or more of the following associated native plant species: *Alyxia oliviformis, Antidesma platyphyllum, Bidens torta, Cibotium chamissoi, Coprosma* sp., *Cyanea longiflora, Hedyotis terminalis, Ilex anomala, Machaerina* sp., *Peperomia* sp., *Perrottetia sandwicensis, Pipturus* sp., and *Psydrax odorata*. The plant community, associated species, and elevations are indicative of important features such as soil moisture, nutrient cycling and availability, temperature ranges, and light levels which are primary constituent elements of the habitat required for the species' conservation.

Threats to the Critical Habitat See introduction to "Status and Environmental Baseline of the Species and Critical Habitat" section.

Environmental Baseline of the Species and Critical Habitat

Status of the Species in the Action Area According to U.S. Army Garrison (2006d), all known individuals of *Schiedea nuttallii* are located within the previously-designated action area, in the Kahanahaiki to Pahole and Kapuna-Keawapilau Ridge population units (see Table SB 35); see the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. However, we have information that indicates the Kapuna-Keawapilau Ridge population unit is actually located outside the current action area (M. Mansker, pers. comm. 2005). The Kahanahaiki to Pahole population unit currently contains about 91 total individuals, or 97 percent of all remaining individuals of this species. This population unit contains 80 mature individuals and could be considered meeting numerical stabilization targets; however, threat control and genetic storage goals are not yet complete. This population unit increased from 48 total individuals in 2003 to 91 total individuals in 2006, owing primarily to Army augmentation efforts. About 52 percent of all individuals in this population unit are augmentations, including many nursery-propagated seedlings and clones (cuttings). The vigor of outplanted individuals ranges from healthy to poor and survivorship ranges from 50 to 75 percent; so far, there is no regeneration at augmented sites (U.S. Army Garrison 2005b). The Kapuna-Keawapilau Ridge population unit has remained static at three individuals since 2003. Plants of this species in action area are located in zones at risk of training-related wildfire. About 84 individuals occur in the low fire risk zone and 10 individuals in the very low fire risk zone. Thus, *S. nuttallii* in the

action area is characterized by one population unit meeting minimum numerical criteria for stabilization but that is increasing primarily by augmentation, with 100 percent of all remaining individuals at low and very low risks of training-related wildfire.

Status of the Critical Habitat in the Action Area The action area contains a total of 199.7 ha (493.5 ac), or 16 percent of the total critical habitat for *Schiedea nuttallii* on Oahu. Critical habitat was designated for this species on other islands in 2003; however, plants on Kauai and Maui are no longer considered within the taxon *S. nuttallii* (Wagner et al 2005). Designated critical habitat on Oahu is located within one unit in the northeastern portion of the Makua action area. This critical habitat is a portion of a larger 527 ha (1,304 ac) critical habitat unit that extends outside the action area boundary and provides habitat for four populations of *S. nuttallii*. About 16 percent of critical habitat for this species on Oahu is located in an area at risk of training-related wildfire, with 0.2 ha (0.6 ac) located in the high fire risk zone, 17.1 ha (42.3 ac) in the low fire risk zone, and 182.2 ha (450.2 ac) in the very low fire risk zone. It is estimated that nearly one-half of the critical habitat in the Makua action area is found in areas comprised of 50 to 75 percent native plant cover and another one-quarter is found in areas with greater than 75 percent native plant cover (K. Kawelo, pers. comm. 2004; Service 2004a).

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Schiedea nuttallii* and its critical habitat in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section, and are tabulated in Appendix E. *Schiedea nuttallii* in the action area is particularly vulnerable to predation by non-native slugs and snails, and may be susceptible to predation by the black twig borer (U.S. Army Garrison 2004a). About 16 percent of critical habitat for this species on Oahu is located in an area at high, low, and very low risks of training-related wildfire. Thus, because 100 percent of all known remaining individuals occur within the action area, *S. nuttallii* in the action area has a very high background risk of species extinction and any additional threats could eliminate the expectation of its long-term persistence.

Conservation Needs of the Species and Critical Habitat in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) includes *Schiedea nuttallii* because more than 50 percent of all known individuals occur within the action area and no population units meeting minimum numeric criteria for stabilization exist outside the action area. Furthermore, because of its low numbers, this species is considered particularly at risk from project-related impacts and is included in Army plans for expedited stabilization. Three population units have been identified for expedited stabilization of *S. nuttallii*: Kahanahaiki to Pahole within the action area, and Kapuna-Keawapilau Ridge and Makaha outside the action area. The Makaha population unit will be established through reintroduction after an ungulate-exclosure fence is built in 2007. Post-fire revegetation plans and site-specific fuel modification are needed where individuals and critical habitat are located in the action area. Slug control research is needed to find ways to reduce threats to *S. nuttallii* and associated native plants. Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species and Critical Habitat in the Action Area The Kahanahaiki to Pahole and Kapuna-Keawapilau Ridge population units, which contain all of the

total remaining individuals of *Schiedea nuttallii*, are being managed for stabilization as specified in the Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). These individuals are located in the Kahanahaiki (subunit II) and Pahole Management Units, which are fenced; and in the Upper Kapuna Management Unit, which is not fenced. All but one wild site in the Pahole part contain good-quality habitat within fenced exclosures, are augmented with outplanted individuals, and are partially controlled to reduce cover of non-native weeds. A total of about 332.3 ha (821.1 ac) of critical habitat for this species is located within management units both within and outside of the action area (East Makaleha, Ekahanui, Kahanahaiki, Kaluaa and Waieli, Pahole, Upper Kapuna, West Makaleha). About 170.5 ha (421.1 ac) of the total critical habitat that is within management units is located inside the action area (Kahanahaiki, Pahole, Upper Kapuna, West Makaleha). As of 2005, genetic storage goals were 11 percent complete, with 11 plants from both remaining population units combined towards meeting the goals outlined in the Makua Implementation Plan, and 23 plants growing in the Army nursery (U.S. Army Garrison 2005b).

Status of the Species and Critical Habitat – *Schiedea obovata* (No Common Name)

Species Description *Schiedea obovata* is a short-lived perennial of the Caryophyllaceae (pink family). It is an erect subshrub (stems woody at the base) up to 1 m (3.3 ft) tall, with oppositely arranged, elliptic leaves 4 to 11 cm (1.6 to 4.3 in) long. The small, perfect flowers (with both male and female reproductive parts) lack petals and are borne in axillary clusters. The berry-like seed capsules are covered by fleshy purple calyx lobes and contain many tiny black seeds (Wagner et al 1999; Makua Implementation Team 2003).

Listing Status *Alsinidendron obovatum* was federally listed as endangered on October 29, 1991 (56 FR 55770), and was State listed as endangered at the same time. This species is included in recovery plans for Waianae plants (Service 1995a) and Oahu plants (Service 1998a). Critical habitat for the listed taxon was designated on June 17, 2003 (68 FR 35950). The recently revised taxonomy of *Schiedea* incorporates species previously classified as *Alsinidendron*, and *Alsinidendron obovatum* has been reclassified as *Schiedea obovata* (Wagner et al 2005). The status of *Schiedea obovata* is identical to that of *Alsinidendron obovatum*, the federally listed taxon. The genus *Schiedea* (including species formerly classified as *Alsinidendron*) has the highest proportion of endangered taxa in Hawaii (Wagner et al 2005), with 19 of 35 taxa (54 percent) listed as endangered and three identified as candidates for listing (Service 2006a).

Historic and Current Distribution *Schiedea* is a genus endemic to the Hawaiian Islands. Historic data indicate that *Schiedea obovata* has declined significantly in the last 20 years (Makua Implementation Team 2003). Historically, this species was known from the northern and southern parts of the Waianae Mountains. When the species was listed in 1991, two occurrences totaling about 100 individuals were known, in Kapuna Gulch and Pahole Gulch (56 FR 55770). Since then, more occurrences have been discovered, but by 2003 plants were no longer found at some locations (Makua Implementation Team 2003). In late 2003, a new population unit was discovered in North West Makaleha, near a historical Keawapilau population, but surveys to locate other population units in the southern Waianae Mountains were unsuccessful (U.S. Army Garrison 2004a. Currently, two population units, Kahanahaiki to Pahole and Keawapilau to West Makaleha, total 389 individuals located on Federal and State

lands (68 FR 35950) (Table SB 36). The Kahanahaiki to Pahole population unit has met numerical criteria for stabilization (defined for this species as 100 mature individuals per population unit) (Makua Implementation Team 2003). The existing population units also are located within low and very low fire risk zones for training-related wildfire.

Demographic data indicate *Schiedea obovata* is increasing in numbers only due to augmentation efforts and the discovery of a new population unit in North West Makaleha. About 82 percent of all of individuals are augmentations from greenhouse-propagated stock. Recruitment of seedlings and immature plants into the mature population is limited by predation by non-native slugs and snails that feed on and damage leaves and stems (Makua Implementation Team 2003; U.S. Army Garrison 2004a; U.S. Army Garrison 2005b). One study noted, for example, that seedling mortality doubled when exposed to slug herbivory (U.S. Army Garrison 2005b). Furthermore, slugs have the potential to completely halt seedling regeneration in several sites (U.S. Army Garrison 2004a, 2005b). Thus, *S. obovata* is characterized by declining in the current range and two existing population units with low numbers, of which one is exceeding minimum numerical criteria for stabilization and increasing through augmentation and discovery of new individuals.

Table SB 36. Range-wide distribution of *Schiedea obovata.*

Population Units	Number of Known Individuals					
	1991 (1)	**1995-1998** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Kahanahaiki*	--	--	0	0/0[‡] [65/25][§]	0/0 [58/183]	0/0 [103/190]
Pahole*	--	--	0			
Keawapilau*	--	--	0	21/12	42/34	44/27 [11/14]
North West Makaleha*	--	--	--			
West Makaleha*	--	--	3			
Makaha*	--	--	--	0	0	0
Other Locations	--	--	--	--	--	13
Total Individuals	**100**	**11-12**	**3-10**	**123** (21/12)[†] [65/25]	**317** (42/34) [58/183]	**389** (44/27) [114/204]

Shaded population units are inside the action area.
*Stabilization population units
[‡]Total mature/immature individuals
[†]Total (mature/immature)
[§][augmented and or reintroduced]

(1) Listing rule (56 FR 55770)
(2) Recovery plans (Service 1995a, 1998a)
(3) Makua Implementation Plan (Makua Implementation Team 2003)
(4) MIP Addendum and 2004 status report (U.S. Army Garrison 2005a, 2004)
(5) 2005 status update (U.S. Army Garrison 2005b)
(6) 2006 status update (U.S. Army Garrison 2006c)

Ecology *Schiedea obovata* occurs on ridges and slopes in lowland diverse mesic forests dominated by *Acacia koa* and *Metrosideros polymorpha*, at elevations of 560 to 760 m (1,837 to 2,494 ft). Plants generally flower after two years of growth, and are normally self-fertilizing (Makua Implementation Team 2003). Flowers and fruit are produced year-round, especially in

response to rainfall during winter and spring. Seed dispersal mechanism is unknown, although the plant's "false berry" possibly may attract fruit-eating birds that may disperse the seeds (Makua Implementation Team 2003). Plants survive 3 to 6 years, or less under drought conditions (Service 1995a, Service 1998a). Population units in the wild have been known to disappear for a number of years and then reappear after large rainfall events, apparently owing to persistence of seeds in the soil seed bank (U.S. Army Garrison 2004a). Other demographic information for *S. obovata* in the wild is unknown, including number of seeds produced, survivorship to sexual maturity, number of years in reproductive condition, survivorship during reproductive life, seed dispersal, vegetative reproduction and specific environmental requirements.

Threats to the Species *Schiedea obovata* was listed as endangered because of major, ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section, and are tabulated in Appendix E. *Schiedea obovata* is particularly vulnerable to predation by non-native slugs and snails (Makua Implementation Team 2003; U.S. Army Garrison 2005b). The decline and possible extirpation of the southern Waianae population units of *S. obovata* are partially attributed to residential development, establishment of military installations, reforestation with non-native trees in the early 1900s, and trampling and illegal collecting by people (Makua Implementation Team 2003). Most importantly, population units of *S. obovata* are vulnerable to extirpation from naturally occurring events such as rockslides and/or reduced reproductive vigor due to small population size and limited distribution (56 FR 55770; 68 FR 35950; Service 1995a, 1998a). Because *S. obovata* is thought to be a facultative self-pollinator, inbreeding depression may not be significant (U.S. Army Garrison 2004a). This species experiences large population fluctuations related to drought and its natural recruitment is severely reduced by slug predation (U.S. Army Garrison 2005c). The science of conservation biology has documented a general pattern of population collapse for a wide range of plant and animal species (Dennis et al 1991; Schemske et al 1994; Morris et al 1999; Menges 2000). Thus, *S. obovata* has a very high background risk of species extinction and any additional threats could reduce expectation of its long-term persistence.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Schiedea obovata* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve stabilization of all existing populations (Service 1995a, 1998a). At least 50 mature, reproducing individuals are needed per population unit to attain stabilization criteria for short-lived perennials. However, because of the common, large declines or fluctuations in numbers of *S. obovata*, the Makua Implementation Team (2003) identified a stabilization target of at least 100 mature individuals for each population unit of this species. An increased stabilization criterion is needed because any adverse disturbance during a major low point in a population unit's fluctuation could extirpate that unit. In addition to stabilizing the two existing population units, a third population unit must be established by reintroduction and managed for stabilization outside the action area. Research on slug control in forest settings is needed to find ways to reduce this threat to *S. obovata* and associated native plants.

Ongoing Conservation Actions The Makua Implementation Team (2003) has developed stabilization protocols for *Schiedea obovata*, which are incorporated in the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). This species occurs in the Kahanahaiki, Pahole, and West Makaleha Management Units where it will benefit from population unit and/or ecosystem-level protection. The Army and the Hawaii Division of Forestry and Wildlife have been outplanting this species within fenced exclosures since 1999. The Kahanahaiki to Pahole population unit is located within the fenced Kahanahaiki and Pahole Management Units, and the North West Makaleha site within the Keawapilau to West Makaleha population unit is fenced. Fence construction is planned for the entire West Makaleha Management Unit in 2007. Invasive weeds are controlled at extant *S. obovata* sites, but not at historical sites.

Schiedea obovata seed can be successfully stored and remain viable for several years, and outplantings have been successful (U.S. Army Garrison 2005b). In 2005, this species was represented in the following *ex situ* collections: one cutting in a nursery (Army Environmental Division, Oahu), 14 plants in a botanical garden (Waimea Valley Audubon Center), 161 seeds in micropropagation (Harold L. Lyon Arboretum), 236,814 seeds in seed storage (Lyon Arboretum Seed Storage Facility), and 13 seedlings in micropropagation (Harold L. Lyon Arboretum) (Service 2005b).

Critical Habitat Description A total of 232 ha (574 ac) of critical habitat was designated for *Schiedea obovata* on June 17, 2003, in three separate units. Critical habitat was designated on State lands (Mokuleia, Nanakuli, and Waianae Kai Forest Reserves, and Pahole Natural Area Reserve), to provide habitat for seven populations. To meet recovery goals, a population should be represented by at least 300 mature, reproducing individuals of *S. obovata* (68 FR 35950).

The primary constituent elements of critical habitat include ridges and slopes in lowland diverse mesic forest dominated by *Acacia koa* and *Metrosideros polymorpha* at elevations between 477 and 943 m (1,565 and 3,093 ft). In addition, all units contain one or more of the following associated native plant species: *Alyxia oliviformis, Antidesma platyphyllum, Bidens torta, Cibotium chamissoi*, *Coprosma* sp., *Cyanea longiflora, Hedyotis terminalis, Ilex anomala*, *Machaerina* sp., *Peperomia* sp., *Perrottetia sandwicensis*, *Pipturus* sp., and *Psydrax odorata*. The plant community, associated species, and elevations are indicative of important features such as soil moisture, nutrient cycling and availability, temperature ranges, and light levels which are primary constituent elements of the habitat required for the species' conservation.

Threats to the Critical Habitat See introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section

Environmental Baseline of the Species and Critical Habitat

Status of the Species in the Action Area All known individuals of *Schiedea obovata* are located within the action area, in the Kahanahaiki to Pahole and Keawapilau to West Makaleha population units (see Table SB 36). The Kahanahaiki to Pahole population unit, with 103 mature individuals, may be considered exceeding numerical criteria for stabilization (defined for this species as 100 mature individuals per population unit), but threats are not adequately controlled and genetic storage is not complete. All naturally occurring *S. obovata* plants in the

Kahanahaiki, Pahole, and Keawapilau sites had disappeared by 2001 and no seedlings have regenerated from the soil seed bank (U.S. Army Garrison 2004a). All current individuals in the Kahanahaiki to Pahole population unit are augmentations from greenhouse-propagated stock. The Keawapilau to West Makaleha population unit has increased from 3 individuals in 2003 to 96 in 2006, due to augmentation and discovery of new subpopulations within the population unit. About 74 percent of total individuals in this population unit are naturally occurring, not augments. The Army has augmented wild populations at three sites (Kahanahaiki, Pahole, and West Makaleha). High seedling recruitment has resulted from plants reintroduced at Pahole. Plants reintroduced at Kahanahaiki are less vigorous, perhaps reflecting differences in genetic founder material (U.S. Army Garrison 2005b). All plants within the action area are located in areas at risk of training-related wildfire. About 91 individuals occur in the low fire risk zone and 298 individuals in the very low fire risk zone. Thus, *S. obovata* in the action area is characterized by one population unit meeting numerical criteria for stabilization and one population unit not exceeding numerical criteria that contain all remaining individuals in low and very low fire risk zones, and by numbers that are increasing almost entirely by augmentation and discovery of new individuals.

Status of the Critical Habitat in the Action Area The action area contains a total of 164.5 ha (406.4 ac), or 71 percent, of the total critical habitat for *Schiedea obovata*. Most of the critical habitat is located on State land in the northeastern portion of the action area. This critical habitat is part of a total 176 ha (436 ac) critical habitat unit that extends beyond the action area and provides potential habitat to support five populations of 300 mature, reproducing individuals each. Critical habitat for this species in the action area is located in an area at risk of training-related wildfire, with 0.04 ha (0.1 ac) in the high fire risk zone, 14.5 ha (35.9 ac) in the low fire risk zone and 149.9 ha (370.4 ac) in the very low fire risk zone. It is estimated that almost the entire critical habitat is within areas that contain more than 50 percent native plant cover (K. Kawelo, pers. comm. 2004; Service 2004a).

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Schiedea obovata* and its critical habitat in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section, and are tabulated in Appendix E. *Schiedea obovata* in the action area is particularly vulnerable to predation by non-native slugs and snails. The action area critical habitat in the high to low and very low fire risk zones represents about 71 percent of total critical habitat for this species. Thus, because all known individuals occur within the action area and all are within fire risk zones, *S. obovata* in the action area has a very high background risk of species extinction and any additional threats could reduce the expectation of its long-term persistence.

Conservation Needs of the Species and Critical Habitat in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrsion 2005a) includes *Schiedea obovata* because more than 50 percent of all known individuals occur within the action area, and population units exceeding numerical criteria for stabilization do not exist outside the action area. Furthermore, because of its low numbers, this species is considered particularly at risk from project-related impacts and is included in Army plans for expedited stabilization. Three population units have been identified for stabilization of *S. obovata*: Kahanahaiki to Pahole and Keawapilau to West Makaleha within the action area, and Makaha, to be reintroduced outside the action area after fence construction. Fencing and control of feral ungulates is needed for the West Makaleha and Upper Kapuna Management Units, along with additional control of non-

native vegetation. Post-fire revegetation plans and site-specific fuel modification are needed where individuals and critical habitat are located in the action area. Slug control research is needed to find ways to reduce threats to *S. obovata* and associated native plants. Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species and Critical Habitat in the Action Area The Kahanahaiki to Pahole population unit and Keawapilau to West Makaleha population units are being managed for stabilization as specified by the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). Within the Kahanahaiki to Pahole population unit, the Army has augmented the Kahanahaiki occurrence and the State has augmented the Pahole occurrence, and both areas are fenced. This species in the action area also occurs at a fenced site within the West Makaleha Management Unit. Weeds are controlled around extant *Schiedea obovata* sites in both population units. A total of about 183.5 ha (453.5 ac) of critical habitat for this species is located within management units both within and outside of the action area (Makaha, Pahole, Palikea, Upper Kapuna, West Makaleha). About 152.4 ha (376.6 ac) of the total critical habitat that is within management units is located inside the action area (Pahole, Upper Kapuna, West Makaleha). As of 2005, genetic storage goals were 31 percent complete, with 31 plants from both population units combined towards meeting the goals outlined in the Makua Implementation Plan, and 12 plants growing in the Army nursery (U.S. Army Garrison 2005b).

Status of the Species – *Silene lanceolata* (No Common Name)

Species Description *Silene lanceolata*, a member of the Caryophyllaceae (pink) family, is a short-lived perennial. Flowers are white with deeply lobed, clawed petals, and stems are 15 to 50 cm (6 to 20 in) long and woody at the base. Leaves are narrow, smooth and fringed with hairs. This species is distinguished from other Hawaiian members of the genus by its erect stem, terminal inflorescence, and length of the calyx, clawed petals, and carpophore (ovary structure) (Wagner et al 1999).

Listing Status *Silene lanceolata* was federally listed as endangered on October 8, 1992 (57 FR 46325) and state listed as endangered at the same time. A recovery plan was prepared for this species in September 1996 (Service 1996). Critical habitat was designated for *S. lanceolata* on Molokai and Oahu in 2003 (68 FR 12982; 68 FR 35950).

Historic and Current Distribution Historically, *Silene lanceolata* was found on Kauai, in Makua Valley on Oahu, below Puu Kolekole in east Molokai, Maunalei on Lanai, and on Mauna Kea on Hawaii. *Silene lanceolata* is currently known from a total of 2,640 individuals on the islands of Molokai, Oahu, and Hawaii. On Molokai, a single occurrence of approximately 100 individuals was reported in 1987 on private land near Puu Kolekole. On Hawaii, it is found on the Army's Pohakuloa Training Area in Kipuka Kalawamauna, Puu KeeKee, and Kipuka Alala. These three occurrences are distributed over a distance of approximately 15 km (9 mi) and total more than 2,500 individuals. On Oahu, this species has increased from approximately 40 known individuals in five occurrences in mid to late 1990s to 157 known individuals in two occurrences

in 2006 (U.S. Army Garrison 1999a, U.S. Army Garrison 2006c) (Table SB 37). Thus, *S. lanceolata* is characterized by two population units at low numbers, and an overall abundance on Oahu that appears to be increasing but is due in part to increased monitoring efforts.

Table SB 37. Range-wide Distribution of *Silene lanceolata.*

Population Units	**Number of Known Individuals**					
	1991 (1)	**1996** (2)	**1999** (3)	**2003** (4)	**2005** (5)	**2006** (6)
Ohikilolo	--	40	40	--	24	11/6
Waianae Kai	--	--	--	12	80/60[‡]	80/60
Total Population Units on Oahu	--	1	1	4	2	2
Total Individuals on Oahu	--	**40**	**40**	**62**	**164**	**157** (91/66)
Total PopulationUnits State-wide	3	5	5	--	3	--
Total Individuals State-wide	100-130	<1500	>2640	--	**664 -1164** (604-1,104/60)[†]	--

Shaded occurrences are inside the action area.
[‡]Total mature/immature individuals
[†]Total (mature/immature)

(1) Listing rule (56 FR 55770)
(2) Molokai Recovery plan (Service 1996)
(3) Makua Endangered Species Mitigation Plan (Service 1999b)
(4) Critical habitat rule (68 FR 35950)
(5) Army re-initiation request (U.S. Army Garrison 2005c)
(6) Army database (U.S. Army Garrison 2006d)

Ecology On Oahu, *Silene lanceolata* grows on cliff faces and ledges of gullies in dry to mesic shrublands at elevations between 351 and 978 m (1,151 to 3,208 ft). Associated native plant species include *Artemisia australis*, *Bidens* sp., *Carex* sp., *Chamaesyce* sp., *Dodonaea viscosa*, *Lysimachia* sp., *Osteomeles anthyllidifolia*, *Schiedea mannii*, or *Tetramolopium filiforme*. Information on the reproductive cycles, longevity, specific environmental requirements, and limiting factors for this species are unknown (68 FR 35950).

Threats to the Species *Silene lanceolata* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. Habitat destruction by feral goats, pigs, and sheep; fire from military activities; and competition with non-native plant species threaten *S. lanceolata* (U.S. Army Garrison 1999a; 68 FR 35950). Thus, although almost half of individuals (98 percent) are located outside the action area, *S. lanceolata* has a moderate background risk of species extinction range wide and high background risk of species extinction (because of low numbers of individuals) on Oahu without protection from existing and additional threats.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Silene lanceolata* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to the limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve stabilization of all existing populations (Service 1999a). Conservation actions required for stabilization are described in the "Stabilization" section of the project description for this opinion. However, *S. lanceolata* is not included as a target taxon for stabilization under the Makua Implementation Plan Addendum. The Army does not actively manage this species on Oahu (Service 2003a).

The recovery plan for *Silene lanceolata* identifies several conservation actions that should be implemented for its recovery. Fenced exclosures should be constructed at all known occurrences to reduce impacts from ungulates. Subsequent control of ungulates and rats from all occupied sites will remove their impact on this species and its habitat. Control measures for non-native plant species that threaten *S. lanceolata* should be implemented. Augmentation of existing occurrences and the establishment of new occurrences should be done by outplanting when adequate propagated materials are available. Control of highly flammable vegetation and maintenance of fuelbreaks is also needed, for plant occurrences found growing in areas of high risk from fire.

Ongoing Conservation Actions A State-wide strategic plan is being developed by the Hawaii and Pacific Plants Recovery Coordinating Committee that will address the long-term conservation of *Silene lanceolata* (Hawaii and Pacific Plant Recovery Coordinating Committee 2007). This plan will include broader landscape actions that are needed for the recovery of this plant throughout its range. This species is also being propagated at Pahole Mid-Elevation Rare Plant Facility, Pohakuloa Training Area Plant Facility, and the Volcano Rare Plant Facility (Service 1999a; Service 2005b). In addition occurrences of this species occur in two management units where they may benefit from stabilization management of other species and/or ecosystem-level protection. The management units are Ohikilolo, which is fenced; and Waianae Kai Management Unit, which are not fenced.

Environmental Baseline of the Species

Status of the Species in the Action Area Approximately 17 individuals, or less than two percent of the total known individuals of *Silene lanceolata,* occur within the Makua action area and are located within the Ohikilolo Management Unit in area of low fire risk.

Threats to the Species in the Action Area The primary threats to *Silene lanceolata* in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. *Silene lanceolata* is threatened by competition for light, space, and nutrients from non-native plant species; fires that result from Army training activities; and habitat degradation and destruction by feral goats and pigs (U.S. Army Garrison 1999a).

Conservation Needs of the Species in the Action Area *Silene lanceolata* does not require stabilization pursuant to the guidelines established in the Makua Implementation Plan because only two percent of the known individuals occur within the action area. This species will,

however, benefit from additional conservation actions such as fencing, ungulate and non-native plant control, and control of wildfires that are undertaken for other native plants in the action area (U.S. Army Garrison 1999a). Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species in the Action Area The Service is unaware of any species-specific management activities occurring in the action area for *Silene lanceolata*.

Status of the Critical Habitat – *Solanum sandwicense* (Popolo aiakeakua)

Critical Habitat Description A total of 2,975 ha (7,352 ac) of critical habitat was designated in five separate units on Kauai and Oahu for *Solanum sandwicense*. Two units were designated on Kauai and three units (328 ha; 811 ac) was designated on Oahu. To meet recovery goals, each unit is intended to provide habitat for one population, each represented by a minimum of 300 mature, reproducing individuals of *S. sandwicense*. Critical habitat has been designated on State lands on both islands (e.g., Kuia Natural Area Reserve, and Kokee and Na Pali Coast State Parks on Kauai, and Mokuleia Forest Reserve and Pahole Natural Area Reserve on Oahu) and private lands (Honouliuli Preserve) on Oahu (68 FR 9116; 68 FR 35950).

The primary constituent elements for the units on Oahu include talus slopes or streambeds at elevations between 471 and 1,006 m (1,545 and 3,300 ft), which occur in open, sunny areas that contain the associated native plant species *Pisonia* sp. and *Psychotria* sp. The plant community, associated species, and elevations are indicative of important features such as soil moisture, nutrient cycling and availability, temperature ranges, and light levels, which are primary constituent elements of the habitat required for the conservation of this species (68 FR 35950).

Threats to Critical Habitat The primary threats to critical habitat for this species on Oahu include habitat degradation by feral pigs, competition with non-native plant species, fire, and stochastic events such as landslides (68 FR 35950).

Environmental Baseline of the Critical Habitat

Status of the Critical Habitat in the Action Area Four percent (105 ha; 258 ac) of the State-wide critical habitat for *Solanum sandwicense* is located in one unit in the Makua action area. The critical habitat unit is located in the northeastern portion of the action area in the low fire risk area. This critical habitat unit provides habitat for the conservation of one population of *S. sandwicense*. It is estimated that nearly one-half of the critical habitat occurs in areas with greater than 75 percent native plant cover (K. Kawelo, pers. comm. 2004).

Threats to Critical Habitat in the Action Area Threats to primary constituent elements of the critical habitat in the action area include habitat degradation by feral pigs, competition from non-native plant species, and fire from military training activities (68 FR 35950).

Ongoing Conservation Actions Within the Action Area A total of 102 ha (253 ac), or 98 percent, of the critical habitat in the action area is in the Pahole, Upper Kapuna Sub-Unit and

Upper Kapuna Management Units. The Pahole Management Unit is fenced, and non-native plant species and ungulates within the unit are controlled. A fence for the Upper Kapuna Management Unit is planned for the near future (K. Kawelo, pers. comm. 2004).

Status of the Species and Critical Habitat – *Spermolepis hawaiiensis* (No Common Name)

Species Description *Spermolepis hawaiiensis*, a member of the Apiaceae (parsley) family, is a slender annual herb with few branches. Its leaves are dissected into narrow, lance-shaped divisions. *Spermolepis hawaiiensis* is the only member of the genus native to Hawaii. It is distinguished from other members of the family by being a non-succulent annual with an umbrella-shaped inflorescence (68 FR 35950).

Listing Status *Spermolepis hawaiiensis* was federally listed as endangered on November 10, 1994, and state listed as endangered in Hawaii at the same time. A recovery plan was prepared for this species in July 1999 (Multi Island Recovery Plan 1999; 59 FR 56333). Critical habitat was designated for this species on February 27, 2003 for the islands of Niihau and Kauai; March 18, 2003 for the island of Molokai; May 14, 2003 for the island of Kahoolawe and Maui; and June 17, 2003 for the island of Oahu (68 FR 9115; 68 FR 12981; 68 FR 25934; 68 FR 35950).

Historic and Current Distribution Historically, *Spermolepis hawaiiensis* was known from (Waimea) Kauai, (Koko Head) Oahu, (Paomai and Kahinahina) Lanai, and (Apua) Hawaii. Currently, a total of 12 occurrences of *S. hawaiiensis* are known on Kauai, Oahu, Molokai, Lanai, West Maui, and Hawaii. The total number of individuals State-wide is estimated between 5,000 and 10,000 individuals. On Kauai, this species has been observed in the Koaie branch and other unspecified locations within Waimea Canyon, Hanapepe at Kapahili Gulch, and Hipalau on State and private land. The total number of plants on Kauai is a few thousand. On Oahu, this species is known from a total of fewer than 60 individuals at Diamond Head and Makua-Keaau ridge on State and Federal lands, respectively. On Molokai, about 600 plants were reported from Kamalo, on private land. On Lanai, two occurrences of *S. hawaiiensis* are known: east of Puu Manu with 50 to 100 individuals and Kaa Gulch with about 300 individuals, both on private lands. On West Maui, *S. hawaiiensis* is known from two occurrences in the Lihau section of the West Maui Natural Area Reserve with 60 to 100 individuals and several hundred to thousands of plants, respectively; and, above Lahainaluna School with about 100 individuals. On the island of Hawaii, three occurrences of about 500 individuals are found on the U.S. Army's Pohakuloa Training Area in Kipuka Alala, Puu Anahulu, and an unnamed kipuka within the 1859 lava flow (Makua Implementation Team 2003) (Table SB 38).

Table SB 38. Range-wide Distribution of *Spermolepis hawaiiensis.*

Population Units	**Number of Known Individuals**					
	1991 (1)	**1999** (2)	**1999** (3)	**2003** (4)	**2005** (5)	**2006** (6)
Punapohaku	--	--	--	--	--	2/0
Ohikilolo	--	several hundred	<50 -several hundred	--	several hundred	170/184‡

Diamond Head	--	10-thousands	10-thousands	--	thousands	--
Total Population Units on Oahu	--	2	2	6	2	2
Total Individuals on Oahu	--	several hundred	<60– several hundred	110-910	thousands	(172/184)[†]
Total Population Units State-wide	6	12	12	6	9+	--
Total Individuals State-wide	thou-sands	2000-6000	5000 – 10,000	6,385-12,135*	thousands	--

Shaded occurrences are inside the action area.
*Taken from the USFWS list of Hawaiian Island Plants, August 11, 2003.
[‡]Total mature/immature individuals
[†]Total (mature/immature)

(1) Listing rule (56 FR55770)
(2) Recovery plan (Service 1999a)
(3) Makua Endangered Species Mitigation Plan (Service 1999b)
(4) Critical habitat rule (68 FR35950)
(5) Army re-initiation request (U.S. Army Garrison 2005c)
(6) Army database (U.S. Army Garrison 2006d)

Ecology *Spermolepis hawaiiensis* is known from various vegetation types, including *Metrosideros polymorpha* forests, *Dodonaea viscosa* lowland dry shrubland, cultivated fields, and pastures between about 300 and 600 m (1,000 and 2,000 ft) in elevation. Associated plant species include *Doryopteris* sp., *Gouania hillebrandii*, and *Sida fallax*. This species is an annual, and numbers fluctuate greatly from year to year, depending on climatic conditions and other unknown factors. Little else is known about the life history of this taxon. Reproductive cycles, specific environmental requirements, and limiting factors are unknown (Makua Implementation Team 2003).

Threats to the Species *Spermolepis hawaiiensis* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. Current threats to *S. hawaiiensis* are habitat degradation by feral goats, axis deer, and mouflon sheep; competition with various non-native plants; wildfire; military activities; and destruction of habitat, as well as direct destruction of individual plants by erosion, landslides, and rockslides (Service 1999a; 68 FR 35950).

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Spermolepis hawaiiensis* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to the limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve stabilization of all existing populations (Service 1999a). However, *S. hawaiiensis* is not included as a target taxon for stabilization pursuant to the Makua Implementation Plan Addendum. The Army does not actively manage this species in the Makua action area (Service 2003a).

The recovery plan for this species identifies the following important conservation actions. Fenced exclosures should be constructed around all known occurrences to reduce impacts from feral ungulates. Control of non-native plant species within the exclosures is also needed. Collection, storage, and propagation of representative genetic stock are needed, as well as augmentation of existing occurrences and establishment of additional occurrences (Service 1999a).

Ongoing Conservation Actions A State-wide strategic plan is being developed by the Hawaii and Pacific Plants Recovery Coordinating Committee that will address the long-term conservation of *Spermolepis hawaiiensis*. This plan will also include broader landscape actions that are needed for the recovery of this plant throughout its range. This species is being propagated at the Pohakuloa Training Area Rare Plant Facility. Currently, no other management actions are known for this species (Service 1999b; Service 2005b; Durand, pers. comm. 2004, Koob1996).

Critical Habitat Description A total of 578.6 ha (1,429.7 ac) in seven separate units on four islands has been designated as critical habitat for *Spermolepis hawaiiensis*. Two units were designated on Kauai (totaling 182 ha; 452 ac), two units were designated on Maui (totaling 114 ha; 280 ac), one unit was designated on Molokai (85 ha; 211 ac), and two units were designated on Oahu (totaling 137 ha; 339 ac). Critical habitat has been designated on State (e.g., Puu Ka Pele Forest Reserve and Waimea Canyon on Kauai; Kanaio and West Maui Natural Area Reserves on Maui; Diamond Head State Park on Oahu) and private lands. Each unit provides habitat for one population of 300, mature, reproductive individuals of *S. hawaiiensis* (68 FR 9116, 68 FR 25934, 68 FR 12982, 68 FR 35950). To meet recovery goals, a population should be represented by at least 300 mature, reproducing individuals of *S. hawaiiensis* (68 FR 35950).

The primary constituent elements of the units on Oahu include steep or vertical cliffs or the base of cliffs or ridges in coastal dry cliff vegetation containing one or more of the following associated native plant species: *Artemisia australis*, *Bidens* sp., *Dodonaea viscosa*, *Doryopteris* sp., *Heteropogon contortus*, *Santalum ellipticum*, or *Waltheria indica;* and elevations between 25 to 306 m (82 to 1,004 ft). The plant community, associated species, and elevations are a barometer for such things as soil moisture, nutrient cycling and availability, temperature ranges, and light levels, which are included as primary constituent elements of the habitat required for the conservation of this species (68 FR 35950).

Threats to the Critical Habitat The primary threats to critical habitat for this species on Oahu include habitat degradation by feral ungulates; non-native plant species; and habitat degradation or destruction from erosion, landslides, and wildland fire (68 FR 35950). See the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Environmental Baseline of the Species and Critical Habitat

Status of the Species in the Action Area Currently, fewer than 356 individuals, approximately three to seven percent, of the estimated 5,000 to 10,000 individuals of *Spermolepis hawaiiensis*, are found within the Makua action area (Service 1999a, Makua Implementation Team 2003,U.S. Army Garrison; 2005c, 2006d). Two occurrences of *S. hawaiiensis* are found in the action area in the Punapohaku and Ohikilolo Management Units. Both occurrences are at risk from training-

related wildfire and are within the high fire risk zone, which includes 356 individuals (172 mature plants and 184 seedlings). Thus, *S. hawaiiensis* in the action area is characterized by one stabilization population unit exceeding minimum numerical criteria comprising roughly 10 percent of all remaining individuals on Oahu and three to seven percent of the State-wide individuals, with numbers that have increased slowly due to discovery of new individuals. All individuals are within high risk fire zones (Service 2005b).

Status of the Critical Habitat in the Action Area There is one critical habitat unit within the Makua action area, comprising four percent, 21 ha (53 ac), of the total State-wide critical habitat for *Spermolepis hawaiiensis*. The critical habitat unit is located in the southwestern portion of the action area in the Lower Ohikilolo Management Unit. This habitat unit was designated to provide a portion of the habitat for the conservation of one population with a minimum of 300 mature, reproducing individuals of *S. hawaiiensis* (68 FR 35950). Approximately 1 ha (2 ac) is in the high fire risk zone and the remaining portion in the low fire risk zone. The constituent elements essential for this species include, but are not limited to, steep or vertical cliffs or the base of cliffs or ridges in coastal dry cliff vegetation. The primary constituent elements that may be affected by a training related fire include those associated native plant species found within coastal dry cliff vegetation. It is estimated that the entire critical habitat is within an area of vegetation that is predominantly non-native (K. Kawelo, pers. comm. 2004; Service 2004). This indicates that this critical habitat unit is degraded due to non-native plant encroachment.

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Spermolepis hawaiiensis* and its critical habitat in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. The primary threats to *S. hawaiiensis* and its critical habitat include destruction of habitat and direct destruction of *S. hawaiiensis* plants due to; habitat degradation by feral ungulates; competition for light, space, and nutrients from non-native plant species; and wildfire from military activities. In addition, critical habitat is threatened by predation of associated native plants by rats, slugs, the black twig borer, and the Chinese rose beetle (Makua Implementation Team 2003; 68 FR 35950).

Conservation Needs of the Species and Critical Habitat in the Action Area *Spermolepis hawaiiensis* will not be stabilized pursuant to the guidelines established in the Makua Implementation Plan because the individuals in the Makua action area represent less than one percent of the known individuals of this species. However, this species will benefit from ecosystem-level management within the action area that includes activities such as fencing, ungulate removal, and reduction of non-native plant species and control of wildfires (Makua Implementation Team 2003, U.S. Army Garrison 2004a, 2005b, 2006c). A post-fire revegetation plan and a site-specific fire management plan has been developed for the lower Ohikilolo Management Unit (U.S. Army Garrison2003a). Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species and Critical Habitat in the Action Area At this time, the Service is unaware of any specific species management activities occurring in the action area for *Spermolepis hawaiiensis*. Approximately four percent, 21 ha (53 ac), of the critical habitat occurs within the action area The Army controls non-native plants to reduce

competition with associated plant species and to reduce the risk of fire within the Ohikilolo Management Unit that contains a portion of this critical habitat (K. Kawelo, pers. comm. 2004).

Status of the Species and Critical Habitat – *Tetramolopium filiforme* (No Common Name)

Species Description *Tetramolopium filiforme* is a short-lived perennial of the Asteraceae (sunflower) family. It is a dwarf shrub 5 to 15 cm (2 to 6 in) tall, often mounded in shape. The narrow leaves are 1 to 2 cm (0.4 to 0.8 in) long and are clustered at the branch tips. The purple-white flower heads are held above the foliage on long slender stalks. The white to pale lavender ray florets are female, and the maroon or (rarely) yellow disk florets are functionally male. The achenes (a type of dry, closed fruit) are 2 to 2.7 mm (about 0.1 in) long, tipped with bristles almost as long as the achenes, and may have sparse, short glandular hairs (Wagner et al 1999; Makua Implementation Team 2003).

There are two varieties of *Tetramolopium filiforme*, which are differentiated primarily by leaf shape and leaf margin. Variety *filiforme* has extremely narrow, linear leaves with no teeth along the leaf margins; var. *polyphyllum* has leaves that widen towards the leaf apex, with prominent teeth along the leaf margins. These two morphological types are not clearly separated geographically, and their taxonomy needs clarification (Makua Implementation Team 2003). Occurrences along the higher part of Ohikilolo Ridge may contain either of the two varieties, as well as plants with intermediate characteristics. In general, Hawaiian *Tetramolopium* species are highly inter-fertile and appear to be maintained as separate entities through either geographical or ecological separation (Makua Implementation Team 2003).

Listing Status *Tetramolopium filiforme* was federally listed as endangered on October 29, 1991 (56 FR 55770), and was State listed as endangered at the same time. This species is included in recovery plans for Waianae plants (Service 1995a) and Oahu plants (Service 1998a). Critical habitat for the listed taxon was designated on June 17, 2003 (68 FR 35950). Both varieties of *T. filiforme* are included in the listed taxon.

Historic and Current Distribution *Tetramolopium filiforme* is narrowly endemic to the northern leeward Waianae Mountains of Oahu, with its center of abundance on Ohikilolo Ridge in Makua (Makua Implementation Team 2003). Historically, this species was known from Ohikilolo Ridge, Keaau Valley, and Makaha Valley (56 FR 55770). Currently, it is found only in small outlying population units from Kahanahaiki in the north to Kamaileunu Ridge and Puhawai in the south. Only on Ohikilolo Ridge do both varieties occur. Plants on the low, dry, seaward end of the ridge are all typical var. *filiforme*. With ascending elevation into more mesic habitats, plants with var. *polyphyllum* traits begin to appear together with plants of var. *filiforme*. At the highest part of the ridge, most plants show var. *polyphyllum* traits to some degree, and this variety is found only at the higher, wetter part of the ridge. Nowhere along the ridge, however, do all the plants represent var. *polyphyllum*. All known plants occurring outside Ohikilolo Ridge represent var. *filiforme* (Makua Implementation Team 2003). Trends in distribution indicate the number of plants on Ohikilolo Ridge has declined significantly over the last few decades owing to damage by feral goats. In the 1970s, many plants occurred along the crest of the ridge; however, because of a proliferation of goats on the ridge in the 1980s and 1990s, *T. filiforme* is

no longer abundant on the accessible parts of the ridge top. This species still persists in relatively large numbers on cliff faces inaccessible to goats (Makua Implementation Team 2003).

Currently, *Tetramolopium filiforme* occurs in seven population units totaling approximately 3,500 individuals (Table SB 39). These population units are found on Federal and State lands (68 FR 35950). Three of the existing population units have exceeded minimum criteria for stabilization population (at least 50 mature, reproducing individuals for short-lived perennials). Trends in numbers since listing indicate increases until 2003 and decreasing numbers since then in all population units except Keaau and Waianae Kai. In 2003, the last plant in the Waianae Kai population unit was reported as dead (Makua Implementation Team 2003). By 2004, a new population had appeared there, presumably from viable seeds in the soil seed bank (U.S. Army Garrison 2004a). Plants in the Kahanahaiki, Keaau, Makaha/Ohikilolo Ridge, and Ohikilolo population units are located in zones at risk from training-related wildfire. Thus, *T. filiforme* is characterized by seven population units and an overall decreasing trend in numbers since 2003, including three stabilization population units with relatively large numbers that are located in all fire risk zones.

Table SB 39. Range-wide Distribution of *Tetramolopium filiforme.*

Population Units	**Number of Known Individuals**					
	1991 (1)	**1995-1998** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Kahanahaiki	--	--	50	34/0	45/0	45/0
Keaau	--	--	25	16/4	16/4	30/58
Kaiena*	--	--	--	--	--	9/0
Makaha/ Ohikilolo Ridge*¶	--	--	2500	2500	200/0	200/0
Ohikilolo Mauka*	--	--			2445/552	2442/553
Ohikilolo Makai*	--	--	2500	2500		
Makaha/ Ohikilolo Ridge*¶	--	--	--	--	100/0	100/0
Puhawai*	--	--	6/6‡	2/0	2/11	1/5 [18/0]§
Waianae Kai*	--	--	0	20/2	30/9	30/9
Total Individuals	**500**	**1500-1550**	**5087** (5081/6)†	**5078** (5072/6)	**3414** (2838/576)	**3500** (2857/625) [18/0]§

Shaded population units are inside the action area.
*Stabilization population units
¶ Makaha/Ohikilolo Ridge population unit is partially within the action area.
‡Total mature/immature individuals
†Total (mature/immature)
§[augmented and or reintroduced]

(1) Listing rule (61 FR 53108)
(2) Recovery plan (Service 1998a)
(3) MIP (MIT 2003), Oahu Biological Opinion (Service 2003a)
(4) MIP Addendum and 2004 status update (U.S. Army Garrison 2005a, 2004)
(5) 2005 status update (U.S. Army Garrison 2005b)

(5) Critical habitat rule (68 FR 35950)
(6) 2006 status update (U.S. Army Garrison 2006c)

Ecology *Tetramolopium filiforme* occurs in dry habitat at the seaward end of the Ohikilolo population unit and in dry-mesic and mesic habitats at higher, more inland locations. In general, the plants are found on exposed rocky ridges and sparsely vegetated, nearly vertical cliffs, often rooted in cracks in the rock, at elevations of 340 to 900 m (1,116 to 2,953 ft) (Makua Implementation Team 2003). Flowering usually occurs in the late winter and spring. Although capable of self-pollination, *T. filiforme* probably is insect-pollinated, as are most species in the sunflower family with conspicuous flowers. The seeds of *T. filiforme* are presumed to be wind-dispersed, as bristle-bearing achenes also are characteristic of wind-dispersed members of the sunflower family. Birds may also disperse the seeds because the bristles may adhere the achenes to their feathers (Makua Implementation Team 2003). This species is relatively short-lived, usually less than five years. Other demographic information for *T. filiforme* in the wild is unknown, including number of seeds produced, age at sexual maturity, survivorship to sexual maturity, number of years in reproductive condition, survivorship during reproductive life, pollination and seed dispersal, vegetative reproduction and specific environmental requirements.

Threats to the Species *Tetramolopium filiforme* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. In particular, *T. filiforme* is one of the Makua target taxa most threatened by fire. Over the last 20 years, fires have burned into the lower reaches of the Ohikilolo population unit and have almost reached the Kahanahaiki population unit. In addition, infestations of at least two species of non-native scale insects have been observed on *T. filiforme* and need further research (Makua Implementation Plan 2003). Thus, despite its overall relative abundance, *T. filiforme* has a high background risk of species extinction due to its occurrence in high fire risk zones, and protection from existing and additional threats is needed to ensure its long-term persistence.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Tetramolopium filiforme* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve management of stabilization populations and abatements to threats (Service 1995a, 1998a).

Ongoing Conservation Actions The Makua Implementation Team (2003) has developed stabilization protocols for *Tetramolopium filiforme*, which are incorporated in the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). In addition, this species occurs in two management units where it will benefit from population unit and/or ecosystem-level protection. The management units include Puu Kumakalii, which is not fenced and for which no fence construction is planned, and Ohikilolo, which is fenced.

Tetramolopium filiforme seeds store well for several years, but viability is poor. The Army is focusing on collecting seed from fire-threatened sites in the lower Ohikilolo population unit. Plants can be propagated from both seed and cuttings. Cuttings are more than 90 percent

successful, and The Nature Conservancy of Hawaii has successfully propagated the related *T. lepidotum* from seed. Outplanting has yet been attempted for *T. filiforme* in the wild because this species commonly grows in shallow cracks on exposed rocky ledges and cliffs; transitioning greenhouse plants to such sites may be difficult (U.S. Army Garrison 2005b). Current *ex situ* collections for this species include 31,000 seeds in seed storage (Lyon Arboretum Seed Storage Facility) (Service 2005b).

Environmental Baseline of the Species

Status of the Species in the Action Area About 96 percent of all known individuals of *Tetramolopium filiforme* are located within the action area, in the Kahanahaiki, Keaau, Makaha/Ohikilolo Ridge, and Ohikilolo population units (see Table SB 39). No critical habitat for this species is located within the action area. Two population units within the action area (Makaha/Ohikilolo Ridge and Ohikilolo) have exceeded minimum criteria for a stabilization population (defined as at least 50 mature, reproducing individuals). However, threats are not controlled and genetic storage goals are not complete, so these population units are not met all criteria for a stabilization population. Overall numbers in the action area have declined since 2003, from 5,087 to 3,500 total individuals in 2006.

The Ohikilolo population unit is the center of abundance for *Tetramolopium filiforme* and is the numerically the most significant unit. Army Natural Resources Staff split Ohikilolo occurrences into two population units to demonstrate management differences between the Makua and Makaha sides of the ridge (U.S. Army Garrison 2005b). The Ohikilolo population unit is on the Makua side of the fence along the installation boundary, and the Makaha/Oikikilolo Ridge population unit is outside of it. The Ohikilolo population unit is located within the Ohikilolo Management Unit, along the steep south wall of Makua valley. Vegetation consists of native dry cliff communities, ridgetop mesic native shrubland dominated in some areas by *Dodonaea* and *Metrosideros* species, and areas of *Pritchardia kaalae* lowland mesic forest, a rare natural community (U.S. Army Garrison 2005a). The Keaau population unit is located near the Ohikilolo population unit but outside the installation's south boundary. The Kahanahaiki population unit is located in the C ridge vicinity of Makua, outside the Kahanahaiki Management Unit. *Tetramolopium filiforme* plants are located on a small, sparsely vegetated cliff surrounded by *Diospyros sandwicensis* forest. The Kahanahaiki population unit is not fenced, but ungulates are not a threat, as goats have been virtually eliminated from the installation. Approximately 50 percent of the known individuals of *T. filiforme* are protected from ungulates by fencing.

All *Tetramolopium filiforme* plants in action area population units are located in areas at risk from training-related wildfire. About 1,045 individuals (30 percent of known individuals) occur in the high fire risk zone; the remainder occurs in the low and very fire risk zones. However, most of the plants in the Ohikilolo population unit are located on the ridge farther back in the valley in an area that is not continuous with the dense fuels of the lower valley. In the seaward part of this population unit, most of the plants are located on steep cliffs lacking dense fuel vegetation and probably would not be burned (U.S. Army Garrison 2005b). Plants in the Kahanahaiki population unit, however, are extremely vulnerable to fire. The July 2003 prescribed fire burned at least 2 ha (5 ac) of native forest within 20 m (66 ft) of this site, which is now buffered by only a small strip of forest and could be extirpated by future fires (U.S. Army Garrison 2003b, 2005b). Thus, *T. filiforme* in the action area is characterized by four population

units located within high to low to very low fire risk zones, including three population units meeting minimum numerical criteria for stabilization with relatively high but decreasing numbers.

Threats to the Species in the Action Area The primary threats to *Tetramolopium filiforme* in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. *Tetramolopium filiforme* in the action area, and especially within the installation boundary, is extremely vulnerable to wildfire from military training activities. Fire has severely degraded habitat in the Ohikilolo and Kahanahaiki population units (U.S. Army Garrison 2005b). Thus, because 96 percent of all known individuals occur within the action area in zones of high to very low fire risk, *T. filiforme* in the action area has a high background risk of species extinction, and protection from existing and additional threats is needed to ensure its long-term persistence.

Conservation Needs of the Species in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) includes *Tetramolopium filiforme* because there are no stabilization population units outside the action area, threats are not fully controlled, and genetic storage is not complete. Three population units have been identified for stabilization of *T. filiforme*: Ohikilolo within the action area, and Puhawai and Waianae Kai outside the action area. Post-fire revegetation plans and site-specific fuels modification are needed where individuals are located in the action area. About 15 ha (38 ac) of the Ohikilolo Management Unit is not fenced (fence construction for this area is planned for 2011). The Keaau and Makaha/Ohikilolo Ridge population units are not fenced, and goats are a problem in both areas. Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species in the Action Area The action area contains 96 percent of the total remaining individuals of *Tetramolopium filiforme*. The Ohikilolo stabilization population unit, which contains 86 percent of the total remaining individuals, is being managed for stabilization as specified by the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). This population unit is located within the Ohikilolo Management Unit. A major part of the Ohikilolo Management Unit is protected by a boundary ridgeline fence, and goats have been virtually eradicated from Makua. Genetic storage goals for *T. filiforme* are 25 percent complete, with 75 plants from all six population units combined meeting the goals of the Makua Implementation Plan, and there are currently four plants growing in the Army nursery (U.S. Army Garrison 2005b).

Status of the Species and Critical Habitat – *Viola chamissoniana* ssp. *chammissoniana* (Pamakani)

Species Description *Viola chamissoniana* ssp. *chamissoniana* is a short-lived perennial of the Violaceae (violet) family. It is a basal-branching woody shrub with branches 20 to 60 cm (8 to 23 in) long. Some occurrences, especially on steep cliffs, have plants with reclining or drooping branches; plants in other occurrences have erect branches forming upright shrubs. The triangular leaves are 2 to 4 cm (0.8 to 1.6 in) long and clustered at the ends of the stems. The flowers are

large, white, and held above the leaves. The tiny, dark, egg-shaped seeds are borne in capsules that open as they dry (Wagner et al 1999; Makua Implementation Team 2003).

There are three subspecies of *Viola chamissoniana*: ssp. *chamissoniana* (Oahu), ssp. *tracheliifolia* (Kauai, Oahu, Molokai, and Maui), and ssp. *robusta* (Molokai). The subspecies *tracheliifolia* and *robusta* are not considered rare. The only other native *Viola* occurring in the Waianae Mountains of Oahu is the common *V. chamissoniana* ssp. *tracheliifolia*, which like ssp. *chamissoniana*, occurs throughout that mountain range. Subspecies *tracheliifolia* is generally found growing in the forest understory, whereas ssp. *chamissoniana* is most often in open, exposed habitats. Several sites are known where the two subspecies grow side by side, without natural hybridization.

Listing Status *Viola chamissoniana* ssp. *chamissoniana* was federally listed as endangered on October 29, 1991 (56 FR 55770), and was State listed as endangered at the same time. This species is included in recovery plans for Waianae plants (Service 1995a) and Oahu plants (Service 1998a). Critical habitat for the listed taxon was designated on June 17, 2003 (68 FR 35950). Only the subspecies *chamissoniana* is listed as the endangered taxon.

Historic and Current Distribution *Viola chamissoniana* ssp. *chamissoniana* is a species endemic to the Hawaiian Islands. *Viola chamissoniana* ssp. *chamissoniana* is endemic to the island of Oahu and is known only from the Waianae Mountains. It has been recorded throughout the mountain range on both the windward and leeward sides. Demographic data for this species is deficient, and apparent increases in the number of population units probably reflect more consistent survey efforts since the species was listed, and because all known occurrences were discovered only within the last 20 years. Many *V. chamissoniana* ssp. *chamissoniana* plants grow on steep cliffs inaccessible to feral ungulates, so this taxon may not have declined as much as other taxa that are not cliff-dwelling. *Viola chamissoniana* ssp. *chamissoniana* also may once have been more common on gentler slopes and has persisted only on steep cliffs inaccessible to feral ungulates (Makua Implementation Team 2003).

Currently, *Viola chamissoniana* ssp. *chamissoniana* occurs in eight population units totaling approximately 618 individuals (Table SB 40). These population units are found on Federal and State lands (68 FR 35950). One of these population units has exceeded minimum numerical criteria for a stabilization (defined as at least 50 mature, reproducing individuals for short-lived perennials). Data on numbers of individuals has only been consistent with monitoring since 2003 and indicate an increase from 374 to 618 total known individuals. This increase includes some additional individuals recently discovered in the Puu Kamakalii population unit. The Keaau and Ohikilolo population units are located in the Makua action area, and the Puu Kamakalii population is located in the action area of Schofield Barracks Military Reservation. These occurrences are located in zones at risk from training-related wildfire. Thus, *V. chamissoniana* ssp. *chamissoniana* is characterized by eight population units with low numbers, except for one population unit that exceeds minimum criteria for stabilization.

Table SB 40. Range-wide Distribution of *Viola chamissoniana* ssp. *chammissoniana.*

Population Units	Number of Known Individuals					
	1991 (1)	**1995-1998** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Keaau	--	--	--	40/10	40/10	40/10
Makaha/Ohikilolo Ridge*	--	--	250/0‡	250/0	12/0	7/0
Ohikilolo*					377/2	433/10
Halona	--	--	3	32/3	32/3	41/3
Kamaileunu	--	--	38	38/0	35/0	35/0
Makaha*	--	--	50	50/0	24/2	24/2
Makaha/Ohikilolo Ridge*	--	--	--	--	20/0	--
Puu Hapapa	--	--	10/3	10/0	10/6	13/0
Puu Kamakalii (SBMR) *	--	--	19/1	53/0	44/0	--
Total Individuals	**14**	**237-257**	**374**	**486** (473/13)†	**617** (594/23)	**618** (593/25)

Shaded population units are inside the action area.
‡Total mature/immature individuals
*Stabilization population units
†Total (mature/immature)
SBMR = Schofield Barracks Military Reservation

(1) Listing rule (56 FR 55770)
(2) Recovery plans (Service 1995a, 1998a)
(3) Makua Implementation Plan (Makua Implementation Team 2003)
(4) MIP Addendum and 2004 status report (U.S. Army Garrison 2005a, 2004)
(5) 2005 status report (U.S. Army Garrison 2005b), K. Kawelo (pers. comm., 2005)
(6) 2006 status update (U.S. Army Garrison 2006c)

Ecology *Viola chamissoniana* ssp. *chamissoniana* occurs in mesic habitats at elevations of 700 to 1,000 m (2,297 to 3,281 ft). It is usually found on north-facing cliffs and cliff ledges that are sparsely to moderately vegetated with native shrubs, grasses, and sedges. Such sites are among the most native and undisturbed mesic habitats of the Waianae Mountains. This taxon also is found on gentle slopes in native shrubland (Makua Implementation Team 2003). Little is known about the breeding system of *V. chamissoniana* ssp. *chamissoniana*. The large, white, fragrant flowers held above the leaves suggest pollination by moths. Plant longevity probably is similar to that of other small shrubs that live less than 10 years (i.e., short-lived perennials) (Makua Implementation Team 2003). Other demographic information for *V. chamissoniana* ssp. *chamissoniana* in the wild is uncertain, including number of seeds produced, age at sexual maturity, survivorship to sexual maturity, number of years in reproductive condition, survivorship during reproductive life, timing of reproductive output, pollination and seed dispersal, vegetative reproduction and specific environmental requirements.

Threats to the Species *Viola chamissoniana* ssp. *chamissoniana* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat"

section and tabulated in Appendix E. Because of its overall relative abundance and population units in fire risk zones, *V. chamissoniana* ssp. *chamissoniana* has a high background risk of species extinction, and protection from existing and additional threats is needed to ensure its long-term persistence.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Viola chamissoniana* ssp. *chamissoniana* are described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section. Due to limited knowledge of life history requirements for short-term and long-term survival, the recovery plan for this species specifies interim objectives to downlisting and delisting that involve utilizing stabilization populations to aid in recovery (Service 1995a, 1998a).

Ongoing Conservation Actions The Makua Implementation Team (2003) has developed stabilization criteria for *Viola chamissoniana* ssp. *chamissoniana*, which are incorporated in the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). In addition, this species occurs in four management units where it will benefit from population unit and/or ecosystem-level protection. The management units include Makaha, Palikea, and Puu Kumakalii, which are not fenced, and Ohikilolo, which is fenced.

Viola chamissoniana ssp. *chamissoniana* is easy to propagate from seeds and cuttings. Seeds can be stored at appropriate conditions for several years with 60 percent germination success, and cuttings are also about 60 percent successful. Seed is difficult to collect because wild plants produce very few flowers and seeds at a time. Flowering of some greenhouse plants is more prolific, but most of the fruits are aborted. The Army is conducting nursery pollination experiments to determine limiting factors to seed production (U.S. Army Garrison 2005b). Current *ex situ* collections for this species include 31,000 seeds in seed storage (Lyon Arboretum Seed Storage Facility) (Service 2005b).

Environmental Baseline of the Species

Status of the Species in the Action Area Approximately 81 percent of all known individuals of *Viola chamissoniana* ssp. *chamissoniana* are located within the action area, in the Keaau, Makaha/Ohikilolo Ridge, and Ohikilolo population units (see table above). No critical habitat for this species is located within the action area. One population unit (Ohikilolo) has met minimum criteria for stabilization (at least 50 mature, reproducing individuals). However, threats are not controlled and genetic storage goals are not complete, so this population unit is not considered meeting overall criteria for stabilization (U.S. Army Garrison 2005b). Overall numbers in the action area have increased since 2003, from 250 to approximately 500 total individuals. This increase includes an additional sub-population recently discovered in the Makaha/Ohikilolo Ridge population unit (U.S. Army Garrison 2005b). All plants in the action are located in areas at risk from training-related wildfire; however, all individuals of *V. chamissoniana* ssp. *chamissoniana* are located in the very low fire risk zone. These individuals at risk from fire in the action area represent about 81 percent of the species' total range-wide numbers.

Army Natural Resources Staff split Ohikilolo occurrences into two population units to demonstrate management differences between the Makua and Makaha sides of the ridge (U.S.

Army Garrison 2005b). The Ohikilolo population unit is on the Makua side of the fence along the installation boundary, and the Makaha/Oikikilolo Ridge population unit is outside of it. The Ohikilolo population unit is located within the Ohikilolo Management Unit, along the steep, south wall of Makua valley. Vegetation consists of native, dry cliff communities, ridgetop mesic native shrubland dominated in some areas by *Dodonaea* and *Metrosideros* species, and areas of *Pritchardia kaalae* lowland mesic forest, a rare natural community (U.S. Army Garrison 2005a). The Keaau population unit is located near the Ohikilolo population unit but outside the installation's south boundary. Thus, *V. chamissoniana* ssp. *chamissoniana* in the action area is characterized by three population units located within high to very low fire risk zones, including one population unit that exceeds minimum number of individuals suggested in the recovery plans for Waianae plants and Oahu plants for stabilization populations.

Threats to the Species in the Action Area The primary threats to *Viola chamissoniana* ssp. *chamissoniana* in the action area are those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. Because about 81 percent of all known individuals occur within the action area in the very low fire risk zones, *V. chamissoniana* ssp. *chamissoniana* in the action area has a high background risk of species extinction, and protection from existing and additional threats is needed to ensure its long-term persistence.

Conservation Needs of the Species in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) includes *Viola chamissoniana* ssp. *chamissoniana* because more than 80 percent of remaining individuals are located within the action area and there is only one population unit that has met criteria for stabilization outside the action area. In addition, threats are not fully controlled and genetic storage is not complete. Three population units are identified for stabilization of *V. chamissoniana* ssp. *chamissoniana*: Ohikilolo within the action area, and Puu Kumakalii and Makaha outside the action area. Post-fire revegetation plans and site-specific fuels modification are needed where individuals are located in the action area. About 15 ha (38 ac) of the Ohikilolo Management Unit is not fenced; fence construction for this area is planned for 2011. Fence construction is planned for the Makaha Management Unit in 2007 thru 2009. Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the "Status and Environmental Baseline of the Species and Critical Habitat" section.

Ongoing Conservation Actions for the Species in the Action Area The three population units in the action area contain 81 percent of the total remaining individuals of *Viola chamissoniana* ssp. *chamissoniana*. The population unit inside the action area, which contains 72 percent of the total remaining individuals, is being managed for stabilization as specified by the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). The Ohikilolo population unit is located within the Ohikilolo Management Unit. A major part of the Ohikilolo Management Unit is protected by a boundary ridgeline fence, and goats have been virtually eradicated from Makua. Genetic storage goals for *V. chamissoniana* ssp. *chamissoniana* are over two percent complete, with 10 plants from all eight population units combined meeting the goals of the Makua Implementation Plan. There are currently 37 plants growing in the Army nursery (U.S. Army Garrison 2005b).

Status of the Species – *Achatinella mustelina* tree snails (Oahu Tree Snails)

Species Description Adult *Achatinella mustelina* snails have oblong to ovate shells 19 to 24 mm (0.75 to 0.94 in) in length and with a glossy to semi-glossy surface. The shell may coil either to the left (sinistral) or to the right (dextral) and has between five to seven whorls. The umbilicus (the space along the axis of coiling) is closed. The lip at the opening of the adult shell is smooth and simple with no ribs, ridges, or folds, and become thickened and flares outward at maturity. The columella (the internal shell material around the axis of coiling) has a well developed spiral lamella (ridge). The shells of *A. mustelina* have a range of colors and patterns that vary with location along the Waianae mountain range. In the vicinity of the Makua Valley, the shells are most often colored brown with a single spiral white band (Pilsbry and Cooke 1912-1914).

Listing Status All 41 species of Oahu tree snails were listed on January 13, 1981, as endangered under the single genus name *Achatinella* (46 FR 3178) and simultaneously listed under the State of Hawaii Endangered Species Act (HRS 195D-4a). A recovery plan covering all 41 snail species was prepared in 1993 (Service 1993). Critical habitat has not been designated for these snails. The Oahu Tree Snail Recovery Plan maps four essential habitat areas in the Waianae and Koolau Mountains (north and south in each range).

Historic and Current Distribution Before human settlement of the Hawaiian Islands, dry, mesic, and wet forests covered approximately 127,000 ha (approximately 314,000 ac) on Oahu (HINHP 1991). It is likely that the *Achatinella* tree snails occupied all but the driest of these forest environments. This view is supported by the known historic and current distributions of these snails. Historically, tree snails were reported at elevations as low as 300 m (1,000 ft) and this lower limit was set by the clearing of forests for agriculture and cattle pastures (Pilsbry and Cooke 1912-1914). Sub-fossil shell collections show that snails occurred almost to the shore on the windward coast of Oahu. Information on the historic distribution of *A. mustelina* showed that this tree snail flourished in mesic forests in the Waianae Mountains of Oahu (Pilsbry and Cooke 1912-1914). Shells found at lower and dryer locations in the Waianae Mountains indicate that this snail species can tolerate moderately dry conditions.

Hadfield (1986) reviewed the literature on the historic abundance of Hawaiian tree snails and reports that Hawaiian tree snails were generally very abundant in many forested areas. Shell collectors often spoke of hundreds or thousands of snails in each collecting lot, and they would often collect from horse back as they rode through the forests of the Koolau and Waianae Mountains. There are several reports indicating that hundreds to thousands of snails could be collected in a single afternoon. In Nuuanu Valley, Cooke (1903) reported collecting 3,000 *Achatinella bellula* from an area 91 by 366 m (300 ft by 1,200 ft) and at an elevation of 300 to 427 m (984 to 1,401 ft). In Palolo Valley, snails of *A. viridans* were so dense that they "...hung in clusters on the hoe vines". Based on these types of historic records, we can conclude that many *Achatinella* tree snails were very abundant prior to impacts from humans. The population trend for all Oahu tree snails is an overall decline in numbers of individuals within an occurrence and a decline in the number of occurrences throughout the range of the species. This has resulted in a significant reduction in the occupied range of each species, which was probably already substantially reduced for some species by the early 1900s (Pilsbry and Cooke 1912-1914).

Current assessment of the status and current trends of *Achatinella mustelina* is somewhat tentative, due to the continuing loss of individuals, mostly from predation by non-native rats and snails. Information on the numbers of remaining populations is more reliable. Data used to assess the current status of these snails was obtained from the most current records from the Army (K. Kawelo, pers. comm. 2007). The detailed status and location information for these data will be presented in the environmental baseline.

Achatinella mustelina was historically known from middle to upper elevation locations throughout the northern and southern Waianae Mountains. Currently, *A. mustelina* is the most abundant of the Oahu tree snails, and is known from 120 point occurrences representing approximately 94 populations. Qualitative estimates from counts of snails during day visits indicate that there are approximately 2,000 Oahu trees snails in the wild. Seventeen (18 percent) of the populations are within the Makua action area (see Environmental Baseline for status and location information). Seventy-seven (82 percent) of the populations (approximately 72 percent of the known individuals) are outside of the Makua action area. Based on information from the Army (K. Kawelo, pers. comm. 2007), snails are known from to following general areas (listed in geographic proximity to one another, from north to south):

Kahanahaiki (4 occurrences)
Pahole Gulch (2 occurrences)
Kapuna-Makua ridge (3 occurrences)
South Makua ridge (8 occurrences)
West Makaleha (6 occurrence)
East Makaleha (12 occurrence)
Upper Kaala NAR (4 occurrence)
Lower Kaala NAR (9 occurrences)
Makaha-Waianae Kai ridge (13 occurrences)
Schofield Barracks (4 occurrences)
Puu Kalena (10 occurrences)
Puu Kumakalii (5 occurrences)
Puu Hapapa (11 occurrences)
Puu Kanehoa (5 occurrences)
Puukaua (8 occurrences)
north of Puu Palikea (5 occurrences)
Puu Palikea (10 occurrences)
Mauna Kapu (1 occurrence).

Thirty-seven (39 percent) of the populations have only a single recorded count of the numbers of snails in the population. No data is available for eight populations. Among the remaining populations, 20 appear to be stable, 6 appear to be increasing, and 23 appear to be decreasing. Based on these values, approximately 48 percent of the known populations are probably in decline, 40 percent appear to be stable, and 12 percent may be increasing.

Ecology *Achatinella* tree snails are arboreal and feed on fungus and algae that grown on the surface of leaves of native plants (Pilsbry and Cooke 1912-1914; Hadfield and Miller 1989). The snails are most often found in mesic and wet forests above about 366 m (1,200 ft) elevation in the Waianae and Koolau Mountains but are not found above about 1,158 m (3,800 ft)

elevation on Mount Kaala, the highest point on Oahu. They are occasionally seen on alien vegetation, but rarely establish populations on non-native plants and usually avoid native trees and shrubs with pubescent leaves (Service 1993; Pilsbry and Cooke 1912-1914). Snails seal themselves to leaves or stems during the day, and at night they move about freely. Movement is limited, and marked snails have been observed in the same bush or tree for years at a time (Service 1993; Hadfield and Miller 1989; Hadfield et al 1993; Kobayashi and Hadfield 1996). Dispersal appears to be mostly due to occasional storms or high winds that blow snails out of the trees. Subsequently, the snails will crawl on the ground until they encounter vegetation that allows them to get back up into a host tree. Following periods of high winds, marked snails have been observed to be dispersed as much 18 m (60 ft) from where they were last seen (Hadfield, pers. comm. 1986).

Tree snails become sexually mature in three to five years, and they may live for 15 to 20 years. Sexual maturity is marked by a termination of shell growth and a thickening of the growth margin of the shell. All members of the genus are hermaphroditic, and a species of the sister genus *Partulina* is known to be capable of self-fertilization (Kobayashi and Hadfield 1996), this may also apply to some of the *Achatinella* species. Reproductive output is low with an adult snail giving birth to 4 to 6 live young per year. Each new born snail is between 3.5 to 5 mm (0.14 to 0.20 in) long at birth (Service 1993; Hadfield and Miller 1989; Hadfield et al 1993; Kobayashi and Hadfield 1996).

The genetic structure of *Achatinella mustelina* was recently investigated by Holland and Hadfield (2002), and Holland (2007). Gene sequence analyses of cytochrome oxidase I of *A. mustelina* has been done using snails from multiple tree snail occurrences that cover the full species range in the Waianae Mountains. The results show two main features: previously described subspecies are not supported by the genetic analyses and the subspecies should be synonymized (Holland and Hadfield 2007); and population genetic structure is strongly correlated with topographic features (Holland and Hadfield 2002). Maximum genetic distances were independent of geographic distances, and instead were influenced by deep valleys or steep mountain peaks. Six evolutionarily significant units (ESUs) were identified in this study, and two additional tree snail occurrences were included to cover the full range of the two largest ESUs.

Threats Rats and predatory snails (*Euglandina rosea*) are known to occur throughout the Waianae Mountains and are major causes of decline and extinction of tree snail populations (Hadfield and Mountain 1980; Hadfield 1986; Hadfield and Miller 1989; Hadfield et al 1993). The Recovery Plan for the Oahu Tree Snails (Service 1993) reviews documented declines in tree snail occurrences associated with predation by non-native snails and rats. Other alien species that may prey upon Oahu tree snails include two terrestrial flatworms (*Geoplana septemlineata* and *Platydemis manokwari*) and a small terrestrial snail *Oxychilus alliarius*. *Platydemis manokwari* is a documented major predator on tree snails from other Pacific Islands and is known to occur on Oahu. *Geoplana septemlineata* and *Oxychilus alliarius* are regularly found feeding on the tissues of dead Oahu tree snails, but it is not known if these two animals were the cause of death.

Habitat disturbance and destruction also threaten Oahu tree snails, including *Achtinella mustelina*. Rooting by pigs, browsing by goats, and hiking, hunting, camping or similar

activities can disturb native habitat and destroy host trees that support snails. These activities also promote the spread of non-native plants that displace native plants used by Oahu tree snails. Fire is not a likely threat to Oahu tree snails that occur in wet forested areas. However, given the very low number of occurrences and individuals of Oahu tree snails, any fires that impact these snails would have a significant effect on the overall stability and future survival of the species. For Oahu tree snail occurrences in mesic or dry forest, the threat from fire is an important factor in their long-term conservation. Finally, the small numbers of individuals that remain in each of the Oahu tree snail species may make them highly vulnerable to stochastic effects, such as inbreeding or genetic drift, as well as catastrophic events such as large storms or landslides that could reduce or eliminate any of the smaller occurrences.

Conservation Needs of the Species A State-wide management plan should be developed and implemented for the long-term conservation of all known occurrences of *Achatinella mustelina*. This plan should include broader landscape actions that are needed for the recovery of the snail throughout its range. The Recovery Plan for the Oahu tree snails identifies important conservation actions. Along with the Makua Implementation Plan actions for *A. mustelina*, these documents should be used to guide ongoing and future conservation actions. The stabilization plan for *A. mustelina* provides a detailed assessment of all the critical tree snail conservation issues actions. Based on the current information on the life history of Oahu tree snails and on the nature of the threats to these snails, the conservation needs of these snails are dependent on the following ecological features: (1) the presence of suitable habitat, which includes a functionally intact native forest with a close or closed canopy and an understory of native plants that can support tree snail occurrences; (2) a population structure that includes all age classes and supports reproductive rates that are high enough to sustain the occurrence; (3) a landscape distribution of occurrences that preserves the remaining genetic diversity of each of the tree snail species; and (4) ecological conditions that can support metapopulation dynamics where specific occurrences may decline or disappear over time while new occurrences within the landscape become established and grow. To achieve these biological requirements, land management actions must (1) effectively control alien species that prey on tree snails, particularly *Euglandina rosea* and all rat species; (2) must protect native forests from excessive disturbance and destruction by ungulates, especially pigs and goats on Oahu; by fire, which can affect some occurrences in the Waianae Mountains; and by invasive non-native plants that can displace native plants used by tree snails; and (3) must assist in protecting existing occurrences and establishing new occurrences throughout the known range of the snail. Captive propagation of tree snails can greatly aid in achieving the conservation needs and management actions. Note, however, that captive populations can undergo occasional declines due to disease or other effects, and that these declines may be rapid. To secure snails using a captive breeding program, a captive population should exceed 100 individuals and there should be two to four populations located at more than one site.

Ongoing Conservation Actions *Achatinella mustelina* is well represented in the tree snail captive propagation facility at the University of Hawaii (approximately 240 individuals in all age classes). Currently, the tree snail captive propagation facility at the University of Hawaii is working at or near maximum capacity. The addition of more species or more individuals from the field will require an expansion in the capacity of the facility. The Nature Conservancy of Hawaii does some management of *A. mustelina* at its Honouliuli Preserve. The State of Hawaii, Department of Land and Natural Resources, funded two snail enclosures for *A. mustelina* at the

Pahole Natural Area Reserve and on the south ridge of Makua Valley. These enclosures exclude rats and predatory snails and are managed by the Army Natural Resources Staff and the State. The Makua Implementation Plan (U.S. Army Garrison 2003) includes predator protection for eight occurrences (each with 300 individuals) of *A. mustelina* throughout the Waianae Mountains. These actions will use a variety of techniques such as poison rat baits, rat snap traps, manual killing of any cannibal snails, and the construction of enclosure fences.

Environmental Baseline

Status of the Species in the Action Area Recent observations (2003 to 2006) show that there are 17 point occurrences (populations) of *Achatinella mustelina* within the Makua action area. The know locations are Kahanahaiki (4 populations, approximately 86 snails); Pahole Gulch (2 populations, 2 snails), Kapuna-Makua ridge (3 populations, approximately 16 snails), and south Makua ridge (8 populations, approximately 358 snails). Four of these populations appear to be stable, two appear to be increasing, and two appear to be decreasing. Eight of the populations have only a single recorded count and one population has no available data; no general trend can be given for these populations.

Within the action area, fourteen of the tree snail populations are within management units that are part of the Makua Implementation Plan: four populations in the Kahanhaiki Management Unit; two populations in the Pahole Management Unit; two populations in the Upper Kapuna Management Unit; and six populations in the Ohikilolo Management Unit. However, only two populations are within fenced areas that protect the snails from rats and alien predatory snails: one in Kahanahaiki (stable at approximately 70 snails) and one in Pahole Gulch (declining with approximately 15 to 30 snails).

Outside of the action area, forty-three populations are within management unit areas. Seven are in the East Makaha Management Unit, one is in the Manuwai Management Unit, eleven are in the Makaha Management Units, two are in the Puu Kumakalii Management Unit, five are in the Puu Hapapa Management Units, eight are in the Puukaua Management Units, and nine are in the Palikea Management Unit. Most of these units have not yet been fenced and receive minimal management actions.

Currently, snails from all six of the evolutionarily significant units (ESUs) are in the Hawaiian tree snail captive propagation facility at the University of Hawaii. In all cases, these populations have not increased to the point that they can provide individuals for reintroduction into the wild; laboratory population sizes range from twelve to thirty individuals (U.S. Army 2006c). Reintroduction into the wild should begin when these populations reach about 300 individuals. Reintroduced snails may be used to establish new populations or enhance existing populations within the appropriate ESU.

Threats in the Action Area. As stated above in the Status of the Species, Threats Section, rats and predatory snails are the greatest threats to the Oahu tree snails and are the major causes of decline and extinction of tree snail occurrences. Other alien species that may prey on Oahu tree snail include two terrestrial flatworms (*Geoplana septemlineata* and *Platydemis manokwari*) and a small terrestrial snail *Oxychilus alliarius*. Additional threats also include loss of habitat from pigs, goats, hiking, hunting, camping, or other activities that can disturb or destroy native habitat,

damage tree snail host trees, or spread of non-native plants that displace native plants used by tree snails.

The threat of fire due to military activities in Makua is a concern for some of the occurrences of *Achatinella mustelina* that are within the action area. Uncontrolled fires originating in these areas could destroy tree snail habitat and tree snail occurrences. As assessed by the fire risk modeling (see General Effects section), snails within the action area are at low risk from fire. Finally, small numbers of individuals at each of the occurrences make them vulnerable to stochastic effects, such as inbreeding or genetic drift, as well as catastrophic events such as large storms or landslides that could reduce or eliminate any of the known occurrences.

Conservation Needs in the Action Area A stabilization plan has been developed for *Achatinella mustelina* as part of the Makua Implementation Plan (U.S. Army Garrison 2003). This plan provides a detailed assessment of critical tree snail conservation issues and needs. Based on the *Biological Assessment* (U.S. Army. 2003a) and the Makua Implementation Plan (U.S. Army Garrison 2003), conservation needs on military lands include the following: 1) protect tree snail occurrences from alien species that prey on tree snails, particularly *Euglandina rosea* and all rat species; 2) protect tree snail habitat from disturbance and destruction by ungulates; 3) where conditions and training uses warrant, protect tree snail habitat from fire; 4) control invasive non-native plants that can displace native plants used by tree snails; and 5) employ captive propagation to protect existing occurrences and to support the establishing new occurrences throughout the known range of these snails.

Ongoing Conservation Actions in the Action Area As stated above in the Status of the Species, Ongoing Conservation Actions section, conservation actions for *Achatinella mustelina* are being conducted within the Makua action area and in the snail captive propagation facility at the University of Hawaii. Field conservation actions are mainly focused at monitoring and occasional rat trapping by Army Natural Resources Staff at known occurrences within the Makua action area. The State of Hawaii, Department of Land and Natural Resources operates two snail enclosures for *A. mustelina* within the Pahole Natural Area Reserve and on the south ridge of Makua Valley. These enclosures exclude rats and predatory snails and are managed by the Army Natural Resources Staff and the State. The Makua Implementation Plan (U.S. Army Garrison 2003) includes predator protection for 10 occurrences (each with 300 individuals) of *A. mustelina* throughout the Waianae Mountains. These actions will use a variety of techniques such as poison rat baits, rat snap traps, manual killing of any cannibal snails, and the construction of enclosure fences. At this time, the Makua Implementation Plan for *A. mustelina* is not fully funded and has not been fully implemented.

Status of the Species and Critical Habitat – *Chasiempis sandwichensis ibidis* (Oahu elepaio)

Species Description The Oahu elepaio is a small (12.5 g, 0.4 oz), 15 cm (5.9 in) monarch flycatcher subspecies endemic to the island of Oahu (VanderWerf 1998a). It is dark brown above and white below, with light brown streaks on the breast. The tail is 6.5 cm (2.6 in) long and often held cocked up at an angle. Adults have conspicuous white wingbars, a white rump, and white tips on the tail feathers that are often displayed. The throat is white with black markings in both sexes, but males tend to have more black than females, especially on the chin.

Listing Status Oahu elepaio was federally listed as endangered on April 18, 2000 (65 FR 20760), and was State listed as endangered at the same time. The Revised Hawaiian Forest Birds Recovery Plan (Service 2006c) includes this species, and critical habitat was designated on December 10, 2001 (66 FR 63752).

Historic and Current Distribution Before humans arrived in Hawaii 1,600 years ago, forests covered about 127,000 ha (313,690 ac) of Oahu, and it is likely that elepaio once inhabited much of that area. This species' range is currently limited to approximately 5,451 ha (13,464 ac) (VanderWerf et al. 2001). The Oahu elepaio occupies only about 4 percent of its presumed prehistoric range. As recently as 1975, elepaio inhabited approximately 20,900 ha (51,623 ac) on Oahu, nearly four times the area of the current range (VanderWerf et al. 2001). The range of the elepaio has thus declined by roughly 75 percent in the last 25 years.

In addition to the extent of this species current range decreasing, and despite its adaptability, the total number of Oahu elepaio individuals has dropped significantly since humans arrived (Shallenberger 1977, Shallenberger and Vaughn 1978, Williams 1987, VanderWerf et al. 1997). Based on the dates when elepaio were last observed in various locations, the decline of elepaio began in three areas, the northern Koolau Mountains, the northern slope of Mt. Kaala in the northern Waianae Range, and near Konahuanui in the south-central Koolau Mountains. Perhaps not coincidentally, these are also the three areas with the highest rainfall on Oahu, suggesting mosquito-borne diseases may have played an important role in the decline. Most recent surveys indicate that there are only a total of 7 birds in Makua Valley where in 2001 there had been 26 birds (a 73 percent decline) (S. Mosier, U.S. Army Natural Resources, pers. comm. 2007). Complete surveys of The Nature Conservancy's Honouliuli Preserve indicate that there are a total of 47 Oahu Elepaio on a site where in 2001, there had been 307 (an 85 percent decline) (VanderWerf et al 2000 and VanderWerf 2006). In 2001, the breeding population of Oahu elepaio was estimated to be 1,770 birds with a total population of 1,982, due to a male-biased sex-ratio; only 84 percent of territorial males within large populations have mates (E. VanderWerf, unpubl. data), and many small, declining populations contain mostly males.

Table SB 41. Range-wide Distribution of Oahu elepaio.

Location	2000 (1)	2001 (2)	2006 (6)
Kaluakauila	615	0 / 1	0
Kahanahaiki, Pahole		4 / 14	0 / 1
Makua Valley*		2 / 5	4 / 2
Makaha Valley*		112 / 11	2 / 12
Makaha Valley*			28 / 24
Waianae Kai			Incomplete surveys
Schofield Ranges*		310 / 36	Incomplete surveys
Waianae (other)		2 / 6	Incomplete surveys
Ekahanui		138 / 13	Incomplete surveys
Honouliuli*		280 / 27	26 / 21
Moanalua Valley*	885	206 / 20	Incomplete surveys
Waikana / Kahana Valley*		26 / 0	Incomplete surveys
Koolau Mts (elsewhere)		696 / 73	Incomplete surveys
Total Individuals	1,500	1,982	< 1,703

Shaded population units are inside the action area.
*Army currently conducts predator control
‡Total breeding birds / total single birds

(1) Listing rule (65 FR 20760)
(2) VanderWerf et al. (2001)
(3) Final Implementation Plan (Makua Implementation Team 2003), Oahu biological opinion (Service 2003a)
(4) Addendum to Final Implementation Plan and 2004 status report (U.S. Army Garrison 2005a, 2004)
(5) 2005 status update (U.S. Army Garrison 2005b)
(6) 2006 status update (U.S. Army Garrison 2006c), Recovery plan (Service 2006c)

The genetically-effective population size probably is further reduced by the geographic isolation of populations (Grant and Grant 1992). Adults have high site fidelity and natal dispersal distances usually are less than a km (0.6 mi) (VanderWerf 1998a), but most elepaio populations on Oahu are separated by many kilometers of unsuitable urban or agricultural habitat. There may be infrequent dispersal among populations within each mountain range, but it is unlikely that elepaio cross the extensive pineapple fields that separate the Waianae and Koolau Mountains. The current distribution appears to constitute a metapopulation (Hanski and Gilpin 1997). Investigation of the genetic population structure has begun (Burgess 2005), but requires additional analysis.

Ecology Elepaio are non-migratory and defend all-purpose territories year-round (Conant 1977, VanderWerf 1998a). The average territory size is 2.0 ha (4.9 ac) in a forest composed of alien plant species in Manoa Valley (Conant 1977) and ranged from 1.2 to 1.8 ha (3.1 to 4.5 ac) in three valleys in southeastern Oahu, depending on forest structure (VanderWerf and Smith 2002). Annual survival is high, 81 percent in the absence of predation by alien mammals, but survival of females is heavily impacted by predation from alien rats (VanderWerf and Smith 2002). Elepaio are socially monogamous and have high mate and site fidelity; in the absence of predation by alien mammals, 97 percent of males and 95 percent of females remain on the same territory between years, and nearly all pairs remain together between years (VanderWerf and Smith 2002). Young birds are subordinate and act as floaters while they attempt to acquire a territory and a mate. The nesting season usually extends from February to May, but active nests have been found from January to July (VanderWerf 1998a).

The nest is a finely-woven, free standing cup made of rootlets, bark strips, leaf skeletons, lichens, and spider silk, and is placed in a fork or on top of a branch (Conant 1977, VanderWerf 1998a). Nests have been found in a variety of plants, including 7 native species and 15 introduced species (E. VanderWerf, unpubl. data). Oahu elepaio nests are built 2 to 19 m (6 to 62 ft) off the ground in shrubs and trees (VanderWerf and Smith 2002). Both sexes participate in all aspects of reproduction, but the female plays a slightly greater role in nest building and the male provides more food for the nestlings (VanderWerf 1998a). Although both sexes incubate and brood, only the female develops a brood patch and only the female incubates at night. Clutch size is usually two, sometimes one or three, and eggs hatch after 18 days (Conant 1977, VanderWerf 1998a). The nestling period averages 16 days, and fledglings are fed by their parents for more than a month after leaving the nest, remaining on the natal territory for up to 9 months at the start of the next breeding season (VanderWerf 1998a). Fecundity is low; even if nest predators are controlled, the mean number of fledglings per pair is 0.70 per year (VanderWerf and Smith 2002). Oahu elepaio will re-nest once or twice after failure, but they rarely attempt to re-nest if the first nest is successful. Other than introduced predators, the most common cause of nest failure is storms with heavy rain and strong winds (VanderWerf 1998a).

Survival and reproduction of Oahu elepaio vary considerably among years (VanderWerf and Smith 2002; E. VanderWerf, unpubl. data), probably in association with climatic factors that affect populations of nest predators and disease-carrying mosquitoes. These annual variations are stochastic, but the average interval of between occurrences of both rodent irruptions and disease episodes is approximately 5 years. Demographic monitoring from 1995 to 2006 revealed that there were 2 years (1996 and 2004) with high disease prevalence and 2 years (1999 and 2004) with high rodent abundance (E. VanderWerf, unpubl data). Conditions that increase the severity of these two threats do not necessarily coincide, and elepaio populations therefore can be expected to fluctuate over time in a complex pattern.

The foraging behavior and diet of elepaio are extremely varied. In a study on Hawaii Island, VanderWerf (1993, 1994) found that elepaio foraged at all heights on all available plant species, and that they caught insects from a variety of substrates, including the ground and fallen logs (2 percent), trunks (5 percent), branches (24 percent), twigs (38 percent), foliage (20 percent), and in the air (11 percent). Elepaio are versatile and agile in pursuit of prey, using a diversity of foraging behaviors that is among the highest recorded for any bird, including perch-gleaning (48 percent), several forms of flight-gleaning (30 percent), hanging (11 percent), aerial flycatching (7

percent), and active pursuit (four percent) (VanderWerf 1994). The diet consists of a wide range of arthropods, particularly insects and spiders, and includes nonnative taxa such as fruit flies (VanderWerf 1998a). Large prey such as moths and caterpillars are beaten against a branch before being eaten.

Oahu elepaio are adaptable and occur in a variety of forest types composed of both native and introduced species (Conant 1977; VanderWerf 1993, 1994, 1998a). Plant species composition in elepaio habitat varies considerably depending on location and elevation, but some of the most common native plants in areas where elepaio occur are alahee (*Psydrax odorata*), papala kepau (*Pisonia umbellifera*), lama (*Diospyros sandwicensis*), hame (*Antidesma platyphyllum*), mamaki (*Pipturus albidus*), kaulu (*Sapindus oahuensis*), and alaa (*Pouteria sandwicensis*), and some of the most common introduced plants are strawberry guava (*Psidium cattleianum*), common guava (*Psidium guajava*), kukui (*Aleurites moluccana*), mango (*Mangifera indica*), and Christmas berry (*Schinus terebinthifolius*) (VanderWerf et al. 1997, VanderWerf 1998a). Nest site selection by Oahu elepaio is non-specialized; nests have been found in 7 native and 15 introduced plant species (E. VanderWerf, unpubl. data). Shallenberger and Vaughn (1978) found the highest relative abundance of elepaio in forest dominated by introduced guava (*Psidium* spp.) and kukui (*Aleurites moluccana*) trees, but they were also found in the following forest types (in order of decreasing abundance): mixed native-exotic; tall exotic; koa (*Acacia koa*) dominant; mixed koa-ohia (*Metrosideros polymorpha*); low exotic; Ohia dominant; and Ohia scrub. They currently are not found in very wet, stunted forest on windswept summits or in very dry scrubland. Unlike many Hawaiian forest birds, elepaio have adapted well to disturbed forest composed of introduced plants (Conant 1977, VanderWerf 1998a). VanderWerf et al. (1997) found that: 1) forest structure was more important to elepaio than plant species composition, 2) most elepaio occurred in areas with a continuous forest canopy and a dense understory, and 3) population density was roughly twice as high in tall riparian vegetation in valleys than in scrubby vegetation on ridges. Fifty-five percent of the elepaio's current range is dominated by introduced plants, and 45 percent is dominated by native plants (VanderWerf et al. 2001). This does not imply that elepaio prefer introduced plant species, but simply reflects a preference by elepaio for riparian vegetation in valleys and the high degree of habitat disturbance and abundance of alien plants in these riparian areas (VanderWerf et al. 1997). Of the 45 percent dominated by native plants, 23 percent is categorized as wet forest, 17 percent as mesic forest, and 5 percent as dry forest, shrubland, and cliffs (Hawaii Heritage Program 1991).

Threats to the Species Habitat loss, predator and disease impacts have resulted in significant reductions in Oahua elepaio numbers over the past 25 years. Much of the historical decline of the Oahu elepaio can be attributed to habitat loss, especially at low elevations. Fifty-six percent of the original prehistoric range has been developed for urban or agricultural use, and no elepaio remain in these developed areas (VanderWerf et al. 2001). Habitat loss thus has been a major cause of decline, but elepaio are adaptable, and moderate habitat alteration in the form of gradual replacement of native forest with alien forest has not limited their distribution (VanderWerf et al. 1997). Moreover, several areas of Oahu that recently supported large elepaio populations and still contain suitable native forest habitat are unoccupied, demonstrating that habitat loss is not the only threat. Elepaio were observed regularly into the 1970s or early 1980s at Poamoho, Schofield-Waikāne, Mānana, and other areas (Shallenberger 1977, Shallenberger and Vaughn 1978), but they have since disappeared from all of these areas even though the forest is still largely intact (VanderWerf et al. 2001).

Recent declines in Oahu elepaio populations are due to a combination of low adult survival and low reproductive success. The two main causes of reduced survival and reproduction on Oahu are nest predation by alien black rats (*Rattus rattus*) and diseases, particularly avian pox (*Poxvirus avium*), which is carried by the introduced southern house mosquito (*Culex quinquefasciatus*) and avian malaria (*Plasmodium relictum*).

Fires ignited by the public and military training activities are a serious long-term threat to elepaio and have reduced the amount of suitable habitat for the species, including areas designated as critical habitat for the Oahu elepaio (Service 2003c). Fire removes habitat, which is replaced by nonnative fire-adapted plants that are not used by elepaio, such as swamp mahogany (*Eucalyptus robusta*) and bottlebrush (*Melaleuca quinquenervia*). If this pattern is allowed to continue, there eventually will be no mesic forest left at Schofield Barracks and Makua Valley, and those populations will be lost. Oahu elepaio also are threatened by human actions, such as the potential introduction of the brown treesnake (*Boiga irregularis*) from the Mariana Islands, which has devastated the avifauna on Guam (Savidge 1987). A study of the effects of noise from military training showed that Oahu elepaio at U.S. Army Schofield Barracks are not affected by noise from military training (VanderWerf et al. 2000).

The remaining elepaio populations are small and isolated, comprising 6 core populations that contain between 100 and 500 birds each, and several small remnant populations, most of which contain fewer than 10 birds and few or no breeding pairs. Even if the threats responsible for their decline are controlled, the existing populations will still be threatened with extinction because their small sizes and restricted distributions make them vulnerable to a variety of natural processes, including reduced reproductive vigor caused by inbreeding depression, loss of genetic variability and evolutionary potential over time due to random genetic drift, stochastic fluctuations in population size and sex ratio, and natural disasters such as hurricanes and fires (Lande 1988, International Union for the Conservation of Nature 2000).

Conservation Needs of the Species Conservation efforts for the Oahu elepaio include surveys to determine current distribution and abundance (VanderWerf et al. 1997, 2001), demographic monitoring to assess population status and identify threats (VanderWerf 1999), removal of introduced predators (VanderWerf and Smith 2002), and investigation and control of disease. Long-term demographic studies have shown that the two most important current threats are nest predation by black rats and introduced mosquito-borne diseases. Rat control is a promising conservation technique for increasing both reproductive success and survival of adult females. Populations which do not receive rodent control decline at an average rate of 24 percent per year, while sites with rodent control, on average, remain unchanged (VanderWerf and Smith 2002).

Ongoing Conservation Actions Ground-based rodent control using snap traps and diphacinone bait stations has been conducted in the Honolulu Watershed Forest Reserve by the Hawaii State Division of Forestry and Wildlife since 1997, at Schofield Barracks West Range and Makua by the U.S. Army Environmental Division since 1998, at Honouliuli Preserve by The Nature Conservancy of Hawaii since 2000, in Lualualei Naval Magazine by the U.S. Navy and U.S. Department of Agriculture, Wildlife Services from 2002 to 2004, in Makaha Valley by the City and County of Honolulu Board of Water Supply and the U.S. Army since 2004, and in and Moanalua Valley by the U.S. Army since 2005. Blood samples have been collected from over

150 elepaio for use in disease screening, determination of genetic population structure, and to assist in identification of potentially disease-resistant populations or individuals.

Critical Habitat Description Critical habitat for the Oahu elepaio was designated in five units totaling 26,661 ha (65,879 ac), primarily encompassing undeveloped high elevation areas of the island. Lands designated as critical habitat provide the full range of primary constituent elements needed by the Oahu elepaio, including: a variety of undeveloped forested areas that are currently occupied by elepaio and used for foraging, roosting, sheltering, nesting, and raising offspring; a variety of currently unoccupied undeveloped forested areas that are adjacent to occupied areas and provide for conservation of the species through expansion of existing subpopulations; and shrub land and cliff habitats that link populations and can be used for dispersal. If elepaio were restored throughout each of the critical habitat units, the resulting distribution would resemble the distribution in 1975, when elepaio populations were larger and less isolated, the overall population appeared to be viable, and the Oahu elepaio was not considered endangered.

Critical habitat for the Oahu elepaio was designated on December 10, 2001, to provide additional protection for occupied and unoccupied lands considered essential to the conservation of the species (66 FR 63752). The primary constituent elements required by Oahu elepaio for foraging, sheltering, roosting, nesting, and rearing of young are undeveloped wet, mesic, and dry forest habitats composed of native or introduced plant species. Higher population density can be expected in tall, mesic, closed-canopy riparian forest with a well-developed understory than in dry, low-stature, or scrubby forest on ridges and summits, but elepaio are adaptable and able to forage and nest in a variety of forest types composed of both native and introduced plant species (Conant 1977, VanderWerf 1993, 1994, 1998). Nest site selection by elepaio is non-specialized; nests have been found in seven native and 13 introduced plant species (E. VanderWerf, unpubl. data). In addition, the primary constituent elements associated with the biological needs of dispersal and genetic exchange among populations are undeveloped wet or dry shrub land and wet or dry cliff habitats. Elepaio may not establish territories in shrub or cliff habitats and may use them only transiently, but areas containing these habitats are important for linking populations by providing opportunities for birds to disperse among populations, thereby exchanging genetic information and increasing the effective population size.

Critical habitat for the Oahu elepaio includes land under Federal, State, and private ownership, with Federal lands being managed by the Department of Defense and the Department of the Interior. Designated lands include most (99 percent) of the species' current range and encompass approximately 21 percent of the species'original range. Approximately 22 percent of designated lands are currently occupied by elepaio, and 78 percent are currently unoccupied but were occupied recently (since 1975) and are generally still suitable. A detailed description of each critical habitat unit and reasons for designating each portion of the unit as critical habitat are presented below. A detailed description of the critical habitat unit that encompasses the action area is presented below.

Unit 1 Northern Waianae Mountains: Unit 1 consists of approximately 4,454 ha (11,005 ac) encompassing the higher elevations of the northern Waianae Mountains, including a large portion of the Makua action area. The unit is bounded on the south by Kolekole Pass, and on the north, east, and west by forest edge created by human actions. Natural features within the unit

include Mt. Kaala, the highest peak on Oahu at 1,227 m (4,025 ft), several other high peaks along the spine of the Waianae Range, and the upper portions of valleys and slopes, including Waianae Kai, Makaha, Makua, Kahanahaiki, and Kuaokala valleys on the west slope, Haleauau and Mohiakea gulches on the east slope, and several narrow valleys on the north slope. Vegetation consists primarily of mixed-species wet, mesic, and dry forest communities composed of native and introduced plants, with smaller amounts of dry shrub land and cliff plant communities (Hawaii Heritage Program 1991).

Unit 1 contains two important "core" elepaio populations: one in upper Haleauau and Mohiakea gulches above the firebreak road on U.S. Army Schofield Barracks West Range, and the other in upper Makaha and Waianae Kai valleys on Waianae Kai State Forest Reserve and City and County of Honolulu land. The unit also includes scattered small elepaio populations in Pahole and Kaala State Natural Area Reserves, Mokuleia, Makua-Keaau, and Kuaokala State Forest Reserves, and the upper portion of the Makua installation. Thirty percent of Unit 1 is currently occupied by elepaio. Approximately 70 percent of critical habitat lands on the West Range of Schofield Barracks are currently occupied by elepaio. Elepaio in the northern, leeward (western) Waianae Mountains are morphologically and behaviorally distinct from elepaio in other parts of the island, and conservation of the full range of morphological and ecological diversity present in the species would not be possible without the populations in the northern Waianae Mountains.

In addition to protecting lands occupied by two core elepaio populations and six smaller populations, designated lands in Unit 1 provide for expansion of these populations by including currently unoccupied lands that were occupied within the past 30 years and that still contain the types of forest most preferred by elepaio. Specifically, currently unoccupied lands in Pahole and Kaala State Natural Area Reserves, Mokuleia, Makua-Keaau, and Kuaokala State Forest Reserves, upper Makua Valley, and upper Kahanahaiki Valley are needed for recovery to allow the number of birds in existing populations to increase. The current distribution of elepaio in Unit 1 represents a remnant of what was once a single, large, continuous elepaio population in the northern Waianae Mountains. Inclusion of currently unoccupied forested lands that provide for expansion and shrub land and cliff habitats that provide for dispersal among populations will provide linkage needed to approximate the original genetic and demographic conditions that once existed in this area.

Threats to the Critical Habitat The primary threats to elepaio critical habitat are fires, browsing by feral goats, rooting by feral pigs, predation by rats on seeds of native plant species, and replacement of native forest by alien plant species. Fires degrade or destroy the primary constituent elements needed by elepaio by directly burning forest and by facilitating the expansion of fire adapted alien plant species that are not useful to elepaio, such as *Eucalyptus robusta*, silk oak (*Grevillea robusta*), ironwood (*Casuarina* spp.), and California grass (*Brachiaria mutica*), which grow back after a fire more rapidly than native plant species. Browsing by feral goats, rooting by feral pigs, and seed predation by rats can reduce the density of canopy tree species, thin the forest under story, inhibit recruitment of trees and shrubs, and increase erosion, thereby diminishing the long-term structural integrity of the forest.

Environmental Baseline of the Species and Critical Habitat

Status of the Species in the Action Area Within the action area elepaio maintain territories in Kahanahaiki and Ohikilolo Management Units, the East Rim area of the valley, and the Makaha Valley. Currently, a total of 16 Oahu elepaio maintain territories within the Makua action area (3 pairs, 1 single female, and 9 single male birds). Seven of these birds have been captured and banded. Areas outside Makua, but within the Makua action area, that have previously harbored elepaio include the Mokuleia Forest Reserve (Kuaokala) and the Pahole Natural Area Reserve. Most recent surveys indicate that there are only 7 birds in Makua Valley where there had been 26 birds in 2001.

Table SB 42. Historic Elepaio Nesting at Makua
MMR-01 Kahanahaiki (Male: GBAR & Female BABW)

Year	# of Nests Observed	# of Successful Nests	Family Group Observed	# of Fledglings Observed
1996	1	0	0	0
1997	1	0	0	0
1998	0	0	1	1
1999	0	0	0	0
2000	0	0	0	0
2001	1	1	0	1
2002	1	1	0	2
2003	2	1	0	1
2004	2	1	0	1
2005				
2006				
2007				
Total	**8**	**4**	**1**	**6**

Only single female (BABW) in territory: 2005, 2006, and 2007

MMR-02 (Male: ARGB & Female Unbanded)

Year	# of Nests Observed	# of Successful Nests	Family Group Observed	# of Fledglings Observed
2001	0	0	0	0
2002	0	0	0	0
2003	1	0	0	0
2004	0	0	0	0
2005	No Access to Lower Makua			
2006	0	0	0	0
2007	Current Season			
Total	**1**	**0**	**0**	**0**

MRR-03 (Male: ABBB & Female: AGWR)

Year	# of Nests Observed	# of Successful Nests	Family Group Observed	# of Fledglings Observed
2002	0	0	0	0
2003	1	0	0	0
2004	1	0	0	0
2005	No Access to Lower Makua			
2006	0	0	0	0
2007	Current Season			
Total	**2**	**0**	**0**	**0**

Status of the Critical Habitat in the Action Area The Makua action area includes 1,106 hectares (2,734 acres) of Oahu elepaio critical habitat in Unit 1 (66 FR 63752). Elepaio critical habitat in the Makua action area represents approximately 4 percent of the 26,868 hectares (66,390 ac) designated as critical habitat for this species on the island, and approximately 36 percent of critical habitat Unit 1. The lower boundary of critical habitat within the Makua action area roughly follows the forest edge, with areas below the critical habitat covered by dry shrubland and grass-dominated communities.

The critical habitat lands within the Makua action area are part of what once was a large, continuous elepaio population in the northern Waianae Mountains. As described in the Revised Recovery Plan Hawaiian Forest Bird (Service 2006c), recovery of the Oahu elepaio will require restoration of populations that represent the geographic, morphological, and behavioral variation within the species. Elepaio on the drier, western side of the Waianae Range are paler and grayer than elepaio in other areas, and elepaio vocalizations vary between the Waianae and Koolau Mountains and among valleys within the Waianae Mountains (VanderWerf 1998, unpubl. data), so the elepaio in Makua Valley are needed to represent the complete geographic, morphological, and behavioral variation. The loss of Makua would decrease the potential size of any elepaio population in the northern Waianae Range, would cause a gap in the distribution of elepaio on the western side of the Waianae Range, would inhibit dispersal and genetic exchange among populations to the north and south, and thus would reduce the possibility of restoring a viable population in the northern Waianae Mountains. In addition to lands occupied by the two core elepaio populations and six smaller populations, Unit 1 provides for expansion of existing populations by including currently unoccupied lands that were occupied within the past 30 years and contain the types of forest most preferred by elepaio.

Threats to the Species and Critical Habitat in the Action Area Wildland fire, disease, predation, and feral ungulate disturbance impact Oahu elepaio and elepaio critical habitat in the action area. Of the 1,106 ha (2,734 ac) of elepaio critical habitat in the Makua Action Area, 178 ha (441 ac) are in the high fire risk zone, 388 ha (960 ac) are located in the low fire risk zone, and 540 ha (1,333 ac) occur in the very low fire risk zone. In September 2003, a prescribed burn at the Makua installation escaped containment and resulted in an uncontrolled fire that burned approximately 61 ha (150 ac) of designated Oahu elepaio critical habitat within the Makua action area. Some of this area consisted of dry shrubland that would have been used by elepaio only for dispersal, but the fire also burned parts of three elepaio territories that were occupied by single males. These burned areas no longer contain the primary constituent elements needed by elepaio

for foraging, nesting, sheltering, or dispersal and thus have lost their function. Browsing by feral goats and rooting by feral pigs has degraded the quality of the primary constituent elements in portions of elepaio critical habitat within the action area by reducing the forest density and inhibiting recruitment of native plants.

Conservation Needs of the Species and Critical Habitat in the Action Area Habitat loss, nest predation by alien black rats and diseases are the main causes of the decline in numbers of Oahu elepaio. Historically habitat loss resulting from escaped fires caused by Army training has occurred within the action area. Additionally, non-military wildfire sources also occur within the action area. Non-military wildfire sources include arson and accidental ignitions by cigarettes, fireworks, and campfires. Fire destroys native vegetation and wildlife, and facilitates conversion of native habitats to alien-dominated cover types with dense grass fuel loads that favor future fires (see General Effects). Elepaio rely on mesic forest vegetation and grass-dominated ecosystems are not suitable habitat for elepaio. In order to minimize the loss of habitat resulting from wildfires, a post-fire revegetation plan and site-specific fuels modification plan are needed where elepaio, and elepaio critical habitat, are present in the action area.

Feral ungulates (goats and pigs) also reduce the extent of suitable habitat by degrading native ecosystems via trampling and uprooting vegetation, increasing erosion, and spreading seeds of invasive plants. To prevent the further degradation of habitat by feral ungulates, areas of designated elepaio critical habitat, as well as areas with suitable habitat for elepaio, should be fenced and ungulates removed.

Nest predation by black rats also effects survivorship and recruitment of Oahu elepaio. Elimination of rats in territories with Oahu elepaio will increase the survival and recruitment of this species. Currently bait stations, live traps and snap traps are the only feasible and approved means of controlling rats. If aerial rodenticide is approved for use, this will be a more feasible and effective method controlling of rats and should be used to eliminate rats from Oahu eleapaio breeding territories and potential territories.

Other general conservation needs of the species and critical habitat in the action area are the same as those described in the introduction to the Status and Environmental Baseline of the Species and Critical Habitat section.

Ongoing Conservation Actions for the Species and Critical Habitat in the Action Area The Army has implemented a Wildland Fire Management Plan and maintains a firebreak road in Makua that reduces the risk of and helps prevent fires escaping the impact area and burning areas of critical habitat. The Army also conducts a variety of management actions aimed at conserving and restoring native forest in various management units throughout the action area, including control of feral goats and pigs, control of non-native plants to reduce competition with native plant species and to reduce the risk of fire. Approximately 30 percent of elepaio critical habitat within the action area coincides with these management units and thus benefits from these actions, including Keaau Ohikilolo (93 ha; 229 ac), West Makaleha (33 ha; 81 ac), Upper Kapuna (55 ha; 136 ac), Upper Kapuna sub-unit (12 ha; 29 ac), Pahole (87 ha; 215 ac), Kahanahaiki (37 ha; 93 ac), and Kaluakauila (20 ha; 50 ac).

The Army Natural Resources Staff survey for elepaio and control rats in the Ohikilolo Management Unit, the East Rim Ungulate Control Area, the Kahanahaiki Management Unit and Makaha Valley. Since 2001, the Army Natural Resources Staff have controlled predators within territories of known pairs of Oahu elepaio within the Ohikilolo Management Unit. Predator control was initiated in 2002 for the pair located in the East Rim Ungulate Control Area. From 1996 until the 2006 breeding season, the Army Natural Resources Staff have conducted predator control around the breeding pair within the Kahanahaiki Management Unit. This pair has successfully fledged young over the years. Since 1998, 132 rats have been snap trapped, 25 mongoose and 8 feral cats live trapped from the elepaio breeding territory in the Kahanahaiki Management Unit.

GENERAL EFFECTS - OVERVIEW

The "General Effects" section summarizes the adverse impacts of Army training at Makua that potentially will affect 38 plant taxa, the Oahu tree snail, the Oahu elepaio, and critical habitat for 36 plant taxa and the Oahu elepaio. This overview summarizes the ecosystem-level effects of the proposed action that will impact all these listed resources similarly. However, here we focus on general effects to plants; effects to the Oahu elepaio and Oahu tree snail will be treated separately. Actions to avoid and minimize these impacts also are summarized jointly. Following this general discussion, we address these general effects for six groups of listed resources covered by this Biological Opinion: (1) 16 target plant taxa identified for stabilization in the Makua Implementation Plan Addendum, (2) 12 at-risk plant taxa identified for expedited stabilization, (3) 11 plant taxa that do not require active stabilization measures, (4) designated critical habitat for 36 plant taxa, (5) the Oahu tree snail *Achatinella mustelina*, and (6) the Oahu elepaio and its designated critical habitat. Taxa included within the four plant groupings are tabulated below. The group effects analyses also include pertinent details for each species and critical habitat.

Stabilization Target Plant Taxa

Alectryon macrococcus var. *macrococcus*
Cenchrus agrimonioides var. *agrimonioides*
Chamaesyce celastroides var. *kaenana*
Cyrtandra dentata
Dubautia herbstobatae
Flueggea neowawraea
Hedyotis degeneri var. *degeneri*
Hedyotis parvula
Hesperomannia arbuscula
Melanthera tenuifolia
Nototrichium humile
Plantago princeps var. *princeps*
Pritchardia kaalae
Schiedea kaalae
Tetramolopium filiforme
Viola chamissoniana ssp. *chamissoniana*

Expedited Stabilization Target Plant Taxa

Chamaesyce herbstii
Cyanea grimesiana ssp. *obatae*
Cyanea longiflora
Cyanea superba ssp. *superba*
Delissea subcordata
Gouania vitifolia
Hibiscus brackenridegei ssp. *mokuleianus*
Neraudia angulata
Phyllostegia kaalaensis
Sanicula mariversa
Schiedea nuttallii
Schiedea obovata

Non-Stabilization Plant Taxa

Abutilon sandwicense
Bonamia menziesii
Ctenitis squamigera
Diellia falcata
Euphorbia haeleeleana
Lepidium arbuscula
Lobelia niihauensis
Peucedanum sandwicense
Schiedea hookeri
Silene lanceolata
Spermolepis hawaiiensis

Plant Critical Habitat

Bonamia menziesii
Cenchrus agrimonioides var. *agrimonioides*
Chamaesyce celastroides var. *kaenana*
Chamaesyce herbstii
Colubrina oppositifolia
Cyanea grimesiana ssp. *obatae*
Cyanea longiflora
Cyanea superba ssp. *superba*
Cyrtandra dentata
Delissea subcordata
Diellia falcata
Dubautia herbstobatae
Euphorbia haeleeleana
Flueggea neowawraea
Gouania vitifolia
Hedyotis degeneri var. *degeneri*
Hedyotis parvula
Hesperomannia arbuscula
Hibiscus brackenridgei ssp. *mokuleianus*
Isodendrion laurifolium
Isodendrion longifolium
Isodendrion pyrifolium
Mariscus pennatiformis
Melanthera tenuifolia
Melicope pallida
Neraudia angulata
Nototrichium humile
Phyllostegia kaalaensis
Plantago princeps var. *princeps*
Sanicula mariversa
Schiedea hookeri
Schiedea kaalae
Schiedea nuttallii
Schiedea obovata
Solanum sandwicense
Spermolepis hawaiiensis

Exposure Analysis Approach

The Service has developed an analysis framework for Section 7 consultations that incorporates the general structure, primary concepts, and nomenclature of the U.S. Environmental Protection Agency's ecological risk assessment framework (Service 2005a). Factors causing adverse effects or impacts are called "stressors" and beneficial effects are called "subsidies." In this approach, the Service determines the listed resources that will be exposed to the proposed action's stressors and subsidies. First, the location, timing, duration, frequency, and intensity of potential exposure to each stressor and subsidy are used to delineate the action area and to identify the physical, chemical, and biotic features that will be directly and indirectly exposed. Then the causal relationships between sources of stressors and subsidies and the response of listed resources are analyzed. The exposure analysis also estimates future changes in the abundance or distribution of listed species expected to result from exposure to stressors and subsidies, as well as future changes in the quality, quantity, and availability of primary constituent elements of critical habitat.

General Effects of the Proposed Action on Listed Species

Physical features within the Makua action area that will be exposed to project stressors and subsidies include cliffs, gulches, and other topographic and microclimate conditions. Chemical features include temperature and soil nutrient/moisture relations, and biotic features include vegetation types and their associated plant and animal species. Most of the proposed action's stressors are associated with military training activities, including the use of various weapons systems and munitions, mounted maneuvers (using vehicles and aircraft),

and ground maneuvers (troop marches, bivouac, etc.). Most of the subsidies are associated with the Army's conservation and stewardship programs, including the Wildland Fire Management Plan, Integrated Natural Resource Management Plan, Integrated Training Area Management (ITAM), and Makua Implementation Plan Addendum.

Individual listed plants, tree snails, elepaio, and primary constituent elements of critical habitat will be exposed to three major sources of stressors: (1) training-related wildfire (heat, flames, smoke, and ash associated with fires ignited by weapons systems and munitions); (2) introduction and spread of non-native plants, animals, and invertebrates (trampling, grazing, soil erosion, predation, herbivory, competition, and disease); and (3) human disturbance (trampling, soil erosion, and plant breakage). In addition to the stressors listed above, the Oahu elepaio will be exposed to noise stressors (auditory disturbance associated with ordnance and aircraft). Regarding the effects of fire, this Biological Opinion focuses on the effects of training-related wildfire, usually ignited by weaponry used during live-fire exercises. Training-related wildfire also includes the spontaneous ignition of old, buried white phosphorus rounds that may become exposed to the air and accidental detonation of unexploded ordnance. The proposed action also includes protocols for prescribed burns to reduce fuel loads in the training impact area inside the firebreak roads. Prescribed burns have escaped the firebreak roads in the past, with impacts to listed resources. Conformance with the proposed action's burn prescription, however, will preclude future escapes. Although the possibility exists that properly managed prescribed burns may escape the firebreak roads, the risk is considered negligible.

Subsidies associated with the proposed action's conservation and stewardship programs are intended to minimize the exposure of listed resources to project stressors. Five major sources of subsidies include: (1) Wildland Fire Management Plan and ITAM activities (fire suppression and fuels management to reduce the ignition and spread of training-related wildfire), (2) habitat management activities to control invasive species (fencing, weeding, invertebrate pest removal, and phytosanitation measures), (3) stabilization activities for target plant and Oahu tree snail population units (outplanting to augment and reintroduce plants, and captive propagation of tree snails), (4) rat control to reduce predation on Oahu tree snails and Oahu elepaio, and (5) standard operating procedures (to reduce the impacts of human disturbance and damage to soils and native plants).

The response of listed resources to direct and indirect exposure to the proposed action's stressors and subsidies involves three types of effects. Effects of direct exposure to stressors (i.e., direct effects) include immediate injury or death of individual plants, tree snails, and elepaio, and destruction of primary constituent elements of critical habitat. Effects of indirect exposure (i.e., indirect effects) are caused by the proposed action and occur later in time, but are reasonably certain to occur. Beneficial effects of subsidies are contemporaneous positive effects without any adverse effects to the species. Any short-term negative effects associated with beneficial actions are insignificant (never reaching the scale where take of listed animals or loss of listed plants occurs) or discountable (undetectable and extremely unlikely to occur). The major response variables evaluated in this opinion's effects analyses for covered plants are the number of stable population units for each taxon,

which is determined according to the number of mature, reproducing individuals that comprise each population unit managed for stability.

Direct effects caused by training-related wildfire, trampling and grazing by feral ungulates, herbivory by rats (*Rattus* spp.) and invertebrates, and trampling by troops will immediately injure or destroy individuals or entire occurrences of listed plants, tree snails, elepaio, and constituent elements of critical habitat. Indirect effects of fire, trampling, and non-native animals and invertebrates will result in loss or degradation of habitat by injuring listed species, removing vegetation cover, altering microclimate and soil nutrient/moisture regimes, reducing the vigor of surviving plants, and altering patterns of plant community composition and succession. Habitat destruction by fire also will drive pigs (*Sus scrofa*), goats (*Capra hircus*), and rats from burned areas into adjacent areas occupied by listed species and into critical habitat units. Additional indirect effects to species and critical habitats will result from the introduction and spread of non-native invasive plants through the movement of troops, maintenance crews, natural resources staff, vehicles, and equipment. The quality, quantity, and availability of constituent elements for critical habitat also will diminish due to erosion, microclimate changes, competition by alien plants for growing space and resources, and changes in species composition due to loss of native species and invasion of alien plants. Indirect beneficial effects (subsidies) include increased survival of listed species and enhanced value of critical habitat due to fire suppression, fuels management, control of non-native species, and endangered species stabilization.

Most of the adverse impacts of military training will be located within the PFC Pililaau Range Complex ("training impact area") within the north and south firebreak roads, where listed resources will not be affected. However, there is a risk of fire ignition and spread outside the firebreak roads to areas where listed species and critical habitats are located. Listed resources will also be exposed to other project stressors and subsidies throughout the action area (Table E 1).

Table E 1. Area Impacted by Training.

Action Area	**Hectares**	**Acres**
Makua Military Reservation		
Training Impact Area	460	1,136
South firebreak road	185	457
North firebreak road	144	355
Outside Training Impact Area	1,236	3,054

General Effects of the Proposed Action on Plant Critical Habitat

The Army's proposed action is likely to adversely affect designated critical habitats in similar ways throughout the action area. All critical habitats within the action area are parts of larger critical habitat units that extend beyond the action area to provide habitat capable of supporting one or more populations of the listed species.

In the action area, some critical habitat areas are located in fire risk zones where they will be exposed to project stressors associated with training-related wildfire, introduction and spread of invasive species, and physical disturbance associated with human activities. Some critical

habitat areas are located in management units where primary constituent elements will be exposed to project subsidies associated with endangered plant stabilization. The stressors and subsidies to critical habitat are similar in effect to those described above for listed plants. Likewise, primary constituent elements of critical habitat that will be exposed to stressors and subsidies include the same physical, chemical, and biotic features described above for listed plants. These constituent elements are expected to change in quality, quantity, or availability in response to direct and indirect exposure to project stressors and subsidies in much the same way as discussed above for listed plants. For example, fire will degrade critical habitat by removing native plant cover in mixed native and non-native forest, which will facilitate the invasion of non-native invasive plants and further inhibit the natural regeneration of native vegetation. Without active management, burned areas in Hawaii do not recover their native plant components, and alien grass cover predisposes adjacent areas to burn in future fires. Eventually a succession of fires will convert native ecosystems to non-native grasslands and shrublands.

In contrast, subsidies associated with Wildland Fire Management Plan, ITAM, and Makua Implementation Plan Addendum activities will enhance the conservation value of critical habitat by decreasing the risk of fire ignition and spread, reducing the fuel load of alien grasses, and excluding feral ungulates. Some critical habitat areas within the action area are located within or adjacent to endangered plant management units, and thus are separated from the training impact area by zones of low or very low fire risk. In addition, Army stabilization of target taxa and revegetation of burned critical habitat areas will help replace primary constituent elements. A temporary loss of function of some critical habitat units may occur during the revegetation process. Over the long-term, however, revegetation of burned critical habitat in the action area will contribute to the conservation value of larger critical habitat units essential for conservation of the species. Without these project subsidies, critical habitat in the action area eventually would lose most of the primary constituent elements essential to species' survival and recovery because of the ongoing impacts of non-native ungulates and plants. The continued degradation of critical habitat that would occur without the Army's conservation and stewardship programs is a major factor considered in our evaluation of the proposed action.

General Effects of Fire on Native Hawaiian Plants

Fire is a relatively new, human-related threat to native species and natural vegetation in Hawaii. The historical fire regime in Hawaii was characterized by infrequent, low severity fires (Cuddihy and Stone 1990; Smith and Tunison 1992). Few natural ignition sources existed, natural fuel beds were often discontinuous, and rainfall in many areas on most islands is moderate to high. Fires inadvertently and intentionally ignited by the original Polynesians in Hawaii probably contributed to the initial decline of native vegetation in the drier plains and foothills. These early settlers practiced slash-and-burn agriculture that created open lowland areas suitable for the later colonization of non-native, fire-adapted grasses (Kirch 1982; Cuddihy and Stone 1990). Beginning in the late 18th century, Europeans and Americans introduced plants and animals that further degraded native Hawaiian ecosystems. Pasturage and ranching, in particular, created highly fire-prone areas of non-native grasses and shrubs. Today, although fires are infrequent in mountainous

regions, extensive fires have occurred in lowland mesic areas, and up to half of the areas dominated by alien species have been damaged by fire (D'Antonio and Vitousek 1992).

Fires of all intensities, seasons, and sources are destructive to native Hawaiian ecosystems (Brown and Smith 2000), and a single grass-fueled fire can kill most native trees and shrubs (D'Antonio and Vitousek 1992). Few native Hawaiian plants and animals are adapted to withstand fire, and none is known to depend on fire for its existence or regeneration. Consequently, most native plants and animals perish during fires with little recovery afterwards. In lowland communities, alien-dominated grasslands and shrublands constitute the greatest fire threat to native vegetation. Many non-native invasive plants, especially fire-tolerant grasses in dry areas, outcompete native plants and inhibit their regeneration (D'Antonio and Vitousek 1992; Tunison et al 2001; Tunison 2002). Successive fires that burn farther and farther into native forest destroy endangered plants and remove habitat for native species by altering canopy conditions to favor alien plants.

Alien plant species most likely to be spread as a consequence of fire are those that produce a high fuel load, are adapted to survive and regenerate after fire, and establish rapidly in newly burned areas. For example, a documented increase in the frequency and size of fires at Hawaii Volcanoes National Park since 1968 coincided with an increasing cover of alien grasses (Smith and Tunison 1992). The conversion of Makua to a military live-fire range in the 1940s introduced seed spread and a daily source of ignition (Beavers et al 1999). Currently, alien grasses such as guinea grass (*Panicum maximum*) and molasses grass (*Melinis minutiflora*) dominate the valley floor, C-Ridge, and the northern ridge of Makua.

Fire Stressors in the Makua Action Area

The Army's proposed action is likely to adversely affect listed plants, animals, and critical habitats that are exposed to training-related wildfire. This conclusion is supported by the Army's biological assessment (U.S. Army Garrison 1998) and draft environmental impact statement (U.S. Army Corps of Engineers 2005), the interagency Makua Implementation Plan (Makua Implementation Team 2003), the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a), Army status reports on implementation of the Makua Implementation Plan (U.S. Army Garrison 2004, 2005b), Army computer fire simulations (Beavers 2005), and additional Service fire modeling for this consultation. Stressors associated with training-related wildfire include flames, heat, smoke, and ash. In the action area, occurrences of listed plants and critical habitats will be exposed to these stressors within zones of high, low, and very low fire risk.

Fire Exposure Area

The Service's methodology for delineating the training-related wildfire threat in the action area is fully described in the section General Effects—Fire Suppression. The high, low, and very low fire risk zones are shown on Figure E 7.

The low fire risk zone is defined as the area where the misfired or malfunctioning long-range weapons systems and munitions can potentially ignite a fire, including endangered species

occurrences on the upper slopes of the Makua Valley rim and beyond. In particular, long-range ignitions from Javelin anti-tank missiles, helicopter-launched 2.75-caliber rockets, and TOW missiles may ignite fires outside the firebreak roads. The exact location where listed resources will be exposed to any particular source of training-related wildfire is unpredictable. With the fire-fighting productivity improvements included as part of the proposed action, most fires are expected to be suppressed before they escape the firebreak roads and will not affect listed resources. However, there is a risk of fires igniting and spreading outside the firebreak roads, or spreading outside the firebreak roads from ignitions within the impact area, to areas where listed species are located. Therefore, we anticipate the Army will reduce but not eliminate the ignition and spread of training-related wildfire over the 30 years covered by this Biological Opinion.

Fire Timing, Duration, and Frequency

Depending on the season when fire occurs, any or all plant life stages (mature, immature, and seedling) will be exposed to fire stressors throughout the year. Potential fire risk is assessed by the National Fire Danger Rating System (NFDRS) and live fuel moisture conditions under which particular weapons systems and munitions may be used (see Table PD 2). The potential for fire ignition and spread is greatest when exercises are conducted in other than Green NFDRS conditions. According to Service analysis of fire weather conditions at Makua, In addition, any fire has the potential to spread outside the firebreak road if conditions change to Red before the fire is contained (see General Effects—Fire Suppression).

Once ignited, the duration of exposure of listed resources to fire is variable and depends on weather, wind speed and direction, fuel loadings, and the effectiveness of firefighting response. In general, past fires at Makua have burned anywhere from 30 minutes up to three days before being extinguished (U.S. Army Corps of Engineers 2005). Fire duration, and thus the extent of area that burns, is expected to be considerably reduced with the Army's proposed improvements in helicopter fire-bucket productivity (see General Effects—Fire Suppression). The frequency that listed resources will be exposed to training-related wildfire is unknown for the proposed action.

The Army will also conduct prescribed burns to help manage fuels within the training impact area. According to the prescription proposed as part of the proposed action, prescribed burns will only be conducted during tightly specified conditions of weather, wind, and live fuel moisture. The exposure area for prescribed burns will be within the training impact area inside the firebreak roads. The burn prescription covered by this Biological Opinion, including timing (season), duration, frequency, and intensity of prescribed burns, is described in Appendix D. The physical, chemical, and biotic features exposed to prescribed burns are the same as the general effects of fire described below. No listed resources will be exposed to properly managed prescribed burns.

Fire Intensity

Heat and flames are the stressors to which plants will be most directly exposed, and intensity of exposure will vary according to fire severity. A regime of high and low severity fires is characteristic in the mixed native and non-native vegetation types of Makua (U.S. Army Garrison 2003b) and throughout Hawaii (Brown and Smith 2000). In Hawaii, a high-severity fire is defined as a lethal (catastrophic) crown and/or surface fire fueled by non-native grasses that kills at least 80 percent of the dominant vegetation. A low severity fire is defined as a sub-lethal understory fire that does not substantially change the structure of the dominant vegetation and usually involves surface fires fueled by non-native grasses and forest litter in the understory or at the forest edge. In mixed forest types, lethal catastrophic fires carried by grass in the understory kill trees and facilitate grass encroachment farther inside the canopy of native forest types. The fire encroachment zone thus expands over time as a result of a series of lethal catastrophic fires, sub-lethal surface fires, or a combination of both. Also, with each successive fire, the growth of grass fuels encroaches farther into the forest. Thus, the expansion of this encroachment zone increases the risk of a catastrophic, stand replacement fire in mixed and native-dominated forest where non-native grasses have invaded the understory. Over time, such a fire regime creates a positive feedback cycle that changes a non-flammable, native-dominated woodland to a self-perpetuating, highly flammable, alien-dominated grassland (Hughes et al 1991; D'Antonio and Vitousek 1992; Smith and Tunison 1992; Freifelder et al 1998; Brown and Smith 2000; Tunison et al 2001; Brooks et al 2004; Hawaii Volcanoes National Park 2004).

Physical, Chemical, and Biotic Features Exposed to Fire

Within the exposure areas at Makua delineated by fire risk zones, habitat features essential to listed resources will be exposed to heat, flames, smoke, and ash (Brown and Smith 2000). Intensity and duration of exposure will depend on where the fire is ignited, local weather, topography, grass cover, and firefighting response. Physical features that will be exposed to heat and flames include soil structure and microclimate conditions. Fire will increase soil temperatures, alter soil moisture holding capacity, and reduce soil rainfall infiltration (Barbour et al 1987). These physical features will be indirectly exposed to post-fire erosion and alterations of light/shade, temperature, humidity, and wind as a result of vegetation destruction. Light levels, temperatures, and wind speeds will increase with destruction of canopy plants, and relative humidity will decrease. Alternatively, in burned areas that are invaded by dense mats of molasses grass, shading of the soil surface may reduce temperature and increase humidity (Tunison et al 2001). Soil erosion may occur after fire except where rapid establishment of alien grasses is prevalent (Hawaii Volcanoes National Park 2004). Chemical features that will be exposed to heat, flames, smoke, and ash include soil nutrients and water, which will be indirectly exposed to post-fire changes in content and cycling rates. Soil nutrient availability will be altered through volatilization of certain elements to the atmosphere in smoke (e.g., carbon, nitrogen, and sulfur), conversion to more available forms in the ash (e.g., potassium, phosphorus, and divalent cations), wind dispersal of the ash, and surface erosion (D'Antonio and Vitousek 1992; Waring and Running 1998; Tunison et al 2001).

Biotic features that will be exposed to heat, flames, smoke, and ash include all living organisms in the exposure area, litter layers on the forest floor, organic matter within the surface soil horizon, and seeds within the litter and surface soil. Living organisms will be directly exposed to injury or death, and seeds, litter, and organic matter will be directly exposed to destruction and loss (Kinnaird and O'Brien 1998; Van Nieuwstadt et al 2001). These effects in turn will indirectly expose soils to long-term changes in fertility and structure as a result of disrupted decomposition and nutrient cycling processes, reduced nutrient and water retention by organic matter, increased nutrient losses in runoff and leaching, and reduced ecosystem primary production due to loss of leaf area and photosynthesis (Kinnaird and O'Brien 1998). Mobile birds and animals are able to escape fire; relatively sedentary animals such as native tree snails and Oahu elepaio eggs and nestlings, however, will be exposed to fire injury and death. Woody vegetation injured by fire will become more susceptible to wood-boring and bark beetles, such as the black twig borer. All these factors will result, over time, in ecosystem changes to species composition and the relative abundance of native and non-native plants and animals, which in turn will alter post-fire patterns of vegetation development and succession.

Within the action area, the biotic features that will be exposed to fire includes various mixtures of native and non-native vegetation in dry and mesic forest, and native-dominated forest and shrubland (see Tables PD1 and PD2). In any habitat, the exposure of listed plants and critical habitats to fire will depend in large part on the density of alien grass cover within endangered plant occurrences, management units, and critical habitats. Some endangered species occurrences within the action area are directly adjacent to dense cover of alien grasses and shrubs.

Mesic forest conditions with closed canopies and sparse, understory grass cover typically slow the spread of fire, whereas dry conditions with open canopies and dense grass facilitate fire spread. Mesic forest is characterized by higher rainfall and humidity, which inhibit the drying of fuels in the understory and on the forest floor. In fact, undisturbed tropical rainforest was long thought to be virtually immune to fire (Whitmore 1990). Biologists now recognize that even rainforest conditions do not preclude the incidence of fire, especially during prolonged drought conditions. Extensive fires in the equatorial rainforests of Indonesia have occurred since the early 1980s, during five prolonged droughts associated with strong El Niño events (Kinnaird and O'Brien 1998; Uhl 1998; Van Nieuwstadt et al 2001). Although intact rainforest was impacted, about two-thirds of the thousands of square kilometers that burned had been previously selectively logged or otherwise disturbed. Most of the fires were low intensity ground fires ignited by small-scale, slash-and-burn agricultural activities and hunting/fishing campfires. In general, forest damage was not severe and was limited to the litter and understory, although subcanopy and canopy trees also died. Almost all trees less than 8 cm (3 in) in diameter measured at a height of 1.37 m (4.5 ft) died within one year after the 1997 to 1998 fires, and many surviving larger trees became increasingly susceptible to windthrow (Van Nieuwstadt et al 2001). Similar fire impacts occurred in selectively logged areas of the Amazon rainforest where gaps created by single-tree felling resulted in warmer, drier microclimate conditions and drier fuels (Uhl and Kauffman 1990). Thus, forest disturbance and prolonged drought may significantly increase the probability of

fire in tropical rainforest (Uhl and Kauffman 1990; Kinnaird and O'Brien 1998; Uhl 1998; Mueller-Dombois 2001; Van Nieuwstadt et al 2001).

Drought is a significant problem in Hawaii, affecting parts of the state at least once every five years, with severe droughts occurring about every 15 years (Hawaii Commission on Water Resource Management 2005). Substantial variation in rainfall is caused in large part by the El Niño Southern Oscillation (ENSO) (Juvik and Juvik 1998; Hawaii Commission on Water Resource Management 2005). The ENSO phenomenon is a Pacific-wide warming of surface waters associated with persistent high-pressure atmospheric systems that generally occur every two to seven years and result in reduced rainfall in the Hawaiian Islands. About 20 severe droughts in Hawaii since 1905 were likely associated with ENSO, including recent record El Niño droughts during the winter and/or spring of 1982 to 1984, 1996, and 1997 to 2003 (Hawaii Commission on Water Resource Management 2005, Pacific Disaster Center 2006). In 1998, for example, mean rainfall on Oahu was only one-third of normal levels. Rainfall and climate in Hawaii are also influenced by the Pacific Decadal Oscillation, which causes long-term shifts of surface ocean temperatures in the North Pacific over periods of 30 to 40 years. Since the 1970s, the Pacific Decadal Oscillation has been in a warm phase and Hawaii rainfall has generally been below normal. According to the Hawaii Drought Plan, agriculture and environmental resources are generally considered vulnerable to drought in the Waianae and Makaha areas, respectively, of leeward Oahu (Hawaii Commission on Water Resource Management 2005).

Listed Resources That Will Be Exposed to Fire

In total, 38 listed plant taxa, host trees for Oahu tree snails, and nest trees and foraging habitat for the Oahu elepaio will be directly and indirectly exposed to fire within the action area. All life stages of native plants will be exposed to the risk of fire throughout the year, depending on season, although exposure will be reduced during the dry summer months when fire weather and live fuel moisture conditions preclude training with certain weapons systems and munitions. Exposure of reproductive stages (flowers/fruits, seedlings, eggs, etc.) will depend on the season in which fires occur. The reproductive stage of some plant species is seasonal whereas others produce flowers and fruits throughout the year. Oahu tree snails may breed throughout the year, and the Oahu elepaio nesting season is January through June. The number of individuals and occurrences of each species that will be exposed depends on the location, intensity, and duration of fire, as well as local weather, topography, grass cover, and firefighting response. Alien plant invasion in burned areas of critical habitat also will adversely affect native plants that comprise the vegetative primary constituent elements determined to be essential for the survival and recovery of listed plants and the Oahu elepaio. The number of individuals and occurrences of each species that will be exposed to fire at Makua is discussed in the species-specific effects analyses that follow this General Effects section.

Response of Endangered Plants to Fire

Direct Effects

The response of listed plants and associated native plants that will be directly exposed to fire includes both lethal and sub-lethal components. Lethal exposure will result in the death of individual plants (canopy and subcanopy trees, saplings, shrubs, understory herbs and grasses, and seedlings) or entire occurrences from destruction of vital tissues. Terrestrial plants require a minimum leaf area for photosynthesis and transpiration, roots for water and nutrient uptake, and stems for physical support and internal transport of water and nutrients. Without these physiological functions, plants cannot survive, grow, and reproduce. Plants are vulnerable to crown and surface fires, depending on their height. Above-ground parts of small plants are almost always killed, whereas tall shrubs and trees may survive crown scorch if some buds and cambium survive. Lethal heating of the cambium layer kills trees and shrubs. Fire resistance is related in part to thick bark, which is not characteristic of Hawaiian species. Sub-lethal exposure will result in injury to leaves, stems, exposed cambium, roots, growing tissues, buds, flowers, fruits, and seeds.

Indirect Effects

The response of listed plants and associated native plants to sub-lethal exposure to fire will result in decreased individual plant fitness due to physiological stress in fire-injured plants. Physiological stress associated with reduced leaf area will result in decreased photosynthesis and increased transpiration water stress. Loss of meristematic tissue on branches and stems temporarily halts plant growth and reproduction. Although root injury may directly kill trees and shrubs, it more commonly weakens them by increasing the physiological stress of reduced water and nutrient uptake capacity. The physiological stress resulting from these injuries will decrease overall vigor, growth, and fecundity of individual plants. The consequences of physiological stress on individual fitness will vary among individuals exposed to fire and will range from reduced growth and vigor, to reduced reproduction and recruitment, to delayed mortality. Post-fire plant mortality often results from injury to several plant parts, such as crown and cambium, and may not occur for several years. Fire-injured plants also are more likely to die from environmental stresses such as disease pathogens, fungi, insects, or drought (Brown and Smith 2000).

Non-injured plants, especially seedlings and saplings, will be more vulnerable to physiological stress due to post-fire microclimate changes and competition with invasive plants. The response to fire-altered habitat conditions and competition with alien grasses will differ for individual native plants. Little information is available on the specific responses of rare Hawaiian species to fire, but they may be generally inferred from the response of other native species and vegetation types, especially in relation to long-term successional patterns (Smith and Tunison 1992). For example, the loss of dry forest habitat in Hawaii, caused in large part by humans, is believed to have contributed to the extinction of endemic plant and animal species (Cuddihy and Stone 1990).

A major indirect effect of the loss of native vegetation from fire is the reduced availability of suitable habitat for regeneration of native plants. Fire changes the relative composition and abundance of native and non-native plant and animal species, as well as future patterns of vegetation development and succession. Loss or reduction of canopy vegetation reduces shade and creates ambient temperature, humidity, and wind conditions unfavorable to plants accustomed to more mesic or understory sites. Most native Hawaiian plants do not resprout or regenerate from buried seeds after a fire has passed. Whether listed species in the action area resprout or regenerate from buried seeds after fire is unknown, but they are probably similar to most native Hawaiian plants in lack of resistance or tolerance to fire. The non-native grass species at Makua are typical of open, dry habitats that result after fire. Increased cover of faster-growing, fire-resistant, non-native grasses in and adjacent to burned areas will reduce the availability of growing space, light, water, and nutrients for native plants of all stages. Competition for these resources will exacerbate physiological stress, especially in any fire-injured plants that survive. In addition, if fence exclosures are destroyed or damaged by fire, survival and regeneration of listed plants will be constrained by post-fire effects of soil disturbance and compaction, root injury, and trampling by feral ungulates. Ungulates and rats escaping from fire are likely to increase in numbers adjacent to burned areas.

Most importantly, invasion by non-native, fire-adapted grasses will alter fuel load and fire hazard in burned areas. In Hawaii, non-native grasses quickly resprout within weeks after fire and can attain pre-burn cover densities in 18 to 24 months, converting seasonally dry woodlands into savannas of scattered trees (Mueller-Dombois and Goldammer 1990; Hughes et al 1991; D'Antonio and Vitousek 1992; Tunison et al 1992, D'Antonio et al 1998; Tunison et al 2001; Hawaii Volcanoes National Park 2004). The Service infers from these documented examples that training-related wildfire will similarly favor the invasions of alien grasses and reduce the persistence probability of listed species in the Makua action area. The overall effect of indirect exposure of listed plants to fire will be reduced reproductive fitness and recruitment of individuals, a further decline in numbers, and reduced viability of population units.

General Effects of Non-Native Invasive Species

All 49 taxa and/or critical habitats covered by this Biological Opinion are variously threatened by non-native invasive plants, animals, and invertebrates (Appendix E). After habitat loss, alien species are the second-greatest threat to imperiled species in the United States (Wilcove et al 1998). In Hawaii, non-native feral ungulates and invasive plants are the two most serious threats to native habitats (Cuddihy and Stone 1990). As of the early 1990s, over 4,600 alien species had been introduced to Hawaii, of which 86 are recognized as serious threats (Scrowcroft and Conrad 1992).

Non-Native Ungulates

It has long been known that feral ungulates are important causes of native vegetation decline in Hawaii. Native flora evolved in absence of mammalian grazers and most native woody plants lack defenses against grazing (Cuddihy and Stone 1990). Long-term damage by ungulates can eliminate native plants and deplete soil seed banks; alter habitat microclimate,

water balance, and nutrient cycling processes; and increase vulnerability of native plants to insect attacks (Stone et al 1992). Two species of feral ungulates, pigs (*Sus scrofa*) and goats (*Capra hircus*), are present throughout parts of the action area. Feral pigs and goats damage a wide elevational range of wet, mesic, and dry native ecosystems in Hawaii (Stone et al 1992). Both pigs and goats spread alien plants into native habitats by transporting seeds in their feces and fur, and by creating areas of bare soil and open canopy for alien plants to become established and spread (Stone 1985; Cuddihy and Stone 1990; Stone et al 1992). Both pigs and goats are naturalized in Hawaii and are managed as game animals, but they may inhabit inaccessible areas where hunting has little effect on their numbers (Service 1998a).

Feral pigs have been in the Koolau and Waianae Mountains of Oahu for about 150 years, and goats were introduced in the Waianae Mountains in the early 1820s (Cuddihy and Stone 1990; Service 1998). Pigs eat both plant and animal material, including native ferns, tree ferns, lilies, mints, lobelioids, koa seedlings, and other woody plants. Pigs also uproot and trample vegetation, and expose earth by rooting soil for earthworms, rhizomes, and tubers (Stone 1985). The last known population of three *Cyanea truncata* plants in windward Oahu was destroyed in recent years by feral pigs (Service 1998). Pigs also are known dispersal agents for habitat-altering, non-native plants such as *Psidium cattleianum* (strawberry guava), *Passiflora tarminiana* (banana poka), *Schinus terebinthifolius* (Christmas berry), and *Rubus argutus* (blackberry), which threaten several taxa in the action area (Stone 1985; Cuddihy and Stone 1990). Feral goats browse on native and non-native plants, especially in dry, open ecosystems. Goats also trample roots and seedlings, increase erosion and watershed degradation by removing plant cover and trampling soil, and promote the invasion of alien plants (Service 1998). Goat damage to native vegetation has permanently altered some native ecosystems on Oahu (Cuddihy and Stone 1990).

In the Makua action area, grazing and trampling by feral pigs and goats have degraded extensive tracts of native vegetation, impacted habitats of listed species and critical habitats, and directly injured listed plants. In the action area and generally, pigs prefer moister areas, whereas goats prefer drier, steeper areas. Of the eight management units located entirely or partially within the action area, three are fenced (Kaluakauila, Lower Ohikilolo, and Pahole), two are partially fenced (Kahanahaiki and Ohikilolo), and three are not fenced to exclude ungulates (Upper Kapuna, West Makaleha, and Keaau-and-Makaha). Army Natural Resources Staff believe goats have been virtually eradicated from all of Makua (although not from the entire action area). As long as fences are maintained and ungulate sign is monitored, exclosures are effective in protecting native habitats from ungulate damage. However, fences are occasionally damaged by rockslides, and fire (such as the July 2003 prescribed burn, and the July 2006 non-military fires) can damage the galvanized anti-corrosion coating of wire mesh, facilitating future breaches (U.S. Army Garrison 2005b, 2006a, 2006b).

The fenced management units are generally considered ungulate-free (U.S. Army Garrison 2005b). The fenced Kaluakauila Management Unit is still accessed occasionally by pigs, particularly during the strawberry guava fruiting season. The partially fenced Ohikilolo Management Unit is protected by a perimeter fence at the installation boundary with

Ohikilolo Ranch and the Keaau Game Management Area, both of which support large populations of feral goats. Goats have contributed to serious erosion problems on Ohikilolo Ridge. As a result of Army removal efforts, monitoring results since 2004 indicate that goats have been eradicated from the Ohikilolo Management Unit. In addition, over a hundred pigs and goats have been removed from the unfenced Kahanahaiki Sub-Unit II Management Unit and adjacent areas since 1998. Ungulate numbers in this subunit seem to increase during the winter-spring breeding season and during the August dog-hunting season in adjacent state public hunting areas. The other unfenced management units are located on State lands where Army staff is not involved in active ungulate management.

Non-Native Rodents

Several small rodent species are found in the Makua action area, including rats (*Rattus* spp.) and mice *(Mus domesticus*). These rodents occur on all the main Hawaiian Islands around human habitations, in cultivated fields, and in dry, mesic, and wet forests. Rats eat the fruit and strip the bark of some native plants, particularly fruits of native *Pritchardia* palms and plants in the lobelia (Campanulaceae) and African violet (Gesneriaceae) families with fleshy stems and fruits (Cuddihy and Stone 1990). Many native Hawaiian plants produce their fruits or seeds over an extended period, providing a prolonged food supply that supports rodent populations. Rats are suspected predators of about half of the 49 species covered in this Biological Opinion, including plants, Oahu tree snails, and Oahu elepaio.

Non-Native Invertebrates

Major non-native invertebrate pests in the Makua action area include slugs (such as *Deroceras reticulatum*), carnivorous snail (*Euglandina rosea*), black twig borer (*Xylosandrus compactus*), Chinese rose beetle (*Adoretus sinicus*), two-spotted leafhopper (*Sophonia rufofascia*), and mosquito (*Culex quinquefasciatus*). Army activities are unlikely to directly increase the spread of these invertebrate pests. However, invertebrate pests constrain the Army's ability to maintain baseline numbers and stabilize certain target species. In addition, training-related wildfire may indirectly predispose individual plants to infestation through fire injuries and habitat alteration. Physiological stress in fire-injured plants increases susceptibility to pests and pathogens, especially during excessively dry or wet conditions (Brown and Smith 2000). Invertebrate pests are particularly threatening to listed species because specific management tools for use in forests and natural areas are currently unavailable. In particular, systemic insecticides applied to individual plants to control alien insect pests are unsuitable because they also are likely to injure or kill native insects.

Slugs are widespread in Hawaii and a serious threat to many native plants (Howarth 1985). The common slug on Oahu, *Vaginulus plebeius*, was introduced accidentally from South America and the Caribbean in the 1970s (Staples and Cowie 2001). Slugs are major horticultural and agricultural pests of seedlings and non-woody plants, and are common in residential landscapes as well as in mesic to wet forests. They are particularly active at night and in wet weather. Slugs feed on plants with fleshy leaves, stems, and fruits, including all taxa in the lobelia family in Hawaii and many taxa in the Hawaiian endemic genus *Schiedea* (Service 1998; U.S. Army Garrison 2005b). Slugs currently are an uncontrollable threat to

the successful stabilization of several plant taxa in the Makua action area, including *Cyanea grimesiana* ssp. *obatae*, *Cyanea longiflora*, *Cyanea superba* ssp. *superba*, *Plantago princeps* var. *princeps*, *Schiedea kaalae*, *S. nuttallii*, and *S. obovata*. Slugs have been shown to reduce survival of *Cyanea angustifolia* seedlings by as much as 80 percent (see discussion in U.S. Army Garrison 2006d). Recent research funded by the Army has shown that mortality of *S. obovata* seedlings doubled within a month of outplanting when exposed to slug herbivory (U.S. Army Garrison 2005b). However, slug exclusion significantly enhanced survival of *S. obovata* and *C. superba* ssp. *superba* (U.S. Army Garrison 2006d). Slugs are particularly threatening to vulnerable native plants because no cost-effective control method has yet proved effective in forest conditions. Commonly used garden methods such as beer traps and copper barriers have mixed success and can only be used on a small scale (about a square meter (10.7 square feet). Currently no chemical control for mollusks are registered for forest or conservation use, especially where native snails may be present. The Army will fund research on the basic biology and ecology of slugs, including distribution, species composition, population density, seasonality of activity, and feeding habits (U.S. Army Garrison 2006d).

The carnivorous snail *Euglandina rosea* is a significant predator on native land snails, including *Achatinella mustelina*, and a major factor in their decline and extinction (Hadfield 1986; S. Miller, Service, pers. comm. 1988; Staples and Cowie 2001). *Euglandina rosea* was intentionally introduced from the southeastern United States for biocontrol of the non-native giant African snail (*Achatina fulica*), a major crop pest, for which it proved unsuccessful (Staples and Cowie 2001). *Euglandina rosea* is widespread in damp habitats, including residential landscapes and disturbed and native forests. It is generally found on the ground but can climb trees. Two snail exclosures with solid metal walls, salt troughs, and electrical barriers have been constructed in the action area, and appear to be excluding *Euglandina* (although *Euglandina* have been found within the Pahole exclosure in the past). At times, however, *Achatinella mustelina* also have been found in the salt troughs, and the electrical barriers often do not function properly (U.S. Army Garrison 2005b). *Euglandina rosea* is particularly threatening to Oahu tree snails because no cost-effective control method has yet proved effective in forest conditions.

The black twig borer was accidentally introduced from Japan and Singapore in 1931 and now inhabits dry, mesic, and wet forests throughout most of Hawaii (Staples and Cowie 2001). It is a tiny beetle that attacks over 100 species of trees and shrubs by burrowing into woody branches, where it lays its eggs and introduces a pathogenic fungus as food for its larvae. The fungus is responsible for decline or death of twigs, branches, and entire plants. In Hawaii, the black twig borer has many native and non-native plant hosts, disperses easily, and probably occurs at most elevations up to 670 m (2,500 ft) (Howarth 1985). In the action area, black twig borers are a major threat to *Alectryon macrococcus* var. *macrococcus* and *Flueggea neowawraea*, and may be a threat to *Schiedea nuttallii* (Service 1998b; U.S. Army Garrison 2004). Several parasitoids have been introduced to control this beetle, but have not become established. Further research on biological control proceeds cautiously as several rare, native scolytid beetles are closely related to the black twig borer and could be impacted by control measures (Service 1998).

The Chinese rose beetle was accidentally introduced from Japan and Taiwan in the late 1800s and is now a common pest of shrubs and plants. It is usually found in lowland areas and occasionally up to elevations of 1,220 m (4,000 ft) (Staples and Cowie 2001). Known hosts for this beetle include over 250 species of ornamental and cultivated plants, and its presence is increasing in native habitats. These beetles feed at night on plant tissue between leaf veins, creating a "lace-like" appearance, which reduces the plant's photosynthetic capability and vigor and increases its vulnerability to disease pathogens. In severe cases, most leaves are skeletonized and the plant may die (Staples and Cowie 2001; Mau and Kessing 2004). Chinese rose beetles cause major damage to hibiscus plants in Hawaii, including *Hibiscus brackenridgei* ssp. *mokuleianus* in some of the wetter *in situ* sites where it has been planted in the Makua action area.

The two-spotted leafhopper, a recent accidental introduction from China, causes mechanical damage on leaves, typically in the form of stippling and yellowing. Damage from sap-sucking or egg-laying reduces the plant's photosynthetic capability and vigor, and may result in dieback of plant parts or death of the entire plant. In feeding, this insect also may introduce a plant virus or toxin. The two-spotted leafhopper has been found to cause economic damage to crops and ornamental plants in Hawaii, including over 250 species of native and non-native plants, from sea level to elevations of about 1,220 m (4,000 ft) (Staples and Cowie 2001). Although the two-spotted leafhopper is not known to threaten listed species in the action area, it is suspected of causing severe dieback of the native fern *Dicranopteris linearis* and may threaten this and other native plants in the surrounding ecosystem (Service 1998).

Five non-native species of biting mosquitoes that prey on warm-blooded vertebrates have been present in Hawaii since the early 1800s, beginning with the accidental introduction of *Culex quinquefasciatus* in the water casks of whaling ships (Staples and Cowie 2001). Mosquitoes carry avian malaria parasites (*Plasmodium rilictum*) and avian pox virus (*Avipox* spp.). These disease pathogens have contributed to the decline and extinction of native forest birds and may infect the Oahu elepaio (Service 2003b). These nocturnal insects inhabit wet areas of residential, rural, and forested areas from sea level to about 1,500 m (4,900 ft).

Exposure Area: Non-Native Animals

Stressors associated with the introduction and spread of non-native invasive animals include trampling and uprooting of native plants, grazing and browsing, and erosion caused by feral ungulates; seed/fruit predation by rats and mice; and tree snail and elepaio predation by rats. Stressors associated with the introduction and spread of non-native invasive invertebrates include herbivory, seed/fruit predation, tree snail predation, and transfer of plant and avian pathogens. The area exposed to these effects includes various locations throughout the action area, wherever these pests are not excluded or controlled. Because invasive animals and invertebrates are already present throughout the action area and on adjacent lands throughout Oahu, if uncontrolled, they will increase and spread in the action area without new introductions. Most feral pigs and goats, for example, have been removed from fenced exclosures, and goats have been virtually eliminated from Makua (U.S. Army Garrison 2005b). Pigs and goats are not excluded from many non-Army lands outside the installation.

Non-native carnivorous snails are excluded only from the Kahanahaiki and Pahole snail exclosures. Rats are controlled at the snail exclosures, in various plant stabilization population units, and at Oahu elepaio nesting sites. Other invertebrates such as snails and insects occasionally may be controlled in some areas.

Timing, Frequency, Duration, and Intensity: Exposure to Non-Native Animals

The timing and frequency at which listed resources will be exposed to non-native invasive animals and invertebrates are continual and ongoing throughout the year. The frequency of fire also will affect the movements of feral ungulates and rats out of burned sites into adjacent escape areas that contain listed resources. The intensity of exposure depends on existing population levels of alien species and the effectiveness of Army control efforts. The duration of stressors associated with alien species is permanent, unless and until they can be totally eradicated and controlled in the action area and throughout Hawaii.

Physical, Chemical, and Biotic Features Exposed to Non-Native Animals

Within areas exposed to non-native animals and invertebrates, listed resources will be directly exposed to trampling, erosion, predation, herbivory, and infestation by feral ungulates, rodents, invertebrates, and pathogens. Physical features that will be directly exposed to trampling and erosion include soil texture and bulk density, which influence soil loss and compaction rates. Biotic features that will be directly exposed include all living organisms, litter layers on the forest floor, and organic matter within the surface soil layer. Living organisms will be directly exposed to injury and death, and litter layers and organic matter will be indirectly exposed to erosion and loss. Loss of these biotic features will result in changes to species composition and the relative abundance of native and non-native plants.

Listed Resources Exposed to Non-Native Animals

All life stages of listed species and primary constituent elements of critical habitat will be exposed to stressors from invasive species throughout the year. Some plants may be more vulnerable to or less able to recover from predation by invertebrates and rats, or infestations of insects and slugs, during reproductive, seedling, and immature stages. Some plants may be more vulnerable if already stressed by fire injuries, fire-altered or drought-affected habitats, or excessively wet conditions. Depending on their reproductive cycle, all life stages of native plants and animals will be exposed to invasive species throughout the year. In addition, essential habitat features such as tree-snail host trees, elepaio nest trees, and primary constituent elements of critical habitat (including topography, soil substrates, microclimate, and native plant associates) will be exposed to invasive animals and invertebrates. The number of individuals of listed species that will be exposed depends on the local population levels of invasive species and Army control efforts, and are discussed in the species-specific effects analyses that follow.

Response of Listed Resources to Non-Native Animals

Direct Effects

The response of listed resources that will be directly exposed to non-native animals and invertebrates includes both lethal and sub-lethal components. Lethal exposure will result in the death of individual plants from grazing, trampling, or uprooting by feral ungulates, and from herbivory by insects and slugs. Terrestrial plants require a minimum leaf area for photosynthesis and transpiration, roots for water and nutrient uptake, and stems for physical support and internal transport of water and nutrients. Without these physiological functions, plants cannot survive, grow, and reproduce. Sub-lethal exposure will result in injury to leaves, stems, roots, growing tissues, buds, flowers, fruits, and seeds from ungulate trampling and grazing, herbivory by slugs and insects, and seed and fruit predation by rodents and insects. Oahu tree snails will be directly exposed to injury or death by rat and *Euglandina rosea* predation, and Oahu elepaio will be directly exposed to injury or death by rat predation of nestlings and eggs.

Indirect Effects

The sub-lethal response of listed resources to direct and indirect exposure to invasive mammals and invertebrates will result in diminished individual plant fitness due to physiological stress in injured or diseased plants. These effects are similar to those described above in General Effects of Fire on Native Hawaiian Plants. Physiological stress due from loss of leaf area results in decreased photosynthesis and increased transpiration water stress. Damaged root systems and those in compacted or eroded soils have reduced water and nutrient uptake capacity, and loss of meristematic tissue on branches and stems temporarily halts plant growth and reproduction. The physiological stress resulting from these injuries will reduce overall vigor, growth, and fecundity of individual plants. The consequences of physiological stress on individual plant fitness will vary among individuals exposed to invasive species, and will range from reduced growth and vigor, to reduced reproduction and recruitment, to delayed mortality. Moreover, fire-injured plants are more likely to die from environmental stresses such as disease pathogens, fungi, or insects. The overall effect of invasive mammals and invertebrates on listed resources will be reduced individual fitness and a further decline in numbers and population viability.

A major indirect effect of the loss of native vegetation due to non-native invasive mammals and invertebrates is the reduced availability of suitable habitat for regeneration of native plants. By inducing changes in the relative composition and abundance of native and non-native species, invasive mammals and invertebrates also alter future patterns of vegetation development and succession. Pigs and goats are known dispersal agents for habitat-altering, non-native plants; they also increase erosion and watershed degradation by removing plant cover and trampling soil. Long-term damage by feral ungulates results in simplification of native vegetation types and the continued presence and spread of alien plants (Stone et al 1992). The Service infers from documented examples of ecosystem effects of invasive species on native Hawaiian vegetation that introduction and spread of non-native animals

will similarly reduce the persistence probability of listed species in the Makua action area (Cuddihy and Stone 1990; Stone and Tunison 1992; Stone et al 1992; Cabin et al 2000).

Non-Native Plants in the Makua Action Area

All 49 listed taxa and/or critical habitats covered by this Biological Opinion are threatened by competition with non-native invasive plants (see Appendix E). An increase in resource availability (light, nutrients, and water) is likely a key factor controlling the susceptibility of natural communities to invasion by alien species (Davis et al 2000). Resource availability increases when uptake by existing plants declines because of death or injury from fire, ungulates, invertebrate pests, and disease. According to a review of 150 published, peer-reviewed studies, however, research results on the "invasibility" of natural communities by non-native species have been inconsistent and the long-term mechanisms that underlie competition mechanisms are poorly understood (Levine et al 2003; Gurevitch and Padilla 2004).

According to Gurevitch and Padilla (2004), examination of the International Union for Conservation of Nature and Natural Resource's IUCN "Red List" data of worldwide threatened species reveals that only four percent of U.S. plant species (e.g., *Xylosma crenatum* on the island of Kauai) and two percent of plant species worldwide are threatened solely by invasive plants, and not also by cattle, pigs, goats, or direct habitat alteration. In most cases, the correlation between alien plant invasions and native plant extinctions is due to limited observation and is supported by few causation studies. Thus, research so far has not determined whether alien plant species cause the decline of native plants, or whether alien invasions and native declines both result from habitat alteration. Even if competition with invasive plants is not in itself a cause for decline of native species, non-native plants do alter vulnerable native ecosystems through changes in primary production, decomposition, water balance, soil fertility, nutrient cycling, carbon storage, allelopathy, and disturbance regimes (e.g., fire, hydrology) (Vitousek 1992; Mack et al 2001; Levine et al 2003).

In general, invasive plants affect Hawaiian ecosystems primarily through impacts to resource availability, disturbance frequency and intensity, and interactions with agents of disturbance such as fire, animals, or disease (Smith 1985; Cuddihy and Stone 1990; Vitousek 1992). Alien grasses in dry habitats in Hawaii, for example, outcompete native woody plants because the dense, near-surface roots of grasses reduce the availability of soil nutrients and water for deeper-rooted woody plants (D'Antonio et al 1998). The competitive superiority of alien grasses usually is not apparent, however, without a causative disturbance such as fire. The most severe impact of alien species to community structure occurs through alteration of the natural fire regime, which results in conversion of native vegetation to alien grassland (see General Effects of Fire on Native Hawaiian Plants) (Vitousek 1992; Levine et al 2003). Dense cover of several fire-tolerant, alien grass species, including molasses grass and guinea grass at Makua, prevents seedling germination, growth, and reproduction of native plants, and facilitates the spread of fire into native dry and mesic woodlands (Cuddihy and Stone 1990; Hughes and Tunison 1991; Smith and Tunison 1992).

Environmental disturbances favor invasion by non-native plants through physical disruption and exposure of the soil surface to increased sunlight and ambient temperatures. These altered microclimate conditions can result in increased nitrogen mineralization, soil nitrate levels, nitrogen cycling rates, and carbon storage (Vitousek 1992; D'Antonio et al 1998; Mack et al 2001; D'Antonio and Meyerson 2002; Levine et al 2003). Such conditions generally benefit fast-growing species in open habitats, especially those with large, persistent soil seedbanks (D'Antonio and Meyerson 2002). The positive feedback cycle between alien grasses and fire frequency has altered soil nitrogen cycling through the loss of nitrogen accumulation, uptake, and litterfall provided by the native species that have been destroyed by fire (Mack et al 2001). Experimental removal of the non-native bunchgrass, *Schizachyrium condensatum,* from a seasonally dry woodland on the island of Hawaii, for example, has shown that grasses adversely affect growth and recruitment of native shrubs, even in the absence of fire, through soil nitrogen depletion and shading (D'Antonio et al 1998). In general, grass removal results in higher seedling density of all shrub species (D'Antonio et al 1998).

Some of the major invasive plants on leeward Oahu (and in the Makua action area) include Christmas berry (*Schinus terebinthifolius*), strawberry guava (*Psidium cattleianum*), koa haole (*Leucaena leucocephala*), Florida prickly blackberry (*Rubus argutus*), silk oak (*Grevillea robusta*), molasses grass (*Melinis minutifolius*), and guinea grass (*Panicum maximum*) (Service 1998). Christmas berry, a tree, and strawberry guava, a small tree or shrub, were introduced from tropical America and are now naturalized in disturbed mesic and wet forest habitats on most of the main Hawaiian Islands. Both produce large numbers of fruits that are dispersed by feral pigs and fruit-eating birds, and form dense stands that shade out and displace native plants. In addition, both may have allelopathic effects that inhibit the germination and growth of other species (Service 1998; Staples and Cowie 2001). The Australian silk oak tree was planted extensively in Hawaii for watershed reforestation. It is now naturalized in dry and mesic forests and disturbed areas on most of the main islands. Koa haole is an aggressive, naturalized nitrogen-fixing shrub or small tree from Central America. It dominates many low-elevation, dry, disturbed areas on all of the main Hawaiian Islands. Prickly Florida blackberry forms dense, impenetrable thickets in openings of mesic and wet forests where its fruits have been dispersed by birds. Molasses grass and guinea grass are perennial grasses introduced for cattle fodder that are now naturalized in disturbed, dry and mesic areas throughout most of the main Hawaiian Islands. Other invasive plants present in the Makua action area are described in the Makua Implementation Plan (Makua Implementation Team 2003) and the Army's status reports (e.g., U.S. Army Garrison 2005b). Appendix 3.1 of the Makua Implementation Plan lists 82 species of non-native priority weeds for control in selected stabilization management units.

Exposure Area: Non-Native Plants

Stressors associated with the introduction and spread of non-native invasive plants involve the establishment of grasses, broadleaf weeds, shrubs, and trees that displace native plants through alteration of microclimate and competition for growing space, water, and nutrients. The entire action area is vulnerable to the introduction and spread of non-native plants, which are prevalent within and adjacent to high-disturbance areas such as military training facilities.

Potential sources of non-native plant introduction into the Makua action area include mounted and dismounted maneuvers; movement of equipment, vehicles, and troops; and range maintenance and natural resource conservation activities. Troop movements into Hawaii from other states and countries, and from other installations in Hawaii and on Oahu, increase the likelihood that habitat-altering weeds will be introduced and spread into native habitats in the action area. For example, new invasive weeds at Makua were recently introduced from Pohakuloa Training Area on the island of Hawaii (U.S. Army Garrison 2005b).

Timing, Frequency, Duration, and Intensity: Exposure to Non-Native Plants

The timing and frequency at which listed resources will be exposed to the introduction and spread of non-native invasive plants are both continual and ongoing throughout the year whenever personnel, vehicles, and equipment enter the action area. Military training is expected to take place over 242 days each year, including up to 50 CALFEXs per year. In addition, managers and maintenance staff are on-site almost daily throughout the work week. Alien plants are ubiquitous throughout the Hawaiian Islands and comprise the majority of plants in developed coastal and lowland areas of Oahu. Therefore, weed seeds will be introduced and spread at Makua throughout the year via transport in vehicles, tire treads, equipment, clothing, backpacks, boots, and other gear. Non-native invasive plants also will be spread by pollination and seed dispersal from areas on Makua and Oahu where they have already become established. The timing and frequency of invasive plant introduction and spread will also be influenced by the frequency of fire (which will create openings for seed germination and establishment) and the movements of feral ungulates (which will create openings and disperse seeds). The duration of impacts associated with non-native plants is permanent, unless and until they can be totally eradicated and controlled in the action area and throughout Hawaii.

The intensity of stressors introduced and spread with invasive plants will depend on the level of traffic in personnel, vehicles, and equipment entering Makua. Convoy and ammunition transport vehicles arrive at Makua from Schofield Barracks, Wheeler Army Airfield, and Lualualei Naval Magazine on Oahu. Troops and equipment are also airlifted to Makua from Wheeler. Up to 62 ground vehicles will arrive at Makua for each CALFEX, including HMMWVs and trailers, Strykers, cargo trucks, flatbed trucks, tractors, forklift, and passenger vans and buses; a small bobcat loader and two HMMWVs equipped as fire trucks are assigned on-site (U.S. Army Corps of Engineers 2005). In addition, ITAM crews and other on-site staff arrive daily throughout the work week in personal vehicles from various locations on Oahu. The intensity of weed introduction and spread also depends on the effectiveness of Army phytosanitation measures to clean vehicles, equipment, and personal gear before entry into the action area; existing levels of alien plants available to spread into burned areas and other forest openings; and the effectiveness of Army efforts to control non-native ungulates and plants.

Physical, Chemical, and Biotic Features Exposed to Non-Native Plants

Listed resources will be indirectly exposed to stressors associated with microclimate changes and competition wherever sparsely vegetated areas offer seed germination beds for invasive plants. Seedbeds will be created by disturbances associated with military ground activities (such as munitions explosions, foot trampling, vehicle ruts, etc.), training-related wildfire, and grazing and movements of feral ungulates. These soil disturbances also will stimulate germination of alien seeds in soil seedbanks, which likely are plentiful in the action area. All plants require light, oxygen, carbon dioxide, water, and mineral nutrients to survive, grow, and reproduce. Terrestrial plants also require a substrate for rooting and establishment, such as bare soil, boulders, downed woody debris, or other plants. Physical features exposed to invasive plants include seed germination substrates and microclimate conditions (light/shade, temperature, humidity, wind), which will change after establishment of alien plant cover. Chemical features include soil nutrient and moisture levels that will change with alterations in the relative abundance of alien and native plants. Biotic features include all life forms, litter layers on the forest floor, and soil organic matter.

Listed Resources Exposed to Non-Native Plants

All life stages of listed plant species, and all native plant associates that are primary constituent elements of critical habitat, will be indirectly exposed to habitat alterations resulting from the introduction and spread of invasive plants. Native plants that provide essential habitat features include host trees for Oahu tree snails and nesting and foraging habitat for Oahu elepaio. Alien plant invasion in critical habitat also will adversely affect native plants that comprise the vegetative primary constituent elements determined to be essential for the survival and recovery of listed plants and the Oahu elepaio. The number of individuals and occurrences of listed resources that will be exposed depends on local population levels of invasive plants and Army control efforts, and are discussed in the species-specific effects analyses that follow.

Response of Listed Resources to Introduction and Spread of Non-Native Plants

The response of listed resources to indirect exposure to invasive plants involves diminished individual plant fitness due to physiological stress. Dense cover of alien grasses, shrubs, and trees will increase shade and create ambient temperatures unfavorable to seed germination and establishment of many native plants. Plants are generally more vulnerable to unfavorable microclimate conditions and competition during the seed germination and seedling establishment stages. In addition, physiological stress at any life stage may increase a plant's vulnerability to fire injury, grazing, insect infestation, drought, or excessively wet conditions. The consequences of physiological stress on individual fitness will vary among individuals exposed to invasive species, and will range from reduced growth and vigor to reduced reproduction and recruitment.

In addition, a major indirect effect of invasive plant competition is the reduced availability of suitable habitat for regeneration of native plants. Species differ in their response to environmental changes owing to differences in transpiration rates, leaf area, rooting depth,

and phenology (flowering and fruiting seasons). These differences allow invasive species to exploit conditions unfavorable to native plants and alter future patterns of vegetation development and succession. Habitat resources associated with these features will become less available to native plants as the cover and density of invasive plants increase. In general, native communities and long-term patterns of vegetation development and succession will change as non-native plants increasingly displace native species. From documented examples of long-term ecosystem and succession effects of invasive species on native Hawaiian vegetation (Cuddihy and Stone 1990; Smith and Tunison 1992; D'Antonio et al 1998; Mack et al 2001; Cabin et al 2000, 2002a, 2002b), the Service infers that introduction and spread of non-native plants will similarly reduce the persistence probability of listed species in the Makua action area. The overall effect of indirect exposure of listed resources to invasive plants will be reduced reproductive fitness and recruitment of individuals, and a further decline in numbers and population viability.

General Effects of Human Disturbance

Physical Disturbance Stressors in the Makua Action Area

Listed resources will be exposed to physical disturbance associated with personnel movements in vegetated areas, including trampling and breakage of vegetation, trampling of soils, and dislodgment and crushing of tree snails. These impacts will occur during troop marches and other ground maneuvers by military personnel; construction and maintenance of firebreaks, fuels modification areas, and fences; and conservation management and monitoring activities. In particular, troop marches will increase the level of human activity along trails and access roads already established throughout parts of the action area (U.S. Army Corps of Engineers 2005). Army standard operating procedures to minimize the impacts of ground maneuvers include smoking bans for all personnel along trails and troop briefings regarding the need to avoid off-trail activities in sensitive areas.

Physical Disturbance Exposure Area

The northern ridgeline of Makua, including portions of Kuaokala Access Road and Trail, will be exposed to physical disturbance during troop marches. Kuaokala Access Road is a steep paved road to an old Nike missile site now used as an endangered plant nursery. The surrounding area supports a variety of common native plants and habitats, as well as non-native and mixed vegetation types (U.S. Army Corps of Engineers 2005).

Fences will be constructed and maintained around endangered species management units and in some cases around species-specific population units. Existing fences within the action area are maintained at the Kaluakauila, Kahanahaiki subunit I, Pahole, Ohikilolo, and Lower Ohikilolo management units. New fences in the action area will be constructed and maintained at the Kahanahaiki subunit II, Upper Kapuna, West Makaleha, Ohikilolo (Lower Makua), and Makaha management units (see Stabilization section of Project Description). Endangered species population units are managed and monitored by Army Natural Resources staff in population units accessed by foot trails (see General Effects of Endangered Species Stabilization, page 54 of this chapter). Firebreaks and fuel modification areas will be

constructed and maintained by clearing vegetation (manually and/or by herbicide) around the firebreak roads, and below the Kaluakauila, Kahanahaiki, C-Ridge area, Okikilolo, and Lower Ohikilolo management units (see General Effects—Fire Suppression).

Timing, Duration, Frequency, and Intensity of Physical Disturbance

A maximum 150-Soldier company will march once a month on the Kuaokala Trail, at any time of day or night (U.S. Army Corps of Engineers 2005). Troop marches will add a maximum 1,800 people per year using Kuaokala Trail.

Physical, Chemical, and Biotic Features Exposed to Physical Disturbance

Physical features that will be directly exposed to physical disturbance by people include soil texture and bulk density characteristics. Biotic features that will be directly exposed to physical disturbance include all living organisms, litter layers, and soil organic matter. Litter layers and organic matter will be indirectly exposed to erosion and loss, which in turn affect chemical features such as soil fertility and moisture holding capacity.

Listed Resources Exposed to Physical Disturbance

Listed resources will be directly exposed to physical disturbance by humans passing on foot through vegetated areas, including stressors associated with trampling and breakage of vegetation, trampling and disruption of soils, and dislodgment and crushing of tree snails. Essential habitat features such as tree-snail host trees, elepaio nest trees, and primary constituent elements of critical habitat (including soil substrates and native plant associates) also will be exposed to trampling and breakage by people. Depending on their reproductive cycle, all life stages of listed species and primary constituent elements of critical habitat will be exposed to these physical disturbance impacts throughout the year. Some plants may be less able to sustain or recover from these disturbances if already under physiological stress from excessively dry or wet conditions. The number of individuals that will be exposed is discussed in the species-specific effects analyses that follow. Disturbance effects in critical habitat also will adversely affect native plants and substrates that comprise the primary constituent elements determined to be essential for the survival and recovery of listed plants and the Oahu elepaio.

Response of Listed Resources to Physical Disturbance

Over time, military use of the Kuaokala Trail, particularly in narrow portions, will reduce vegetation cover adjacent to the trails and result in less suitable habitat for listed plants, tree snails, and the Oahu elepaio. Listed plants and tree snails adjacent to the trail are at risk of injury and death as a result of trampling and breakage by personnel during troop marches and in conjunction with various fire and conservation management activities. Further impacts to listed resources, and indirect impacts resulting in habitat degradation, will occur if personnel stray off the trails. The response of listed resources that will be directly exposed to trampling and breakage includes both lethal (death) and sub-lethal components (injury to leaves, stems,

roots, growing tissues, buds, flowers, fruits, and seeds; and to tree snails dislodged from their host trees).

Physiological stress in plants due to loss of leaf area results in decreased photosynthesis and increased transpiration water stress. Repeated foot traffic disrupts the soil surface or compacts near-surface horizons, resulting in soil loss or compaction. The root systems of plants adjacent to trails are either exposed by displaced soils or smothered by compacted soils; either condition can result in restricted water/nutrient uptake in the plant. Loss of flowers, fruits, or meristematic tissue on branches and stems temporarily halts plant reproduction or growth. The physiological stress resulting from these injuries will reduce overall vigor, growth, and fecundity of individual plants. The consequences of physiological stress on individual plant fitness will vary among individuals, ranging from reduced growth and vigor, to reduced reproduction and recruitment, to delayed mortality. The overall effect of exposure to human disturbance will be reduced individual fitness and a contribution to further decline in numbers and population viability.

General Effects of Small Population Size

Many of the listed plant taxa within the action area are limited in abundance and distribution, with low numbers of individuals and populations. Five of the 28 target plant taxa to be stabilized under the Makua Implementation Plan Addendum currently consist of fewer than 100 individuals range-wide (*Chamaesyce herbstii*, *Gouania vitifolia*, *Hesperomannia arbuscula*, *Phyllostegia kaalaensis*, and *Schiedea nuttallii*). Small populations are more vulnerable than large populations to extirpation from naturally occurring events (environmental stochasticity), reduced reproductive vigor (demographic stochasticity), or a combination of both factors (Dennis et al 1991; Schemske et al 1994). Demographic stochasticity refers to random effects on population vital rates (birth, growth, survival) resulting from chance variation among individuals in survival or reproduction (due, for example, to lack of pollination or seed dispersal). Environmental stochasticity refers to random effects on population vital rates resulting from chance variation in the occurrence of natural events or disturbances related to weather, competition, predation, or disease. The limited gene pools of small plant populations also may depress reproductive vigor through loss of genetic variation resulting from inbreeding, accumulation of deleterious mutations, and genetic drift. Reduced genetic variability in a population thus represents a decline in individual fitness, population viability, and resilience to environmental change.

Although many population viability analysis (PVA) models show that small populations are at greater risk of extirpation due to stochastic processes than large populations, little empirical evidence exists for plants. In one study, for example, the relationship between population size and survival over 10 years was tracked for 359 occurrences of eight short-lived (annual and biennial), threatened plants in northern Germany (Matthies et al 2004). Based solely on changes in numbers, large populations had a significantly greater probability of survival over the 10-year study period than small populations. Most occurrences consisting of fewer than six and many with fewer than 100 individuals did not survive over 10 years, while occurrences of more than 1,000 individuals survived. Although the study did not track disturbance factors, the local extirpations of some populations likely were caused in

part by stochastic processes, because many other small populations did survive and grow larger. For the eight species, estimated population size required for 90 percent probability of survival over 10 years varied widely, from 71 to 1,276 individuals (Matthies et al 2004).

In another study, a PVA model estimated rates of environmental stochasticity (natural catastrophe) and predicted the extinction probability of an endangered riparian plant in the northeastern United States (Menges 1990). The model was based on demographic data from over 6,000 individual plants in 17 populations monitored over four years. The observed zero to six percent annual probability of natural catastrophe (riverine ice scour) predicted only a 13 percent probability of species survival over 100 years. The author concluded that protecting the "best" populations may not necessarily ensure a species' persistence; dispersal and establishment of new colonies may be essential to avoid species extinction due to natural disturbance regimes. Even so, few species in the Makua action area consist of thousands of individuals in many occurrences. We infer from this and the previous example that many Makua species also will have a low probability of persistence in the face of periodic, catastrophic disturbance.

According to current conservation biology principles, demographic and environmental variation, including catastrophic occurrences (such as flooding or fire), are important determinants of population extinction for plants (Menges 1990; Mangel and Tier 1994; Schemske et al 1994). A general pattern of population collapse has been documented for a wide range of plant and animal species with small population sizes (Dennis et al 1991; Schemske et al 1994; Morris et al 1999; Menges 2000). According to this pattern some species in the action area already are in a phase of "quasi-extinction," with numbers that have declined to the point where environmental or demographic stochasticity alone can result in extirpation. (Quasi-extinction refers to a specified population threshold considered too low for species survival.) Such species have a high background risk of extinction and any additional threats, such as training-related wildfire, could eliminate expectation of their long-term persistence.

Dennis et al (1991) developed statistical methods for estimating growth rates and quasi-extinction probabilities for populations of several endangered bird and animal species, based on 15 to 40 years of time-series monitoring data. Results predicted that, without intensive management, the Yellowstone grizzly bear population, Kirtland's warbler, California condor, and Puerto Rican parrot would decrease to 10 or fewer reproducing adults in 13 to 109 years. Graphical representations of population trends for these species indicate the general pattern of population collapse except for the parrot. Numbers of Puerto Rican parrots are increasing, but solely due to release of captive-reared birds, protection of juveniles, and intensive habitat management; the breeding population has remained nearly constant, and effects of environmental catastrophes like hurricanes were not considered in the model. For plants, Burgman et al (2001) defined quasi-extinction risk as a 0.1 percent probability of decline below 50 adult individuals over 50 years, and used this criterion to determine a species' background probability of persistence. Although lack of demographic data precludes PVA modeling or quantification of quasi-extinction risks for Hawaiian native plants, the 50-adult threshold generally used in conservation practice indicates the extirpation danger faced by species with small population sizes in the Makua action area.

The factors that caused a species' extinction are generally unknown (Gurevitch and Padilla 2004). Norton (1991) was able to document these factors for *Trilepidea adamsii*, an endemic New Zealand mistletoe species. *Trilepidea adamsii* is now presumed extinct due to interacting factors of habitat loss, limited distribution, reduced seed dispersal, overcollecting, and browsing by the non-native brushtailed possum (*Trichosurus vulpecula*). In the United States, the heath hen (*Tympanuchus cupido cupido*) was driven to extinction by a combination of catastrophes including fire, harsh winter weather, predation, and disease (cited in Mangel and Tier 1994). Catastrophes combined with other kinds of environmental fluctuation have been associated with extinction of the great auk (*Pinguinus impennis*) and with the severe population decrease of the Laysan duck (*Anas laysanensis*) and short-tailed albatross (*Phoebastria albatrus*) (cited in Mangel and Tier 1994).

Burgman et al (2001) list plant ecological and life history factors that are likely to contribute to extinction vulnerability in plants, based on the population size required to provide an adequate probability of persistence. Those factors we consider descriptive of action area plants include: few small, isolated populations; restricted distribution; adaptation to unique habitat requirements; wide fluctuations in population size; low post-disturbance regeneration rates; slow, weak growth, poor competitive ability; susceptibility to fire injury/death; lack of adaptation to browsers; drought, or fire regimes; inability to resprout; and vulnerability to non-native pathogens, disease, and insects. Our understanding of the factors that contribute to the extinction vulnerability of action-area species are poorly understood, but may include: dysfunctional breeding systems (i.e., loss of pollinators), variable seed production, low seed production and viability, and no longer functioning seed dispersal mechanisms (i.e., loss of seed dispersal).

Factors that contribute to demographic and environmental stochasticity in the action area include naturally occurring events such as drought and landslides, catastrophic events such as hurricanes and wildfire, competition from non-native invasive plants, predation and herbivory by non-native animals and invertebrates, and trampling and uprooting by feral ungulates. The Service infers from the theories and examples of the current conservation biology literature discussed in this section that some species within the action area are vulnerable to extinction due to random demographic, environmental, and catastrophic events (including training-related wildfire). We also infer from the results of statistical models and population viability analyses provided by these examples, that if adequate data were to become available for the action-area species whose population sizes are small, statistical models would likely demonstrate a the probability of long-term persistence is low.

General Effects - Fire Suppression

Fire History

All fires caused by live-fire training, for which records are available, were successfully suppressed during the initial attack period. Fire perimeter maps were generated for the 35 training-related fires that burned outside the firebreak road between 1970 and 2006 (Figure E 1). Most fire perimeters were digitized based on maps in Army fire reports. Fires for which perimeter maps were not found were mapped as ovals centered at the fire's reported grid location, equal in acreage to the fire's reported size.

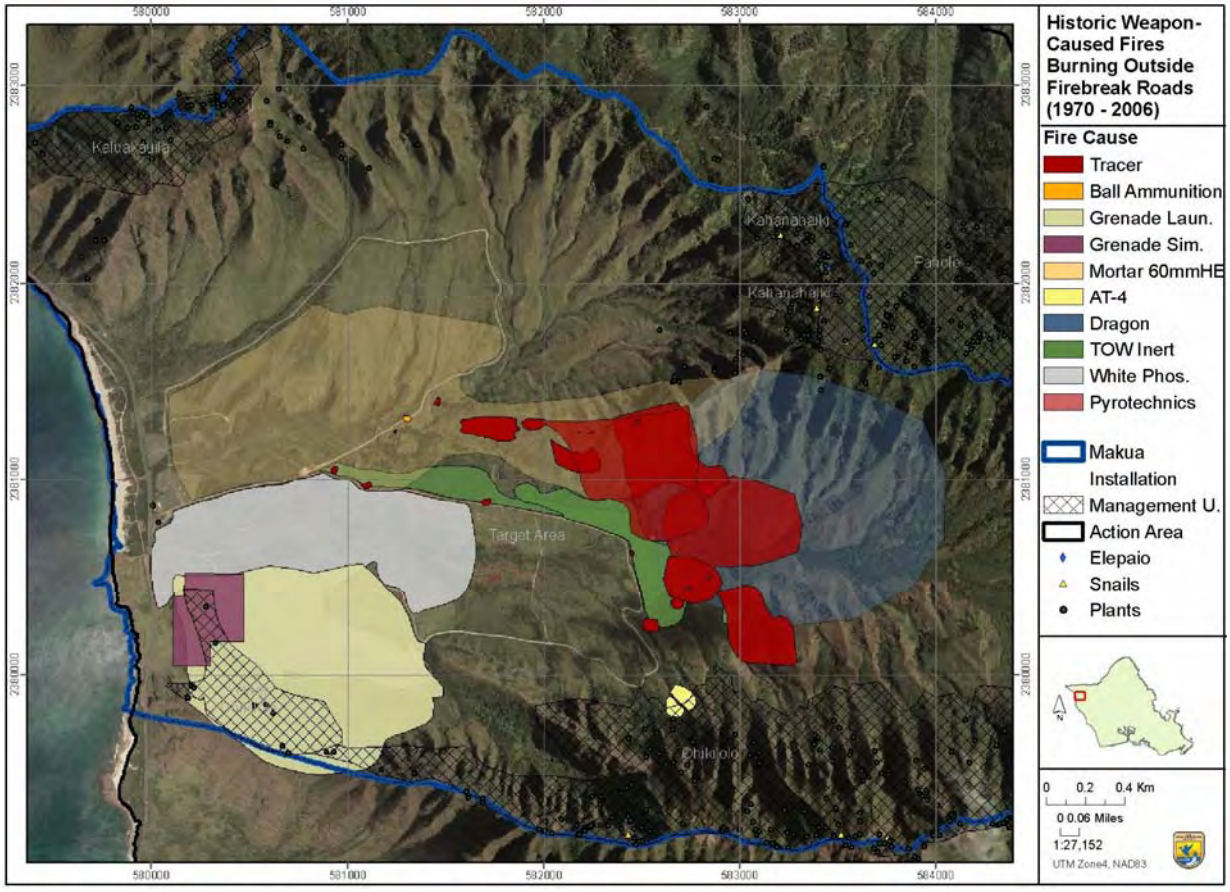


Figure E 1. Weapon-related fires burning outside the firebreak road at Makua (1970-2006).

All documented wildland fires that have occurred at Makua as a result of the proposed weapons are summarized in Table E 2, listed in order of total number of fires ignited. Fires ignited by the public along Farrington Highway are not analyzed. Although white phosphorus rounds are no longer used at Makua, remnant white phosphorus rounds may ignite fires, which could impact endangered species and critical habitat areas.

Table E 2. Fire Ignitions by Weapon, Location, and Fire Danger Rating Period.

Weapon Causing Fire	Total # Fires (recorded 1970 - 2005*)	Percent of Fires Ignited by Weapon	Number of Fires Burning Outside Firebreak Road	Percent of Fires that Burned Outside Firebreak Road	Percent of all Fires Outside Firebreak Road Caused by Weapon	Fire Danger Percent of Historic Fire Starts (1970 - 2005)		
						Green	Yellow	Red
Tracers	156	61%	23	15%	68%	3%	84%	14%
Javelin/Dragon	33	13%	1	3%	3%	0%	31%	69%
Demolitions	17	7%	0	0%	0%	11%	0%	89%
Ball Ammo	15	6%	1	7%	3%	0%	63%	38%
Mortars/Artillery	10	4%	1	10%	3%	0%	13%	88%
2.75 Rocket	7	3%	unknown	unknown	unknown	unknown	unknown	unknown
Mines / Simulators	6	2%	1	17%	3%	0%	0%	100%
TOW	5	2%	4	80%	12%	0%	0%	100%
AT-4/SMAW	4	2%	2	50%	6%	0%	100%	0%
Grenades	3	1%	1 (MK19)	33%	3%	0%	0%	100%
TOTALS:	256	100%	34		100%			

* Beavers et al (1999) and U.S. Army Fire Reports (unpublished)

Tracers Of the 156 recorded tracer fires, 23 occurred outside the firebreak road, accounting for 68 percent of all fire ignitions outside the firebreak road. Although 85 percent of tracer fires burn entirely within the firebreak road, tracers which overshoot the target may not burn out until after they cross the firebreak road, and burning material from tracers can ricochet and ignite a fire outside the firebreak road. Of the 93 tracer fires for which fire danger rating index was recorded, only three ignited when the fire danger rating was Green. Two of those three ignitions occurred outside the firebreak road. On March 30, 1994, a tracer fire burned 0.5 ha (1.1 ac) outside the firebreak road and was extinguished in 1.3 hours after 11 bucket drops from a Blackhawk helicopter (Army Fire Report 1994). On March 16, 1995, a tracer fire burned 0.004 ha (0.0091 ac) outside the firebreak road and was extinguished in 35 minutes with two bucket drops from a Blackhawk helicopter. Eighty-four percent of all of the tracer fires recorded ignited when fire danger rating conditions were in the Yellow, and 14 percent of all tracer fires occurred when fire danger rating conditions were in the Red. Tracer fires burning outside the firebreak road under Yellow and Red fire danger conditions ranged in size from 0.004 ha to 88 ha (0.01 to 217.5 ac) (average 8 ha (19.8 ac)); it took between zero and five helicopters to suppress them, and suppression times ranged from 9 minutes to 12 hours and 20 minutes (Army Fire Reports 1990 through 1995 and Beavers et al 1999).

Restriction of the use of tracers to seasons when live herbaceous fuel moisture is 100 percent or higher and to periods when the burning index is 20 or lower (Fire Danger Rating Green) will minimize the fire risk associated with the use of this weapon. Even with these restrictions in place, tracers are likely to ignite fires outside the firebreak road. Therefore, no tracers will be used until Kaluakauila, Kahanahaiki and Ohikilolo management unit perimeter fire protection systems are completed. Furthermore, tracer use will be limited to live herbaceous fuel moistures of 100 percent or greater until the expedited stabilization of 12 species is completed. The static firing point and 1,800 m (5,906 ft) burnout distance of the M1 is expected to limit all ignitions to the area where historic fire ignitions from this weapon appear to have been ignited (Figure E 2).

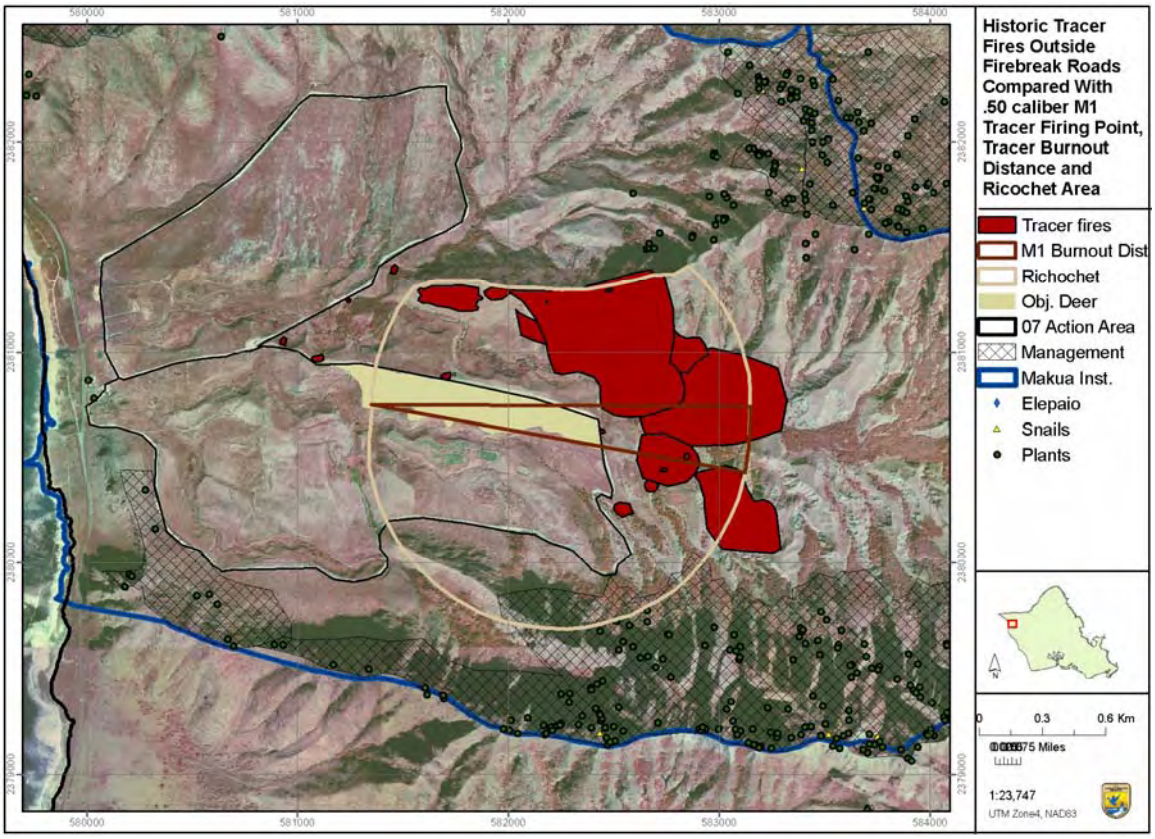


Figure E 2. Historic tracer fires outside firebreak roads compared with .50-caliber M1 tracer burnout distance and potential tracer ricochet area.

Current understanding of the guinea grass fire behavior in green grass and fire suppression capabilities of assigned aerial firefighting resources indicates that fires ignited outside the firebreak road when live herbaceous fuel moisture is 100 percent or greater and fire danger rating is Green/Low are likely to be contained at sizes smaller than approximately 8 ha (20 ac). Estimated size of a fire still burning at 1 p.m. on a 97th percentile fire weather day is 58.3 ha (144 ac) (Table PD 11). It is possible that a spot fire, spawned by a fire burning in Makua Valley, could ignite within the forest vegetation of a management unit. Our best understanding of fire behavior and helicopter fire suppression capabilities in forest fuels indicates that the assigned Makua suppression helicopter staffing, designed to suppress fires in heavy guinea grass fuels, will be sufficient to suppress a fire ignited by this weapon in shrub or forest fuels at 0.12 ha (0.3 ac) or less, even if the fire ignites on a 60 percent slope, with upslope winds of 18 mph and 1-hour fuel moisture of six percent. If a spot fire ignited in local forest fuels were to burn undetected for 48 hours, it could grow to more than 40.5 ha (100 ac). These results are dependent on helicopter productivity in forest fuels being equal to helicopter productivity in guinea grass fuels. Our analysis of fire behavior in guinea grass indicates that spot fires are not likely to occur when live herbaceous fuel moisture is 100 percent or greater. A detailed analysis of spot fire potential is addressed in the prescribed burning and firebreak portions of this section of the Biological Opinion, below. Fire suppression helicopter productivity in forest fuels will be accumulated by firefighters suppressing fires throughout the Waianae Mountains over the next 15 years. Because tracer use will be restricted to seasons when live herbaceous fuel moisture is 100 percent and

greater for approximately 15 years while the expedited stabilization of 12 endangered plants is being completed, fires ignited by tracers are unlikely to cause spot fires in forest fuels until after more thorough assessments of anticipated acreages of these fires are completed.

Javelin The second most frequent cause of fire at Makua was the Dragon missile, the precursor to the Javelin. Thirty-three fire ignitions, including one outside the firebreak road (a 162-ha; 400-ac) fire in 1989), are documented to have been ignited by use of Dragon missiles (Beavers et al 1999). The new Javelin is a self-guided warhead, and locks onto and fires at a heat source. At 1,000 m (0.6 mi), the flight motor is fully exhausted. Therefore, the surface danger zones and potential ignition areas (see Figure PD 29) created for flat terrain overestimate the maximum range of the weapon. On impact, the detonation is likely to create enough heat to ignite a wildland fire. Although the Javelin is a guided weapon, it has the potential to malfunction and ignite fires within management units populated by endangered species. Therefore this weapon will not be used until the expedited stabilization of 12 endangered plant species is completed. The restriction of the use of this weapon to Green fire danger rating periods and periods of time when live herbaceous fuel moisture is 100 percent or higher will further reduce the fire risk associated with the use of this weapon.

Current understanding of the guinea grass fire behavior in green grass and fire suppression capabilities of assigned aerial firefighting resources indicates that fires ignited outside the firebreak road when live herbaceous fuel moisture is 100 percent or greater are likely to be contained at sizes smaller than approximately 8 ha (20 ac). Estimated size of a fire still burning at 1 p.m. on a 97th percentile fire weather day is 58.3 ha (144 ac) (see Table PD 11). Therefore, no Javelin will be fired until Kaluakauila, Kahanahaiki and Ohikilolo management unit perimeter fire protection systems are completed and the expedited stabilization of 12 species is achieved. Our best understanding of fire behavior and helicopter fire suppression capability in forest fuels indicates that the assigned Makua suppression helicopter staffing, designed to suppress fires in heavy guinea grass fuels, will be sufficient to suppress a fire ignited by this weapon in shrub or forest fuels at 0.12 ha (0.3 ac) or less, even if the fire ignites on a 60 percent slope, with upslope winds of 18 mph and 1-hour fuel moisture of six percent. If a Javelin fire ignited in local forest fuels were to burn undetected for 48 hours, it could grow to more than 40.5 ha (100 ac). One-hour fire detection flights will be flown by the Army Wildland Fire Incident Commander and, if there are multiple on-site helicopters, by additional firefighters, following the use of a Javelin.

Demolitions None of the 17 fires caused by demolitions at Makua burned outside the firebreak road (Beavers et al 1999). Most demolition-caused fires were extinguished at less than one acre (Beavers et al 1999). On July 25, 1991, Range Control personnel contained a demolitions caused fire to 162 ha (400 ac), within the south lobe of the firebreak road. Unexploded ordinance disposal demolitions may occur outside the firebreak road when live herbaceous fuel moisture is 100 percent or higher and fire danger rating is in the Green. Fire suppression helicopter staffing will be on-site to suppress any fire ignition in an inaccessible area.

Ball Ammunition Only one of the 15 recorded ball ammunition fires occurred outside the firebreak road. It ignited under Yellow fire danger conditions on April 30, 1991, burned the

inside and outside grass edges of the north lobe of the firebreak road, and was extinguished at 0.01 ha (0.037 ac) by ground forces in 13 minutes (Army Fire Report 1991). It is not clear from the fire report whether this road location was being used as a firing point. An August 29, 1990, ball ammunition fire with a recorded location inside the south lobe of the firebreak road had an approximate area of 324 ha (800 ac). Given that the total acreage within the south lobe of the firebreak road is approximately 136 ha (337 ac) and the north lobe contains an additional 186 ha (459 ac), it is assumed that the acreage reported in the fire report was inaccurate and that this fire did not burn outside the firebreak road. The fire report stated that notifying the Service was not required, which would have been the case if the fire was outside the firebreak road. Muzzle flash and hot particles resulting from the use of short-range training ammunition and blanks may ignite fires in the vicinity of the firing point. Because spot fires may result from fires burning in unmowed guinea grass stands within the south lobe of the firebreak road, short-range training ammunition and blanks may be used with reduced fire suppression helicopter staffing (see Table PD 4) when the use is limited to designated areas where there is a bare mineral soil firebreak between the firing point and any unmowed guinea grass fuels in the interior area of the south lobe of the firebreak road.

Mortars and Artillery Seven mortar fires are recorded, including one that ignited outside the firebreak road (Beavers et al 1999). One 60 mm mortar fire ignited a fire outside the south lobe of the firebreak road on September 16, 1998, due to an apparent misalignment of the firing trajectory. Five helicopters working during the day and two helicopters working at night made a total of 432 bucket drops to extinguish the fire. The fire report indicates a fire size of 324 ha (800 ac). GIS analysis of the digitized fire perimeter indicates that the fire acreage may be updated to a size of 176 ha (434 ac). Between October 2001 and June 2004, between 469 (U.S. Army, unpublished fax, January 10, 2006) and 1,992 (U.S. Army unpublished information paper May 14, 2007) inert and HE mortars were fired in Makua. Although rigorous measures had been instituted to minimize the risk of rounds landing outside the firebreak road, in several instances mortar impacts outside the firebreak road (adjacent to the target area, in Makua Stream, and on C-Ridge) were documented by civilian observers (*Malama Makua v. Donald H. Rumsfeld*, 2006). Therefore, mortar ignitions of fires outside the firebreak road appear to be inevitable.

Three artillery fires (September 4, 1991; May 25, 1993; and April 7, 1994) are recorded (Beavers et al 1999). None escaped the interior of the south lobe of the firebreak road. They ranged in size from 0.4 ha (0.9 ac) to 30 ha (75 ac), and it took zero, one, and two helicopters and ground firefighting resources to suppress them. Fire danger indices are recorded for two of them and these both occurred in Red fire danger conditions. Although the Project Description stipulates all munitions will land within the impact area, ignitions outside the firebreak road are anticipated because the potential ignition area designated for artillery (see Figures PD 21, PD 23) extends outside the firebreak road.

Current understanding of the guinea grass fire behavior and fire suppression capabilities of assigned aerial firefighting resources indicates that a fire ignited outside the firebreak road under 97th percentile fire weather conditions, when live herbaceous fuel moisture is 60 percent, is likely to burn 271 ha (669 ac) (Table PD 11). Therefore, use of mortars and artillery will be restricted to Green fire danger conditions when live herbaceous fuel moisture

is lower than 100 percent, until Kaluakauila, Kahanahaiki and Ohikilolo management unit perimeter fire protection systems are completed and the expedited stabilization of three species is achieved (see Column C, Table PD 2). Prior to fuelbreak completion, mortars may ignite fires outside the firebreak road when live herbaceous fuel moisture is 100 percent or greater, but fire acreages are expected to be 58 ha (144 ac) or less. These smaller fires are less likely to reach endangered species locations.

2.75-caliber rocket In 1987 and 1988, seven fires ignited by 2.75-caliber rockets are recorded to have occurred in May (two fires), June (one fire), August (three fires) and October (1 fire). One fire took approximately two hours to extinguish and another was declared out after approximately six hours (Beavers et al 1999). Fire danger, location, and size information are not available.

We assessed the effect of 2.75-caliber rocket fire ignitions within the surface danger zones presented by the Army (Figure PD 27). The inaccuracy of this weapon is likely to result in rocket impacts outside the south lobe of the firebreak road. A passing score for a 2.75-caliber rocket qualification exercise is one out of three, or three out of seven hits within a 100 by 100 m (328 by 328 ft) box around a tank-sized object (S. Lodge, U.S. Army, pers. comm. 2006). Approximately one third of the target box's perimeter is bounded by the firebreak road. Out of the approximately 5,040 rounds scheduled for use over the next 30 years (Table PD 3), a maximum of 3,360 rounds may land outside the target box, and approximately one third of those, or 1,120 rockets, may land outside the firebreak road. Limitations in the use of this weapon to fully qualified pilots, who are not firing the weapon for training or recertification purposes, assure that this estimate would not be exceeded.

Although the Army is minimizing the risk of fire by firing only MK66 MOD 4 rocket motors, and blue spear WTU1B inert, ten-pound steel training warheads, with motor propellant that burns out at approximately 450 m (1,476 ft), the tube remains hot enough that it can ignite vegetation on impact 3.0 km (1.9 mi) down-range (S. Lodge, U.S. Army Garrison, pers. comm. 2006). Although the likelihood of a fire ignition from a 2.75-caliber rocket is not as great as fire ignition likelihood from a tracer (S. Lodge, U.S. Army pers. comm. 2006), fire ignitions outside the firebreak roads resulting from this weapon are expected. Therefore, use of this weapon will be restricted to seasons when the live herbaceous fuel moisture, calculated by the Makua Range weather station, is 100 percent or greater, and furthermore, to periods when the burning index is 20 or lower and the fire danger is rated Green/Low as a result of high fuel moistures and/or light winds.

Current understanding of the guinea grass fire behavior in green grass and fire suppression capabilities of assigned aerial firefighting resources indicates that fires ignited outside the firebreak road when live herbaceous fuel moisture is 100 percent or greater are likely to be contained at sizes smaller than approximately 8 ha (20 ac). Estimated size of a fire still burning at 1 p.m. on a 97th percentile fire weather day is 58.3 ha (144 ac) (see Table PD 11). Therefore, no 2.75-caliber rockets will be fired until Kaluakauila, Kahanahaiki and Ohikilolo management unit perimeter fire protection systems are completed and expedited stabilization of 12 species is achieved. Our best understanding of fire behavior and helicopter fire suppression capability in forest fuels indicates that the assigned Makua suppression

helicopter staffing, designed to suppress fires in heavy guinea grass fuels, will be sufficient to suppress a fire ignited by this weapon in shrub or forest fuels at 0.12 ha (0.3 ac) or less, even if the fire ignites on a 60 percent slope, with upslope winds of 18 mph and 1-hour fuel moisture of six percent. If a 2.75-caliber rocket fire, ignited in local forest fuels were to burn undetected for 48 hours, it could grow to more than 40.5 ha (100 ac). One hour fire detection flights will be flown by the Army Wildland Fire Incident Commander, and, if there are multiple on-site helicopters, by additional firefighters, following the use of 2.75-caliber rockets. This fire detection plan appears to be sufficient to ensure that all fires ignited in forest areas that are not visible from the Range Control tower are immediately detected and suppressed.

Mines and Simulators On March 18, 1998, a grenade simulator ignited a fire outside the firebreak road in the vicinity of Lower Ohikilolo, burning 20.2 ha (50 ac) inside and outside the firebreak road. Three helicopters (a Ch-47, a Ch-53 and a UH-60) dropped 50 bucket drops on the fire during the 3 hour and 50 minute suppression period.

TOW Malfunction rate information for the TOW is limited. Data published by Redstone Arsenal for airborne TOW missiles fired in combat in 1972 and 1973 indicates that 82 percent of TOW missiles hit their targets, seven percent malfunction (http://www.redstone.army.mil/history/tow/tow_chronology.htm.). TOW use will be limited to periods when live herbaceous fuel moisture is 100 percent or greater, limiting the use of the TOW to the three to seven month wet part of the year. Although the TOW missile is inert, the rocket motor may still be hot enough to ignite a fire when it lands. Current understanding of the guinea grass fire behavior in green grass and fire suppression capabilities of assigned aerial firefighting resources indicates that fires ignited outside the firebreak road when live herbaceous fuel moisture is 100 percent or greater are likely to be contained at sizes smaller than 8 ha (20 ac). Estimated size of a fire still burning at 1 p.m. on a 97th percentile fire weather day is 58.3 ha (144 ac) (Table PD 11). Therefore, no TOW missiles will be fired until Kaluakauila, Kahanahaiki and Ohikilolo management unit perimeter fire protection systems are completed and full stabilization of 12 species is achieved. Our best understanding of fire behavior and helicopter fire suppression capability in forest fuels indicates that the assigned Makua suppression helicopter staffing, designed to suppress fires in heavy guinea grass fuels, will be sufficient to suppress a fire ignited by this weapon in shrub or forest fuels at 0.12 ha (0.3 ac) or less, even if the fire ignites on a 60 percent slope, with upslope winds of 18 mph and 1-hour fuel moisture of six percent. If a TOW fire, ignited in local forest fuels were to burn undetected for 48 hours, it could grow to more than 40.5 ha (100 ac). One hour fire detection flights will be flown by the Army Wildland Fire Incident Commander and, if there are multiple on-site helicopters, by additional firefighters, following the use of TOW missiles. This fire detection plan appears to be sufficient to ensure that all fires ignited in forest areas which are not visible from the Range Control tower, are immediately detected and suppressed. If a TOW fire occurs in the shrub/forest vegetation, the proposed fire detection and fire suppression staffing protocols will minimize the risk of damage by fire.

AT-4 / SMAW Two of the four recorded fires resulting from AT-4 use at Makua were located outside the firebreak road (Beavers et al 1999) (see Figure E 1). All four fires

occurred in July or August when live herbaceous fuel moisture was likely to have been low. Fire sizes ranged from 0.004 ha (.01 ac) to 1.2 ha (3 ac) and were suppressed with between zero and two Blackhawk helicopters. Between 2001 and 2004, a total of 18 AT-4 rounds were fired in Makua (U.S. Army, unpublished fax, July 2004) and only one 2 by 2 m (6.6 by 6.6 ft) fire occurred (G. Enriques, U.S. Army Garrison, pers. comm. 2006). By restricting use of the AT-4 to periods of low fire danger when live herbaceous fuel moisture is less than 100 percent, the Army is minimizing the risk that use of this weapon will result in a large fire outside the firebreak road.

Grenades An MK-19 round ignited a fire outside the firebreak road on June 26, 1993, when fire danger was in the Red. Three helicopters suppressed the fire at approximately 2 ha (5 ac). There are no records of an M79 or M203 causing fires (Beavers et al 1999). To minimize the risk of a large fire outside the firebreak road, only inert MK19 practice rounds will be fired at Makua when live herbaceous fuel moisture is lower than 100 percent. Live MK19 rounds may be used during periods when live herbaceous fuel moisture is 100 percent or higher, and after management unit fuelbreaks and expedited stabilization of three endangered plant species is completed. Fire acreages are expected to be relatively small under these higher live herbaceous fuel moisture conditions (see Table PD 11).

Historic Fires Escaping Initial Attack

Four large fires not directly associated with live-fire training, but according to fire reports ignited within the military reservation, have burned the Makua Valley (Figure E 3).

On August 5, 1970, a cigarette caused a fire that burned 617 ha (1,525 ac) within and to the north of Makua Valley (Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife Fire Records 1970). According to Pat Costales (Hawaii Department of Land and Natural Resources, pers. comm. 2006), suppression forces battling the 1970 Makua fire were limited to ground forces. This fire was suppressed when it reached accessible areas.

According to State of Hawaii fire records (Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife Fire Records 1984), at 3:00 p.m. on May 16, 1984, a fire was observed burning in the vicinity of the observation tower near Farrington Highway at Makua. The fire record indicates that no action was taken to suppress this fire until 8:20 the following morning. The fire burned into the intact shrub vegetation (Costales, Hawaii Department of Land and Natural Resources, pers. comm. 2007). GIS interpretation of the fire perimeter indicates that the final fire size was 704 ha (1,740 ac). According to weather records maintained by Glenn Shishido (Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife, Forest Management Supervisor, Maui District) and Pat Costales, May 1984 was likely a drought period at Makua. A strong El Niño event in 1983, followed by a developing La Niña event, appeared to have resulted in a lack of winter rains in early 1983 over much of the State (P. Costales and G. Shishido, Hawaii Department of Land and Natural Resources, pers. comm. 2006). Live herbaceous fuel moisture data for the Kahului Airport area on Maui, which receives similar annual average rainfall totals to Makua Valley, suggests that live herbaceous fuel moisture was below 60 percent in May 1984 (G. Shishido, pers. comm. 2007). To ensure that fires do not burn under the worst

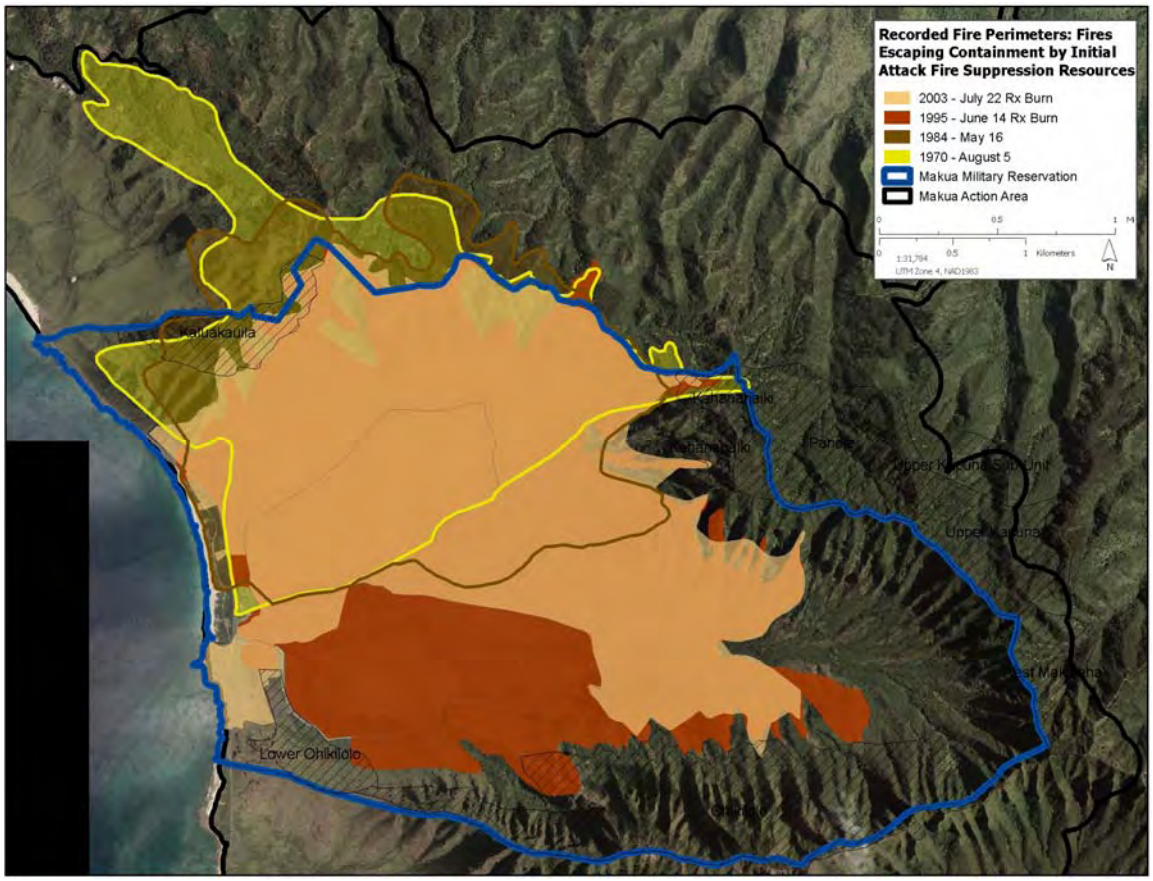


Figure E 3. Recorded perimeters of four fires that escaped initial attack fire suppression resources at Makua.

drought conditions when shrubs would be more susceptible to burning, all live-fire training will be restricted to periods when live herbaceous fuel moisture is 60 percent or higher.

We have records for four prescribed burns conducted by the Army at Makua that escaped containment. Records indicate that three of them were conducted in a manner inconsistent with the prescribed burn plans that were agreed to by the Service during the Section 7 consultation process. A short description of each burn is outlined below.

Beavers et al (1999) cite the cause of the August 11, 1987, fire at Makua as a prescribed burn escape. No additional information about this fire is recorded.

On April 18, 1990, the Service received a letter from the Army requesting initiation of formal consultation for the implementation of a controlled burn in Makua Valley. A burn (or burns) was conducted in early July 1992, outside the fuelbreak roadway system to expose the ground to facilitate the work of Army engineers and planners who were extending the outer firebreak road system. The fire(s) escaped control and burned up several lower-elevation side ridges. According to our August 21, 1992 letter to the Army, the proposed burns were supposed to be conducted within areas encircled by a network of firebreaks. No fire report or map is available for this fire.

On May 16, 1995, the Service received Prescribed Fire Plan 95-1 for Makua outlining procedures that would be followed for burning an area outside the firebreak road, utilizing chemical retardant as a fireline. Two helicopters were required to be on-site during the prescribed burn of Area C, with one helicopter on standby at Wheeler Army Airfield (Army 1995). On June 2, 1995, the Service concurred with the Army's determination that the prescribed burn was not likely to adversely affect listed species. On June 14, 1995, after areas inside the firebreak road had been successfully burned utilizing Prescribed Fire Plan 95-1, Area C, on C-Ridge, outside the firebreak road, was burned. The retardant was not substantial enough and the fire crept through the line in several places (D. Bowen, Service, pers.comm. 1995). The upper dip site had not been completed when this fire escaped. Service employees who witnessed the prescribed burn believe that with trained pilots and on-site fire suppression helicopter fueling at Makua, this prescribed burn may not have escaped (D. Bowen, Service, pers.comm. 1995). They also recommended that future burns be conducted during the rainy season instead of the driest time of the year (D. Bowen, pers. comm. 1995). The inexperience and insufficient number of fire suppression helicopters contributed to this fire escape. GIS analysis of the digitized fireline presented in the U.S. Army fire report indicates that the fire burned approximately 998 ha (2,465 ac) (Figures E 3 and E 4). On August 9, 1995, the Service provided the Army with a letter documenting impacts of the escaped prescribed burn to endangered *Lipochaeta tenuifolia* (now *Melanthera tenuifolia*) (fewer than 20 plants burned), *Lobelia niihauensis* (one or two may have burned), *Neraudia angulata* var. *angulata* (one plant burned), *Nototrichium humile* (approximately 90 plants burned), and *Tetramolopium filiforme* (approximately 20 plants burned) individuals. No prescribed burns outside the firebreak road are proposed in the current Project Description.

Figure E 4. Service photographs taken after the 1995 escaped prescribed burn (Service, 2005).

On November 25, 2002, the Service received a letter from the Army requesting initiation of formal consultation for the implementation of a prescribed burn at Makua described in The Environmental Assessment for a Prescribed Burn at Makua Island of Oahu, August 2002 (U.S. Army Garrison 2002). The Service reviewed the prescription parameters and determined that the burn was not likely to adversely affect listed species. On July 22, 2003, a prescribed burn being conducted inside the north lobe of the firebreak road at Makua escaped to burn a total of 850 ha (2,100 ac) (U.S. Army Garrison, Army Natural Resources, August 2003). Approximately 60.7 ha (150 ac) of unoccupied Oahu elepaio critical habitat on Army

lands at Makua and approximately 2.4 ha (6 ac) of plant critical habitat on State land were burned in this fire (Figures E 3 and E 5).

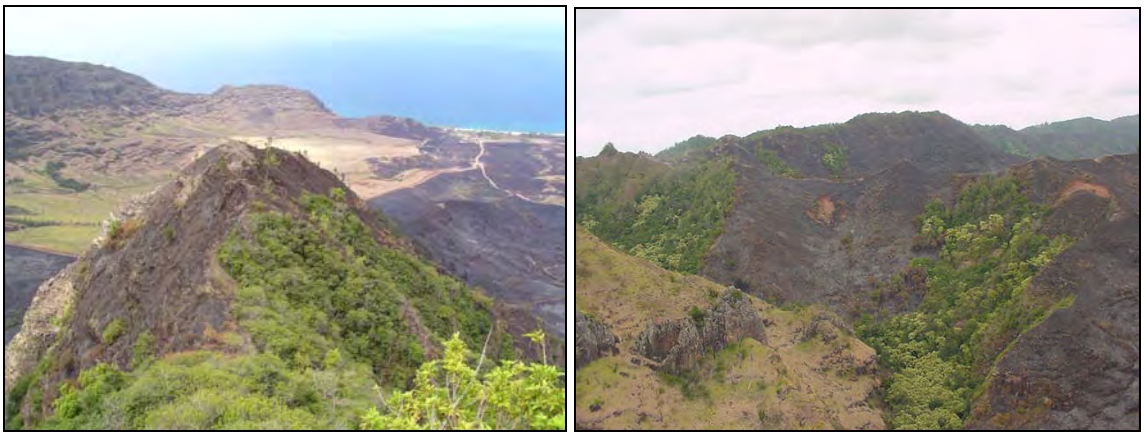


Figure E 5. Areas burned by the 2003 escaped prescribed burn (Army Natural Resources, August 8, 2003).

The July 22, 2003 prescribed burn was conducted on a day when weather conditions were predicted to be outside the limits specified in the 2002 Prescribed Burn Environmental Assessment (U.S. Army Garrison 2002) for temperature, relative humidity, 1-hour fuel moisture, and wind speed (Table E 3). The prescribed burn escaped containment by initial attack resources and burned at least 37 *Chamaesyce celastroides* var. *kaenana,* 29 *Melanthera tenuifolia* (*Lipochaeta tenuifolia)*, and five *Nototrichium humile* individuals (U.S. Army Garrison, 2003).

Table E 3. Conditions on July 22, 2003, were not forecasted to be in prescription for burning based on the prescription in the 2002 Prescribed Burn Environmental Assessment (U.S. Army Garrison 2002).

Weather and Fuel Moisture Parameters: Prescribed, Forecasted, and Observed: Makua Prescribed Burn July 22, 2003.	**Prescription USFWS Consultated on and Agreed to (2002 EA)**	**Spot Weather Forecast ***	**Actual Observed Weather at Makua Range Wx Station ****
Temperature (Degrees F)	**65-85**	**HI NEAR 90**	**82-87**
Relative Humidity (%)	**50-80**	**MIN 45-50**	**43-52**
1-hour fuel moisture (%)	**10-20**	**7**	**6**
Eye-Level Wind (mph)	**0-10**	**15-20**	**1.5 - 8**
20-ft wind (mph)* **	**0-20**	**30 - 40**	**3 - 16**
*** National Weather Service (unpublished)**			
**** Western Regional Climate Ctr http://www.wrcc.dri.edu/wraws/hiF.html**			
**** Assumes eye level wind = 20-foot wind x 0.5 wind adjustment factor**			

On the day of the burn, the Army's Burn Boss appears to have been operating under a prescribed burn plan containing prescription parameters different than those specified in the 2002 Prescribed Burn EA. On August 4, 2003, the U.S. Army Burn Boss provided the Service with a briefing package (U.S. Army Garrison 2003b), in which he presented the prescription he had used on the July 22 burn (Figure E 6).

FIRE PRESCRIPTION:

	HOT (Dry)	DESIRED RANGE	COOL (Wet)
Dry Bulb Temp (F°)	85	55-90	65
Relative Humidity (%)	40	50-80	60
1-Hour Time Lag (%)	5	7-25	20
10-Hr Time Lag (%)	N/A		
100-Hr Time Lag (%)	N/A		
Mid-Flame Wind Speed	10mph	2-15mph	

Figure E 6. Image from Army handout (U.S. Army Garrison, August 4, 2003).

The Service and the Army recognize that the specifications of prescribed burn prescriptions are technical. Beginning in November 2006, the Army has invited a Fish and Wildlife Biologist with Prescribed Fire Burn Boss qualifications to each Army prescribed burn to assist the Army's Burn Boss with fire weather and suppression resource tracking. Since November 2006, two prescribed burns occurred at Makua (March 9, 2006 and December 6, 2006), and both burns were conducted in accordance with the agreed upon prescriptions (D. Greenlee, Service, pers. comm. 2006).

The Army provided the Service with a summary of additional factors which contributed to the escape of the 2003 prescribed burn. According to Army Fire Chief Gayland Enriques (pers. comm. 2005), a spot fire that ignited outside the firebreak road a short distance from an engine was not successfully suppressed by the engine crew and the two on-site Blackhawk fire suppression helicopters. A diurnal wind shift that was not mentioned in the Spot Weather Forecast, appears to have caught the Army fire managers by surprise and, in conjunction with their firing pattern, appears to have contributed to multiple areas of fire spread within the burn unit and multiple spot fires outside the firebreak road (Honolulu Advertiser 2003; G. Enriques, pers. comm. 2005; M. Mansker, U.S. Army, pers. comm. 2006). At a point when the spot fires were almost contained, the helicopters ran low on fuel and had to leave the fire to return to Wheeler Army Airfield for fuel. A CH-47 responded from Wheeler Army Airfield to assist with the suppression effort, but poor communications slowed the helicopter's response time (G. Enriques, pers. comm. 2005).

Analysis of Fire Risk

Fire risk zones were delineated to assign the baseline risk to endangered species and critical habitat occurring within the action area in the absence of the new firebreaks and fuelbreaks and skilled application of new Makua fire suppression staffing guidelines.

High Fire Risk Zone We designated the area mapped within the perimeter of historic wildland fires (see Figures E 1 and E 3) as the high fire risk zone (Figure E 7). There is a

greater risk that endangered plants growing within this zone will be burned within the next 30 years, unless they are located behind protective firebreaks and fuelbreaks.

Figure E 7. Fire risk zones within Makua action area.

Low Fire Risk Zone Fires ignited within grass areas in Makua Valley may grow large enough to burn into existing forest vegetation outside of the perimeters of historic wildland fires. This may occur for several reasons: (1) fires unrelated to training, (e.g., fires caused by remnant white phosphorus rounds may occur when the range is not staffed by fire suppression forces); (2) fires occurring outside the firebreak road when live herbaceous fuel moisture is less than 100 percent may have large acreages in high wind conditions; (3) a level of fire suppression equipment malfunction and human error that is not factored into fire suppression staffing requirements may result in larger fires than anticipated. These factors put endangered species and critical habitat adjacent to the high fire risk zone at risk of burning.

In some areas of the valley, the forest – grass ecotone does not appear to have shifted since 1977 (the earliest available aerial photograph), however, in specific areas of the valley, these escaped fires resulted in conversion of forested areas to grassland. The northeastern edge of Kaluakauila is one area where this loss of forest occurred (Figures E 8 and E 9).

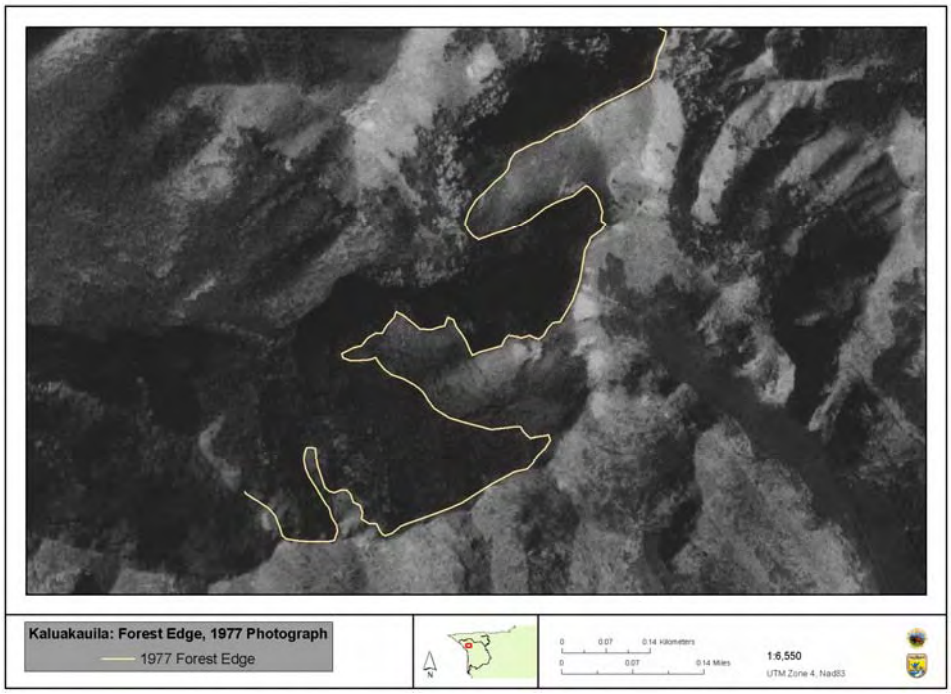


Figure E 8. Kaluakauila forest edge in 1977.

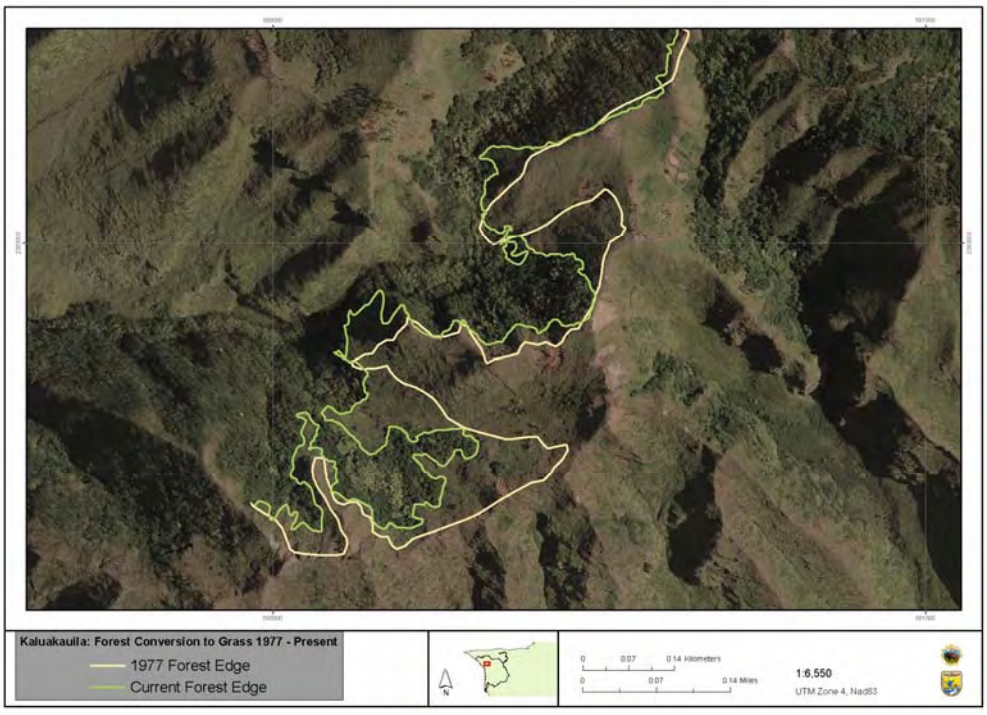


Figure E 9. Kaluakauila forest edge today, compared with its location in 1977.

We do not have a model that adequately predicts the locations of the actual future patches of habitat loss within the low fire risk zone. To delineate the area where the potential impact could occur, we ran a FARSITE fire spread model using three of the worst weather periods on record since 1999 (Aug 3-5 2000, Aug 9-11 2000 and Aug 17-19 2003) to predict the maximum extent of spread for fires from three ignition points within the valley burning for 48 hours. The outer perimeter of the compilation of all FARSITE simulations was designated as the outer perimeter of the low fire risk zone (Figure E 10).

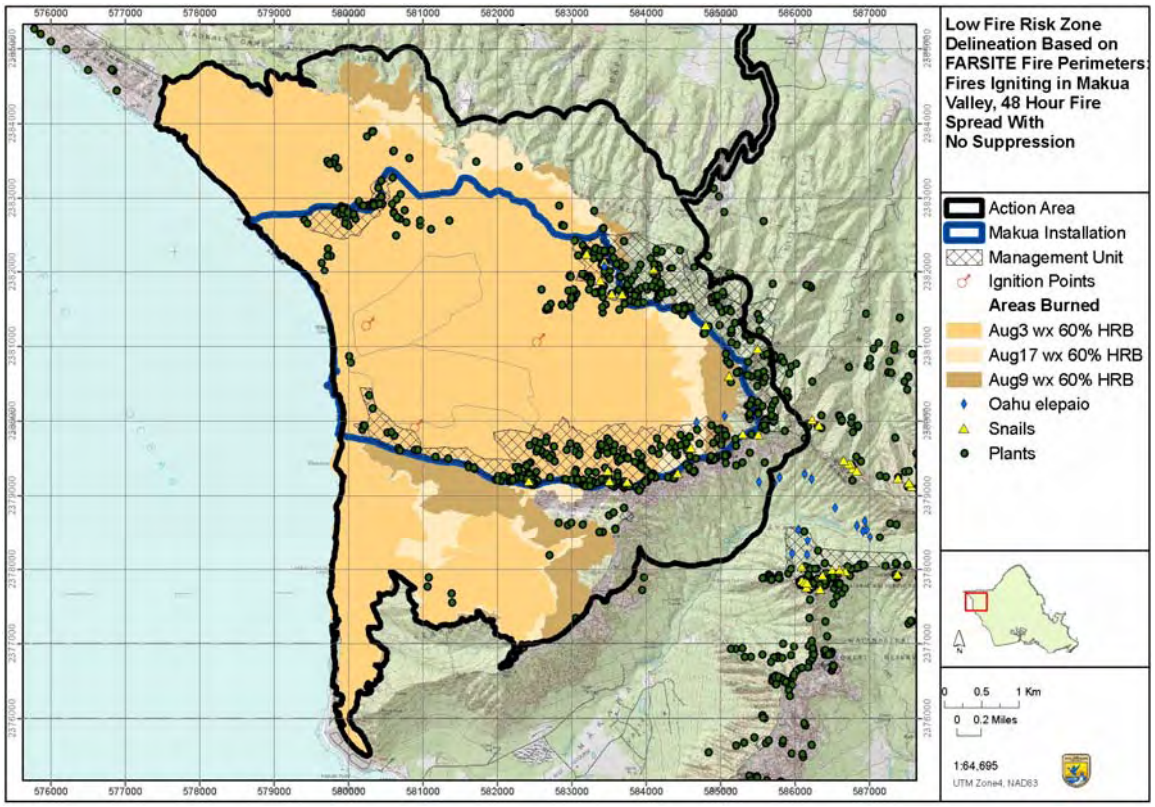


Figure E 10. Low fire risk zone delineation was based on the perimeter of fires burning in FARSITE for 48 hours with no suppression.

It should be noted that discontinuous and patchy fuels growing on rocky cliffs are poorly represented on the two dimensional, rough scale fuel model map. Therefore, FARSITE overpredicts rate of spread in cliff areas such as the cliffs in Ohikilolo Management Unit, where vertically discontinuous fuels will preclude fire spread. Locations of endangered species and patches of critical habitat growing in small protected areas such as cliffs are analyzed in relation to their individual fire risk in the effects analysis section. Plants growing on rock cliffs with discontinuous fuel are at risk of being burned by fires caused by weapons capable of landing directly on the site where the individual occurs. Grass fuels were assumed to not be grazed. Grazing is likely to limit fire spread in many patches of fuel in the areas south of the Makua.

Very Low Fire Risk Zone and Action Area Determination The Javelin and TOW both have the potential to land outside the Makua installation boundary, and spot fires from fires inside the valley may be ignited approximately 1.3 km (0.8 mi) from the fire front (Table E 4). Although the TOW carries an inert concrete warhead, remnant heat from the propellant burning in its motor can ignite a fire when the errant warhead impacts. The area where the errant TOW missiles are expected to land is bounded by the TOW surface danger zone. The chance of the TOW falling outside this area is less than 1:1million. A 1:1 million surface danger zone is also defined for the Javelin impact areas. To determine the area that may be burned by a fire ignited by a malfunctioning or misfired TOW or Javelin, FARSITE was run using the same three periods of wind and weather data as in the previous section, but because the TOW and Javelin will not be fired unless live herbaceous fuel moisture is 100 percent or higher, the following live fuel moistures were used for these simulations: 150 percent (fuel models 161, 182, and 188), 110 percent (all other fuel models). Fires were ignited along the entire outer perimeters of the TOW and Javelin potential ignition areas and allowed to grow, with no suppression, for 48 hours (Figure E 11).

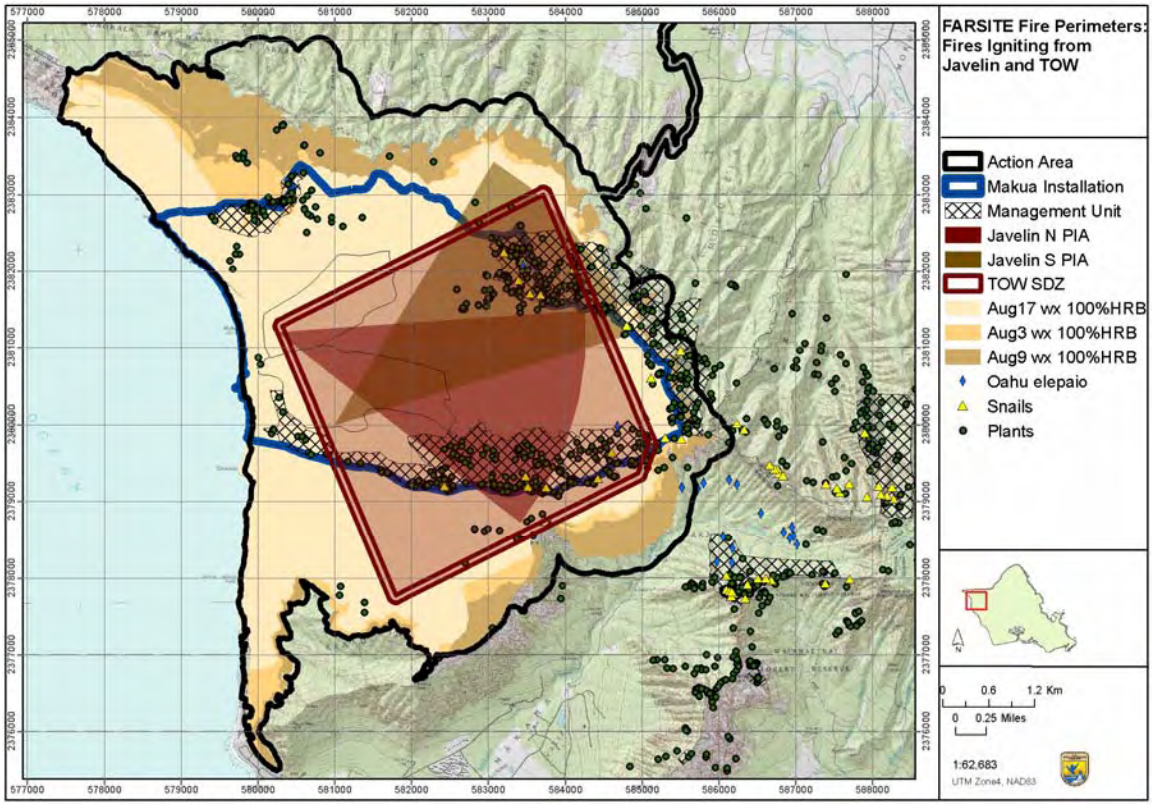


Figure E 11. Very low risk fire zone, based on areas burned after 48 hours in FARSITE simulations from fires ignited along the perimeters of Javelin and TOW potential ignition areas.

The very low fire risk zone and the outer perimeter of the action area were delineated by adding a 200-m (656-ft) buffer to the perimeter of the areas burned in the FARSITE simulations in areas that have not already been converted to grasslands to account for the future “creep” zone which may occur if forested areas are not restored prior to a subsequent fire event (see Figures E 8 and E 9). If grass invasion is not controlled in a burned site, a

subsequent fire will burn a larger area, burning the forested area on the other side. This additional area also corresponds to the maximum spotting distance (the maximum distance a firebrand may be expected to ignite a fire given west wind conditions and a large fire burning within the heavy grass fuels in high fire risk zone).

Measures to Minimize Fire Risk

Prescribed Burning Risk Minimization Measures Burns conducted in conformance with the specifications outlined in the Makua 06-03 Prescribed Burn Plan will not occur when live herbaceous fuel moisture is lower than 100 percent. Fire behavior in guinea grass appears to be a factor of the greenness, or live herbaceous fuel moisture, of the grass. Although the layer of dead grass in the understory can support fire spread year-round (P. Costales, pers. comm. 2006), fire behavior appears to be substantially reduced during periods when the standing grass contains a substantial component of green leaves with high moisture contents. Much of the heat of any fire burning through a stand of green grass is absorbed by the water in the grass, slowing the rate of fire spread. Guinea grass growth and grass greenness appear to be closely related to soil moisture. Consequently, during wet months a high proportion of the standing grass leaves are green and the fuel moisture in those green leaves is high. During dry summer months only a few of the leaves in the grass stand are green and the rest of the leaves are either standing dead or they are alive but with very low fuel moisture contents. In the summer, when the majority of the stand is brown, this plant appears to produce a few fresh, green leaves following substantial rainfall events. The WIMS uses the NFDRS algorithm for calculating live herbaceous fuel moisture based on precipitation.

This live herbaceous fuel moisture stipulation has been applied successfully to two burns at Makua since March 2006 (March 8 and December 6, 2006; Figure E 12). In preparation for both of these burns, the vegetation in the burn unit was pre-treated with herbicide so that it would carry fire more readily under the cooler burning conditions specified by the prescribed burn prescription. Although the herbicide pre-treatment is not compulsory, in instances where the objective is a clean, continuous burn pattern, herbicide may be used to ensure that burn treatment objectives can be met.

Figure E 12. March 8 (left) and December 6, 2006 (right), burns conducted when live herbaceous fuel moisture outside the burn unit was greater than 100 percent and grass inside the burn unit (left center in both photos) had been pre-treated with herbicide.

The Makua 06-03 Prescribed Burn Plan specifies various 1-hour fuel moisture cutoff levels, depending on live herbaceous fuel moisture and fire suppression helicopter staffing. The probability of a firebrand igniting vegetation, given that it is generated, remains lit, and lands on receptive fuel, varies as a function of 1-hour fuel moisture. Long-range spotting may occur on prescribed burns or wildfires when convection columns loft burning embers from shrubs long distances (Table E 4).

Table E 4. Firebrand Probability of Ignition in Relation to One-Hour Fuel Moisture Percent and Long-Range Spotting Distance at Various Wind Speeds.

1-hour Fuel Moisture %	Firebrand Probability of Ignition *
4%	79%
5%	69%
6%	61%
7%	53%
8%	46%
9%	40%
10%	35%
11%	30%
12%	26%
13%	22%
14%	19%
15%	16%
16%	14%
17%	12%
18%	10%
19%	8%
20%	7%
* Assuming zero shading and 95 degrees F	

20-foot wind speed (mph)	Maximum Spotting Distance	
	(Miles)	(Meters)
0	0 mi	0 m
2	0.1 mi	161 m
4	0.2 mi	322 m
6	0.3 mi	482 m
8	0.3 mi	482 m
10	0.4 mi	644 m
12	0.5 mi	805 m
14	0.5 mi	805 m
16	0.6 mi	965 m
18	0.7 mi	1126 m
20	0.8 mi	1287 m

The Makua 06-03 Prescribed Burn Plan specifies an appropriate Maximum Manageable Area for spot fire occurrence. The burn plan is designed to prevent a spot fire from burning within any area of designated critical habitat or within any management unit (Figure 7 in Appendix D). The Makua 06-03 Prescribed Burn Plan specifies that if a spot fire burns any area of designated critical habitat or any shrub or forest area within a management unit, the site will be restored pursuant to the specifications required for restoration of a training-related fire in these areas. The prescribed burn plan is limiting the risk of spot fire occurrence by limiting ignitions to periods when live herbaceous fuel moisture is 100 percent or greater.

The plan specifies adequate on-site and standby fire suppression helicopter response to contain spot fires so that they will not burn into management units or designated critical habitat areas. The maximum spot fire size predicted by the CONTAIN module of BehavePlus for a fire burning in heavy guinea grass fuels on a 60 percent slope with an upslope wind under prescribed weather conditions is 36 ha (88 ac).

To avoid having multiple fire fronts within the burn unit, in 2006, the Army began implementing firing sequences, which enables the burning portion of the unit to be partitioned from the unburned area with aerial water drops if conditions become unfavorable. In 2006, pursuant to a recommendation by the Service, the Army began requesting more detailed spot weather forecasts from the National Weather Service. Spot weather forecasts received by the Army in 2006 included forecasted conditions for each hour of the burn day and included a narrative of expected diurnal wind shifts (N. Rydelle, National Weather Service, pers. comm. 2006).

A new internet and telephone system has been installed at Makua. During prescribed burns, internet and telephone lines are set up in a command post so that fire personnel have direct communications with contingency helicopter dispatchers. The Army is able to provide all personnel on prescribed burns with Army radios, so that local radio communications among interagency resources are excellent. However, the Makua area does not appear to be serviced by a repeater, so radio communications between the Makua area and the Garrison Command Center is incomplete (K. Kawelo, pers. comm. 2006).

Live-Fire Training Fire Risk Minimization Measures Weapons restrictions based on the burning index are expected to reduce the risk of wildland fire associated with the use of various weapons systems at Makua, in comparison with historic fire risk. Data analysis conducted by the Army indicates that the burning index frequency distribution varies with climate patterns such as El Niño and La Niña. Burning index data for January through August 2006 is shown in Table E 5. February and March 2006 were wet months and fire danger was low on a high percentage of hours on many days of these months. Table PD 3 in the Project Description summarizes actual range use anticipated, given the weapons restrictions which will be applied.

Table E 5. Frequency Distribution of Green, Yellow, and Red Fire Danger Ratings at Various Times of Day in January through August 2006.

Green/Yellow/Red Burning Index at Makua January - August 2006								
	Percent of Days							
Time	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
6:00 AM	37%	43%	90%	43%	30%	37%	17%	13%
	50%	43%	13%	57%	73%	57%	73%	70%
	17%	7%	0%	0%	0%	7%	13%	20%
9:00 AM	33%	33%	90%	23%	17%	3%	3%	0%
	47%	47%	13%	73%	60%	63%	53%	47%
	23%	13%	0%	3%	27%	33%	47%	57%
1:00 PM	10%	27%	70%	10%	10%	0%	3%	0%
	53%	43%	33%	67%	43%	53%	33%	43%
	40%	23%	0%	23%	50%	47%	67%	60%
6:00 PM	20%	40%	83%	10%	7%	0%	10%	3%
	50%	40%	20%	87%	57%	37%	30%	33%
	33%	13%	0%	3%	40%	63%	63%	67%
9:00 PM	23%	27%	87%	27%	17%	7%	13%	7%
	57%	50%	17%	73%	77%	77%	57%	67%
	23%	17%	0%	0%	10%	17%	33%	30%
1:00 AM	37%	37%	97%	50%	33%	10%	13%	13%
	53%	43%	7%	47%	67%	80%	67%	73%
	13%	13%	0%	3%	3%	10%	23%	17%

Although 2006 had a very wet spring, the data indicates that unless it is raining, the occurrence of Green fire danger rating conditions is very limited in the summer and in the afternoons in the winter.

On-site and 1-hour standby fire suppression helicopter staffing is sufficient to suppress fires under 97th percentile fire weather conditions (Table E 6 and see Table PD 11), even though no training will be occurring on the days with the highest fire danger. Analysis of historic fire danger archives and FireFamily Plus calculations for summer conditions (live herbaceous fuel moisture lower than 100 percent) indicates that, on approximately 37 to 50 percent of those 97th percentile fire weather days, the fire danger rating calculated for all hours of daylight were Red. Therefore, we anticipate the Incident Commander will need to dispatch the contingency (two-hour response time) helicopters on only one and a half percent of the training days.

Analysis of the 34 recorded training-related fires that have burned outside the firebreak roads at Makua indicates that it took an average of 53 minutes to suppress fires ignited in Green fire danger conditions and an average of 2 hours and 16 minutes to suppress fires ignited under Yellow fire danger conditions. Therefore, when staffing fire suppression aircraft for training exercises at Makua, staffing will be based on wind speeds predicted during the

training period as well as during periods following training, to ensure that fire suppression staffing is sufficient to suppress a fire ignited at the end of the training period.

Table E 6. Frequency Distribution of Makua Fire Weather conditions at 1 p.m. in the Winter and Summer.

November through March, 1 p.m. 1-hour fuel moisture and wind speed Joint Probability (%) for all available 1999 - 2006 Weather Data, Fire Danger Rating Colors Based on Live Herbaceous Fuel Moisture 100%, Live Woody Fuel Moisture 100-170%						
20-ft wind	1-hour fuel moisture					
	< 6%	6-7%	7-9%	9-11%	11-13%	>13%
0-1 mph	0.00%	0.00%	0.00%	0.11%	0.00%	0.00%
1-3 mph	0.11%	0.11%	0.86%	1.40%	0.54%	0.11%
3-5 mph	0.65%	1.83%	7.63%	5.05%	0.75%	0.54%
5-7 mph	0.65%	2.15%	15.81%	6.24%	0.32%	0.43%
7-9 mph	0.54%	2.26%	9.14%	3.01%	0.65%	0.86%
9-11 mph	0.00%	1.61%	5.70%	3.12%	0.11%	0.00%
11-13 mph	0.11%	0.97%	4.09%	2.04%	0.43%	0.43%
13-15 mph	0.43%	1.83%	4.62%	1.18%	0.43%	0.22%
15-17 mph	0.32%	1.08%	3.01%	0.86%	0.75%	0.22%
17-18 mph	0.00%	0.43%	0.75%	0.43%	0.11%	0.00%
18-19 mph	0.00%	0.11%	0.32%	0.22%	0.00%	0.11%
> 19 mph	0.00%	0.32%	0.97%	0.75%	0.22%	0.00%

June through September, 1 p.m. 1-hour fuel moisture and wind speed Joint Probability (%) for all available 1999 - 2006 Weather Data, Fire Danger Rating Colors Based on Live Herbaceous Fuel Moisture 60%, Live Woody Fuel Moisture 60-130%						
20-ft wind	1-hour fuel moisture					
	<6%	6-7%	7-9%	9-11%	11-13%	>13%
0-1 mph	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1-3 mph	0.00%	0.00%	0.81%	0.48%	0.16%	0.16%
3-5 mph	0.00%	0.32%	1.94%	1.45%	0.48%	0.16%
5-7 mph	0.00%	1.62%	11.79%	4.52%	0.97%	0.48%
7-9 mph	0.48%	2.91%	14.54%	3.23%	0.32%	0.16%
9-11 mph	2.42%	3.07%	7.11%	2.58%	0.16%	0.16%
11-13 mph	2.10%	3.88%	5.01%	1.45%	0.48%	0.32%
13-15 mph	2.58%	3.72%	3.88%	0.97%	0.16%	0.32%
15-17 mph	1.29%	2.42%	3.39%	0.32%	0.00%	0.00%
17-18 mph	0.32%	1.29%	0.97%	0.32%	0.00%	0.00%
18-19 mph	0.65%	0.00%	0.48%	0.16%	0.00%	0.00%
>19 mph	0.16%	0.48%	0.32%	0.00%	0.00%	0.00%

Proposed weapons restrictions based on live herbaceous fuel moisture are expected to reduce fire ignitions as well as fire size and risk of fire escape. When live herbaceous fuel moisture is less than 100 percent, tracers, 2.75-caliber rockets, Javelin, and TOW missiles will not be used; AT-4 and SMAW will only be used in Green fire danger conditions; and prescribed burning will not be conducted. Historic analysis of live herbaceous fuel moisture trends indicates that live herbaceous fuel moisture is expected to be 100 percent and above on most days between approximately mid-October and mid-February and early-May. Fires outside the firebreak road are not expected to be larger than 40.5 ha (100 ac) when live herbaceous fuel moisture is 100 percent or higher (see Table PD 11). Summer fires may be much larger. To protect the management units from summer fires and weapons fires ignited well away

from the interior of the south lobe of the firebreak road a system of firebreaks and fuelbreaks adjacent to the management units and a pre-attack plan for staffing the management unit firebreaks with skilled firefighters during large fire events is included in the Project Description.

Sufficiency of Firebreaks and Fuelbreaks

Firebreak Roads The 60 meters of mown grass inside the perimeter of the south lobe of the firebreak road is expected to prevent all fires from slopping over the firebreak road and prevent most short-range spot fires from igniting fires outside the impact area. In the absence of spotting, the suggested firebreak width required to stop the head fire itself is approximately one and a half to two times the flame length (Byram 1959; Wilson 1988; Fogarty and Alexander 1999). Beavers recorded maximum flame lengths of 14 m (45 ft) in test burns at Schofield Barracks (Beavers 2001) in guinea grass with live herbaceous fuel moisture that FireFamily Plus calculations indicate were approximately 90 to 100 percent.

The onset of significant spotting activity is generally acknowledged to occur at fire intensities of approximately 1,500-2,000 kW/m (500-667 Btu/ft/s) (Taylor and Wendel 1964; Hough and Albini 1978; Hirsch et al 1979). Beavers' (2001) GRASS2 fuel model and the updated version of this fuel model (see Project Description Section 9) both indicate that under the proposed training conditions, guinea grass fire intensity is generally below this threshold under average daily burning conditions when live herbaceous fuel moisture is greater than 120 percent, and it is likely to exceed this threshold when live herbaceous fuel moisture is below 100 percent. Therefore, short-range spotting is expected to be common in fires when live herbaceous fuel moisture is below 100 percent. Long-range spotting up to approximately 1,288 m (0.8 mi) may occur, particularly under higher wind conditions on warmer days and on larger fires with developed convection columns. The presence of koa haole shrubs increases the likelihood of firebrands and spot fires. This shrub appears to colonize sites that are not burned or mowed frequently. Large firebrands will not be produced by a fire burning in the mowed grass area, and fire intensity and flame length will be substantially reduced (Fogarty and Alexander 1999).

Sixty meters (197 ft) separation between heavy grass fuels and koa haole shrubs is expected to minimize spot fire risk, based on the spatial distribution of short-range spot fires documented in guinea grass fires. Spot fires have been observed at the following distances in front of free-burning guinea grass head fires: many spot fires 15 m (50 ft), several spots approximately 30 m (98 ft), some spot fires as far as 50 m (164 ft) (D. Greenlee, pers. comm. 2007). Fuels are reduced to various widths adjacent to firebreaks to limit the number of spot fires igniting fires on the other side of the firebreaks. Wright (1974) recommends a 30 m (100 ft) wide fuelbreak in light rangeland grass fuels. Davis (1965) found that there is a 21 to 50 percent chance of stopping forest fires burning under extreme burning conditions with a 107-m (350-ft) wide fuelbreak and a greater than 50 percent chance of stopping them with a 305-m (1,000-ft) wide fuelbreak. Long-range spotting, resulting from larger firebrands lofted by large convection columns and by fires in high wind conditions, are predicted by BehavePlus (Table E 4). When large fires develop inside or outside the firebreak roads, long-range spotting may occur at Makua.

Kaluakauila Management Unit Protection The endangered species and designated critical habitats within the Kaluakauila Management Unit are within the high fire risk zone. There are only approximately 26 ha (65 ac) of shrub and forest vegetation remaining in this management unit. Five hectares (12 ac) of intact shrub and forest within the management unit perimeter appear to have been lost as a result of wildland fires between 1970 and 2006. The 1970 and 1984 wildland fire perimeter maps indicate that these fires burned around all edges of the intact forest in this area and 1995 and 2003 escaped prescribed burns both consumed shrubs along the perimeter of the intact forest in this management unit (see Figures E 8 and E 9). Accidental and arson fires ignited on State land adjacent to the beach below the management unit have burned into the lower portions of the site (U.S. Army 2006b). The management unit contains *Abutilon sandwicense* (22 plants, 8 percent of total), *Bonamia menziesii (*10 plants out of 28 on Oahu – thousands on other islands), 199 *Euphorbia haeleeleana* (31 percent of total), an *ex situ* population of *Hibiscus brackenridgei* ssp. *mokuleianus,*124 *Melanthera tenuifolia* (4 percent), 31 *Neraudia angulata* var. *angulata*, 230 *Nototrichium humile* (in addition to the 323 on south aspect outside management unit equals 553 (44 percent of total)), and *Schiedea hookeri* (92 plants, 22 percent of total, non-stabilization plant) and designated critical habitat for *Bonamia menzeisii*, *Chamaesyce celastroides* var *kaenana, Euphorbia haeleeleana, Nototrichium humile,* and *Schiedea hookeri*. A fire in the intact forest in this area would result in substantial losses.

Extraordinary measures will be necessary to ensure the future persistence of this patch of forest. The site is likely to be threatened by large Army-related fires and fires ignited by the public, particularly when live herbaceous fuel moisture is below 100 percent. The Army is proposing to prepare a 6-ha (15-ac), 20-m (66-ft) wide strategic fuelbreak with an integrated firebreak along the southern perimeter of the intact forest vegetation and to work with the State to establish and maintain fuelbreaks below the site. The ridge-top firebreak/fuelbreak combination is expected to halt the spread of fires burning up from Makua Valley, but spot fires are likely to ignite in the grass fuels north of the fuelbreak. The Service is relying heavily on the Army Incident Commander's recognition that this site requires the highest priority for assignment of fire suppression helicopter and ground resources. Representatives from the Service and the Army Wildland Fire Management Officer and wildland fire crew have visited Kaluakauila and worked closely to develop the plans in this Biological Opinion. The Army has hired skilled fireline supervisors and is developing supervisory skills within their crew to prepare them to supervise Kaluakauila Management Unit fire suppression operations. Helispots and safety zones will be established and maintained to ensure that rapid and safe deployment of fireline supervisors and firefighters to the site can be completed. Because of the small size of the forest patch (only approximately 1,000 m (3,280 ft) or 50 chains of exposed southern perimeter) compared with the substantial fire suppression helicopter staffing that will be assigned when live herbaceous fuel moisture is below 100 percent (i.e., 98 to 270 chains/hour assigned fire suppression capability), it will take all assigned fire suppression helicopters between 12 and 32 minutes to completely extinguish a fire threatening the southern edge of this forest if all helicopters were directed to protect this site. We believe that the measures proposed are appropriate and adequate to ensure the protection of the endangered species and critical habitats occurring within the Kaluakauila Management Unit from Army-related wildland fire.

Kahanahaiki Management Unit Protection The Army will be establishing a fuelbreak to reduce the risk of fire to the slopes below the Kahanahaiki Management Unit. However, because fire frequency is expected to be high in this area of the valley, and because the fuelbreak is not very wide (40 m;131 ft) and will be established mid-slope, spot fires may burn into areas designated as critical habitat for the Oahu elepaio and into sites where endangered species occur. The specific risk to particular individuals will depend on their location in relation to previously burned areas that have been converted to grass. Spot fires and fires ignited by Javelin and TOW missiles may also occur within intact forest vegetation. The perimeter of the site is only 500 m (1,640 ft) or 25 chains. Given that future Army Incident Commanders are expected to have a thorough understanding of the critical importance of minimizing fire impacts to this area, we anticipate that Incident Commanders will be able to ensure the protection of this relatively small area from substantial fire losses by strategically utilizing their assigned fire suppression helicopters.

The lower reaches of the Kahanahaiki gulch and the south aspect of the upper reaches of the gulch burned in the 1970, 1984, 1995, and 2003 wildfires. All of these fires except for the 1984 fire breeched the Kahanahaiki Management Unit perimeter in this gulch area. The Army will construct either a 20-m (66-ft) wide firebreak, or a 200-meter (656 ft) wide shaded fuelbreak on the south aspect of Kahanahaiki gulch at the Kahanahaiki Management Unit perimeter fence line. The perimeter firebreak and fuelbreak are both well-designed and located at the crest of a small ridge where they are likely to successfully halt the spread of fires. However, if a spot fire does burn into the area, much of the Kahanahaiki gulch area is on a north aspect with intact forest vegetation where firefighters can patrol to direct helicopter bucket drops and use hand tools to protect the forested areas and endangered plant sites from fire. A helispot will be maintained within 500 m (1,640 ft) of the upper reaches of Kahanahaiki gulch, and a safety zone will be established within or adjacent to the management unit so that skilled NWCG-qualified fireline supervisors and firefighters, including red-carded Army Natural Resources staff, can safely staff the outplanting site when fire threatens the gulch area. These efforts are likely to minimize losses of endangered species in the Kahanahaiki area.

Ohikilolo Cliffs Fire suppression helicopter staffing is sufficient to suppress a fire ignited by a TOW in shrub or forest fuels at 0.12 ha (0.3 ac) or less, even if the fire ignites on a 60 percent slope with upslope winds of 18 mph and 1-hour fuel moisture of six percent. If a TOW fire ignited in the shrub/forest fuels burns undetected for 48 hours, it could grow to more than 40.5 ha (100 ac). One-hour fire detection flights will be flown by the Army Wildland Fire Incident Commander and, if there are multiple on-site helicopters, by additional firefighters, following the use of a TOW missile. If a TOW fire occurs in the shrub/forest vegetation, the proposed fire detection and fire suppression staffing protocols will minimize the risk of damage and fire spread.

General Effects of Army Conservation and Stewardship Programs

Subsidies associated with the proposed action include measures to minimize project impacts through various aspects of the Makua Integrated Natural Resource Management Plan, Wildland Fire Management Plan, and Makua Implementation Plan Addendum. Implementation of the Integrated Natural Resource Management Plan and Wildland Fire Management Plan will reduce the exposure of listed resources to stressors associated with the ignition and spread of training-related wildfire. Implementation of the Makua Implementation Plan Addendum will benefit target taxa through habitat protection and restoration, control of invasive species, and augmentation and reintroduction of listed species in the wild. The response of listed resources will be an overall increase in baseline numbers due to increases in individual fitness and population unit viability. Fitness and viability will improve as a result of reduced fire injury and death; increased survival and regeneration due to reduced competition, predation, and herbivory; and increased numbers of target plant taxa due to outplanting. As a result, these programs will improve the likelihood that target taxa reach stabilization and enhance their probability of long-term persistence. It is the Service's biological opinion that the impacts of the proposed action would be of great concern over the next 30 years without implementation of the Army's conservation and stewardship programs.

The INRMP, Wildland Fire Management Plan, and Makua Implementation Plan Addendum are regular budget items for Army training at Makua. Therefore, the Service analyzes the effects of the proposed action based on the reasonable expectation that these proposed minimization measures will be successfully implemented. However, constraints associated with implementation of these programs could delay their effectiveness in protecting listed resources and stabilizing target taxa. For example, the effectiveness of the Wildland Fire Management Plan has not been tested under intensive training conditions with tracers and other long-range, high-fire-risk weaponry never before used at Makua (e.g., 155 mm high-explosive artillery, TOW missiles, Javelin missiles, and 2.75-caliber rockets). In particular, the Army's proposed improvements in firefighting capacity (e.g., increased numbers and effectiveness of on-site helicopters) do not guarantee that fire risk to listed resources will be eliminated. Reduction in wildfire ignition and spread may not succeed to the extent anticipated due to inadequate fuels management or revegetation of burned areas, for which the Army has not yet developed plans or schedules. Monitoring the results of Wildland Fire Management Plan implementation in reducing fire risk over the next 30 years will provide valuable information on the efficacy of these minimization measures.

Implementation of Addendum stabilization actions also does not guarantee that target taxa will be stabilized over a specified timeframe. Therefore, because of uncertainty regarding the timely success of project conservation and stewardship programs, the Service is unable to determine that target taxa will reach stabilization before a castastrophic wildfire occurs in the action area over the next 30 years. Expedited stabilization of the most at-risk plant taxa is intended to protect those taxa from jeopardy while long-term Wildland Fire Management Plan and Makua Implementation Plan Addendum actions are being implemented.

Burned Area Restoration

The Army has proposed that they will restore any portion of critical habitat that is lost during a training related fire event. This measure will offset the adverse impact to critical habitat due to fire. However, as previously discussed in other sections in this general effects section, alien plant species in Hawaii are aggressive, adaptable, numerous and can outcompete native plant species for space, light, and nutrients. It will be expensive and difficult to restore a burned area to pre-burn conditions but not impossible.

While habitat restoration poses many challenges, there have been successful restoration or "rehabilitation" projects in Hawaii. Thousands of acres of dryland forest have been lost to fire at Hawaii Volcanoes National Park during the last few decades. The park managers have had to address the loss of woodland tree species and the subsequent habitat degradation as non-native grasses replaced native tree species. To combat this problem, the managers adopted a rehabilitation approach to create a replacement community of fire-tolerant native plants that can survive and spread in the new grass/fire cycle. After a devastating burn (407.9 ha; 1,008 ac) in June 2000, a Burn Area Emergency Rehabilitation program started revegetating the area days after the fire. More than 15,000 plants and 3,000,000 seeds of 23 native species have been planted including thousands of mamane (*Sophora chrysophylla*) trees and alii (*Dodonaea viscosa*) shrubs as well as rare kookoolau (*Bidens hawaiensis*) and naupaka (*Scaevola kilaueae*) plants. By June 2003, the project goal will have planted 31 native species, including 15 fire-tolerant species that were established through a combination of direct seeding and outplanting into 850 plots across the entire burn area (Loh and Tunison 2002).

Another project on the island of Hawaii began in 1995 and included a study regarding the preservation and restoration of a Hawaiian tropical dry forest. This project is a 2.4 ha (6 ac) site on the dry slopes on the western side of the island and was infested with fountain grass (*Pennisetum setaceum*). After three years of herbicide spraying and hand removal of the fountain grass, signs of natural regeneration of native tree seedlings was evident (Allen 2000).

Integrated Natural Resource Management Plan

The Makua Integrated Natural Resource Management Plan specifies management of Army lands to ensure long-term natural resource productivity in support of the Army mission. The Integrated Natural Resource Management Plan incorporates an ecosystem-level approach to managing natural resources through inclusion of the ITAM, Range and Training Land, and Natural Resources programs. Integrated Natural Resource Management Plan activities also will indirectly expose listed resources in the action area to the introduction and spread of non-native, invasive plants through range revegetation and transport of weed propagules in vehicles, equipment and gear.

The ITAM program provides for the sustainable use of training lands by monitoring and remediating training impacts such as erosion and loss of vegetative cover. The ITAM program annually monitors the long-term carrying capacity of training lands, and prioritizes

and evaluates land rehabilitation projects (U.S. Army Corps of Engineers 2005). Erosion problems are caused by ground disturbance from training activities, including detonation of munitions, troop activities in the training impact area, and troop use of installation trails. Remediation includes mulching, controlling runoff, rotating land uses, and revegetating heavily-used training areas by reseeding and hydroseeding with rapidly growing plants (including non-native species). The exposure area for the ITAM program is located primarily within the training impact area within the firebreak roads. The proposed action does not include erosion remediation measures for troop use of State lands on the Kaena Point and Kuoakala Trails (U.S. Army Corps of Engineers 2005). Listed resources throughout the action area will not be directly exposed to ITAM activities. Indirect exposure to ITAM subsidies will result from firebreak maintenance and fuels modification, which will reduce the risk of ignition and spread of training-related wildfire.

The Range and Training Land program provides for operation and maintenance of military training ranges through weapons delivery and target management, and regulates access to training areas and ranges. Subsidies associated with the Range and Training Land program include Range Safety, which is responsible for developing surface danger zones for all weapons systems and munitions used at Makua. Surface danger zones are weaponry restrictions for personnel safety. The area directly exposed to the Range and Training Land program includes the training impact area within the firebreak roads, and surface danger zones that in some cases extend across the valley floor outside the firebreak roads. Listed resources throughout the action area will be indirectly exposed to Range Safety activities that reduce the risk of projectiles landing outside the firebreak roads through development and enforcement of surface danger zones and NFDRS conditions.

The Natural Resources program manages rare plants and animals and their habitats to ensure the Army is in compliance with the Endangered Species Act and other environmental laws and regulations. This program is beneficial as it improves conditions for listed resources primarily by reducing or removing their exposure to stressors associated with non-native invasive species. Other subsidies are associated with stabilization of target taxa through implementation of the Addendum to the Makua Implementation Plan. The Makua Implementation Plan Addendum also includes phytosanitation standards for greenhouse and outplanting operations, and for maintaining clean equipment and personal gear. The major subsidies associated with the Natural Resources program are described in the General Effects of Endangered Species -Stabilization section.

The proposed action includes troop education and vehicle/equipment/gear cleaning measures to minimize the exposure of listed resources to the introduction and spread of non-native species associated with Integrated Natural Resource Management Plan programs. Phytosanitation measures are emphasized for all personnel, including troops, maintenance crew, and Natural Resources Staff. Education brochures and briefings are given to troops and to road and range maintenance crews to increase awareness and reduce introduction of weed seeds. There are wash racks at Pohakuloa Training Area and Schofield Barracks Military Reservation for cleaning vehicles that leave those installations, but none for vehicles entering Makua. Some weed species identified at Makua apparently originated from Pohakuloa Training Area on the island of Hawaii and their introduction may have been

prevented by proper cleaning procedures. According to Army Natural Resources Staff, the provision of gear-cleaning infrastructure and use of phytosanitation procedures for military personnel at Makua is a "weak area" that "needs improvement" (U.S. Army Garrison 2005b).

General Effects of Endangered Species Stabilization

Stabilization Subsidies in the Makua Action Area

Project subsidies include existing and proposed conservation measures the Army will implement to stabilize 28 target endangered plant taxa and the Oahu tree snail *Achatinella mustelina*. Stabilization was the key component identified in the 1999 Makua consultation to minimize the impacts of military activities by increasing the baselines of target taxa, which otherwise would be jeopardized by military training in the Makua action area (Service 1999b, 2001b, 2004a). The Makua Implementation Plan incorporates stabilization objectives outlined in Service recovery plans, which are based on conservation actions recommended for recovery. The recovery plan goals are consistent with current conservation biology principles addressing the conservation of rare and endangered plants and animals (Ginzburg et al 1990; Menges 1990; Murphy et al1990; Karieva and Wennergren 1995; Taylor 1995; Tear et al 1995; Quintana-Ascencio and Menges 1996; Beissinger and Westphal 1998; Hendrix and Kyhl 2000; Luijten et al 2000; Burgman et al 2001; Podolsky 2001; Wolf and Harrison 2001; Groom et al 2006).

Achieving stabilization for target taxa will enable the Army to comply with the Endangered Species Act jeopardy standard by avoiding or minimizing actions that would reduce appreciably a species' likelihood of both survival and recovery in the wild. Conservation measures the Army proposes to implement for listed plants and tree snails in action area management units also will benefit primary constituent elements of designated critical habitat, in areas where management unit boundaries overlap those of critical habitat. The Service reasonably expects that achievement of stabilization, including expedited stabilization for 12 at-risk taxa, will protect affected species from jeopardy. We also expect the Army will fully fund the Makua Implementation Plan Addendum actions, including actions associated with expedited stabilization and implementation of the Wildland Fire Management Plan, in order to train intensively with new weaponry in compliance with the Endangered Species Act.

We have determined that the effects of stabilization actions will be beneficial to the 28 target plant taxa and the Oahu tree snail *Achatinella mustelina* in the action area, and to the conservation value of critical habitat areas for 36 plant taxa and for the Oahu elepaio that overlap the management units delineated for stabilization. Stabilization actions implemented for the 28 target plant taxa also will benefit individuals and occurrences of 11 non-target taxa where they occur in the management units. Conservation actions to achieve stable threshold numbers for target plant taxa include fencing to exclude non-native feral ungulates; control of non-native ungulates, rats, invertebrates, and plants; outplanting to augment and reintroduce target plant taxa; collection of material for *ex situ* plant genetic storage; and captive propagation of *Achatinella mustelina* tree snails. Specific stabilization actions are outlined in Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) to

the Makua Implementation Plan (Makua Implementation Team 2003). The Makua Implementation Plan was developed by the interagency Makua Implementation Team, which also monitors the Army's implementation of the plan and approves adjustments based on an adaptive management strategy.

In Hawaii, fencing to exclude ungulates is generally a prerequisite for restoration of native ecosystems (Cuddihy and Stone 1990; Scrowcroft and Conrad 1992; Stone et al 1992; Cabin et al 2000; Cabin et al 2002a). The response of native vegetation to ungulate exclusion appears to be related to many interacting plant, habitat, and microclimate variables, including the duration and intensity of prior habitat degradation (Stone et al 1992; Cabin et al 2002b). The proportion of native to non-native plant species, for example, remains low in lowland shrublands even after 13 to 15 years of recovery from goat damage. Few studies, however, have actually quantified the effects of ungulate exclusion on native plants. In the 2.3-ha (5.7-ac) Kaupulehu dry forest preserve on the island of Hawaii, for example, fencing has excluded feral ungulates for over 40 years. Vegetation is now more diverse, with a greater cover of native overstory and understory species. However, regeneration of native canopy trees such as *Diospyos sandwicensis* is poor because of dense fountain grass cover (*Pennisetum setaceum*) in the understory and predation by alien rodents (Cabin et al 2000; Cabin et al 2002a). Experience at Kaupulehu has shown that fencing alone is not sufficient to preserve native dry forest; ongoing control of non-native plants and animals is also needed for the regeneration and recruitment of native plants. Recovery of many Hawaiian ecosystems disturbed by ungulates will likely require ungulate exclusion, aggressive and continual alien plant management, lengthy recovery times, reintroduction of native plant species, and light and water supplementation where needed in dry forest zones (Stone et al 1992; Cabin et al 2000; Cabin et al 2002b).

Exclusion of feral ungulates may result in unintended adverse impacts to fire regimes in mixed native and non-native vegetation types. In some degraded dry habitats, the cover of alien grasses increases after ungulates are removed (Loope and Scowcroft 1985; Stone et al 1992; Blackmore and Vitousek 2000). For example, if grass cover is not controlled by grazing, fuel loads accumulate and may increase the possibility of catastrophic fire. Although cattle grazing in some mesic to seasonally dry forest habitats on the island of Hawaii resulted in less forest cover, it also protected the residual forest from fire by reducing fuel loads (Blackmore and Vitousek 2000). In addition, fire simulation models indicate fires are highly unlikely in grazed fuels (Blackmore and Vitousek 2000). Therefore, ungulate exclusion alone does not necessarily facilitate the recovery of native ecosystems threatened by alien grass fire regimes.

In the Makua action area, eight management units for ecosystem-level habitat management are located entirely or partially within the action area. Four management units on Makua proper are fenced (Kaluakauila, Lower Ohikilolo) or partially fenced (Kahanahaiki, Ohikilolo) and considered ungulate-free (U.S. Army Garrison 2006d). In addition, the installation boundary has been fenced along the east valley rim from the fenced Kahanahaiki subunit I to Ohikilolo. Partially within the action area outside of the installation boundary, the Pahole Management Unit is fenced and ungulate-free, but the Upper Kapuna, West Makaleha, and Kahanahaiki subunit II Management Units are not fenced. Fences also have

been constructed around some of the management units not immediately adjacent to the action area, for example, in the privately owned Honouliuli Preserve.

Army Natural Resources Staff believe the Makua installation is free of goats, due to lack of sign along transects, lack of recent snare captures, and incidental observations by staff and contract hunters (U.S. Army Garrison 2006d). The fenced Kaluakauila Management Unit still offers some access to feral pigs, which seem to increase in numbers there during the strawberry guava fruiting season. In the Ohikilolo Management Unit, goats have contributed to serious erosion problems in the past. A perimeter fence at the installation boundary protects this management unit from large populations of feral goats in the adjacent Keaau Game Management Area and Ohikilolo Ranch. As a result of Army removal efforts, monitoring results since 2004 indicate that goats have been eradicated from this management unit. As long as fences are maintained and ungulate sign is monitored, exclosures seem to be effective in protecting native habitats from ungulate damage; however, fences are occasionally damaged by rockslides and fire. Overall, the Service considers the Army's fencing, control, and monitoring activities to be successful in excluding feral ungulates on Makua.

Feral pigs and goats are common on State, city/county, and private lands within and/or adjacent to the action area. Large goat populations occur in the Mokuleia Forest Reserve and other unfenced source areas, such as Schofield Barracks West Range, Mount Kaala Natural Area Reserve, and the Makaleha and Makaha areas (U.S. Army Garrison 2005b). For example, State personnel have removed about 240 goats from the Lower Kaala Natural Area Reserve since 2000. Small goat populations in the unfenced Upper Kapuna and West Makaleha management units may be able to access parts of the fenced Pahole Management Unit. Portions of The Nature Conservancy of Hawaii's Honouliuli Preserve, which encompasses several management units, is fenced, and pigs and goats are present in unfenced areas. The Makaha Management Unit, owned by the Honolulu Board of Water Supply, is not yet fenced. Both Honouliuli and Makaha areas support population units critical for stabilization and expedited stabilization of target and at-risk taxa. Army Natural Resources Staff is unable to manage ungulates in management units on State, city/county, and private lands on a consistent, ongoing basis without long-term cooperative agreements with landowners. Agreements have been reached between the Army and The Nature Conservancy of Hawaii and the Honolulu Board of Water Supply, but not with the State or other private landowners.

Rodents have been identified as a threat to listed and other native plants in the action area and are controlled in some management units by grids of toxicant bait stations and snap traps. Control grids are focused on areas managed for plant target taxa known to be sensitive to rodent predation. For example, rat control grids are managed in the West Makaleha Management Unit to protect occurrences of *Cyanea grimesiana* ssp. *obatae*, *Delissea subcordata*, and *Cyanea superba* ssp. *superba*, and in the Ohikilolo and West Makaleha Management Units to protect *Pritchardia kaalae* seedlings. In the Kahanahaiki Management Unit, rat control to protect nesting elepaio may also benefit *Cyrtandra dentata*. Rat control grids at elepaio nesting sites during the breeding season (January to June) are also managed in the action area in the Ohikilolo Management Unit and along the east valley rim. In

addition, rats are controlled at two snail exclosures to protect *Achatinella mustelina* tree snails from *Euglandina rosea* predation. Outside the action area, rat control is conducted in the Ekahanui Management Unit to protect *Plantago princeps* var. *princeps* and Oahu elepaio nesting pairs, in the Waianae Kai Management Unit to protect *P. kaalae*, and in various other management unit locations on Oahu.

The Army controls the introduction and spread of non-native invasive plants within management units in the action area primarily through phytosanitation measures, surveying to detect and eradicate new weed species before they become established, and prioritizing weed control areas in management units. Surveys are regularly conducted to detect the introduction of new weed species along potential military introduction corridors (roads, helicopter landing zones) and along fence lines and ungulate-monitoring transects. Appendix 3.1 of the Makua Implementation Plan lists 31 priority incipient weed species, of which about 16 are present and believed to be serious threats in management units (U.S. Army Garrison 2005b). Twelve species are identified for total eradication within the management units: the grasses *Ehrharta stipioides* and *Pennisetum setaceum*; the herbaceous shrub *Achyranthes aspera*; herbaceous thistle *Cisium vulgare*; and herbaceous climber *Desmodium intortum*; the shrubs *Rubus argutus* and *Triumfetta semitriloba*; and the trees *Acacia mearnsii, Araucaria columnaris, Casuarina glauca, Syzgium jambos,* and *Tecoma capensis* (U.S. Army Garrison 2006d). In particular, a large occurrence of *Casuarina glauca* adjacent to the Kahanahaiki Management Unit poses a serious fire threat (U.S. Army Garrison 2005b). Other weed control efforts in the action area focus on "weed control areas" in the eight management units, located entirely or partially within the action area (see Stabilization under Project Description).

Non-native invertebrates are a particularly serious threat to certain listed plants and native associates within the action area because safe, effective control measures are unavailable for use in natural areas. To address this concern, the Army recently hired research and monitoring specialists to conduct management-related research and to coordinate with other researchers to develop control techniques for slugs and black twig borers (U.S. Army Garrison 2005b). A priority issue is development of slug baits that will not harm native tree snails and the development of black twig borer controls that will not harm native scolytid beetles. In addition, the Army is supporting doctoral research on Oahu tree snail predation and *Euglandina rosea* food habits and control methods.

Stabilization Exposure Area

Listed resources in the action area will be exposed to stabilization subsidies that include: (1) reduced exposure to stressors associated with the introduction and spread of non-native species by implementing phytosanitation measures, controlling existing sources of non-native plants on Makua, and reducing the abundance of non-native animals and invertebrates; (2) augmentation and reintroduction to increase baseline numbers of target plant taxa; (3) collection and storage of propagules for propagation and *ex situ* genetic storage; (4) captive propagation of *Achatinella mustelina*; and (5) comprehensive monitoring to assess the biological and compliance goals of the Makua Implementation Plan Addendum.

The area that will be exposed to stabilization subsidies includes all population units for target plant taxa and evolutionarily significant units of Oahu tree snails within the action area and management units where ecosystem-level threats will be controlled. As discussed in the Stabilization section of the Project Description, the Army's Makua Implementation Plan Addendum has modified the Makua Implementation Plan by reducing the number of population units that will be managed for stability and the number and area of management units. The Makua Implementation Plan had included about 188 plant population units for stabilization and approximately 2,571 ha (6,353 ac) of habitat to be actively managed within 31 management units. Under the reduced plan, about 92 plant population units will be stabilized and approximately 934 ha (2,307 ac) will be managed within 23 management units.

Makua Implementation Plan Addendum management units are designated in high quality habitat and designed to provide sufficient area for stabilizing *in situ* (naturally occurring) and reintroduced population units of target plant taxa. The larger management units (e.g., Ohikilolo within the action area and Pahole partially within the action area, and East Makaleha and Ekahanui outside the action area) encompass relatively high densities of many species that are being managed for stability, large areas of relatively intact native-dominated vegetation, and locations accessible to management. Many management units occur at elevations below 762 m (2,500 ft), where most native ecosystem loss has occurred, and will need habitat restoration in selected areas. Some of the management units are surrounded by lands not included in the stabilization program; other management units are adjacent to each other (although separated by boundary fences). Adjacent management units that are entirely or partially within the action area (e.g., Lower Ohikilolo and Ohikilolo; and Kahanahaiki, Pahole, Upper Kapuna, and West Makaleha) provide large contiguous landscapes of habitat for endangered and other native species. Each management unit, however, is managed independently.

Some areas on Makua that contain plant population units, management units, and Oahu elepaio critical habitat are closed to access by Army Natural Resources Staff because of the presence of unexploded ordnance. Listed resources in these areas will not be exposed to the full subsidies of on-site stabilization (e.g., intensive weeding, augmentation, seed collection, and monitoring). The Army also has not had consistent access for weed control and other stabilization activities on State lands in the Pahole, Upper Kapuna, and West Makaleha management units (U.S. Army Garrison 2005b, 2006d). According to Army Natural Resources Staff, restricted access to State lands has resulted in increased grass cover in previously weeded areas.

Stabilization Timing, Duration, and Frequency

The Army has been implementing stabilization actions under the Makua Implementation Plan since 2003, and under the Makua Implementation Plan Addendum since early 2005. In addition, certain "urgent actions" were implemented from 1999 to 2004, while the Makua Implementation Plan was being developed. Stabilization actions are conducted on an ongoing basis throughout the year, depending on the appropriate season for seed collection, greenhouse operations, and outplanting for 27 of the 28 target plant taxa (*Gouania vitifolia* is

a new species to be added to the Makua stabilization plan as a result of this consultation). The frequency of certain actions, including monitoring, varies according to species-specific needs that are outlined in the Makua Implementation Plan Addendum and Makua Implementation Plan. The duration of stabilization subsidies is expected to last as long as the Army trains at Makua and implements the actions outlined in the Makua Implementation Plan Addendum. If the Army discontinues conservation management at Makua or on non-Army lands within the action area, the benefits of stabilization will not be perpetuated. Native species and habitats in Hawaii require active, ongoing management to persist under the constant threat of competition with and displacement by non-native invasive species.

The Makua Implementation Plan was originally designed to be implemented in three phases to achieve stabilization of the original 27 target taxa over 33 years. That planning horizon was considered "speculative," given the lack of information available on the target species and the adaptive management adjustments that were expected over time. Phase A (years 1 to 13) include landowner negotiations, National Environmental Policy Act and other legal responsibilities, genetic storage, and initiation of essential research. Phase B (years 14 to 23) and Phase C (years 24 to 33) include developing and implementing fire management and threat control plans, seed collection, population and habitat monitoring, and population unit management. Specific biological criteria to evaluate the success of management for each taxon, such as minimum viable population size, could not be predicted due to lack of demographic and genetic data. Therefore, the Service originally intended to assess success in the short term by verifying the Army's implementation of management actions according to the schedule stipulated in the Makua Implementation Plan.

The Army has budgeted the Makua Implementation Plan Addendum's planning horizon for 20 years, although the time needed to achieve stabilization of 28 target plant taxa cannot be predicted. No anticipated timeline for success is included in the Makua Implementation Plan Addendum, nor contingency plans for stabilizing population units outside Makua, if State, city/county, or private lands are unavailable. The Makua Implementation Team (2003) recognized that delaying certain actions will adversely affect some population units and perhaps significantly reduce the likelihood of successful stabilization. Because of uncertainty regarding the timely achievement of stabilization goals, the Service is unable to determine that any species will be stabilized over the next 30 years or within any specified timeframe. For this reason, certain Addendum actions for the most at-risk plant taxa will be implemented on an accelerated schedule, and will be completed before tracers and certain other long-range weaponry are used (see General Effects of Expedited Stabilization below). Meanwhile, Makua Implementation Plan Addendum stabilization actions will continue to be implemented over the long-term for all target taxa.

Stabilization Intensity

The intensity of exposure of listed resources to stabilization subsidies depends on species-specific needs for protection against non-native invasive species, and on the need for outplanting to augment and reintroduce individuals and occurrences. For example, five of the eight management units within or partially within the action area are fenced or partially fenced, and fence construction for the others is planned over the next one to seven years

(Upper Kapuna will be partially fenced). Some plant taxa also require small individual strategic fences around particular population units; other population units do not require any fence protection because they are located on cliff faces or other areas inaccessible to feral ungulates. In addition, the amount of ungulate removal, weeding, rat control, and slug and insect control needed in population units and management units is location and species-specific and changes over time. In general, the Makua Implementation Plan Addendum and Makua Implementation Plan provide for the intensity of protection and population augmentation efforts needed to stabilize the target taxa, as determined by the Makua Implementation Team (2003).

Physical, Chemical, and Biotic Features Exposed to Stabilization

Within stabilization exposure areas (i.e., population units and management units), physical, biotic, and chemical features essential to listed species and critical habitats will be directly and indirectly exposed to Makua Implementation Plan Addendum subsidies. Physical features include mineral soil seed beds and microclimate conditions. Chemical features include soil nutrient/moisture levels and availability. Biotic features include all life forms within population units and management units, including listed plants, tree snails, and birds; associated native plants and animals; tree snail host trees; and nesting and foraging habitat for Oahu elepaio.

Listed Resources Exposed to Stabilization

Within the action area, 28 target plant taxa and the Oahu tree snail *Achatinella mustelina* are designated for stabilization management. Stabilization actions implemented for these target also will benefit individuals and occurrences of 11 non-target plant taxa where they occur in the management units, and improve the conservation value of critical habitat areas for 36 plant taxa and for the Oahu elepaio that overlap the management units. The Makua Implementation Plan (Makua Implementation Team 2003) and the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) outline stabilization protocols for 27 plant target taxa and *A. mustelina*. Both documents are based on the action area considered in the Service's previous opinions (Service 1999b, 2001b, 2004a). Because of new information provided primarily by fire model simulations, the new action area for this opinion encompasses all of the existing individuals for an additional plant species, *Gouania vitifolia*, which will be added to the Makua Implementation Plan Addendum's stabilization plan (see Status and Environmental Baseline descriptions for *G. vitifolia*).

Response of Listed Resources Exposed to Stabilization

Target taxa will respond to stabilization subsidies affecting the physical, chemical, and biotic factors identified above. More germination sites will become available to native plants as soil erosion and compaction damage by feral ungulates is reduced and invasive weeds are removed and controlled. Soil nutrient/moisture levels and availability will change with the relative composition of native and non-native plants, and more of these resources will become available to enhance the growth and vigor of native plants. Allelopathic chemicals that inhibit the germination and growth of native plants will diminish as non-native species

such as Christmas berry and strawberry guava are removed and controlled. With canopy management, microclimate conditions will develop that discourage invasive weeds; growth of canopy trees will enhance shade and mesic conditions while open conditions that favor grasses will decrease. For example, in some areas the Army has outplanted the native trees *Acacia koa* and *Myrsine lessertiana* to increase overstory canopy for control of shade-intolerant alien weeds. Over time, the conversion of native habitats to grassland will slow and ecosystem vulnerability to fire will be reduced. In the Lower Ohikilolo Management Unit, control of guinea grass and *Leucaena leucocephala* (koa haole) shrubs in fuelbreaks over the last five years has reduced the incidence of fires that threaten endangered plants. Without competition from non-native grasses and shrubs, these alien-dominated sites developed into mixed native shublands containing alien broadleaf weeds and native shrubs (*Dodonaea viscosa, Sida fallax*, *Waltheria indica*, and *Abutilon incanum*) (U.S. Army Garrison 2005b).

Over time, habitat management, including invasive species control and outplanting of native species, will alter species composition, increase the relative abundance and distribution of native plant species, and influence long-term patterns of vegetation development and succession. The overall response of listed resources to stabilization subsidies will be a measurable increase in numbers of individuals and occurrences of target plant taxa and native plant associates that provide primary constituent elements of plant critical habitat. Listed and other native plants will respond with increased vigor, survival, and reproduction due to reduced habitat degradation by feral ungulates; reduced competition, predation, and herbivory by alien plants, animals, and invertebrates; and increased augmentation and reintroduction of outplanted individuals. The overall response will be increased baseline numbers of individuals of target plant taxa that will improve population viability and reduce the risk of species extinction. Native plant associates, as primary constituent elements of critical habitat, will increase in quantity, quality, and availability, thereby increasing the conservation value of critical habitat for listed species.

The Service has determined that any short-term adverse impacts over the next 30 years associated with stabilization actions will be insignificant or discountable, and will not result in take of Oahu tree snails or Oahu elepaio, or loss of listed plants below existing baselines. Certain management actions, however, may expose listed resources to short-term, insignificant impacts associated with (1) the disturbance of human presence, (2) inadequate control of non-native species, (3) low survival of outplants and over-collection of propagules, and (4) lack of adequate population monitoring data. These minor impacts are discussed below.

(1) Ground disturbance associated with human activity may temporarily disturb Oahu elepaio during monitoring surveys, fence construction and maintenance, ungulate removal (snaring, hunting, aerial shooting), rat baiting/trapping, and outplanting. People also may inadvertently trample native vegetation, spread invasive plant seeds, and dislodge tree snails. These impacts will be minimized by limiting implementation of stabilization actions to trained biologists and technicians.

(2) Inadequate control of non-native species may limit or delay stabilization of certain taxa. Owing to personnel and funding constraints, Army Natural Resources Staff has been unable to fully implement the level of weed control outlined in the Makua Implementation Plan (U.S. Army Garrison 2006d). For example, the goal for incipient weed control is total eradication, but some weed species have increased to levels where eradication is no longer feasible. Moreover, once a species is considered established, it no longer receives special attention for total eradication and is treated only during general weed sweeps in high priority areas. In addition, intensive weed control is conducted only in fenced management units or in unfenced areas where ungulates are not a threat because of steep topography. In some sites at Makua, removal of alien grasses has increased the spread of other herbaceous weeds such as *Leonotis nepetifolia* and *Ageratum conyzoides*. These impacts will be minimized by careful, regular weeding to maintain appropriate microclimate and light/shade regimes and to prevent the replacement of certain alien weeds with others. For example, canopy strawberry guava trees are sometimes left in place because removal would create light gaps that facilitate alien grass invasion in the understory. Canopy shade is also increased in some areas to inhibit weed growth by outplanting native trees in large light gaps.

Weed control techniques also may result in inadvertent damage to listed species and other native plants. Alien weeds are controlled in various action area locations by mowing, weed-whacking, herbicide application, and hand-pulling. Damage to native vegetation associated with these activities will be minimized by limiting implementation of stabilization actions to trained biologists and technicians. Army Natural Resources Staff includes expert botanists who recognize native species and take precautions to avoid harming them. For example, in all herbicide treatment areas, rare native species are flagged before alien vegetation is sprayed. Molasses grass is usually controlled by herbicide spray applications, but is hand-pulled in areas near the native endangered grass *Cenchrus agrimonioides* var. *agrimonioides*. In addition, to control guinea grass, the Army uses herbicides that do not affect native broadleaf species, such as “Round-up Pro” and “Fusilade II.” “Fusilade II” is a grass-specific herbicide that has been successful in maintaining forest understories grass-free (U.S. Army Garrison 2005b). All herbicides are applied according to the label registration.

The current design of snail exclosures may be inadequate to thoroughly protect occurrences of *Achatinella mustelina* from predation by the non-native carnivorous snail *Euglandina rosea*. The two snail exclosures in the Kahanahaiki and Pahole management units consist of sheet-metal fences with salt troughs and electrical barriers. This exclosure design is not impenetrable to rats but appears to be excluding *E. rosea*. However, *A. mustelina* have occasionally been found in the salt troughs, *E. rosea* have been found inside the Pahole exclosure, and the electrical barriers often do not function properly. In addition, overstory clearing along the exclosure’s perimeter to reduce rat access has created a drier environment within the exclosures. These impacts will be minimized by enhanced maintenance of the exclosures and investigation of design modifications to these exclosures and to any new exclosures that may be constructed (U.S. Army Garrison 2005b, 2006d).

Control methods for insect pests (especially the black twig borer and Chinese rose beetle) are currently not available for use in forests and natural areas. Systemic insecticides applied to individual plants to control alien insects may also injure or kill native insects. Similarly,

chemicals to control slugs may also harm native tree snails. Certain *Schiedea* species, for example, are unlikely to be stabilized without adequate slug control. This lack of field control methods will be minimized by Army-supported research to determine the effects of pesticides on native invertebrates so that control methods can benefit stabilization of target plant taxa.

(3) Low survival of outplants and over-collection of propagules may limit the success of augmentation and reintroduction of certain target taxa, particularly those vulnerable to damage by non-native slugs and insects. Until invertebrate threats and other limiting environmental factors can be controlled, constant replenishment by outplanting may be needed to achieve and maintain stable plant numbers. As a result, *in situ* seed sources and *ex situ* storage supplies may be depleted. Other constraints on outplanting include low seed productivity in certain taxa, inaccessibility of some naturally occurring seed sources, and inadequate greenhouse capacity for propagation and pre-outplant conditioning. These impacts will be minimized by careful monitoring of outplant survival, maintenance of genetic seed storage goals, identification of site limiting factors (e.g., shade, water, nutrients), and research on slug and insect control methods.

(4) Lack of adequate long-term population monitoring data may limit or delay stabilization of certain taxa as a result of inadequate knowledge of population dynamics. For example, *Sanicula mariversa* undergoes a complex dormancy cycle that is not well understood. This impact will be minimized by the Army's development of a comprehensive monitoring program to assess completion of the Makua Implementation Plan Addendum's biological and compliance goals, the Army's recent hiring of a manager to oversee the monitoring program, and annual review of all stabilization activities by the interagency Makua Implementation Team. Priority monitoring issues for 2007, for example, include demography studies of *S. mariversa*, *Chamaesyce celastroides* var. *kaenana*, and survivorship analysis of *Phyllostegia kaalaensis* (U.S. Army Garrison 2006d).

Expedited Stabilization of At-Risk Plant Taxa

The Army's proposed action incorporates an expedited stabilization plan over the next 30 years for 12 of the stabilization target taxa identified as most at-risk from exposure to project stressors. The expedited stabilization plan for these taxa modifies certain priorities in the species-specific conservation actions outlined in the Makua Implementation Plan Addendum and Makua Implementation Plan, and accelerates their implementation. Until the 12 at-risk taxa have attained expedited, modified stabilization goals, the Army will not use any weapons systems and munitions that were not covered in the Service's 2001 Supplement and 2004 Critical Habitat Reinitiation (i.e., tracers, 155 mm HE artillery, TOW missiles, Javelin anti-tank missiles, and 2.75-caliber helicopter-launched rockets). In addition, other weapons systems and munitions will be used only according to NFDRS and live fuel moisture conditions outlined in this opinion (see Table PD 2).

The Makua Implementation Team (2003) recognized that the phased approach of the Makua Implementation Plan would delay certain actions, which could significantly reduce the likelihood of successful stabilization for certain seriously endangered plant taxa in the action

area. Therefore, certain taxa at greatest risk from training impacts (i.e., those with very low numbers and located within a high fire risk zone) were intended to receive all needed management during Phase A (years 1 to 13) of the Makua Implementation Plan's 33-year schedule. These taxa included *Hibiscus brackenridgei* ssp. *mokuleianus*, *Chamaesyce celastroides* var. *kaenana*, *Melanthera tenuifolia*, *Nototrichium humile*, and *Tetramolopium filiforme*. One of these, *Hibiscus brackenridgei* ssp. *mokuleianus*, has now been designated as an "at-risk" species scheduled for expedited stabilization over the next 30 years. *Chamaesyce celastroides* var. *kaenana*, *Nototrichium humile*, and *Tetramolopium filiforme* remain as target taxa for stabilization, but are not designated for expedited stabilization due to their relatively high numbers and the existence of at least two numerically stable population units for each taxon. *Melanthera tenuifolia* also remains a target taxon for stabilization, but it is not designated for expedited stabilization due to its relatively high numbers.

Twelve target taxa have been designated as "at-risk" taxa scheduled for expedited stabilization over the next 30 years, based on the criteria discussed in the "Expedited Stabilization" section of this opinion's Project Description. The Service reasonably expects that achievement of expedited stabilization will protect these at-risk taxa from jeopardy over the next 30 years, while long-term stabilization actions are being implemented for all stabilization species. The Service expects the Army will fully fund Makua Implementation Plan Addendum actions, including expedited stabilization.

In general, expedited stabilization measures are based on continuing management of all *in situ* population units for all 28 plant target taxa, which the Army is currently implementing under the Makua Implementation Plan Addendum. In addition, for each of the 12 at-risk taxa, the Army will expedite priorities to attain modified stabilization goals for all action area population units, and of one to three population units outside the action area, as identified in the Addendum. The major purpose of expedited stabilization is accelerated improvement of population units outside the action area, where they will not be exposed to training-related wildfire. In some cases, establishment of reintroductions on State, city/county, or private lands will be accelerated. For all stabilization population units (three or four per taxon), the Army will ensure that adequate numbers of individuals, including both mature and immature, are outplanted and maintained to conform to the modified numerical stabilization criteria. Expedited stabilization involves prioritizing the implementation of conservation actions for the 12 at-risk taxa, according to the protocols and population units identified in the Makua Implementation Plan Addendum and the Makua Implementation Plan; the basic premises and details of those plans have not been changed. The Army estimates that expedited, modified stabilization can be achieved, with adequate funding, within three to seven years for most of the at-risk taxa. One species with periodic dormancy, *Sanicula mariversa*, may require a longer timeline because preliminary monitoring must be conducted and evaluated to determine appropriate population goals and techniques for stabilization.

Expedited stabilization likely will not result in full stabilization of the 12 at-risk taxa over the next 30 years. Full stabilization requires at least three stable population units per taxon, each consisting of specific numerical goals for mature, reproducing individuals; complete control of threats; and complete *ex situ* genetic storage. Expedited stabilization will result in at least

three population units consisting of goal criteria for total individuals (both mature and immature), with threats controlled to the extent that threshold numbers are maintained from year to year. Genetic storage goals may or may not be completed over the next 30 years. Nonetheless, expedited stabilization will significantly increase numbers and distributions of the at-risk taxa. In particular, each will be protected from jeopardy by achieving expedited numerical stabilization goals in at least one population unit, or in most cases at least two population units, outside the action area. To achieve expedited stabilization goals, fence construction schedules will be accelerated for the Makaha, West Makaleha, and Upper Kapuna management units. These management units are needed as stabilization population units for six, four, and six at-risk taxa each, respectively. Besides these, other management units also will be fenced to achieve expedited stabilization for eight at-risk taxa.

The general effects analysis for expedited stabilization is the same as that described above for full stabilization. For expedited stabilization, however, the exposure area and the individuals affected will be limited to population units to be managed for stability for the designated 12 at-risk taxa. Stabilization population units, which also apply to expedited stabilization of the at-risk taxa, are discussed in the species-specific status, environmental baseline, and effects analysis sections of this opinion. In addition to expedited stabilization, certain weapons restrictions and fire protection actions outlined in Table PD 2 are expected to protect the 12 at-risk taxa from jeopardy while full stabilization is being implemented for all 28 plant target taxa over the next 30 years.

The expedited stabilization actions are intended to control threats and increase the baselines in overall numbers and distribution of the 12 at-risk taxa as rapidly as possible. Increased individual fitness and viability of population units, especially of those outside the action area, are considered critical to protect these taxa from jeopardy over the next 30 years. Successful achievement of expedited, modified stabilization for these taxa will not occur without full Army funding of the Makua Implementation Plan Addendum and the Wildland Fire Management Plan. The Service reasonably expects the 12 at-risk taxa will be protected from jeopardy over the next 30 years because the Army will not be able to use certain weapons systems and munitions until those taxa have attained expedited stabilization thresholds. Lack of adequate seed sources for propagation and outplanting, and for genetic storage, may limit or delay augmentation and reintroduction of some taxa. The Army and Service will closely monitor expedited stabilization actions each year to assure adequate survival of outplantings and prevent depletion of seed sources for genetic storage, and to determine the Army's progress toward achieving expedited stabilization of the 12 at-risk taxa. The annual review will also allow for modification of stabilization actions as needed, using an adaptive management approach.

Summary of General Effects Analysis

The proposed action will adversely affect endangered plant and animal species in the action area by exposing them to stressors associated with training-related wildfire, introduction and spread of non-native species, and the physical disturbance of human activity. Fire ignited by live-fire training is the most significant threat to listed species and critical habitat in the action area. In general, the Service anticipates that individuals and occurrences of listed

species, and primary constituent elements of critical habitat, will be exposed to training-related wildfire of high, low and very low severity within the action area. Individuals, occurrences, or entire population units of listed plants in the action area are at various (high, low, or very low) risks of burning over the next 30 years. Fire also will destroy other native plant associates, degrade habitat quality for listed individuals that remain, and inhibit natural regeneration by creating conditions more favorable for faster-growing alien grasses. Enhanced regeneration of non-native grasses will predispose burned areas to future fires and increase the risk of fire ignition and spread to other native habitats. Fire and alien plant invasion in critical habitat areas also will adversely affect native plants that comprise the primary constituent elements determined to be essential for the survival and recovery of listed plants and the Oahu elepaio. Thus, the proposed action's risk of training-related wildfire is likely to reduce baseline numbers of listed species in the action area and reduce the quality, quantity, and availability of primary constituent elements of critical habitat.

To minimize the impacts of training-related wildfire at Makua, the proposed action includes several conservation and stewardship programs to prevent and suppress fire. The Army is implementing a Wildland Fire Management Plan that incorporates the NFDRS and live fuel moisture conditions into standard operating procedures for weapons training. The NFDRS limits on live-fire training will preclude use of high-risk, fire-igniting weapons systems and munitions during adverse weather conditions, such as during the dry summer months. The Army also proposes to significantly increase helicopter support and fire-bucket productivity for firefighting response. The Makua Integrated Natural Resource Management Plan includes components for weed control in training areas to reduce fuel loads. In addition, the Army is proposing additional firebreaks and fuel modification improvements to protect population units of endangered plants as part of the proposed action.

The Army also is implementing endangered species stabilization actions under the proposed Makua Implementation Plan Addendum and the Makua Implementation Plan, which over the long term will increase baseline numbers of 28 plant target taxa and the Oahu tree snail, *Achatinella mustelina*. Stabilization actions will include population unit management of target plant taxa, including augmentation and reintroduction of individual plants as needed; and ecosystem-level habitat improvement in management units, including control of non-native feral ungulates, invasive plants, and invertebrate pests. Twelve of the most at-risk target plant taxa will be managed for expedited stabilization over the next 30 years. Expedited stabilization is expected to result in at least three population units at numerical goals for stability for each taxon, including one or two population units outside the action area where they will not be exposed to training-related wildfire. Furthermore, the Army will not train with certain high-risk, fire-igniting weapons systems and munitions until expedited stabilization of the 12 at-risk taxa is achieved. Finally, any areas of critical habitat destroyed or degraded by fire will be revegetated. The overall response of listed resources to the proposed action's stressors and subsidies will depend on the frequency, intensity, location, and extent of training-related wildfire, the success of the Wildland Fire Management Plan and Integrated Natural Resource Management Plan programs in reducing fire ignition and spread, and the timely success of stabilization under the Makua Implementation Plan Addendum (including expedited stabilization of 12 at-risk plant taxa) over the next 30 years.

EFFECTS OF THE ACTION ON STABILIZATION TAXA

The 16 target taxa listed below have been identified for stabilization, based primarily on their overall status, environmental baseline within the action area, and exposure to the risk of training-related wildland fire (see Table E 7). A taxon was designated for stabilization if certain numerical criteria were not met and if at least 50 percent of all its individuals were located within the action area. Location within the action area by definition means these individuals are at risk of training-related wildland fire. Taxon-specific information supporting this group effects analysis for the 16 stabilization taxa are included in the Status and Baseline Section.

Alectryon macrococcus var. *macrococcus* (tree)
Cenchrus agrimonioides var. *agrimonioides* (grass)
Chamaesyce celastroides var. *kaenana* (shrub, small tree)
Cyrtandra dentata (shrub)
Dubautia herbstobatae (subshrub)
Flueggea neowawraea (tree)
Hedyotis degeneri var. *degeneri* (shrub)
Hedyotis parvula (shrub)
Hesperomannia arbuscula (shrub, small tree)
Melanthera tenuifolia (perennial herb)
Nototrichium humile (shrub, small tree)
Plantago princeps var. *princeps* (subshrub, shrub)
Pritchardia kaalae (palm)
Schiedea kaalae (shrub)
Tetramolopium filiforme (shrub)
Viola chamissoniana ssp. *chamissoniana* (subshrub)

Status Summary of Stabilization Taxa

Data on abundance, distribution, and reproduction of the 16 stabilization taxa are generally inadequate to predict quantifiable changes in their baseline conditions over the next 30 years, with or without the proposed action. Most are limited to population units on Oahu and are endemic to that island. Three stabilization taxa also occur on other islands: *Alectryon macrococcus* var. *macrococcus* (12 percent of total population on Oahu), *Cenchrus agrimonioides* var. *agrimonioides* (52 percent on Oahu), and *Flueggea neowawraea* (49 percent on Oahu). The current abundance of these 16 stabilization taxa on Oahu ranges from 22 total individuals for *Hesperomannia arbuscula* to 3,500 total individuals for *Tetramolopium filiforme*. Ten of the 16 stabilization taxa have not met minimum threshold of individuals to reach stabilization criteria in all population units (based on number of mature individuals, successful reproduction may not be occurring in all cases) inside and outside the action area: *Cyrtandra dentata*, *Dubautia herbstobatae*, *Flueggea neowawraea*, *Hedyotis degeneri* var. *degeneri*, *Hesperomannia arbuscula*, *Plantago princeps* var. *princeps*, *Pritchardia kaalae*, *Schiedea kaalae*, *Tetramolopium filiforme*, and *Viola chamissoniana* ssp. *chamissoniana*. Of these, four taxa have not met minimum threshold of individuals to reach stabilization criteria in any of the stabilization population units: *Flueggea neowawraea*, *Hesperomannia arbuscula*, *Plantago princeps* var. *princeps*, and *Schiedea kaalae*; however, these four taxa were not identified as at-risk taxa for expedited stabilization. *Flueggea neowawraea* occurs in scattered locations on

Table E 7. Status of Stabilization Taxa (U.S. Army Garrison 2006d).

Taxon	Total Number of Individuals (mature/immatur)	Percent of Total Individuals in the Action Area	Number of Stabilization Population Units Exceeding Minimum Number of Individuals (existing‡/required)	Number of Stabilization Population Units Exceeding Minimum Number of Individuals Outside Action Area (existing‡/required)	Population Units with Fences (existing/required)	Fire Risk†
Alectryon macrococcus var. *macrococcus*	223 (198/25)*	30*	2/4	2/2	0/4	L, V
Cenchrus agrimonioides var. *agrimonioides*	529 (432/97)	57*	2/3	1/2	1/3	L, V
Chamaesyce celastroides var. *kaenana*	951 (844/107)	54	4/4	3/3	4/4	H
Cyrtandra dentate	1583 (721/862)	92	2/3	0/1	1/3	L
Dubautia herbstobatae	1217 (1206/11)	98	2/3	0/1	3/3	L, V
Flueggea neowawraea	128 (39/89)*	57*	0/3	0/2	0/3	L, V
Hedyotis degeneri var. *degeneri*	613 (569/44)	86	1/3	0/2	1/3	L
Hedyotis parvula	322 (207/115)	58	2/3	1/2	2/3	V
Hesperomannia arbuscula	22 (11/11=22)	4	0/3	0/2	1/3	V
Melanthera tenuifolia	3254 (2585/669)	50	3/3	2/2	2/3	H, L,V
Nototrichium humile	1256 (1087/153)	68	4/4	2/2	2/4	H, L, V
Plantago princeps var. *princes*	354 (126/228)	12	0/4	0/3	1/4	V
Pritchardia kaalae	911 (137/774)	92	2/3	1/1	2/3	L, V
Schiedea kaalae	235 (185/50)	9	0/4	0/3	4/4	V
Tetramolopium filiforme	3500 (2875/625)	96	1/4	0/2	3/4	H, L, V
Viola chamissoniana ssp. *chamissoniana*	662 (637/25)	81	1/4	0/2	3/4	V

*Totals for the Island of Oahu

‡ Individuals may not be reproducing successfully due to threats which have not yet been abated.

†Fire Risk: H (high), L (low), V (very low)

Oahu, Kauai, Maui, and Hawaii; *Hesperomannia arbuscula* and *Schiedea kaalae* each have only one plant (or five percent and less than one percent, respectively, of their total range-wide populations) located in the action area; and *Plantago princeps* var. *princeps* is relatively abundant at 354 total individuals.

Three taxa meet or exceed the minimum number mature individuals for stabilization populations in all their required stabilization population units: *Chamaesyce celastroides* var. *kaenana*, *Melanthera tenuifolia*, and *Nototrichium humile*. Five taxa are approaching the required number of mature individuals for stabilization population units (two out of a required three or three out of a required four), *Cenchrus agrimonioides* var. *agrimonioides*, *Cyrtandra dentata*, *Dubautia herbstobatae*, *Hedyotis parvula*, and *Pritchardia kaalae*. However, these taxa are not considered stabilized because they are not self-sustaining (*Cenchrus agrimonioides* var. *agrimonioides* and *Pritchardia kaalae* population units rely on augmentation with outplanted seedlings), threats are not controlled (e.g., fire, feral ungulates, rats, invasive plants), and *ex situ* genetic storage is not complete.

Eight of the 16 stabilization taxa (*Chamaesyce celastroides* var. *kaenana*, *Cyrtandra dentata*, *Dubautia herbstobatae*, *Hedyotis degeneri* var. *degeneri*, *Hedyotis parvula*, *Melanthera tenuifolia*, *Nototrichium humile*, and *Viola chamissoniana* ssp. *chamissoniana*) have the capacity to recruit in the wild when threats are managed (ungulate fencing, weed control, herbivore control). These eight taxa generally produce adequate juveniles and seedlings or reproduce vegetatively to a degree that will sustain population units and will not require reintroduction to achieve stabilization (U.S. Army Garrison 2006d). Two other taxa, *Cenchrus agrimonioides* var. *agrimonioides* and *Tetramolopium filiforme*, are also thought to have the capacity to regenerate naturally but will require reintroduction to establish stabilization numeric targets and/or population unit criteria (U.S. Army Garrison 2006d). Four stabilization taxa (*Hesperomannia arbuscula*, *Pritchardia kaalae*, *Plantago princeps* var. *princeps*, and *Schiedea kaalae*) produce seedlings in the wild or at reintroduction sites; however, they may still have uncontrolled threats (slugs or black twig borers), and thus will require reintroduction or augmentation to achieve stabilization. Two stabilization taxa, *Alectryon macrococcus* var. *macrococcus* and *Flueggea neowawraea*, have never produced seedlings in the wild or at reintroduction sites and will require reintroductions or augmentations, probably through additional research on regeneration techniques as well as black twig borer control.

The population trends of most of the stabilization taxa appear to be increasing more or less sustaining their numbers since initiation of the Makua Implementation Plan in 2003. Some of them have increased only slightly; some have increased the number of immature, but not mature, individuals; and some have increased owing in large part to new discoveries of additional plants. The population trends of two taxa, *Hesperomania arbuscula* and *Plantago princeps* var. *princeps*, seem to be decreasing in numbers even with stabilization management, and *Hedyotis degeneri* var. *degeneri* seems to be increasing in the action area and decreasing elsewhere. Because of inadequate numbers of mature, reproducing individuals in some population units and lack of at least three population units at numerical stabilization goals, all 16 stabilization taxa are considered to have a high background risk of extinction both in the action area and range-wide. Thus, stabilization management over the long term is necessary to protect these taxa from jeopardy due to the adverse impacts of military training.

Analyses for Effects of the Action

Individuals of the 16 stabilization taxa in the action area will be exposed to training-related wildland fire and the ongoing impacts of non-native species. Effects of human disturbance (trampling) are considered minor. The life forms of these stabilization taxa include a grass, a perennial herbaceous plant, partially woody subshrubs, woody shrubs and small trees, a palm, and dominant or subdominant forest trees.

Individuals of these 16 taxa will be exposed to the direct and indirect effects of training-related wildland fire over the next 30 years, due to their occurrence within the action area in zones at high, low, or very low risk of training-related wildland fire (Table E 8). All individuals and life stages are vulnerable to high and very low severity fires throughout the year, depending on phenology and the time of year fire occurs. Stabilization taxa with some or many individuals located in areas at high risk of fire include *Chamaesyce celastroides* var. *kaenana*, *Melanthera tenuifolia*, *Nototrichium humile*, and *Tetramolopium filiforme*. These plants are likely to be burned under certain conditions. Even full staffing of on-site and standby fire suppression helicopter forces will not guarantee containment of all fires. On approximately 1.5 percent of historical potential training days analyzed, on-site and standby helicopter containment would have failed to contain a fire burning outside the firebreak road, if the fire had not been successfully contained before 1 p.m. If additional contingency fire suppression resources are not called, these fires would escape initial attack and burn large acreages. Large fires and fires escaping initial attack are likely to burn into the native forest (see General Effects—Fire Suppression Table E 3). In addition, without the fuel treatments proposed, *Chamaesyce celastroides* var. *kaenana* plants (as well as the at-risk taxon *Hibiscus brackenridgei* ssp. *mokuleianus*) in the Lower Ohikilolo Management Unit are particularly vulnerable to training-related wildland fire because they are located within dry, grassy areas that have burned in the past.

Plants growing outside the high fire risk zone (i.e., within the low and very low fire risk zones) are at some risk of burning as a result of training-related wildland fire ignited by a misfired or malfunctioning long-range weapons systems and munitions (tracers, AT-4 and SMAW anti-tank weapons, 2.75-caliber rockets, Javelin anti-tank missiles, and TOW missiles). These plants also have a relatively low potential to burn from spot fires of various sizes, depending on topography, vegetation cover, weather, and suppression capability. The expected fire size resulting from a misfired long-range weapon or spot fire landing within intact shrub and/or forest vegetation is about 0.1 ha (0.3 ac) with immediate fire suppression response. However, if the fire is not noticed for 48 hours, it could spread to 40.5 ha (100 ac) before containment. In addition, plants within the low fire risk zone, especially those near the high fire risk zone could burn if a fire within the high fire risk zone creeps into the edge of the low risk zone. Only a small area is expected to burn because the fire will slow down when it hits the forest/shrub habitat.

The areas exposed to the effects of training-related wildland fire and invasive species in the action area include mixed native and non-native vegetation in mesic forest, dry forest, and dry grassland/shrubland habitats. Many population units of several taxa are at high risk of training-related wildland fire within dry, grassy habitats of the Kaluakauila, Lower Ohikilolo, and Kahanahaiki (C-Ridge vicinity) Management Units (*Cyrtandra dentata*, *Flueggea neowawraea*, *Hedyotis degeneri* var. *degeneri*, *Melanthera tenuifolia*, *Nototrichium humile*, and *Tetramolopium filiforme*). Population units within mesic, forested habitats in the Kahanahaiki,

Table E 8. Fire Risk for Stabilization Taxa.

Taxon	Individuals Occurring In Fire Risk Zones		
	High	Low	Very Low
Alectryon macrococcus var. *macrococcus*	0	22 (9) †*	61 (25)*
Cenchrus agrimonioides var. *agrimonioides*	0	194 (28)*	207 (29)*
Chamaesyce celastroides var. *kaenana*	511 (54)	0	0
Cyrtandra dentate	0	1396 (92)*	0
Dubautia herbstobatae	0	616 (52)*	550 (46)*
Flueggea neowawraea	0	64 (50)*	9 (7)*
Hedyotis degeneri var. *degeneri*	0	188 (53)	0
Hedyotis parvula	0	0	188 (44)
Hesperomannia arbuscula	0	0	1 (4)*
Melanthera tenuifolia	227 (7)	1,384 (42)	0
Nototrichium humile	590 (47)	267 (21)	1 (0)
Plantago princeps var. *princeps*	0	0	16 (5)
Pritchardia kaalae	0	769 (84)	72 (8)
Schiedea kaalae	0	0	22 (19)
Tetramolopium filiforme	1045 (30)	2085 (60)	200 (6)
Viola chamissoniana ssp. *chamissoniana*	0	0	500 (81)

†Number of individuals occurring in fire risk zone (percent of all individuals occurring in fire risk zone).
*Percent of individuals on the island of Oahu only

Pahole, Upper Kapuna, and West Makaleha Management Units are generally at lower risks of fire, except in areas of alien grass encroachment. Population units in the Ohikilolo Management Unit along the south valley rim and in the Keaau area beyond Ohikilolo Ridge are likewise at lesser risks of fire. Mesic conditions in upper slope forests do not preclude the incidence of fire, however, especially during prolonged drought conditions and in disturbed areas with grassy understories. The spread of wildland fire from the C-Ridge area into the Kahanahaiki Management Unit, for example, is strongly influenced by alien grass cover. Past fires, including the 1995 and 2003 escaped prescribed burns, increased the exposure of listed plants near this area to future fires by killing native vegetation and increasing flammable alien grass cover. Over half of the population units of the 16 stabilization taxa are located within fenced management units, but invasive weeds are not regularly controlled over all of them. Individuals under mesic forest canopy in weed control areas are probably fairly well protected from rapidly spreading intense fire. Other individuals in locations lacking weed control are not well protected from long-term fire encroachment into native and mixed forest.

To reduce the risk of training-related wildland fire to certain at-risk species, the Army will use certain types of weapons systems and munitions for training at Makua only after completion of specific measures to protect certain at-risk taxa (see General Effects of Expedited Stabilization and Table PD 2 in Project Description). Delaying the use of these weapons systems and munitions will also benefit stabilization species by reducing the long-range fire risk. In addition, to minimize threats to listed species, as part of the proposed action the Army will implement conservation and stewardship programs to reduce the risk of ignition and spread of training-related wildland fire and wildland fires occurring on State and private lands where these population units occur (Table E 9) (Wildland Fire Management Plan, Integrated Natural Resources Management Plan); reintroduce and augment numbers of stabilization taxa in the wild (Makua Implementation Plan Addendum); and improve native habitat in population units by excluding feral ungulates and controlling non-native weeds (Makua Implementation Addendum).

Table E 9. Stabilization Population Units Located on State, City/County, and Private Lands.

Taxon	State Lands	City/County Lands	Private Lands
Alectryon macrococcus var. *macrococcus*	Kahanahaiki to W. Makaleha*	Makaha	Central Kaluaa
Cenchrus agrimonioides var. *Agrimonioides*	Kahanahaiki & Pahole* Makaha & Waianae Kai		Central Ekahanui
Chamaesyce celastroides var. *kaenana*	Kaena (E. of Alau) Kaena & Keawaula Waianae Kai		
Cyrtandra dentate	Pahole to Upper Kapuna to W. Makaleha*		
Dubautia herbstobatae		Makaha	
Flueggea neowawraea	Kahanahaiki to Upper Kapuna* Central & East Makaleha	Makaha	
Hedyotis degeneri var. *degeneri*	Kahanahaiki to Pahole* Alaiheihe & Manuwai Central Makaleha & W. Branch of E. Makaleha		
Hedyotis parvula	E. Makaleha Halona		
Hesperomannia arbuscula	Upper Kapuna*	Makaha	N. Palawai
Melanthera tenuifolia	Kamaileunu & Waianae Kai Mt Kaala Natural Area Reserve		
Nototrichium humile	Waianae Kai		Kaimuhole & Palikea Gulch
Plantago princeps var. *princeps*			Ekahanui Konahuanui Waiawa
Pritchardia kaalae	Ohikilolo East & W. Makaleha* Makaleha to Manuwai		
Schiedea kaalae	Pahole*		Maakua S. Ekahanui Kaluaa & Waieli
Tetramolopium filiforme	Waianae Kai		
Viola chamissoniana ssp. *chamissoniana*	Halona	Makaha	

*Population units entirely or partially inside action area

The risk of fire to listed species will be minimized by training restrictions, fire management, and expedited stabilization actions. Fire minimization measures are based on required levels of helicopter staffing to contain fires. In addition, to reduce the fire risk to *Chamaesyce celastroides* var. *kaenana* plants (as well as to the at-risk taxon *Hibiscus brackenridgei* ssp. *mokuleianus*) in the Lower Ohikilolo Management Unit, the Army will not begin any live-fire or blank-fire training until alien grass cover is removed and controlled within 3 m (9.8 ft) of these plants and to less than 20 percent cover within the Lower Ohikilolo weed control areas. Additional fuel modification within a 60-m (197-ft) swath along the inside perimeter of the south firebreak road, as shown in Figure PD 6, will allow the Army to reduce the level of on-site

helicopter staffing required for certain weapons. With these fuel modifications in place, the Army may train using small arms, demolitions, grenades, mines, simulators, and mortars and artillery, with the use of certain of these weapons systems and munitions restricted to NFDRS Green conditions. Within 5 to 10 years, plants growing within the Kahanahaiki and Kaluakauila management units will be protected by fuel modification and firebreaks; these protections will benefit the stabilization taxa noted above. With these management units better protected from fire and with completion of expedited stabilization of the at-risk taxa *Cyanea superba* ssp. s*uperba*, *Schiedea nuttalli*, and *Schiedea obovata*, the Army may begin training with more weapons systems and munitions under Yellow fire danger conditions instead of only under Green fire danger conditions and begin using grenade launchers and AT-4 and SMAW weapons under Green or Yellow fire danger conditions, depending on live herbaceous fuel moisture. Expedited stabilization of all 12 at-risk taxa must be complete before the Army may begin training with tracer ammunition, Javelins, and 2.75-caliber rockets. Thus, all listed species in the action area, including the 16 stabilization taxa, will benefit from training restrictions required until expedited stabilization is complete for all 12 at-risk species. Full stabilization of all 16 stabilization and all 12 at-risk taxa must be complete before the Army may begin training with TOWs.

Species Response to the Proposed Action

The response of individuals of the 16 stabilization taxa to training-related wildland fire and invasive species will include the direct and indirect effects of fire injury and death, ungulate grazing and trampling, invertebrate herbivory, and alien plant competition (see General Effects). As a result of these training-related impacts, the number of mature individuals and numerically stable population units of stabilization taxa in the action area are expected to decline over the next 30 years. The overall response to direct and indirect effects will be a measurable reduction in baseline numbers, distribution, and reproduction of individuals and/or entire occurrences in action area population units due to fire injury and death. Reduced individual fitness in plants that survive will further decrease the viability of population units through a continuing decline in baseline numbers. Without implementation of the Army's conservation and stewardship programs, these effects would worsen the existing condition of stabilization taxa in the action area by constraining their resiliency (recovery rate from disturbance) and exacerbating their risk of extinction due to small population size. We infer from conservation biology principles and examples from other species that the 16 stabilization taxa have a high background risk of species extinction, and ongoing stabilization management is needed to protect them from existing and additional threats and to ensure their long-term persistence.

The Service anticipates that implementation of wildland fire suppression, fuels management, and species stabilization actions will prevent training-related declines in baseline numbers of individuals and population units of the 16 stabilization taxa. Over the next 30 years, Army stabilization management is expected to achieve important progress in attaining numerical stability criteria for the 16 stabilization taxa. Numbers of mature, reproducing individuals are expected to increase in at least three or four population units for each taxon, including at least one population unit outside the action area. The Army recently decided to identify four manage for stability population units for seven of the 16 stabilization taxa (U.S. Army Garrison 2006d). The criteria used to identify taxa that will be managed at four stabilization population units include: (1) presence in both the Makua and Schofield Barracks action areas (*Alectryon macrococcus* var. *macrococcus*, *Plantago princeps* var. *princeps*, *Schiedea kaalae*,

Tetramolopium filiforme, *Viola chamissoniana* ssp. *chamissoniana*); and (2) presence in high fire threat areas in the Makua action area (*Chamaesyce celastroides* var. *kaenana*, *Nototrichium humile*). In addition, progress is expected over the next 30 years toward full threat control and full *ex situ* genetic storage for each taxon. Overall, the response of stabilization taxa to project subsidies is expected to result in measurable increases in individual fitness (survival, reproduction, and recruitment), increased baseline numbers of mature and immature individuals within population units, and expanded distribution of population units inside and outside the action area. Thus, Army conservation and stewardship programs will protect the 16 stabilization taxa from jeopardy over the next 30 years, improve their likelihood of reaching full stabilization over the long-term, and enhance their probability of persistence. Responses of certain stabilization taxa to project subsidies may involve indirect adverse effects.

Three of these taxa (*Cyrtandra dentata, Dubautia herbstobatae, Pritchardia kaalae*) will be managed for stability at only one population unit outside the action area. Army biologists believe that action area locations of these taxa represent their currently known and historical centers of abundance (K. Kawelo, U.S. Army Garrison, pers. comm. 2006). For this reason, the Army believes scarce propagule resources should not be used to augment or introduce population units outside their historically documented range. Thus, even when fully stabilized, these three taxa will have fewer individuals located outside the action area. However, the predicted fire risk to these taxa is low, and one population unit outside the action area likely will be adequate to achieve and maintain stability. The Army and the Service will closely monitor these taxa and revise management actions as necessary to ensure stabilization criteria are met.

The analysis in this section is based on information about the proposed action and the environmental baselines of the 16 stabilization taxa in the action area. In addition, we make general inferences from this set of circumstances according to conservation biology principles regarding small populations and from previous experience regarding threats to the conservation of native vegetation in Hawaii (see General Effects). We also make inferences from examples of other species that are closely related to some of the 16 stabilization taxa or have a similar life history, which have become unstable, endangered, or extinct. The genus *Schiedea*, for example, contains the highest proportion of endangered taxa of any species-rich lineage in the Hawaiian Islands, with 19 taxa (about 54 percent) listed as endangered and three designated as candidates for listing (see discussion under Effects of the Action on At-Risk Taxa). The declines of *S. kaalae*, and the at-risk taxa *S. nuttalllii* and *S. obovata* are attributed to habitat degradation by feral pigs and lack of seedling survival due to slug herbivory (Wagner et al 2005). We believe that ongoing threats, if not addressed, are likely to further imperil *Schiedea* species in the action area.

Conclusion

Based on the analysis above, the Service anticipates that stressors associated with training-related wildland fire, and the introduction and spread of invasive species, are likely to result in the reduced fitness of individual plants and decrease the viability of population units of 16 stabilization taxa, by reducing the number of individuals, distribution, and recruitment in the action area. Action area individuals will be exposed to high, low, and very low risks of burning as a result of training-related wildland fire over the next 30 years. The response of stabilization taxa to training-related wildland fire will range from the direct effects of injury and death to the indirect effects of physiological stress, habitat degradation, and competition with non-native

species. The overall effect of training-related wildland fire and spread of invasive species will lead to a further decline in individual fitness, baseline number of individuals, and viability of population units within the action area. For each of these 16 stabilization taxa in the action area, the total number of individuals comprises from less than one percent to nearly 100 percent of all known remaining individuals. Thus, reduced viability in action area population units will significantly affect the range-wide status of these 16 taxa.

We develop our opinion using the best available scientific and commercial information, giving benefit of the doubt to the species if significant information gaps preclude determination of quantifiable effects. For example, the proposed action's training-related wildland fire risk could be estimated more accurately with additional modeling to predict long-term fire frequency and encroachment into native forest, and with collection of adequate demographic data for population viability analysis of listed plants. Lacking that information, we infer from restricted distribution, small population size, and limited recruitment that stabilization taxa in the action area have a high background risk of extinction. We believe any additional threats, including training-related wildland fire and habitat degradation by non-native species, are likely to eliminate expectation of long-term persistence for these 16 taxa. Accordingly, we consider stabilization of population units outside the action area, where they will not be exposed to training-related wildland fire, critical to the persistence of these 16 taxa in the wild. Without stable population units outside the action area, reduced viability of action area population units may be sufficient to appreciably reduce the likelihood that these 16 taxa will be conserved.

Our conclusion is based on our best professional judgment of the likely response of the 16 stabilization taxa to both stressors and subsidies of the proposed action. Military training restrictions and conservation management to attain full stabilization will ensure that at least three population units are achieved over the long-term for each taxon, including one or two population units for each taxon outside the action area that will not be exposed to training-related wildland fire. We anticipate that stabilization management will protect these 16 taxa from jeopardy over the next 30 years, while long-term actions for full stabilization are being implemented. Therefore, after reviewing the current status of the 16 stabilization taxa, the environmental baseline for these taxa in the action area, and the effects of the proposed action, it is the Service's biological opinion that the proposed action is not likely to jeopardize the continued existence of the following 16 stabilization taxa in the wild by reducing their reproduction, numbers, and distribution: *Alectryon macrococcus* var. *macrococcus*, *Cenchrus agrimonioides* var. *agrimonioides*, *Chamaesyce celastroides* var. *kaenana*, *Cyrtandra dentata*, *Dubautia herbstobatae*, *Flueggea neowawraea*, *Hedyotis degeneri* var. *degeneri*, *Hedyotis parvula*, *Hesperomannia arbuscula*, *Melanthera tenuifolia*, *Nototrichium humile*, *Plantago princeps* var. *princeps*, *Pritchardia kaalae*, *Schiedea kaalae*, *Tetramolopium filiforme*, and *Viola chamissoniana* ssp. *chamissoniana*.

EFFECTS OF THE ACTION – *Alectryon macrococcus* var. *macrococcus* (Mahoe)

A total of 273 *Alectryon macrococcus* var. *macrococcus* trees grow on Oahu and 110 individuals on other Hawaiian islands (79 on Kauai, 21 on Maui, and 10 on Molokai). Nineteen percent of all *A. macrococcus* var. *macrococcus* individuals (73 plants) grow in the Makua action area and 17 plants grow in Schofield Barracks West Range (Figure E 13). All known individuals of this species suffer from slight to severe defoliation and reduced vigor due to infestation by the black twig borer, an invasive introduced insect which burrows into branches and introduces a pathogenic fungus to the plants. Chinese rose beetle also defoliates portions of the plants and may kill trees weakened by other threats (Nelson and Davis 1972, and Hara and Beardsley 1979; Mau and Kessing 2004). Rat seed predation and reduced reproduction appear to be the reason that natural recruitment of this species has not been observed (U.S. Army Garrison 2006c). The Army is managing *A. macrococcus* var. *macrococcus* as a stabilization species due to its limited abundance and restricted distribution. Fewer than ten percent of trees in the stabilization population units are considered healthy by Army Natural Resources Staff. Most often, trees have little or no canopy due to black twig borer damage (U.S. Army Garrison 2006c). *Alectryon macrococcus* var. *macrococcus* has a high background risk of extinction due to its very low numbers, low vigor, and insect/pathogen threats.

Species Response to the Proposed Action

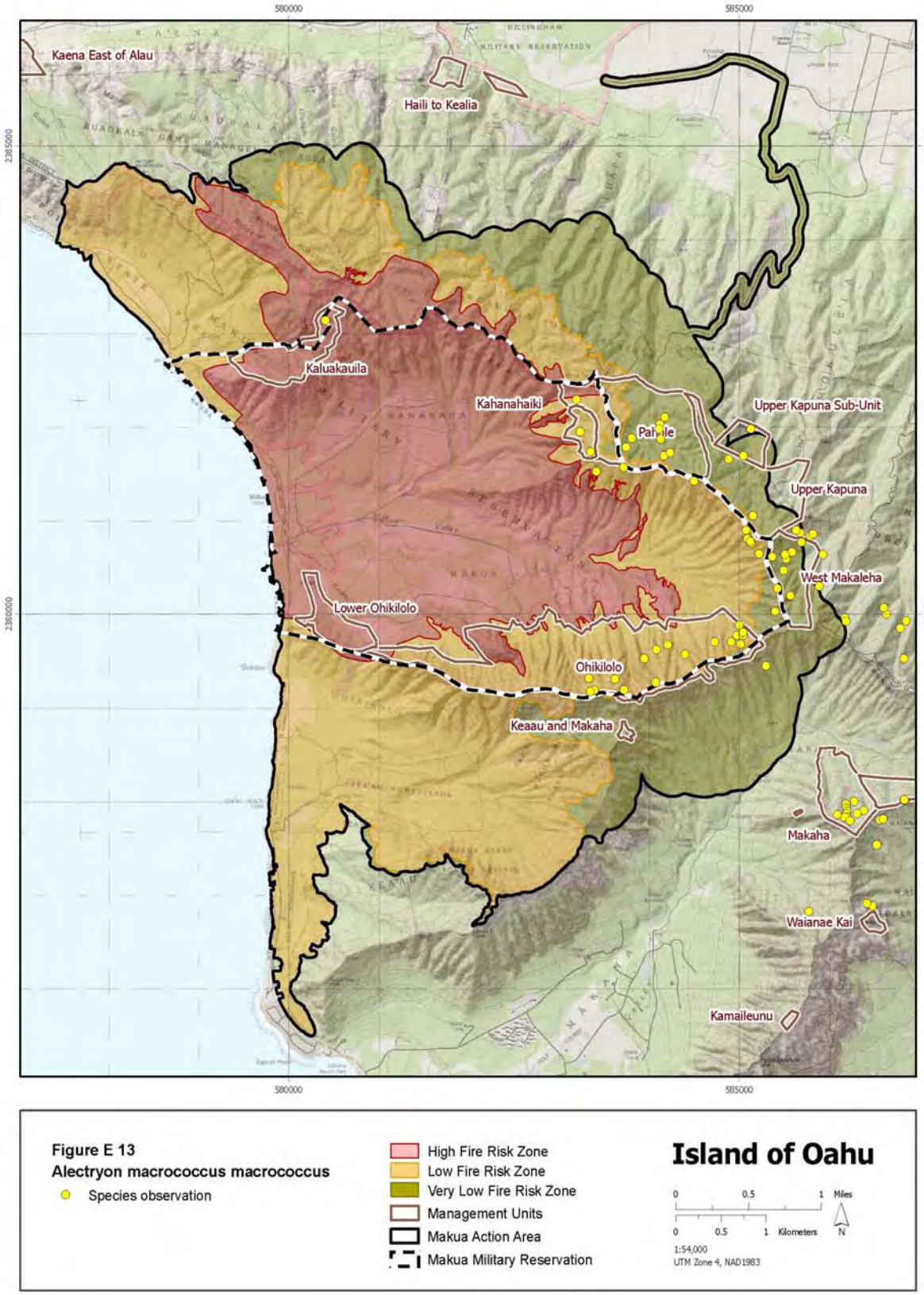
In addition to the insect/pathogen threats to the plants, wildland fires, resulting from the proposed action, could harm or kill the *Alectryon macrococcus* var. *macrococcus* trees in the Makua action area. Twenty two plants grow in the low fire risk zone and 51 individuals occur in the very low fire risk area. Two adult *A. macrococcus* var. *macrococcus* trees persist on the south aspect of C-Ridge, 35 to 150 m (114 to 492 ft) above previously burned grassy slopes. To minimize fire risk to the shrub and forest areas where these trees grow, the Army will utilize targeted aerial herbicide and seeding to discourage grass cover on the previously burned slope on C-Ridge (see Project Description – section 3.1.4.1). Because the shrub and forest vegetation below these plants is also designated Oahu elepaio critical habitat which is slated for restoration if burned, future increases in fire risk to these plants will be minimized. Although this grass control and critical habitat restoration effort will offer some fire protection to these trees, in a large fire, this site will have a lower fire suppression priority than the Kaluakauila and Kahanahaiki areas and these trees may be burned.

Twenty additional trees grow in the low fire risk zone, but their locations behind proposed fuelbreaks, in forested gulches, in high priority fire suppression areas, or at distances greater than 200 m (656 ft) from grass fuels, afford them some protection from training-related fires. These 20 plants (in addition to the 51 individuals occurring in the very low fire risk zone) are also at risk of being impacted by a fire ignited by a misfired long-range, live-fire weapon such as the TOW, and ignitions from a spot fire resulting from an intense grass fire in the valley. Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could enable these fires to burn more than 40 ha (100 ac) in a 48-hr period (see General Effects - Fire Suppression). However, the one hour of post-training fire detection flights will minimize the likelihood of an undetected fire.

The potential damage to or loss of *Alectryon macrococcus* var. *macrococcus* individuals due to wildland fires associated with live-fire training will be offset by ongoing efforts by the Army to complete stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. The Army's black twig borer research and control, propagation and outplanting, and genetic storage efforts will increase this species' likelihood of persistence. The Army is collecting and propagating cuttings and air layers from remaining individuals for the production of new plants and within the next 30 years, outplanting of at least 55 individuals by Army Natural Resources Staff will result in a total of four populations of 50 mature, reproducing *A. macrococcus* var. *macrococcus*. Army Natural Resources Staff have been collaborating with the National Center for Germplasm Research and Preservation, the Harold L. Lyon Arboretum Seed Conservation Lab, and other conservation organizations to develop genetic storage methodology for this species (U.S. Army Garrison 2006c). The Army is studying the soils and pollination systems of several healthy trees in Makaha and Makua Valley which maintain high seed set and fertilization is being examined as a means to increase reproductive effort in declining trees. In addition, research on the black twig borer is being funded by the Army to address this primary threat to the species.

Conclusion

Alectryon macrococcus var. *macrococcus* has a high background risk of extinction due to its very low numbers, low vigor, and insect/pathogen threats. A total of 22 *A. macrococcus* var. *macrococcus* trees are located in the low fire risk zone in the action area and 61 individuals grow in the very low fire risk zone, where they may be injured or killed by fires associated with proposed live-fire training. Weapons restrictions, fire suppression helicopter staffing, pre-planning and implementation of suppression actions by skilled NWCG-qualified fireline supervisors, and new fuelbreaks and firebreaks will minimize the risk of a fire burning these trees. The potential damage or loss of *A. macrococcus* var. *macrococcus* individuals from training-related wildland fire will be offset by the ongoing efforts of the Army's Natural Resources Staff as they implement stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Within the next 30 years, the Natural Resources Staff will outplant at least 55 *A. macrococcus* var. *macrococcus* individuals, implement black twig borer control, and achieve genetic storage stabilization objectives. Army stabilization efforts will improve the likelihood that *A. macrococcus* var. *macrococcus* will persist over the long term. Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service believes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.


580000
585000
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2380000
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Haili to Kealia
Kaluakauila
Kahanahaiki
Upper Kapuna Sub-Unit
Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 13
Alectryon macrococcus macrococcus
Species observation
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
0 0.5 1 Kilometers
N
1:54,000
UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Cenchrus agrimonioides* var. *agrimonioides* (Kamanomano)

Of the *Cenchrus agrimoniodes* var. *agrimonioides* on Oahu, 57 percent (401 plants) occur in the action area, in and adjacent to the Kahanahaiki and Pahole Management Units (Figure E 14). The range-wide distribution of this species includes 704 plants on Oahu, and a total of 354 plants on Maui and Lanai (Makua Implementation Team 2003; 68 FR 35970). Seventy-three percent of the Oahu plants (518 individuals) are the result of outplanting efforts by Army Natural Resources Staff and other interagency conservation organizations. All of these individuals are exposed to the suite of threats, including ungulates, described and analyzed in the General Effects section. *Cenchrus agrimoniodes* var. *agrimonioides* has a high background risk of extinction due to its low numbers and ongoing threats, therefore the Army is managing this species as a stabilization species.

Species Response to the Proposed Action

There are 369 naturally occurring and augmented *Cenchrus agrimonioides* var. *agrimonioides* plants growing in the low fire risk zone where they may be burned by an Army-caused fire. In the very low fire risk zone where fire impacts are less likely, 29 naturally occurring mature plants and three immature individuals occur. A wildland fire could spread into Kahanahaiki Management Unit from the valley floor, start in Kahanahaiki or Pahole management units from a misfired long-range, live-fire weapon such as the TOW, or start from a spot fire resulting from an intense grass fire in the valley. The Kahanahaiki and C-Ridge fuelbreaks and firebreaks will minimize the threat of fire spread to the management units. Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could permit these fires to burn more than 100 acres in a 48-hr period (see General Effects - Fire Suppression). Weapons restrictions, fire suppression helicopter staffing, pre-planning and implementation of suppression actions by skilled NWCG-qualified fireline supervisors, and new fuelbreaks and firebreaks will minimize the risk of a fire burning *C. agrimonioides* var. *agrimonioides* in the action area.

The potential damage to or loss of *Cenchrus agrimonioides* var. *agrimonioides* individuals from live-fire training will be offset by ongoing efforts by the Army to complete stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Over half of the *C. agrimonioides* var. *agrimonioides* on Oahu are the result of outplanting efforts by Army Natural Resources Staff. Outplanting, weed management, ungulate and rat control efforts, and genetic storage by the Army Natural Resources Staff will continue to improve the baseline numbers of this species.

Conclusion

Fifty-two percent of the known Oahu *Cenchrus agrimonioides* var. *agrimonioides* plants occur in the low fire risk zones of the action area and 4 percent grow in the very low fire risk zone. The Army's training related impacts to this species will be offset by completing stabilization actions including outplanting, weed management, fence installation and ungulates and other invasive species threat control. The Army's management actions for this species will increase the abundance of the plants in the population units within the Waianae Mountain Range over time. While any loss of individual plants could be significant to the survival of *C. agrimonioides* var.

agrimonioides as a taxon, implementation of stabilization actions, including outplanting, ungulate control, fire suppression assistance and genetic storage, are expected to increase vigor and distribution of this species and thus its long-term survival. Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service believes that the risks associated with the Army's proposed action are outweighed by the long-term benefits to this species of the Army's stabilization actions and ecosystem management.

Effects of the Action on *Cenchrus agrimonioides* var. *agrimonioides* Critical Habitat

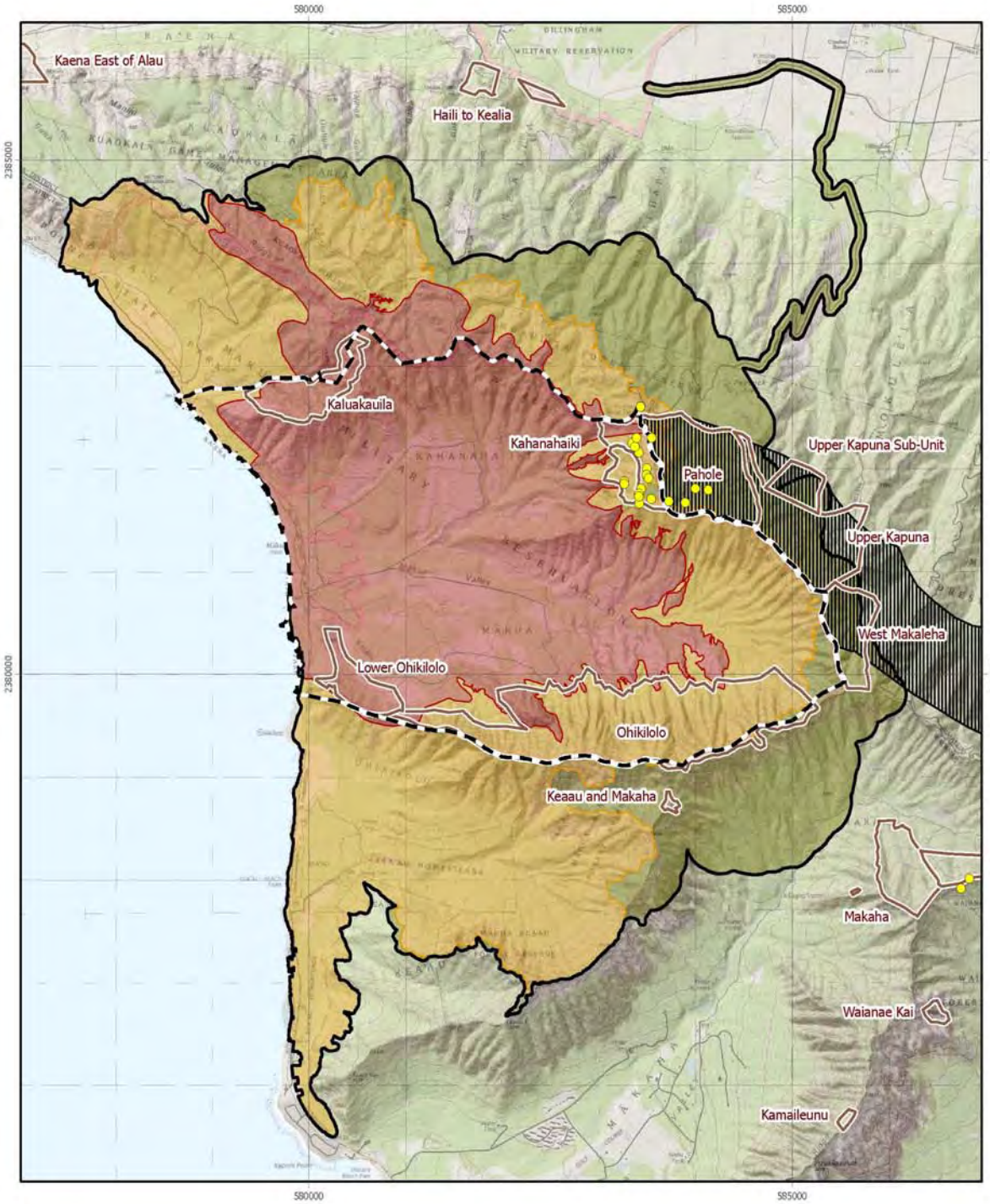
Fifteen percent (189 ha; 467 ac) of the critical habitat designated for *Cenchrus agrimonioides* var. *agrimonioides* is located in one unit within the Makua action area (see Figure E 14). This critical habitat is a portion of a larger 529 ha (1,306 ac) critical habitat unit that extends outside the Makua action area. Located in the northeastern portion of the action area, the entire critical habitat unit is in two low fire risk zones with 14.84 ha (36.67 ac) in the low and 173.96 ha (429.87 ac) in the very low fire risk area. The entire critical habitat unit was designated to provide habitat for the conservation of four populations, with at least 300 mature, reproducing individuals of *C. agrimonioides* var. *agrimonioides* (68 FR 35950). The primary constituent elements essential for this species include, but are not limited to, dry ridges upper slopes, or ridges in lowland mixed mesic forest (68 FR 35950). The primary constituent elements that may be affected by a training-related fire include native plant species found within a lowland mixed mesic forest community on Oahu. It is estimated that more than one-half of the critical habitat for *C. agrimonioides* var. *agrimonioides* is located in an area with at least 50 percent native plant cover, indicating that habitat quality has declined due to the encroachment of non-native plants. Fire would remove the remaining vegetative primary constituent elements, further degrading the habitat. Once a fire has moved through an area, non-native plant species outcompete the native plants, thereby precluding natural recruitment. In the absence of habitat management, post-burn areas have a denser fuel load, which increases the risk of fire and future habitat loss by the incremental encroachment of subsequent burns into native areas.

The designated unit for *Cenchrus agrimonioides* var. *agrimonioides* is situated approximately in the same location as *Schiedea obovata* and the effects discussion is the same for these two species. There are two small differences between these two critical habitat units: (1) Ninety percent (169 ha; 418 ac) of the critical habitat for *C. agrimonioides* var. *agrimonioides* is located within Pahole, Upper Kapuna and West Makaleha management units; and (2) the amount of remaining critical habitat (outside the management units) is approximately 18 ha (48 ac) for *C. agrimonioide* var. *agrimonioides*.

Conclusion

The critical habitat unit for *Cenchrus agrimonioides* var. *agrimonioides* in the Makua action area is almost entirely within the low fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire will be reduced due to the construction of a fuel modification zone between the impact area and the adjacent Kahanahaiki Management Unit. In addition, fuel reduction within the management unit will further buffer the critical habitat from fire. The portion of critical habitat within Pahole, West, East and Central Makaleha, and

the Upper Kapuna management units will be managed to improve its baseline quality, pursuant to the Makua Implementation Plan. Without this management, this critical habitat unit would eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *C. agrimonioides* var. *agrimonioides* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *C. agrimonioides* var. *agrimonioides*.


580000
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Kaena East of Alau
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Kahanahaiki
Pahole
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Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 14
Cenchrus agrimonioides agrimonioides
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
0 0.5 1 Kilometers
N
1:54,000
UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Chamaesyce celastroides* var. *kaenana* (Akoko)

Of the 951 total range-wide individuals of *Chamaesyce celastroides* var. *kaenana*, 513 (54 percent) are located within the Makua action area (Figure E 17). Individuals of this species were first observed in the action area in Lower Ohikilolo Management Unit, in 2001, and upon discovery, there were an estimated 36 individuals (J. Lau, Hawaii Natural Heritage Program, pers. comm. 2001). In addition to the five population units located within the action area, three population units of this Waianae Mountains endemic are found along the Kaena Point cliffs north of the action area, and one population unit is located in the Waianae Kai Forest Reserve south of the action area. Numbers of known individuals have been increasing, primarily as a result of detection of new populations and updated surveys of existing populations. Rats, ungulates, black twig borer, slugs and the Chinese rose beetle are serious threats to *C. celastroides* var. *kaenana*. This species has a high background risk of extinction due to these threats, its range-wide occurrence in dry fire-prone areas, and its low numbers. Between 2005 and 2006, numbers of plants decreased from 19 to 10 in the Kaluakauila Management Unit, due in part to an arson fire ignited at the beach park below the site. The Army is managing this species as a stabilization species pursuant to the Makua Implementation Plan Addendum because of its limited abundance and restricted distribution.

Species Response to the Proposed Action

All 544 plants found within the Makua action area grow in the high fire risk zone, within or adjacent to vegetation that has been converted to grass by previous wildland fires. One hundred and fifty-four *C. celastroides* var. *kaenana* grow in the Lower Ohikilolo Management Unit, 347 plants grow on the cliffs north of Punapohaku Stream (170 on the cliff above Farrington Highway, and 177 in the North Kahanahaiki population unit, in or near steep gulches below Kaluakauila Management Unit), 10 plants occur in the Kaluakauila Stream drainage, and 2 plants grow on C-Ridge (U.S. Army Garrison 2006c). An unknown number of these plants grow on cliffs where they are isolated from flammable vegetation.

High intensity fire kills *Chamaesyce celastroides* var. *kaenana*, although preliminary data indicate that approximately five percent of larger individuals resprout after exposure to low intensity fire (K. Kawelo, Army Natural Resources Staff, pers. comm. 2007). The area in the Lower Ohikilolo Management Unit where 36 *C. celastroides* var. *kaenana* were discovered in 2001 was within the perimeter of a 1998 wildland fire (K. Kawelo, pers. comm. 2007). This site currently supports 154 *C. celastroides* var. *kaenana* shrubs. One of the two plants on C-Ridge was burned in the 2003 escaped prescribed burn and it appears to be recovering, although it is not reproducing (L. Durand, U.S. Army, pers. comm. 2003; U.S. Army Garrison 2004; U.S. Army 2005c).

Fuel reduction treatments, fire suppression staffing, and weapons restrictions were designed to minimize the fire risk to this species. Army Natural Resources Staff clear all grass from within 2 m (7 ft) of the 154 *C. celastroides* var. *kaenana* in the Lower Ohikilolo Management Unit. Grass is also reduced to less than 20 percent cover within weed control areas surrounding these plants in order to minimize fire spread in this area.

Although weapons restrictions and fire suppression staffing will reduce the likelihood of fires escaping initial attack, without the proposed fuels treatments the Punapohaku area is likely to be

burned in large fires at Makua (see General Effects – Fire Suppression). To further reduce the likelihood of a training related fire from burning the 347 *Chamaesyce celastroides* var. *kaenana* (which account for 36 percent of all known individuals of this species) growing on the slopes in the Punapohaku Stream, the Army proposes to institute one of several alternative measures, including fuelbreaks and additional stabilization measures (see Project Description section 3.1.4.2). The 10 *C. celastroides* var. *kaenana* growing in the Kaluakauila drainage would also benefit from these proposed fuels treatments.

Chamaesyce celastroides var. *kaenana* will be stabilized pursuant to the Makua Implementation Plan Addendum. Army stabilization will result in 25 reproducing individuals in four threat controlled population units and genetic storage for this species. Three stabilization population units currently meet numerical criteria for stability and one population unit has only 21 out of the necessary 25 mature, reproducing individuals. Augmentation is not currently planned for the stabilization populations because numerical criteria for stability are expected to be achieved through natural recruitment. The fire threat will be controlled with grass clearance adjacent to all stabilization individuals, fire suppression assistance to the State and City and County (Beavers 2007), and future management unit level fuels management. Approximately 219 plants grow within management units where they will benefit from landscape-level weed control. Rats, ungulates, black twig borer, slugs and the Chinese rose beetle are serious threats to *C. celastroides* var. *kaenana*. The Army is funding black twig borer research to develop black twig borer control methods. Ungulate removal from Makua Valley and the Waianae Kai Management Unit will benefit the plants at these sites. In addition, Army Natural Resources Staff have collected seeds from over 100 *C. celastroides* var. *kaenana* plants outside of the action area where fire risk is also high (U.S. Army Garrison 2006c).

Conclusion

Chamaesyce celastroides var. *kaenana* grows in xeric lowland habitat susceptible to wildland fire. Fifty-four percent of these plants occur within the Makua action area. Weapons restrictions, fire suppression helicopter staffing, pre-planning and implementation of suppression actions by skilled NWCG-qualified fireline supervisors, and new fuelbreaks and firebreaks will minimize the risk of a fire burning most of the *C. celastroides* var. *kaenana* in the action area. To prevent Army live-fire training related fire from burning the *C. celastroides* var. *kaenana* growing on the slopes in the Punapohaku Stream the Army proposes to institute one of several alternative measures, including fuelbreaks and additional stabilization measures (see Project Description section 3.1.4.2). Fencing and ungulate control, weed control, and genetic storage are expected to increase baseline conditions for this species. Management unit level fire protection will provide long-term protection to the *C. celastroides* var. *kaenana* occurring within all management units. Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service concludes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

Effects of the Action on *Chamaesyce celastroides* var. *kaenana* Critical Habitat

There are three critical habitat units within the Makua action area, comprising six percent (30 ha; 73 ac) of the State-wide critical habitat for *Chamaesyce celastroides* var. *kaenana* (see Figure E 15). Two units are located in the high fire risk zone. Critical habitat unit B was designated to provide habitat necessary for the conservation of one population of *C. celastroides* var. *kaenana*, unit D was designated to provide habitat necessary for the conservation of a portion of one population and unit A was designated to provide habitat necessary for the conservation of two populations. Each population will be comprised of at least 300 mature reproducing individuals of this species (68 FR 35950). The primary constituent elements that are essential for this species include, but are not limited to, windward talus slopes, leeward rocky cliffs, open grassy slopes, or vegetated cliff faces in coastal dry shrubland. The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within a coastal dry shrubland community. It is estimated that 78 percent of the critical habitat is located in an area with less than 25 percent native plant cover (K. Kawelo, pers. comm. 2004). This indicates that these critical habitat units are degraded due to non-native plant encroachment. Although degraded, unit B still supports individuals of *C. celastroides* var. *kaenana* and provides habitat that is necessary for the expansion of this population in order to meet the recovery goals for this species. Unit D, currently unoccupied, provides a portion of the habitat necessary for the establishment of an additional population of *C. celastroides* var. *kaenana* in order to meet the recovery goals for this species on Oahu. Portions of unit B have been impacted by past fires which have diminished the conservation value of this habitat. The loss of vegetative primary constituent elements from fire and subsequent invasion by non-native plants precludes natural recruitment. In the absence of habitat management, additional fires from future training actions could add to the degradation of these critical habitat units.

Critical habitat unit B is approximately 4 ha (10 ac), and less than one-half ha (1 ac) of this unit is located in the Kaluakauila Management Unit. Due to the occurrence of this unit in the high fire risk zone, there is a risk that a fire started in the impact area could move north and impact this unit. The risk is increased due to the surrounding vegetation that is dominated by *Panicum maximum*, which is highly flammable and can increase the frequency and size of wildland fires (Beavers et al 1999). The loss of vegetative primary constituent elements within this unit would remove the ability of this unit to provide for the conservation of one population of *Chamaesyce celastroides* var. *kaenana*. To reduce the risk of fire to listed species and sensitive habitats, the Army has prepared a fire management plan for the Kaluakauila Management Unit (see Project Description). Implementation of this plan will reduce the risk of fire due to the construction of a fuel modification zone between the impact area and the management unit. Fuel modification will buffer the Kaluakauila Management Unit from fires that spread outside the impact area and in turn help reduce the probability that critical habitat unit B will burn. In addition, this management unit is currently fenced and the Army is working to reduce non-native plants within the enclosure. The removal of ungulates and non-native invasive plant species within this management unit enhances the conservation value of the critical habitat unit B. The remaining critical habitat (outside of the management unit) is separated from the impact area by the management unit. The fuel modification activities plus other conservation measures implemented by the Army for species stabilization will further reduce the risk of fire to the portion of the critical habitat outside of the management unit.

Critical habitat unit D (4 ha; 10 ac) is located south of the Lower Ohikilolo Management Unit. A small sliver of unit D abuts the high fire risk zone and the risk of fire in this xeric, lowland grassland habitat is high. A prescribed burn in 2003 encroached within 0.3 km (0.2 mi) from unit B (G. Enriques, U.S. Army Garrison, Fire Chief, pers. comm. 2003). The consequence of this fire is the encroachment of non-native grassland that provides more flammable fuel and increases the potential for fires in the future. Presently fuel modification is being conducted along the ridgeline between the management unit and the installation boundary to reduce the risk of fire in this area. The loss of vegetative primary constituent elements within this unit would remove its ability to provide a portion of the habitat for one population of *Chamaesyce celastroides* var. *kaenana*. In the Lower Ohikilolo Management Unit, the Army is reducing non-native plants pursuant to the objectives in the Makua Implementation Plan. This action will decrease the risk of fire within the management unit by reducing the fuel load in the area.

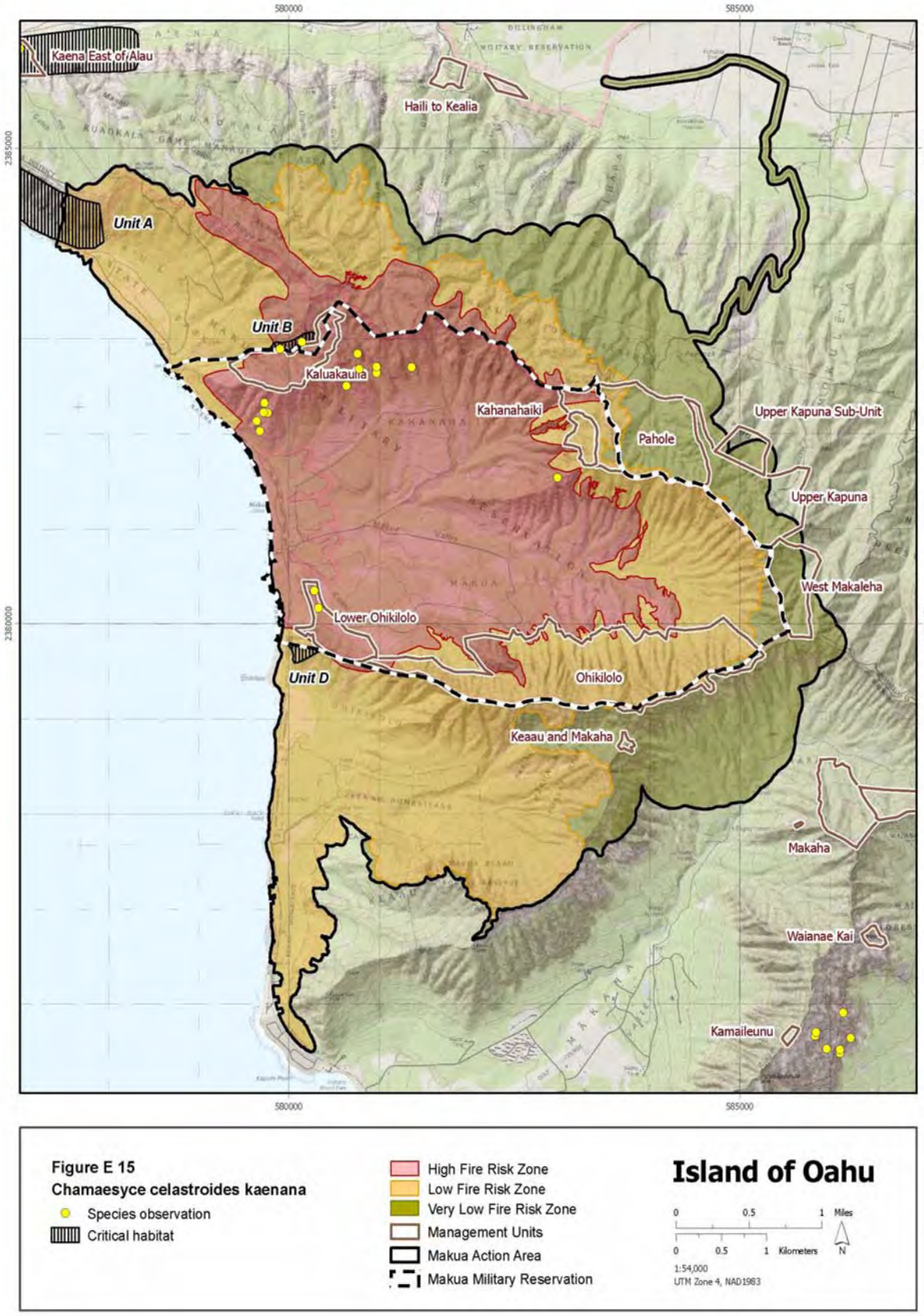
A third critical habitat unit (A) is located in the northwestern portion of the Makua action area. This unit totals 231 ha (571 ac). Nine percent (22 ha, 54 ac) of this unit is located within the action area, though none of this unit is located in a management unit. This unit is located in the low fire risk zone and is one km from the high fire risk zone. In addition, as already discussed for critical habitat unit B, a fuel management plan has been prepared and will be implemented to address fuel modification along the northern portion of this unit. This will further reduce the risk of wildland fire encroaching into this management unit.

To reduce the negative impacts to these three critical habitat units from any fire that escapes the firebreak road, the Army has committed to revegetate burned areas with native plant species to restore the area to pre-burn conditions. The revegetation plan will address restoration of burned areas by replanting native plant species (primary constituent elements) and the control of non-native, competitive plant species. While there may be a temporal loss of the conservation value of these critical habitat units during the revegetation process, the ability of these units to provide habitat essential for the conservation of two populations of *C. celastroides* var. *kaenana* will be retained in the long-term.

Conclusion

The critical habitat units for *Chamaesyce celastroides* var. *kaenana* in the Makua action area are located both inside, and outside the high fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside of the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire will be reduced due to the construction of fuel modification zones between the impact area and their respective management units. In addition, fuel reduction within the management units will further buffer units A, B and D from fire. The portion of critical habitat unit B that is within Kaluakauila Management Unit will be managed to improve its baseline quality, pursuant to the Makua Implementation Plan. Without this management, this critical habitat unit would eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *C. celastroides* var. *kaenana* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *C. celastroides* var. *kaenana* and allow for the long-term recovery goals

of this species. Therefore, training-related fire events would not result in adverse modification of critical habitat for *C. celastroides* var. *kaenana* because the potential temporal loss of two percent of the critical habitat for *C. celastroides* var. *kaenana* would not preclude its recovery.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585000
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Kaena East of Alau
Haili to Kealia
Unit A
Unit B
Kaluakauila
Kahanahaiki
Pahole
Upper Kapuna Sub-Unit
Upper Kapuna
West Makaleha
Lower Ohikilolo
Unit D
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 15
Chamaesyce celastroides kaenana
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
0 0.5 1 Kilometers
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1:54,000
UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Cyrtandra dentata* (Haiwale)

Approximately 92 percent of all *Cyrtandra dentata* plants (1,396 out of 1,525) grow in the action area in the Kahanahaiki, Pahole, and Kapuna population units (Figure E 16). Two smaller population units of this Oahu endemic, containing a total of 125 *C. dentata* plants occur in the Koolau Mountains, outside the action area (U.S. Army 2006). Total numbers of plants of this species have increased as a result of successful stabilization actions recently conducted by the Army. *Cyrtandra dentata* has a high background risk of extinction due to its very low numbers, limited distribution, and reduced vigor due to competition from invasive exotic plants and impacts from ungulates, slugs and snails. The Army is managing this species as a stabilization species due to its limited abundance and restricted distribution.

Species Response to the Proposed Action

There are 240 *Cyrtandra dentata* plants growing in low fire risk zone in the action area where they may be burned by an Army-caused fire and 1,156 plants in the very low fire risk zone where fire impacts are expected to be more limited. Two hundred and forty *C. dentata* grow in Kahanahaiki Gulch, less than 100 m (328 ft) from the south aspect area of the gulch burned in the 1970, 1984, 1995, and 2003 wildland fires. To minimize the risk of fires in Kahanahaiki Gulch, the Army will construct either a 20-m (65-ft) wide firebreak, or a 200-m (656-ft) wide shaded fuelbreak in Kahanahaiki Gulch along the Kahanahaiki Management Unit perimeter. In addition, a helispot will be maintained within 500 m (1,640 ft) of the upper reaches of Kahanahaiki Gulch and a safety zone will be established within or adjacent to the management unit so that skilled NWCG-qualified fireline supervisors and firefighters, including red-carded Army Natural Resources Staff, can be safely stationed at the outplanting site when fire threatens the gulch area. These efforts are likely to result in the prevention of loss of the plants in the Kahanahaiki Gulch area. All *C. dentata* plants growing in the action area may be impacted by spot fires spawned by intense fires burning in Makua valley, or by fires ignited by a misfired long-range, live-fire weapon (such as the TOW). Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac) (see General Effects—Fire Suppression).

The potential damage to or loss of *Cyrtandra dentata* individuals due to Army-caused fires will be offset by ongoing efforts by the Army to complete stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Fencing and ungulate control, weed control, slug and snail control research, and genetic storage actions will help ensure the persistence of *C. dentata*. *Cyrtandra dentata* numbers were declining, but recent ungulate control has resulted in a reversal of that trend (Service 2003b; L. Durand, pers. comm. 2004; U.S. Army Garrison 2005c). Approximately 1,208 *C. dentata* individuals currently benefit from weed control, and fencing and ungulate removal.

Conclusion

There are 240 *Cyrtandra dentata* plants growing in low fire risk zone in the action area where they may be burned by an Army-caused fire and 1,156 plants in the very low fire risk zone where fire impacts are expected to be more limited. Weapons restrictions, fire suppression helicopter staffing, pre-planning and implementation of suppression actions by skilled NWCG-qualified fireline supervisors, and new fuelbreaks and firebreaks will minimize the risk of a fire burning *C.*

dentata in the action area. The potential damage or loss of *C. dentata* individuals from fire will be offset by the ongoing efforts of the Army's Natural Resources Staff as they implement stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Fencing and ungulate control, weed control, slug and snail control research, and genetic storage are expected to result in increased numbers of *C. dentata*. Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service concludes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

Effects of Action on *Cyrtandra dentata* Critical Habitat

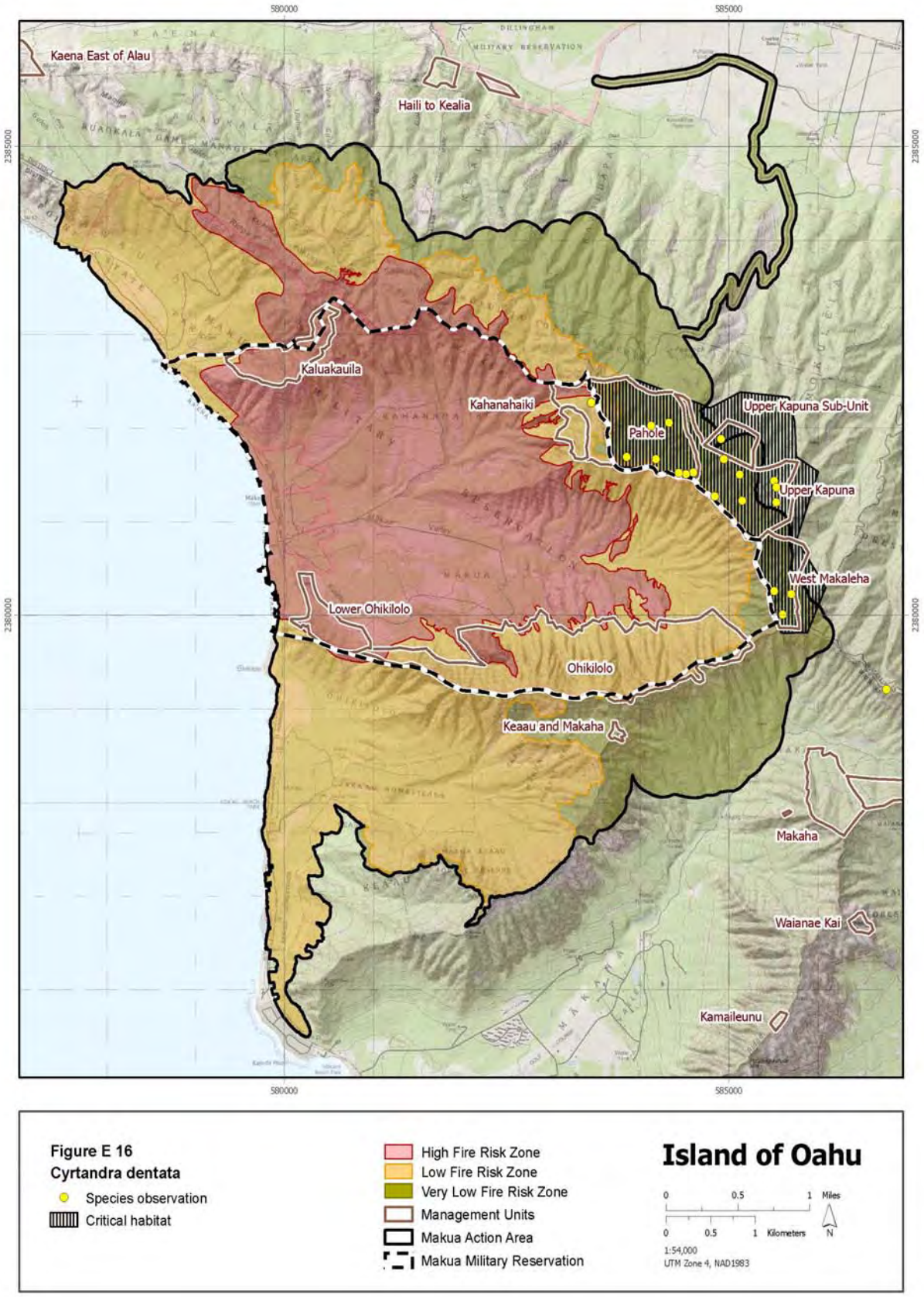
Sixty-eight percent (208 ha; 514 ac) of the critical habitat designated for *Cyrtandra dentata* is located in the Makua action area (see Figure E 16). The unit is located in the northeastern portion of the action area and is almost entirely in the low fire zones, with 17.6 ha (43.6 ac) in the low fire risk zone, 190 ha (470 ac) in the very low zone. This critical habitat, together with 98 ha (243 ac) outside the action area, was designated to provide habitat for the conservation of three populations, each with a minimum of 300 mature individuals of *C. dentata* (68 FR 35950). The primary constituent elements essential for this species include, but are not limited to, gulches, slopes, stream banks, or ravines in mesic or wet forest. The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within mesic or wet forest. It is estimated that more than one-half of the critical habitat is located in forest habitat with greater than 50 percent native plant cover (U.S. Army Garrison 2003b; K. Kawelo, pers. comm. 2004; 68 FR 35950). This indicates that this critical habitat unit still maintains at least half of its native vegetation component although non-native plant encroachment has occurred. Without habitat management, fires could add to the degradation of this critical habitat unit by removing remaining vegetative primary constituent elements in a single burn.

There is a risk that if a fire started in the impact area or if weaponry were misfired, a fire could burn eastward and impact this unit. Eighty-eight percent, or 183 ha (452 ac), of the critical habitat is located in management units (Upper Kapuna, Pahole, West Makaleha, and Upper Kapuna Sub-Unit). The remaining critical habitat (25 ha; 61 ac) outside of the management units is buffered from the impact area by the management units themselves. Please see *Schiedea obovata* for a detailed discussion regarding the reduced risk of fire and the beneficial measures proposed by the Army to offset impacts to this critical habitat unit.

Conclusion

The critical habitat unit for *Cyrtandra dentata* in the Makua action area is located almost entirely in the low fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's Standard operating procedures will reduce the likelihood that a fire will ignite and travel outside of the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire to the critical habitat located in the Pahole Management Unit will be reduced due to the construction of a fuel modification zone between the impact area and the Kahanahaiki Management Unit that is adjacent to the Pahole Management Unit. In addition, fuel reduction within the management units will further buffer the critical habitat unit from fire. The critical habitat that is within Upper Kapuna Sub-Unit, Pahole, Upper Kapuna, and West

Makaleha management units will be managed to improve its baseline quality, pursuant to the Makua Implementation Plan. Without this management, this critical habitat unit could eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *C. dentata* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *C. dentata* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *C. dentata*.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585000
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Kaena East of Alau
Haili to Kealia
Kaluakauila
Kahanahaiki
Pahole
Upper Kapuna Sub-Unit
Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 16
Cyrtandra dentata
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
0 0.5 1 Kilometers
N
1:54,000
UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Dubautia herbstobatae* (Naenae)

Approximately 98 percent (1,166 out of a total of 1,188) of all *Dubautia herbstobatae* shrubs occur within the Makua action area in the Ohikilolo (1,096 plants) and Keaau (70 individuals) population units (Figure E 17). Two smaller population units of this Waianae Mountains endemic occur in the vicinity of the Makaha and Waianae Kai Management Units. All of these individuals are exposed to the suite of threats, including ungulates and wildland fire described and analyzed in the General Effects section. *Dubautia herbstobatae* has a high background risk of extinction due to its low numbers and threats. The Army is managing this species as a stabilization species because of its limited abundance and restricted distribution.

Analysis of Effects of the Proposed Action

The proposed action of increased Army training with long-range, incendiary weapons could result in injury and death of *Dubautia herbstobatae* individuals in the action area. Approximately 822 *D. herbstobatae* plants are growing in the low fire risk zone of the action area, in the Ohikilolo Management Unit and in the vicinity of the Keaau and Makaha Management Unit. An additional 350 mature plants occur in the very low fire risk zone in Makaha Valley. A wildland fire could spread onto Ohikilolo Management Unit from the valley floor, start on the ridge from a misfired long-range, live-fire weapon such as the TOW, and start from a spot fire resulting from an intense grass fire in the valley. New weapons restrictions and refined fire suppression staffing requirements minimize the risk of fire to the *D. herbstobatae* occurring in Ohikilolo Management Unit. Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could enable these fires to burn more than 40 ha (100 ac) in a 48-hr period (see General Effects—Fire Suppression). The effect of fire on *D. herbstobatae* has not been documented but many individuals in the action area grow on cliffs (U.S. Army Garrison 2006c) where fire spread will be limited.

The potential damage to or loss of *Dubautia herbstobatae* individuals due to wildland fires associated with live-fire training will be offset by ongoing efforts by the Army to complete stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. The 84 individuals in the Waianae Kai and Keaau population units are exposed to wildland fires ignited by the public in Waianae Valley and along Farrington Highway (Beavers 2007a). Although the *D. herbstobatae* in the vicinity of the Keaau and Waianae Kai management units are only scheduled for genetic storage protection by Army Natural Resources Staff, these two populations of plants will benefit from the fire suppression, fuels management, control of threats to populations of other species (e.g., *Sanicula mariversa*) located on these sites. Threat control, and, if necessary, outplanting will increase the number of mature, reproducing *D. herbstobatae* in the Makaha population unit by a minimum of 14 plants.

Conclusion

Despite the ongoing exposure of *Dubautia herbstobatae* to wildland fire impacts associated with the proposed project, Army conservation and stewardship programs will improve its baseline condition in the action area and range-wide. Weapons restrictions, fire detection and fire suppression helicopter staffing will minimize the risk of training-related wildland fire to the *D. herbstobatae* occurring in the action area. Stabilization actions, including propagation,

augmentation, ecosystem management, and genetic storage scheduled to be conducted by the Army over the next 30 years will increase baseline numbers of *D. herbstobatae* inside and outside the action area. Therefore, based on our analysis of the effects of the actions outlined in the Project Description, including training-related fire minimization measures, the Service concludes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

Effects of the Action on *Dubautia herbstobatae* Critical Habitat

There are two critical habitat units within the Makua action area, encompassing less than 16 percent (approximately 14 ha; 36 ac) of the total critical habitat for *Dubautia herbstobatae* (see Figure E 17). The entire critical habitat is located in the low fire zones, with 0.31 ha (0.76 ac) in the low fire risk zone and 11.3 ha (27.8 ac) in the very low zone. These units provide habitat for the conservation of a total of three populations in order to meet the recovery goals for this species. Each population will be comprised of at least 300 mature, reproducing individuals of *D. herbstobatae* (68 FR 35950). The primary constituent elements that are essential for this species include, but are not limited to, rock outcrops, ridges, moderate slopes, or vertical cliffs in dry or mesic shrubland (68 FR 35950). The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within a dry or mesic shrubland. It is estimated that more than 90 percent of the critical habitat is in forest habitat with less than 25 percent native plant vegetation (K. Kawelo, pers. comm. 2004). This indicates that these critical habitat units are currently degraded due to non-native plant encroachment. However, unit A still supports individuals of *D. herbstobatae* and provides habitat that is necessary for the expansion of this population.

Should a fire from training actions impact one or both of these units, the loss of their vegetative primary constituent elements and the subsequent invasion by non-native plant species will preclude natural recruitment. In the absence of habitat management, these fires could increase the degradation of these critical habitat units by removing the remaining vegetative primary constituent elements.

Critical habitat unit A is approximately 12 ha (29 ac) on Ohikilolo ridge. One hectare (3 ac) of this critical habitat unit is located in Ohikilolo Management Unit within the low fire risk area. Unit A is approximately 0.5 km (0.25 mi) from the high fire risk zone, and there is a risk that a fire started in the impact area could move up Ohikilolo Ridge from the north or the west and impact this unit. The risk is decreased somewhat by the surrounding vegetation composed of mixed cliff communities and *Schinus terebinthifolius* forest, which are of low and moderate fire hazard, respectively, and can slow the fire (Beavers et al 1999). A prescribed burn in 2003 encroached into Ohikilolo Management Unit at the northern edge, opposite the location of the critical habitat unit, which is on the southern edge of the management unit (G. Enriques, pers. comm. 2003). The consequence of this fire is the encroachment of non-native grassland that provides a more flammable fuel and increases the potential risk for future fires in this area. The loss of vegetative primary constituent elements within this unit would remove its ability to provide habitat for the conservation of one population of *Dubautia herbstobatae*. To reduce the risk of fire to listed species and sensitive habitats, the Army will develop and implement a fire management plan for the Lower Ohikilolo Management Unit, including, but not limited to, the construction of a fuel modification line at the base of the management unit. This fuel modification line will buffer the Ohikilolo Management Unit from fires that spread outside the

firebreak road from the west up and along Ohikilolo Ridge. In addition, this management unit is currently fenced and goat-free and the Army is working to reduce non-native plants within the fence. The Army is monitoring the impacts of feral pigs and will take further measures to remove pigs if they become a threat to *D. herbstobatae* critical habitat. The removal of ungulates and non-native invasive plant species within this management unit enhances the conservation value of critical habitat unit A. The critical habitat outside of the management unit is buffered from the impact area by the management unit. The fuel modification activities, plus other conservation measures implemented by the Army for species stabilization, will further reduce the risk of fire to the portion of the critical habitat outside of the management unit.

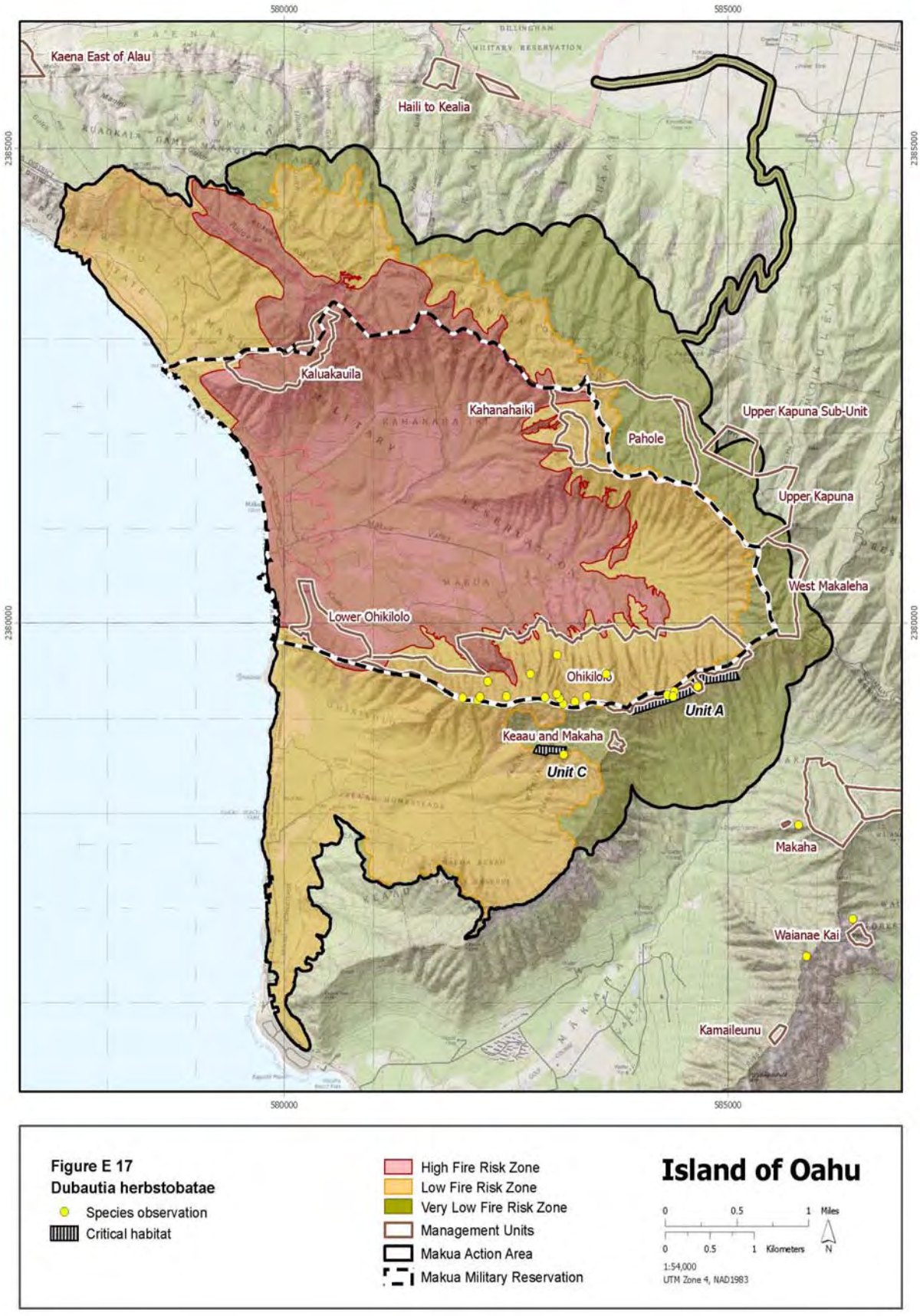
Critical habitat unit C (3 ha; 7 ac) is located within the low fire risk zone near the Keaau and Makaha Management Unit. Unit C is approximately 1 km (0.6 mi) from the high fire risk zone, and the risk of fire in this xeric grassland habitat is high. The 2003 prescribed burn encroached within 1.3 km (0.8 mi) from unit C (G. Enriques, pers. comm. 2003). The consequence of this fire is the encroachment of non-native grasses that provide more flammable fuel and increases the potential for fires in the future. The fuel modification conducted for Unit A will also reduce the risk of fire in this area. The loss of vegetative primary constituent elements within this critical habitat unit would remove its ability to provide for the conservation of two populations of *Dubautia herbstobatae*. In the Upper Keaau Management Unit, the Army will fence and remove ungulates, and reduce non-native plants pursuant to the objectives in the Makua Implementation Plan. In addition, the control of non-native species in the Ohikilolo Management Unit will provide an additional buffer between the Upper Keaau Management Unit and the impact area. These actions will decrease the risk of fire within the management unit by reducing the fuel load in the area.

To reduce the negative impacts to critical habitat from fire that escapes the firebreak road, the Army has committed to revegetate burned areas with native plant species to restore the area to pre-burn conditions. The re-vegetation plan will address restoration of burned areas by replanting native plant species (primary constituent elements) and controlling non-native, competitive plant species. While there may be a temporal loss of the conservation value of these critical habitat units during the re-vegetation process, the ability of these units to provide habitat essential for the conservation of three populations of *Dubautia herbstobatae* will be retained in the long-term.

Conclusion

One hundred percent of the two critical habitat units for *Dubautia herbstobatae* in the Makua action area is located outside of the high fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside of the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire will be reduced due to the construction of fuel modification zones between the impact area and their respective management units. In addition, fuel reduction within the management units will further buffer critical habitat units A and B from fire. The portion of critical habitat unit A that is within Ohikilolo Management Unit and the portion of critical habitat unit C within Upper Keaau Management Unit will be managed to improve their baseline quality pursuant to the Makua Implementation Plan. Without this management, these critical habitat units would eventually lose most of the elements essential to the survival and recovery of the species because of the

ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued risk of degradation of *D. herbstobatae* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *D. herbstobatae* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *D. herbstobatae.*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Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Unit A
Keaau and Makaha
Unit C
Makaha
Waianae Kai
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Figure E 17
Dubautia herbstobatae
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
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Island of Oahu
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0 0.5 1 Kilometers
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UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Flueggea neowawraea* (Mehamehame)

Flueggea neowawraea is a long-lived tree species with 129 individuals occurring in ten population units on Oahu (Figure E 18). An additional 52 to 59 individuals are located in 39 population units on other Hawaiian Islands. Out of the 129 *F. neowawraea* trees on Oahu, only 40 are naturally occurring adults. However, the Army's Natural Resources Staff have outplanted 59 individuals associated with their stabilization efforts for this species. The remaining 30 trees on Oahu are located in gardens and arboretums. Approximately 33 percent of the range-wide population of *F. neowawraea* (including the naturally occurring adult trees (14) and all 59 of the outplanted saplings) are found in the Makua action area. *Flueggea neowawraea* is not reproducing naturally due to a variety of reproductive challenges including isolation (due to the species inability to self-pollinate) and poor vigor due to black twig borer and Chinese rose beetle damage. *Flueggea neowawraea* has a high background risk of extinction due to its very low numbers, low vigor, and insect/pathogen threats. The Army is managing this species as a stabilization species due to its limited abundance and restricted distribution.

Species Response to the Proposed Action

Four mature, naturally occurring *Flueggea neowawraea* trees and 59 outplanted saplings grow in the low fire risk zone where they may be burned by a training-caused fire. Ten naturally occurring trees are found in the very low fire risk zone within the Makua action area where fire impacts are less likely. Army weapons restrictions, fire suppression staffing, and fuels management projects are designed to minimize the risk of fire damage to the *F. neowawraea* growing within the action area. The effect of fire on *F. neowawraea* has not been documented, but the tree's thin bark is not likely to be adequate to prevent fire injury to the cambium.

The Army Natural Resources Staff have outplanted 59 saplings in mesic gulches in the Kahanahaiki Management Unit to augment the one remnant adult tree in this area. The lower reaches of the Kahanahaiki Gulch and the south aspect of the upper reaches of the gulch burned in the 1970, 1984, 1995, and 2003 wildland fires and all of these fires except for the 1984 fire breeched the Kahanahaiki Management Unit perimeter. To minimize the risk of fires in Kahanahaiki Gulch, the Army will construct either a 20-m (65-ft) wide firebreak, or a 200-m (656-ft) wide shaded fuelbreak in Kahanahaiki Gulch along the Kahanahaiki Management Unit perimeter. In addition, a helispot will be maintained within 500 m (1,640 ft) of the upper reaches of Kahanahaiki Gulch and a safety zone will be established within or adjacent to the management unit so that skilled NWCG-qualified fireline supervisors and firefighters, including red-carded Army Natural Resources Staff, can be safely stationed at the outplanting site when fire threatens the gulch area. These efforts are likely to result in the prevention of loss of the trees and saplings in Kahanahaiki Gulch.

One adult *Flueggea neowawraea* persists on the south aspect of C-Ridge, 35 m (114 ft) above previously burned grassy slopes, where it is partially protected by a forested drainage. To minimize fire risk to the forested area where this tree grows, the Army will utilize targeted aerial herbicide and seeding to discourage grass cover on the previously burned slope on C-Ridge (see Project Description – section 3.1.4.1). Although this grass control effort will offer some fire protection to this tree, in a large fire, this site will have a low fire suppression priority and the tree may be burned.

One *Flueggea neowawraea* tree grows on the steep valley walls in the Ohikilolo Management Unit in the low fire risk zone, and 10 *F. neowawraea* trees grow in the very low fire risk zone. The greatest fire risk to these 11 trees is from misfired long-range, live-fire weapons such as the TOW, and spot fires spawned by intense fires in the lower valley. Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac) (see General Effects - Fire Suppression).

The potential damage to or loss of *Flueggea neowawraea* individuals due to fires associated with live-fire training will be offset by ongoing efforts by the Army to complete stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Within the next 30 years, outplanting of at least 84 individuals by Army Natural Resources Staff will result in a total of three populations of 50 *F. neowawraea*. The Army is collecting and propagating cuttings and air layers from remaining individuals for the production of new plants. In addition, research on the black twig borer is being funded by the Army to address this primary threat to this species. Army Natural Resources Staff have currently achieved genetic storage goals for four *F. neowawraea* trees and genetic storage goals are expected to be met for all 40 individuals of this species.

Conclusion

Approximately 73 *Flueggea neowawraea* are located in the low and very low fire risk zones in the Makua action area. Weapons restrictions, fire suppression helicopter staffing, pre-planning and implementation of suppression actions by skilled NWCG-qualified fireline supervisors, and new fuelbreaks and firebreaks will minimize the risk of a fire burning *F. neowawraea* trees. The potential damage or loss of *F. neowawraea* individuals from training-related wildland fire will be offset by the ongoing efforts of the Army's Natural Resources Staff as they implement stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Within the next 30 years, the Natural Resources Staff will outplant at least 84 *F. neowawraea* individuals, implement black twig borer control, and achieve genetic storage stabilization objectives. Army stabilization efforts will improve the likelihood that *F. neowawraea* will persist over the long term. Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service believes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem managment.

Effects of the Action on *Flueggea neowawraea* Critical Habitat

Six percent (174 ha; 431 ac) of the total critical habitat for *Flueggea neowawraea* is located in the Makua action area (see Figure E 18). The critical habitat is located in the northeastern portion of the action area. The unit straddles all fire risk zones with 157.2 ha (388.5 ac) in the low risk zone; 16.8 ha (41.6 ac) in the very low risk zone and only 0.2 hectares (0.6 ac) in the high fire risk area. The critical habitat in the action area, in combination with 670 ha (1,656 ac) of habitat outside the action area, was designated to provide habitat for the conservation of one population of at least 100 mature individuals of *F. neowawraea* (68 FR 35950). The physical and biological habitat features (primary constituent elements) essential for this species include, but are not limited to, gulch slopes, ridge crests, or near streams in dry or mesic forest (68 FR 35950). The primary constituent elements that may be affected by a training-related fire include

those associated native plant species found within a dry or mesic forest community. It is estimated that a little more than one-half of the critical habitat is located in forest habitat with greater than 50 percent native plant cover (K. Kawelo, pers. comm. 2004). This indicates that the habitat in this unit retains some native components but that the area has been impacted by invasive non-native plants. Portions of this critical habitat unit may have been impacted by past fire events, which diminishes the conservation value of the habitat by removing the vegetative primary constituent elements. Non-native plant species subsequently outcompete the native plants so that natural recruitment is precluded. In the absence of habitat management, additional fires resulting from future training actions could add to the degradation of this critical habitat unit by removing the remaining vegetative primary constituent elements.

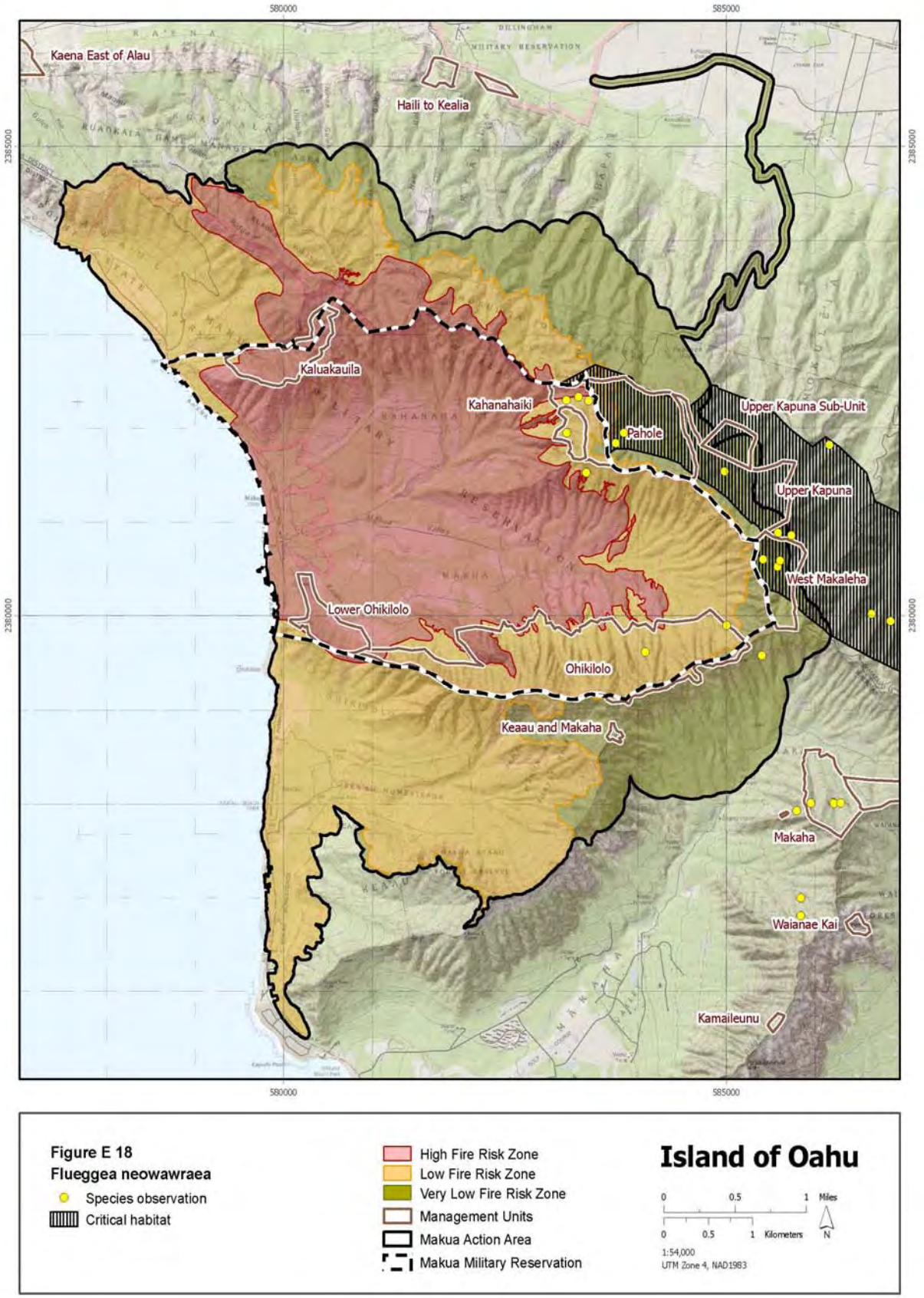
A prescribed burn in 2003 appears to have breached the northwestern-most portion of the critical habitat unit. The consequence of this fire is the encroachment of non-native mixed grassland (*Leucaena leucocephala*/*Panicum maximum*; koa haole/guinea grass) that provides flammable fuel and increases the potential for fires to creep into the critical habitat unit in the future. The eventual loss of this portion of the critical habitat unit would reduce its ability to provide a portion of the habitat necessary for the conservation of one population of *Flueggea neowawraea*. However, only 0.2 ha (0.6 ac) of this unit are in an area of high fire risk and most of the unit's western boundary is immediately adjacent to low and very low fire risk areas.

The critical habitat in the high fire risk area is adjacent to the Kahanahaiki and Pahole management units. Approximately 70 percent or 246 ha (607 ac) of the critical habitat in the action area is found within management units (Pahole, Upper Kapuna, Upper Kapuna Sub-Unit, and West Makaleha). Less than one ha (2 ac) of critical habitat is in the Kahanahaiki, Central, and East Makaleha management units. The implementation of increased fire suppression measures pursuant to this consultation (e.g., helicopter staffing, fuel modification, weapons restrictions) will further reduce the risk of fire to *Flueggea neowawraea* critical habitat. In addition, construction of the fuelbreak will buffer the Kahanahaiki Management Unit from fires that spread outside the impact area (see General Effects-Fire) and, in turn, reduce the probability that fire will burn through the management unit and into the critical habitat in the Pahole Management Unit, which is immediately adjacent. The boundary of this critical habitat unit abuts areas of low and very low fire risk vegetation (mostly native forest).

For other conservation actions that have been or will be implemented pursuant to the Makua Implementation Plan, please see the discussion for *Schiedea obovata*. The remaining critical habitat outside the management units (104 ha; 257 ac) is separated from the impact area by low and very low fire risk areas and by the above-mentioned management units themselves. Spatial separation from the impact area, adjacent low and very low fire risk area along the western boundary of the critical habitat unit, fuel modification actions that will be implemented for the Kahanahaiki Management Unit, and the aforementioned activities implemented by the Army for species stabilization in the Pahole, Upper Kapuna, Upper Kapuna Sub-Unit, West, Central and East Makaleha, and Kahanahaiki management units will further reduce the risk of fire to the portion of critical habitat outside the management units.

Conclusion

The critical habitat unit for *Flueggea neowawraea* in the Makua action area is mostly within the low and very low fire risk area. A small portion (close to zero percent) is within the high fire risk area, and this portion is buffered by fuel reduction actions in the adjacent Kahanahaiki and Pahole management units. The risk of fire will be reduced due to the construction of a fuel modification zone between the impact area and the Kahanahaiki Management Unit. Implementation of the all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside the firebreak road or that a misfired round will ignite outside of the firebreak road. The portion of critical habitat within the Kahanahaiki, Pahole, West, East and Central Makaleha, and Upper Kapuna, Upper Kapuna Sub-Unit management units will be managed to improve its baseline quality pursuant to the Makua Implementation Plan. Without this management, this critical habitat unit would eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *F. neowawraea* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *F. neowawraea* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modifications to *F. neowawraea* critical habitat.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Kaluakauila
Kahanahaiki
Pahole
Upper Kapuna Sub-Unit
Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 18
Flueggea neowawraea
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
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N
1:54,000
UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Hedyotis degeneri* var. *degeneri* (No Common Name)

Hedyotis degeneri var. *degeneri* is endemic to the Waianae mountain range of Oahu and 85 percent of all known individuals (524 out of a total of 617 recorded range-wide individuals) grow in the Kahanahaiki and Pahole management units in the action area (U.S. Army Garrison 2006c) (Figure E 19). Although plant numbers have quadrupled in recent years, this is due to the discovery of new plants; ungulate and weed threats are actually resulting in reductions in numbers (S. Ching, Army Natural Resources, pers. comm. 2007). *Hedyotis degeneri* var. *degeneri* has a high background risk of extinction due to ongoing threats and its low numbers. The Army is managing this species as a stabilization species pursuant to the Makua Implementation Plan Addendum due to its limited abundance and restricted distribution.

Species Response to the Proposed Action

The proposed action could result in injury and death of *Hedyotis degeneri* var. *degeneri* individuals in the action area. A total of 259 plants (42 percent of all range-wide individuals) grow in the low fire risk zone of the Makua action area and there are 265 individuals (accounting for an additional 43 percent of all plants) in the very low fire risk zone in the Pahole Management Unit. Six mature shrubs grow within approximately 30 m (98 ft) of a grassy slope where forest and shrub vegetation was burned by the Army's 1995 and 2003 escaped prescribed burns. The Army will construct and maintain a new 40-m (131-ft) wide fuelbreak to minimize fire risk to Kahanahaiki (see Figure PD 8), and this site will receive high priority by fire suppression helicopters and skilled fireline supervisors (see General Effects - Fire Suppression). This fuelbreak is not likely to be substantial enough to prevent accidental or white phosphorus-caused wildland fires, which may occur when Makua is not staffed by fire suppression resources, from impacting this area of Kahanahaiki Management Unit. Fire risk to the 265 plants growing in the low fire risk zone in Pahole Management Unit will be minimized by the Army's maintenance of the 200-m (656-ft) shaded fuelbreak on C-Ridge, below the management unit (see Project Description section 3.1.3). All plants in the action area may be burned in a fire ignited on the ridge by a misfired long-range, live-fire weapon such as the TOW, or by a spot fire resulting from an intense grass fire in the valley. Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could enable these fires to burn more than 40 ha (100 ac) in a 48-hr period (see General Effects - Fire Suppression).

The potential damage to or loss of *Hedyotis degeneri* var. *degeneri* individuals due to wildland fires associated with live-fire training will be offset by ongoing efforts by the Army to complete stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Stabilization actions proposed by the Army, including outplanting, ungulate control, weed control and genetic storage, are likely to result in increased probability that this species will persist. Fencing and ungulate control (scheduled for completion in 2008 in the East Makaleha Management Unit, 2012 in the Manuwai Management Unit, and five years after the completion of this Biological Opinion in Kahanahaiki Management Unit) and ecosystem-level weed control is likely to result in increased vigor and reproductive success of the *H. degeneri* var. *degeneri* at these sites, and will improve site quality for outplanted individuals. The Army has already met genetic storage goals for 23 out of the 135 plants slated for this protection.

Conclusion

Hedyotis degeneri var. *degeneri* has a high background risk of extinction due to its low numbers, which are declining as a result of ungulate and weed impacts. Approximately 42 percent of all range-wide individuals are located in the low fire risk zone in the action area and an additional 43 percent of all plants grow in the very low fire risk zone, where they may be injured or killed by fires associated with proposed live-fire training. Weapons restrictions, fire detection and fire suppression helicopter staffing, pre-planning and implementation of suppression actions by skilled NWCG-qualified fireline supervisors, and new fuelbreaks and firebreaks will minimize the risk of a fire burning the plants in the action area. The potential damage or loss of *H. degeneri* var. *degeneri* individuals from training-related wildland fire will be offset by the ongoing efforts of the Army's Natural Resources Staff as they implement stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Stabilization actions proposed by the Army, including outplanting, ungulate control, weed control, and genetic storage, significantly increased the probability that this species will persist over the long term. Based on our analysis of the effects of the actions outlined in the Project Description including wildland fire minimization measures, the Service believes that the risks associated with the Army's proposed action, which are low to very low, are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

Effects of the Action on *Hedyotis degeneri* var. *degeneri* Critical Habitat

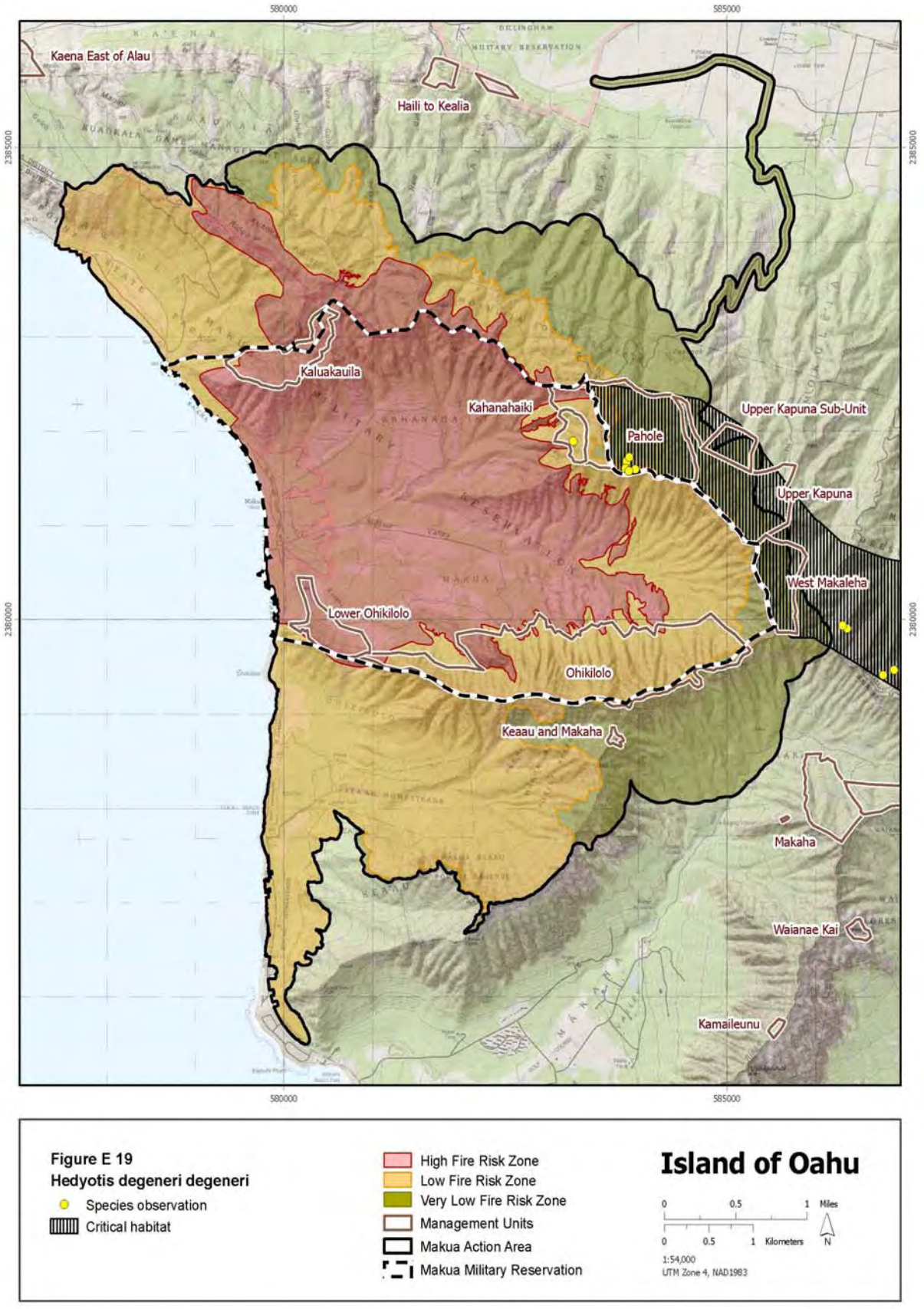
Approximately 23 percent, or 212 ha (524 ac), of the total critical habitat for *Hedyotis degeneri* is located in one unit in the Makua action area (see Figure E 19). The critical habitat in the action area is a portion of 917 ha (2,265 ac) that were designated to provide habitat for the conservation of eight populations of *H. degeneri*. Each population will be comprised of at least 300 mature individuals in order to meet the recovery goals for this species. As with many other species previously discussed, this critical habitat for *H. degeneri* is located in the northeastern portion of the action area, almost entirely in low fire risk zone, with 16.7 ha (41.3 ac) in the low fire risk area and 195 ha (482 ac) in the very low fire risk area. The primary constituent elements essential for this species include, but are not limited to, ridge crests in diverse mesic forest (68 FR 35950). The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within a diverse mesic forest community on Oahu. It is estimated that 70 percent of the critical habitat is located in forest habitat with greater than 50 percent native plant cover, indicating this area still supports a relatively healthy native forest. However, invasive plant species have encroached into this area, and their ability to outcompete native plants slowly degrades native ecosystems. In the absence of resource management, additional fires or even threats from invasive plants and animals add to the incremental degradation of this critical habitat unit by removing vegetative primary constituent elements.

The risk of a training-related fire moving east from the impact area and burning this critical habitat unit is low. Eighty-seven percent or 246 ha (607 ac) of the critical habitat is located in designated management units (Pahole, Upper Kapuna, Upper Kapuna Sub-Unit, Central and West Makaleha, Kahanahaiki, and West Makaleha). Please see *Schiedea obovata* for a detailed discussion regarding the ongoing or proposed Army actions to benefit the aforementioned management units. The amount of critical habitat for *Hedyotis degeneri* outside of the

management units is approximately 37 ha (91 ac). This area is separated from the impact area by low and very low fire risk areas and by the above-mentioned management units themselves. Therefore, spatial separation from the impact area, adjacent low and very low fire risk areas along the western boundary of the critical habitat unit, fuel modification actions that will be implemented for the Kahanahaiki Management Unit, and the activities discussed previously (*S. obovata* effects analysis) will further reduce the risk of fire to all critical habitat for *H. degeneri*.

Conclusion

The critical habitat unit for *Hedyotis degeneri* in the Makua action area is almost entirely within the low and very low fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire will be reduced due to the construction of a fuel modification zone between the impact area and the Kahanahaiki Management Unit. In addition, fuel reduction within the management units will further buffer the critical habitat unit from fire. The portion of critical habitat within Pahole, Kahanahaiki, West, East and Central Makaleha, and Upper Kapuna management units will be managed to improve its baseline quality pursuant to the Makua Implementation Plan. Without this management, this critical habitat unit would eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). The Service considered this continued degradation of *H. degeneri* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *H. degeneri* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *H. degeneri*.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Kaena East of Alau
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Kahanahaiki
Pahole
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Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 19
Hedyotis degeneri degeneri
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
0 0.5 1 Kilometers
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UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Hedyotis parvula* (No Common Name)

There are 188 *Hedyotis parvula* in the action area located in the Ohikilolo Makai and Ohikilolo Mauka population units (Figure E 20). *Hedyotis parvula* is endemic to the Waianae Mountain Range of Oahu and 418 total individuals are known to grow in the wild. Recent wildland fires in Nanakuli and Lualualei burned close to the Halona population unit. Herbivory by ungulates and invasive plants also impact this species throughout its range (U.S. Army Garrison 2006c). We infer from these circumstances, conservation biology principles, and examples from other species that *H. parvula* has a high background extinction risk in the action area and range-wide, and any additional threats associated with training-related wildland fire are likely to eliminate expectation of its long-term persistence. Therefore, the Army is managing *H. parvula* as a stabilization species pursuant to the Makua Implementation Plan Addendum.

Species Response to the Proposed Action

The proposed action of increased Army training with long-range, incendiary weapons could result in injury and death of *Hedyotis parvula* individuals in the action area. All individuals (188 plants, representing 45 percent of all range-wide individuals) grow along the outer edges of the low fire risk zone within the Ohikikilolo Management Unit (Figure E 20). These plants may be burned in a fire ignited on the ridge by a misfired long-range, live-fire weapon such as the TOW, or from a spot fire resulting from an intense grass fire in the valley where fires escaping initial attack in the lower valley may reach them. However, all individuals are located high on the cliffs, farther than 300 m (984 ft) from the grass slopes in the lower valley (see General Effects – Fire Suppression). Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could enable these fires to burn more than 40 ha (100 ac) in a 48-hr period (see General Effects - Fire Suppression).

The potential damage to or loss of *Hedyotis parvula* individuals due to wildland fires associated with live-fire training will be offset by ongoing efforts by the Army to complete stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Stabilization actions that include outplanting, ungulate control, Army fire suppression assistance, and genetic storage, increases the probability this species will persist in the long term. The high risk of fire to the Halona population unit (outside the action area) will be minimized by Army wildland fire suppression and fuels management efforts (Beavers 2007a). Ungulate control at the Ohikilolo Management Unit, and fencing and ungulate control conducted by the Army at the Palekea Management Unit (scheduled for 2009) will provide further protection to this endangered species.

Conclusion

Despite the ongoing exposure of *Hedyotis parvula* to project wildland fire impacts, fire risk to this species is very low, and Army conservation and stewardship programs will improve its baseline condition in the action area and range-wide. The potential damage or loss of *H. parvula* individuals from fire will be offset by the ongoing efforts of the Army Natural Resources Staff as they implement stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Fencing and ungulate control, weed control, fire suppression assistance, and genetic storage are expected to result in increased likelihood that *H. parvula* will persist inside and

outside the action area. Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service believes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

Effects of the Action on *Hedyotis parvula* Critical Habitat

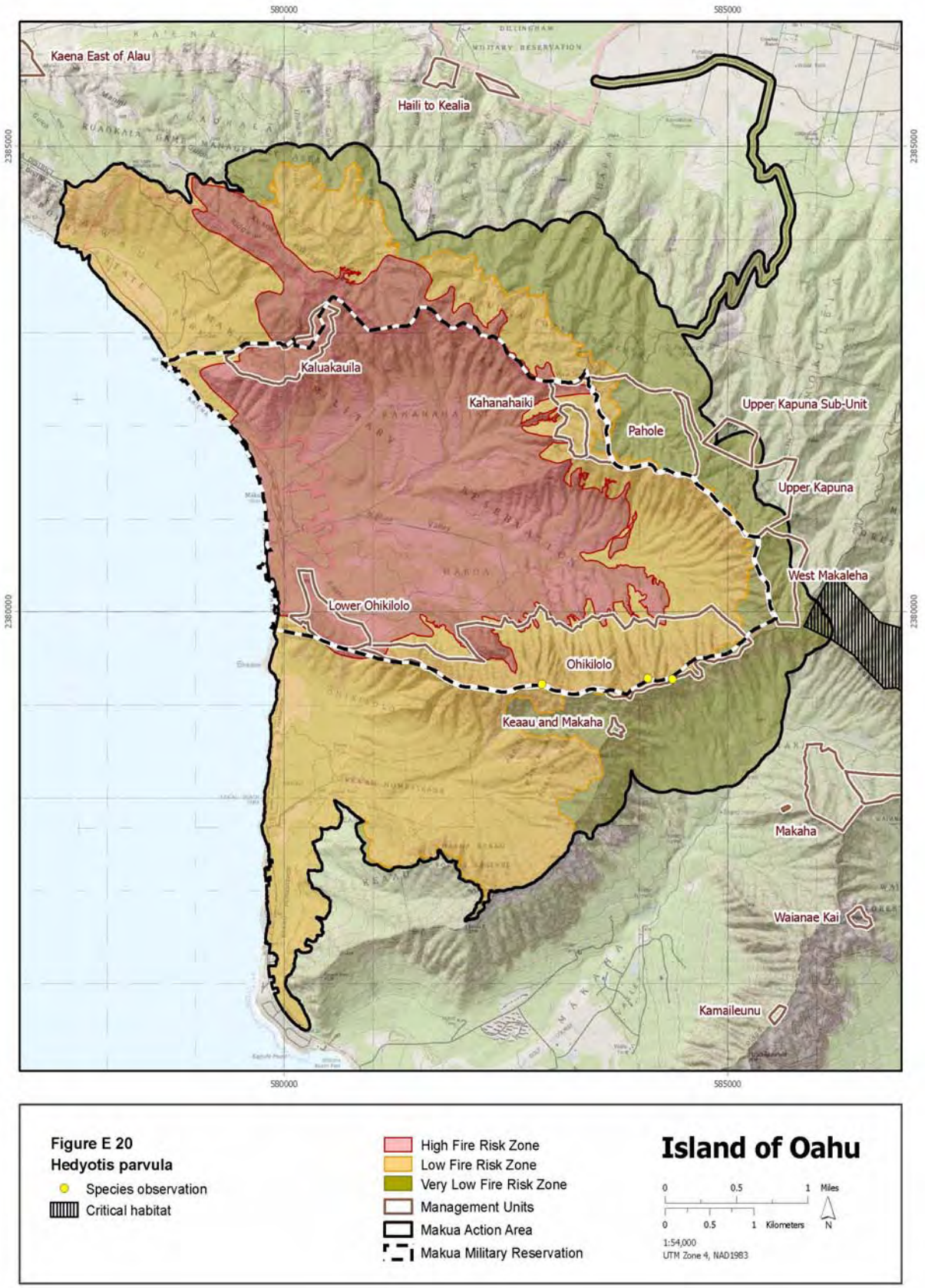
There is one critical habitat unit within the Makua action area, representing one percent (7 ha; 17 ac) of the total critical habitat for *Hedyotis parvula* (see Figure E 20). This critical habitat is part of a larger 387 ha (958 ac), critical habitat unit that includes habitat outside the Makua action area (Figure 27). All critical habitat for this species is found inside the very low fire risk zone, with 6.67 ha (16.47 ac) in the unit. This unit and the 382 ha (945 ac) of habitat outside the action area was designated to provide habitat for the conservation of a total of four populations, each comprising at least 300 reproducing individuals of *H. parvula* (68 FR 35950). The primary constituent elements essential for this species include, but are not limited to, cliff faces or their bases, rock outcrops, or ledges in mesic habitat (68 FR 35950). The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within mesic habitat. On Oahu, it is estimated that more than 80 percent of the forest habitat in the action area has more than 75 percent native plant cover (K. Kawelo pers. comm. 2004; 68 FR 35950). This indicates that there is relatively little non-native plant encroachment in this unit. Fire removes the vegetative primary constituent elements and non-native plant species subsequently outcompete the native plants so that natural recruitment is precluded. In the absence of habitat management, additional fires resulting from future training actions could add to the degradation of this critical habitat unit by removing the remaining vegetative primary constituent elements.

The critical habitat unit is approximately 3 km (2 mi) from the impact area on its eastern end. If a fire started in the impact area, it would have to move east through low and very low fire risk areas, up low flammability cliffs, through the West Makaleha Management Unit, before reaching this unit. However, the loss of this critical habitat, in combination with the 382 ha (945 ac) of habitat outside the Makua action area, would remove its ability to provide for the conservation of four populations of *Hedyotis parvula*. One ha (2.4 ac) or 20 percent of the critical habitat in the action area is found within the Central and East Makaleha Management Unit. A small amount of critical habitat (less than 1 ha; 2.5 ac) is within the West Makaleha Management Unit. Approximately 80 percent of the critical habitat unit in the action area is not within a management unit. However, the fire risk to critical habitat in these management units and the critical habitat immediately adjacent to them is decreased due to the surrounding mesic forest vegetation which is of low flammability (Beavers et al 1999). This entire critical habitat unit is in an area of low and very low fire risk and is bordered by low and very low fire risk areas and management units. Fuel modification will occur within Central and East Makaleha Management Unit due to the control of alien plant species, some of which are highly flammable. In addition, the Central and East Makaleha Management Unit and the West Makaleha Management Unit will eventually be fenced, and non-native plant species will be controlled pursuant to the guidelines of the Makua Implementation Plan. The removal of ungulates and non-native invasive plant species within these management units enhances the conservation value of the critical habitat unit. The critical habitat outside of the management unit is separated from the impact area by other management units and low to very low fire risk areas. The fuel modification activities,

plus other conservation measures implemented by the Army for species stabilization, will further reduce the risk of fire to the portion of the critical habitat outside of the management units. To reduce the negative impacts to critical habitat from any fire that escapes the firebreak road, the Army has committed to revegetate burned areas with native plant species to restore the area to pre-burn conditions. The revegetation plan will address restoration of burned areas by replanting native plant species (primary constituent elements) and controlling non-native, competitive plant species. While there may be a temporal loss of the conservation value of this critical habitat unit (in conjunction with the portion that is outside the Makua action area) during the revegetation process, the ability of this unit to provide habitat essential for the conservation of four populations of *Hedyotis parvula* will be retained in the long-term.

Conclusion

The critical habitat unit for *Hedyotis parvula* in the Makua action area is located entirely within the low and very low fire risk areas. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside of the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire to the critical habitat will be reduced due to fuel reduction within adjacent management units. The portion of critical habitat that is within Central and East Makaleha, and the West Makaleha management units will be managed to improve its baseline quality, pursuant to the Makua Implementation Plan. Without this management, this critical habitat unit would eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *H. parvula* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *H. parvula* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *H. parvula.*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Pahole
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Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 20
Hedyotis parvula
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
0 0.5 1 Kilometers
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UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Hesperomannia arbuscula* (No Common Name)

There is only one individual of *Hesperomannia arbuscula* remaining in the action area (Upper Kapuna Management Unit; see Figure E 21). There are 25 mature individuals of *H. arbuscula* on Oahu and only 90 individuals range-wide. Due to the extremely low numbers of *H. arbuscula*, there is a high background risk of extinction for this species. Some would argue this species is quasi-extinct due to its low numbers, inbreeding depression and high susceptibility to stochastic events. The science of conservation biology has documented a general pattern of population collapse for a wide range of plant and animal species (Dennis et al 1991; Schemske et al 1994; Morris et al 1999; Menges 2000) when the total number of reproductive individuals falls bellow a minimal threshold. The Army is managing this species as a stabilization species due to its limited abundance and restricted distribution. This lone plant is exposed to additional threats as described and analyzed in the General Effects section.

Species Response to the Proposed Action

The only individual of *Hesperomannia arbuscula* in the action area occurs in the very low fire risk zone. The risk of this one individual impacted by a training related wildland fire is very remote due to the mesic condition of its surrounding habitat and the distance from the impact area. The risk to extirpation for this species is greater due to other threats such as ungulate herbivory, non-native pests, lack of pollinators, or a demographic accident.

The data suggest this species is not self-sustaining and the number of individuals on Oahu has declined from approximately 40 individuals in 2003 to 25 in 2006 (see Status/Baseline). There is a small number of naturally occurring mature individuals (not managed) outside of the action area. The number of mature versus immature plants suggests there is not much natural recruitment. This species is not easily cross-pollinated and is susceptible to invertebrate pests like the black twig borer. As part of it efforts to manage this species for stability the Army will be establishing three populations units of 75 individuals each; one inside the action area (Upper Kapuna) and two outside the action area (North Palawi and Waianae Kai). The Army's efforts towards stabilization for this species include controlling threats to the species (feral ungulate control and the removal of exotic plants that compete with this species). According to the Makua Implementation Plan Addendum the Upper Kapuna Management Unit is scheduled to be fenced in 2007 thus removing the threat of predation by feral ungulates.

Conclusion

Hesperomannia arbuscula may already be in a phase of quasi-extinction, with numbers that have declined to the point where demographic stochasticity alone can result in extirpation from the wild. Thus, *H. arbuscula* has a very high background risk of species extinction, and any additional threats could eliminate expectation of its long-term persistence. This species will benefit from the stabilization criteria as outlined in the Makua Implementation Plan and the Makua Implementation Plan Addendum. There will be three occurrences of *H. arbuscula* with 75 mature reproducing individuals maintained over the long-term, including one inside the action area and two outside the action area to reduce the vulnerability of this specie to fire. Overall, the work conducted by the Army Natural Resources Staff will help protect this species from extirpation in Makua and improve its likelihood of persistence with minimal risk of loss due to a training-related wildland fire. Therefore, based on our analysis of the effects of the actions

outlined in the Project Description, including training-related fire minimization measures, the Service concludes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

Effects of Action on *Hesperomannia arbuscula* Critical Habitat

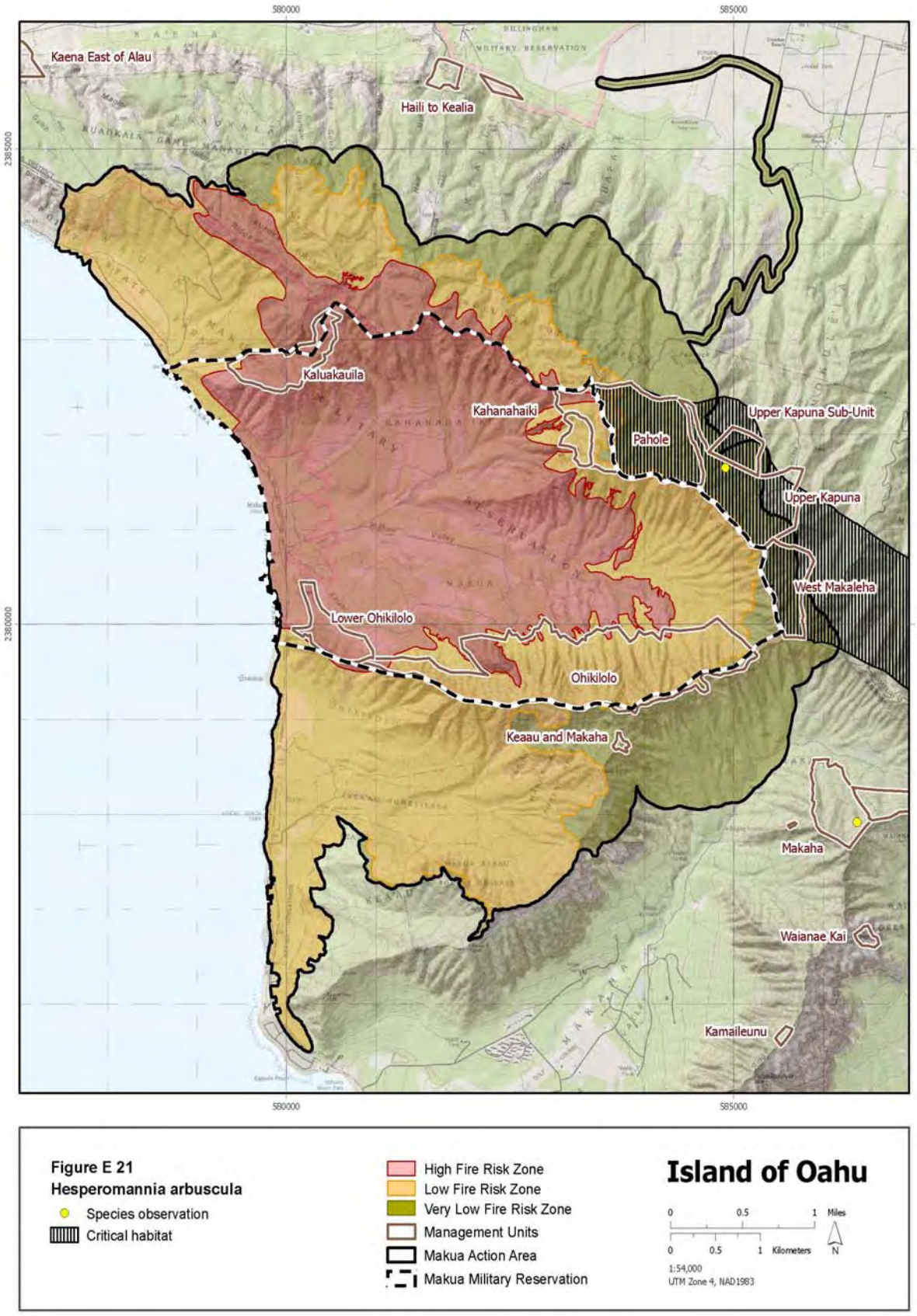
Critical habitat for *Hesperomannia arbuscula* within the Makua action area includes 213 ha (527 ac) or about 12 percent of the designated critical habitat for this species (see Figure E 21). It is located in the northeastern portion of the action area and is almost entirely in the low fire risk zones, with 17.8 ha (44 ac) in the low fire risk area and 195.2 ha (482.3 ac) in the very low fire risk area. A portion of the critical habitat unit, 288 ha (709 ac), is outside of the action area. The entire unit was designated to provide habitat for the conservation of two populations, each of 100 mature, reproducing individuals of *H. arbuscula* (68 FR 35950). The primary constituent elements essential for this species include, but are not limited to, slopes or ridges in dry to wet forest dominated by *Acacia koa* (koa) or *Metrosideros polymorpha* (ohia). The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within dry to wet forest dominated by koa or ohia. It is estimated that more than 60 percent of the critical habitat is located in forest with more than 50 percent native vegetation (U.S. Army Garrison 2003b; K. Kawelo pers. comm. 2004; 68 FR 35950; 68 FR 35950). This indicates that non-native plants are encroaching in this critical habitat unit. In the absence of habitat management, fires or continued non-native plant encroachment will add to the degradation of this critical habitat unit by removing the remaining vegetative primary constituent elements.

Eighty-two percent (253 ha; 625 ac) of the critical habitat unit is located in several management units (Pahole, West Makaleha, Central and East Makaleha, and Upper Kapuna). Due to the location of the critical habitat unit for *Hesperomannia arbuscula* and the similarities of the beneficial and negative impacts, please see *Schiedea obovata* for a more detailed effects analysis. The remaining critical habitat for *H. arbuscula* outside of all management units is approximately 56 ha (138 ac) and this area will be buffered from the impact area by the management units themselves. The fuel modification activities and the other threat reduction measures implemented by the Army for species stabilization will further reduce the risk of fire to all critical habitat inside and outside of the management units.

Conclusion

The critical habitat unit for *Hesperomannia arbuscula* in the Makua action area is located almost entirely in the low and very low fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside of the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire to the critical habitat located in the Pahole Management Unit will be reduced due to the construction of a fuel modification zone between the impact area and the adjacent Kahanahaiki Management Unit. In addition, fuel reduction within the management units will further buffer the critical habitat unit from fire. The critical habitat that is within the Central and East Makaleha, Kahanahaiki, Upper Kapuna Sub-unit, Pahole, Upper Kapuna, and West Makaleha management units will be managed to improve its baseline quality, pursuant to the Makua Implementation Plan. Without this management, this

critical habitat unit could eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *H. arbuscula* critical habitat in the evaluation of the affect of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *H. arbuscula* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *H. arbuscula*.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Pahole
Upper Kapuna
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Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 21
Hesperomannia arbuscula
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
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UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Melanthera tenuifolia* (Nehe)

Approximately 3,254 individuals of *Melanthera tenuifolia* (formerly *Lipochaeta tenuifolia*) occur in seven population units in the Waianae Mountains on Oahu. Approximately 50 percent (1,611 plants) grow within the Makua action area (Figure E 22). Four population units appear to meet numerical criteria for stabilization actions, but genetic differentiation among individuals of these vegetative-reproducing plants is unknown. *M. tenuifolia* appears to be returning to habitat where it had been extirpated by goats (U.S. Army Garrison 2005b). This species has a high background risk of extinction due to its very low numbers and lack of recruitment due to ungulate impacts. The Army is managing this species as a stabilization species pursuant to the Makua Implementation Plan Addendum.

Species Response to the Proposed Action

Wildland fires occurring because of Army actions at Makua are likely to lead to injury and death of *Melanthera tenuifolia* plants. An estimated 227 *M. tenuifolia* individuals are located in the high fire risk zone in the action area. Of these, 124 individuals grow in the Kaluakauila Management Unit where the 20-m (66-ft) wide forest edge fuelbreak with an integrated firebreak, and high priority fire suppression response, will minimize the risk of fire in this area. Fire risk to these plants, and four additional plants in the Punapohaku area below the Kaluakauila Management Unit, will be reduced further if the proposed fuelbreak running along the north lobe of the firebreak road is completed (see General Effects - Section 3.1.4.2). The *M. tenuifolia* individuals on the south side of Makua (11 in Lower Ohikilolo Management Unit and 88 in the lower grass slopes of Ohikilolo Management Unit) grow on sites in the high fire risk zone which are likely to be burned in fires associated with the proposed action. Eventually, fire protection to these management units, which will be implemented to achieve full stabilization, will abate the fire threat to these plants.

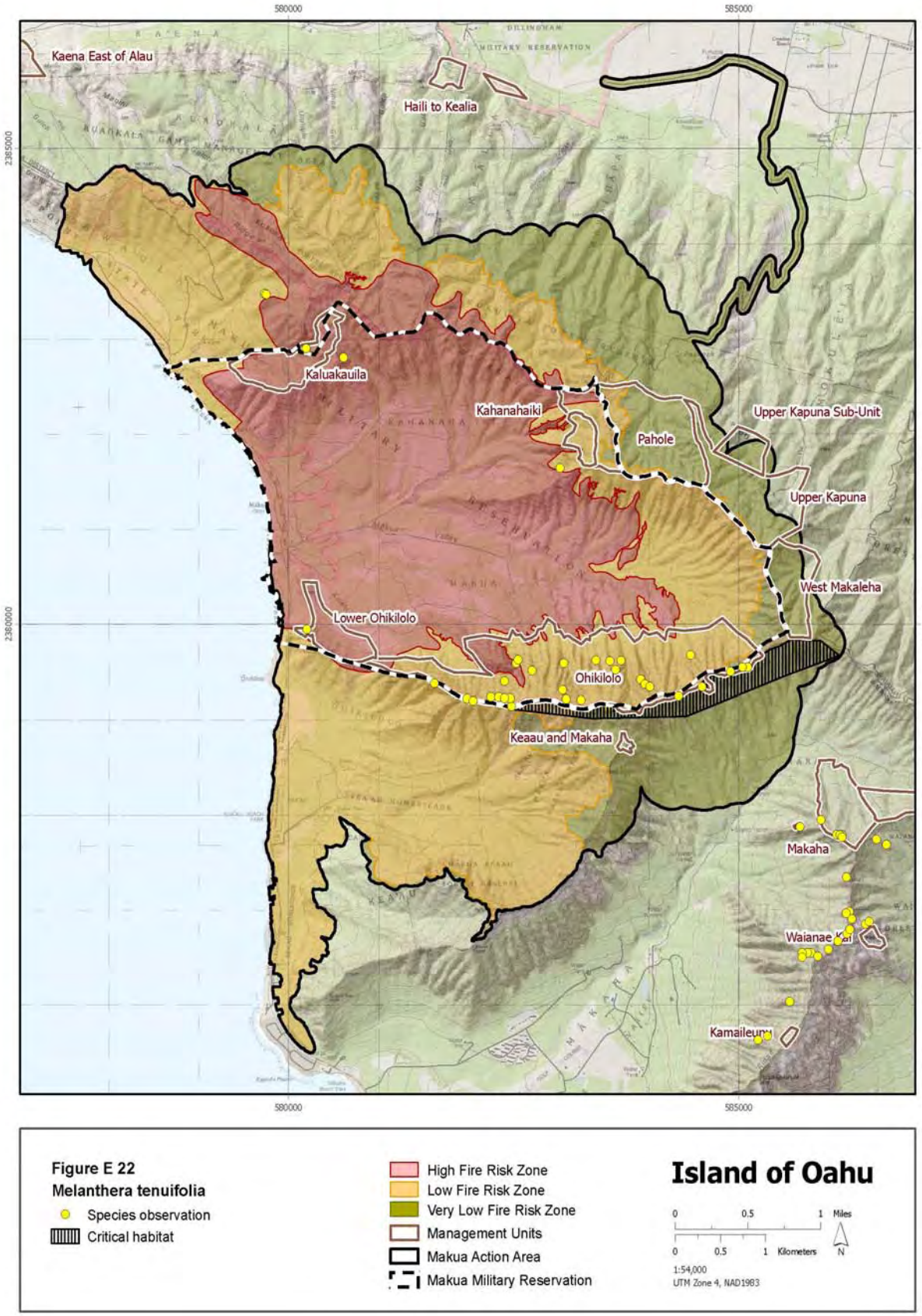
Approximately 42 percent (1,384 individuals) of *Melanthera tenuifolia* plants grow in the low fire risk zon (see Figure E 22). The 60 plants in the Keawaula population unit growing on the slopes north of Kaluakauila and the 1,243 plants growing on the upper cliff areas of Ohikilolo ridge are unlikely to be burned as a result of training-related fires due to the distance from the impact area and fire suppression response. An additional 81 plants, although located in the low fire risk zone (forest vegetation below the Kahanahaiki Management Unit) may be at a slightly higher risk of impact due to fire. These plants are only 20 m (66 ft) from the 2003 burn perimeter where the more flammable grasses have invaded the post-burn area (J. Rohrer, Army Natural Resources, pers. comm. 2007) thus making this area more susceptible to future fires.

The potential loss of *Melanthera tenuifolia* individuals due to Army-caused fires will be offset by ongoing efforts by the Army to complete stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Army Natural Resources Staff will maintain three populations of 50 *M. tenuifolia*. The proposed Makaha fence will protect approximately 63 mature individuals from ungulates. Army Natural Resources Staff have met genetic storage goals for 21 *M. tenuifolia* individuals; complete genetic storage goals are expected to be met for this species. The Army currently maintains living collections from 64 individuals and has stored more than 10 seeds from 35 founders (U.S. Army 2006). The Army is conducting seed storage research to determine the most effective genetic storage techniques for this endangered species. Two wildland fires, ignited by the public adjacent to Farrington Highway in 2006, are believed

to have burned additional individuals of *M. tenuifolia* in the Lower Ohikilolo Management Unit and on the slopes north of Kaluakauila Management Unit (U.S. Army Garrison 2006c). The Waianae Kai population unit is exposed to fires ignited in the grassy Waianae Valley. Fire suppression helicopter assistance, provided by the Army on State and City and County wildland fires will minimize fire impacts to this species and fuel treatments in the vicinity of management units will reduce the fire risk to plants inside and outside the action area.

Conclusion

Approximately 1,611 *Melanthera tenuifolia* plants (50 percent of known individuals of this species) grow within the Makua Action Area. A total of 103 *M. tenuifolia* grow in sites in the high fire risk zone where they are likely to burn unless additional fuel treatments are implemented. An additional 124 individuals are situated in the high fire risk zone within the Kaluakauila Management Unit where fire risk will be minimized by new fuelbreaks and high priority allocation of fire suppression resources and 1,384 plants grow in the low fire risk zone where the likelihood of an unsuppressed wildland fire is minimal. Weapons restrictions, fire suppression helicopter staffing, pre-planning and implementation of suppression actions by skilled NWCG-qualified fireline supervisors, and new fuelbreaks and firebreaks will minimize the risk of a fire burning many of these *M. tenuifolia* plants. The potential damage or loss of *M. tenuifolia* individuals from fire will be offset by the ongoing efforts of the Army's Natural Resources Staff as they implement stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Fencing and ungulate control are expected to result in increases in numbers and vigor of *in situ* plants. The Army's genetic storage efforts will ensure the genetic variability of this endangered species is preserved. The overall effect of the proposed action's stressors and subsidies will result in a net increase in the numbers, distribution, and reproductive success of *M. tenuifolia* in and adjacent to the action area over the next 30 years. Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service concludes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.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Pahole
Upper Kapuna Sub-Unit
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West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileuma
Figure E 22
Melanthera tenuifolia
Species observation
Critical habitat
High Fire Risk Zone
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UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Nototrichium humile* (Kului)

Sixty eight percent (858 out of a total of 1,256) of all *Nototrichium humile* occur within the Makua action area. There are seven population units of this species growing inside the Makua action area and nine population units outside the action area, elsewhere in the Waianae Mountains (Figure E 23). An additional occurrence was documented on Maui in 1979 (68 FR 25934), but the status of this population has not been updated since then. The July 2003 escaped prescribed fire at Makua burned 2.4 ha (6 ac) of *N. humile* critical habitat on State land north of the Kaluakauila Management Unit and killed five plants in the Punapohaku population unit (U.S. Army 2003b). At the time of the 2003 fire, only 11 plants were thought to occur on this slope; more extensive surveys, conducted in August 2003, resulted in an updated estimate of 173 plants in the Punapohaku population unit (K. Kawelo, pers. comm. 2007). This species has a high background risk of extinction due to its occurrence in dry fire-prone areas. The Army is managing this species as a stabilization species pursuant to the Makua Implementation Plan Addendum because of its limited abundance and restricted distribution. Plant numbers already meet numerical criteria for stabilization in three out of the four population units targeted for stabilization management (U.S. Army 2006c).

Analysis of Effects of the Proposed Action

There are 590 *Nototrichium humile* plants (47 percent of all known individuals) growing in the high fire risk zone, 267 individuals (21 percent) in the low fire risk zone, and one plant in the very low fire risk zone in the Makua action area. New weapons restrictions, improved grass mowing around the interior of the south lobe of the firebreak road, and increased fire suppression staffing requirements minimize the risk that a fire will escape containment by initial attack fire suppression resources, particularly prior to implementation of Column C weapons restrictions.

High Fire Risk Zone: In the event that a large fire threatens the 283 plants in the Kaluakauila Management Unit, the 20-m (66-ft) wide fuelbreak running along the forest edge, with its imbedded firebreak, will provide suppression resources, including red-carded Army Natural Resources Staff and fire suppression helicopters, a high likelihood of successfully preventing fires from burning forested areas within the management unit. Four recent fires that escaped initial attack at Makua (1970, 1984, 1995, and 2003) burned the slopes and edges of the forested areas where the 323 plants in the Punapohaku population unit occur. Fewer than 90 *Nototrichium humile* were found burned by the 1995 escaped prescribed burn (U.S. Army 1995) and five were burned by the 2003 escaped prescribed burn (U.S. Army 2003) in this area. Prior to implementation of Column C weapons restrictions, or within the next five years, one of several alternative measures will be instituted to further minimize the risk of fire impacts to the *N. humile* in the Punapohaku population unit (see Project Description section 3.1.4.2).

The Army will be establishing a 40-m (131 ft) wide fuelbreak to reduce the high risk of fire to the 25 *Nototrichium humile* plants growing on the slopes below the Kahanahaiki Management Unit. Plants growing on cliffs, or protected by Kukui drainages, are unlikely to be burned. GIS analysis indicates that most of the plants grow less than 50 m (164 ft) from continuous grass fuels, where they may be impacted by fires burning around or spotting across the fuelbreak. Some of these plants are located south of the fuelbreak location, where their fire risk will not be reduced by the fuel treatment.

Nine *Nototrichium humile* plants grow on a cliff directly below a grassy south aspect slope in Kahanahaiki Gulch that has repeatedly burned in the historic escaped fires at Makua (Hawaii Department of Land and Natural Resources 1970, U.S. Army fire reports 1995 and 2003). If a fire does burn into the Kahanahaiki Management Unit in Kahanahaiki Gulch, the site where the plants occur will be inaccessible to the firefighters staffing the area. The Army is establishing a firebreak or fuelbreak along the perimeter of the Kahanahaiki Management Unit (see Project Description section 3.1.4.1) to minimize the fire risk in Kahanahaiki Gulch. GIS analysis indicates that these fire risk minimization measures will leave approximately 34 *N. humile* at a high risk of burning in fires associated with Army live-fire training.

A total of 267 *Nototrichium humile* individuals (21 percent of the total rangewide individuals) grow in the low fire risk zone (73 in the Ohikilolo Management Unit, 51 plants in the Keaau population unit, and 143 in the Keawaula population unit). Fifty one of the individuals in the Ohikilolo Management Unit grow in the vegetated slopes below the cliff areas, and 22 plants grow high on the cliffs in this area. Fifty one additional *N. humile* plants are in the Keaau population unit, 1,000 m (3,281 ft) south of Ohikilolo Management Unit. The 51 plants growing in the shrub and forest vegetation below the cliffs in Ohikilolo, and the 51 plants growing in the Keaau population unit may be burned by a fire escaping initial attack containment efforts (see General Effects – Fire Suppression). All 124 of the plants in the low fire risk zone may also be impacted by a fire ignited by a misfired long-range, live-fire weapon such as the TOW, and a spot fire resulting from an intense grass fire in the valley. Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could enable these fires to burn more than 40 ha (100 ac) in a 48-hr period (see General Effects - Fire Suppression).

The 143 *Nototrichium humile* plants in the Keawaula population unit occur in a small shrubby gulch on a grassy slope north of the Kaluakauila Management Unit, approximately 50 m (164 ft) from areas burned in previous Army fires escaping containment by initial attack resources (Hawaii Department of Land and Natural Resources 1970 and 1984). A large fire ignited on State land near Farrington Highway burned through this area in 2006 (Hawaii Department of Land and Natural Resources 2006) but impacts to the *N. humile* have not been ascertained. Prior to implementation of Column C weapons restrictions, or within the next five years, one of several alternative measures will be instituted to further minimize the risk of fire impacts to the *N. humile* in this area (see Project Description section 3.1.4.2).

One *Nototrichium humile* individual in the Keaau population unit, south of Ohikilolo Ridge grows in the very low fire risk zone. This plant could be burned by a misfired long-range, live-fire weapon such as the TOW, or a spot fire resulting from an intense grass fire in the valley. Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could enable these fires to burn more than 40 ha (100 ac) in a 48-hr period (see General Effects - Fire Suppression).

Nototrichium humile will be stabilized pursuant to the Makua Implementation Plan Addendum. Army stabilization actions will result in threat control for 25 reproducing individuals in four population units and genetic storage for this species. Three stabilization population units currently exceed these numerical criteria for stabilization and 16 out of the necessary 25 mature

reproducing individuals already occur in Makaha, the fourth managed population unit. Natural recruitment is expected to increase when the Army completes fencing and ungulate removal in the Waianae Kai Management Unit. Ungulate removal in Kaluakauila Management Unit resulted in increased recruitment of *N. humile* (K. Kawelo, pers. comm. 2007) and therefore natural recruitment is expected to increase from the Army's fencing and ungulate removal in Makua Valley (scheduled for completion within five years) and the Waianae Kai Management Unit (scheduled for 2011 completion). Army fire suppression helicopter assistance to State and City and County fire suppression efforts outside the action area (for instance Kaimuhole and Palikea Gulch, Makaha, and Waianae Kai population units) will minimize the likelihood that the 313 plants (24 percent of all known individuals) growing in these population units will be burned. The fire threat to a minimum of 25 individuals in each of the four manage for stability population units will also be minimized, in most cases, by clearing grass from within 3 to 5 m (10 to 16 ft) of each plant (S. Ching, pers. comm. 2007). Future management unit level fire protection will provide long-term protection to these plants, as well as the other individuals occurring within all of the management units.

The Army's genetic storage efforts will ensure that genetic materials from approximately 153 genotypes from plants at high risk from fires occurring outside the action area (Kaimuhole and Palikea Gulch (50 founders), Keawapilau (5 founders), Kolekole (12 founders), Makaha (19 founders), Nanakuli (5 founders), Puu Kaua (12 founders), and Waianae Kai (50 founders) will be maintained (U.S. Army 2006c)). Problems with seed collection and low germination rates in the lab (1 out of 50 seeds germinate) have limited successful seed storage. Sixty two founders are currently maintained as cuttings in an Army plant propagation facility (U.S. Army 2006c).

Conclusion

Weapons restrictions, fire suppression helicopter staffing, pre-planning and implementation of suppression actions by skilled NWCG-qualified fireline supervisors, and new fuelbreaks and firebreaks will minimize the risk of a fire burning *Nototrichium humile* in the action area. The potential damage or loss of *N. humile* individuals from fire will be offset by the ongoing efforts of the Army's Natural Resources Staff as they implement stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Fencing and ungulate control, weed control, and genetic storage are expected to increase numbers of *N. humile*. Army fire suppression helicopter assistance to State and City and County fire suppression efforts outside the action area will minimize the likelihood that the plants growing in these areas will be burned. Future management unit level fire protection will provide long-term protection to the *N. humile* occurring within all management units. Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service concludes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

Effects of the Action on *Nototrichium humile* Critical Habitat

There are two critical habitat units within the Makua action area represented by units A and B for *Nototrichium humile* (see Figure E 23). These two units represent approximately one percent (6 ha; 16 ac) of the total State-wide critical habitat for this species. Critical habitat unit A is located in the northwestern portion of the action area in a high fire risk area. This unit was designated to

provide habitat necessary for the conservation of one population of *N. humile*. Critical habitat unit B is located in the very low fire risk zone with 1.33 ha (3.28 ac) in the northeastern portion of the action area. This unit will provide habitat necessary for the conservation of a portion of two populations of *N. humile*. At least 300 mature, reproducing individuals of *N. humile* will comprise each population (68 FR 35950). The primary constituent elements essential for this species include, but are not limited to, cliff faces, gulches, stream banks or steep slopes in dry or mesic forests often dominated by *Diospyros sandwicensis* (lama) or *Sapindus oahuensis* (lonomea). The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within dry or mesic forests often dominated by lama or lonomea. It is estimated that 79 percent of the critical habitat is in areas with less than 50 percent native plant cover (K. Kawelo pers. comm. 2004; 68 FR 35950). This indicates that these critical habitat units are currently degraded due to non-native plant encroachment. Although degraded, both units still support individuals of *N. humile* and provide habitat that is necessary for the expansion of these populations in order to contribute to the recovery goals for this species.

Portions of critical habitat unit A have been impacted by past fire events, which further diminishes the conservation value of this habitat. Fire removes the vegetative primary constituent elements, and natural recruitment is precluded by the influx of invasive non-native plants. In the absence of habitat management, additional fires resulting from future training actions could add to the degradation of these critical habitat units by removing the remaining vegetative primary constituent elements.

Critical habitat unit A is approximately 6 ha (16 ac), of which 4 ha (11 ac) are in the Kaluakauila Management Unit within the high fire risk area. Due to the close proximity of this unit to the fire source, there is a risk that a fire started in the impact area could move north and impact this unit. The loss of vegetative primary constituent elements of this critical habitat unit would remove its ability to provide habitat for the conservation of one population of *Nototrichium humile*. See *Neraudia angulata* for a discussion of the effects of fire and management.

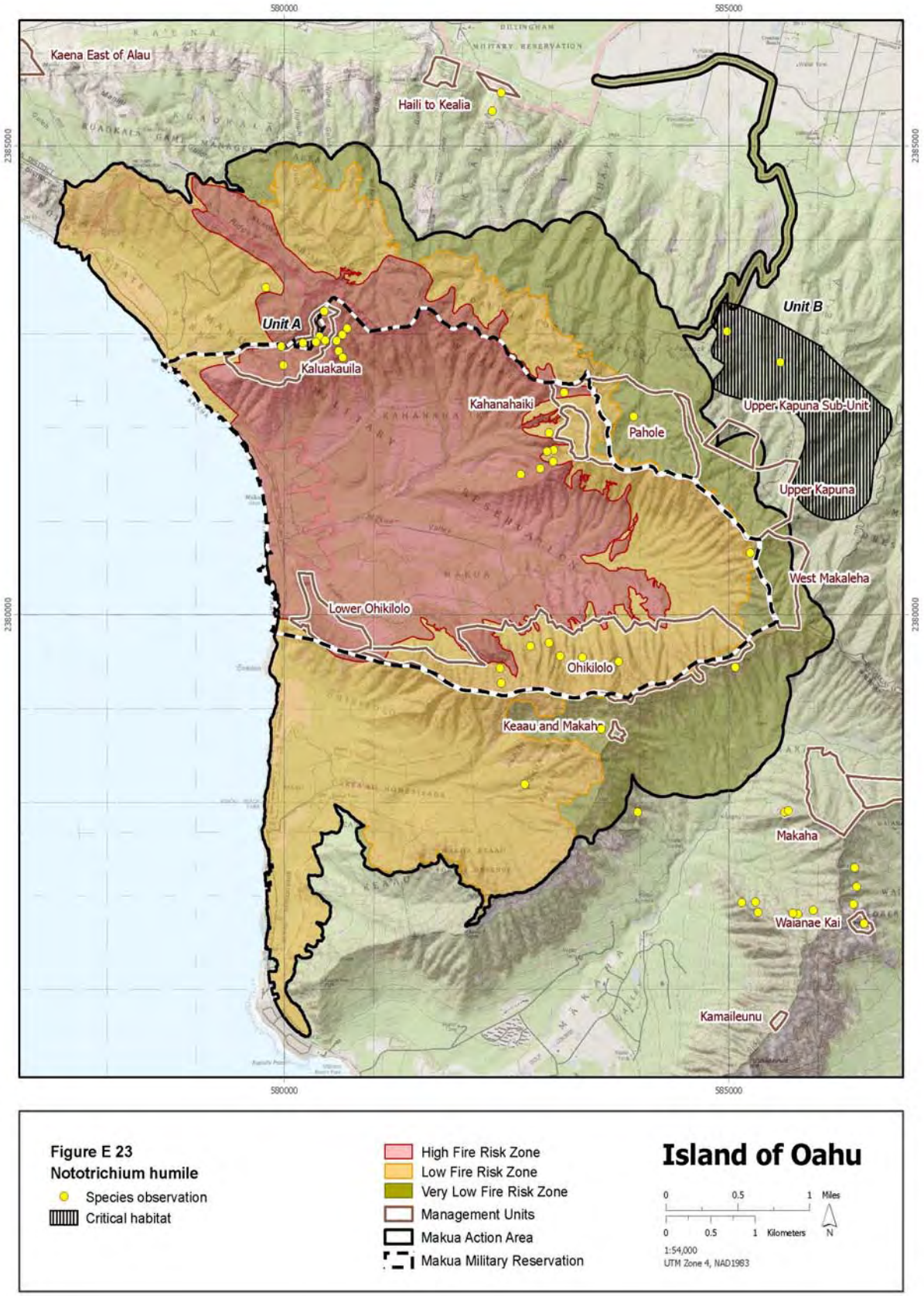
Critical habitat unit B is 1 ha (3 ac) and occurs in the low and very low fire risk area. This unit is part of a larger 230 ha (568 ac) critical habitat unit that extends outside the Makua action area. Unit B is approximately 1 km (0.6 mi) from the impact area along its western boundary and there is a risk, albeit slight, that a fire started in the impact area could move east over cliffs and across management units, where the Army is conducting fuel reduction actions, to impact this unit. However, the fire risk is decreased due to the surrounding mesic forest vegetation which is of low flammability and the buffer of surrounding management units, also of low flammability and managed to reduce non-native plants, and, therefore, fuel load (Beavers et al 1999). The loss of vegetative primary constituent elements within this unit would remove the ability of this unit to provide for the conservation of a portion of two populations of *Nototrichium humile*. See *Neraudia angulata* for a discussion of the effects of fire and management in the Upper Kapuna Sub-unit Management Unit and *Hedyotis parvula* for the West Makaleha Management Unit.

To reduce the impacts to critical habitat from any fire that escapes the firebreak road, the Army has committed to revegetate burned areas with native plant species to restore the area to pre-burn conditions. The revegetation plan will address restoration of burned areas by replanting native plant species (primary constituent elements) and controlling non-native, competitive plant species. While there may be a temporal loss of the conservation value of these critical habitat

units during the revegetation process, their ability to provide habitat essential for the conservation of three populations of *Nototrichium humile* will be retained in the long-term.

Conclusion

Over 99 percent of the critical habitat unit for *Nototrichium humile* in the Makua action area is located within the high fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside of the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire will be reduced for critical habitat unit A due to the construction of a fuel modification zone between the impact area and Kaluakauila Management Unit. In addition, fuel reduction within the management unit will further buffer unit A from fire. Fuel reduction within the Upper Kapuna Sub-unit Management Unit will further buffer unit B from fire. The critical habitat within the Kaluakauila Management Unit and the portion of critical habitat in unit B that is within Upper Kapuna Sub-unit and West Makaleha management units will be managed to improve their baseline quality, pursuant to the Makua Implementation Plan. Without this management, these critical habitat units would eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *N. humile* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *N. humile* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *N. humile.*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Haili to Kealia
Unit A
Kaluakauila
Kahanahaiki
Unit B
Upper Kapuna Sub-Unit
Pahole
Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 23
Nototrichium humile
Species observation
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Island of Oahu
0 0.5 1 Miles
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UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Plantago princeps* var. *princeps* (Ale, Laukahikuahiwi)

Approximately 42 *Plantago princeps* var. *princeps* shrubs (12 percent of all Oahu individuals) grow in the action area, in the Ohikilolo and Pahole Management Units (Figure E 24). A total of 354 *P. princeps* var. *princeps* grow in nine population units on Oahu and an additional 490 to 1,962 plants (of four varieties) occur on other Hawaiian Islands (U.S. Army Garrison 2005b). Recent ungulate removal at the Ekahanui population unit resulted in increased natural recruitment of *P. princeps* var. *princeps* at this site (D. Sailer, Army Natural Resources, pers. comm. 2007). Rat herbivory to this fleshy plant is a problem in the North Palawai and Kahanui population units in Honouliuli Preserve and may have caused the near disappearance of the North Palawai population units (U.S. Army Garrison 2005b). This plant is at a high risk of extirpation from Oahu due to ungulate and rat impacts and other ecosystem-wide threats (see General Effects). The Army is managing this species as a stabilization species pursuant to the Makua Implementation Plan Addendum because of its limited abundance and restricted distribution.

Species Response to the Proposed Action

The proposed action of increased Army training with long-range, incendiary weapons could result in injury and death of *Plantago princeps* var. *princeps* individuals in the action area. Sixteen *P. princeps* var. *princeps* individuals growing in the low fire risk zone in the Pahole Management Unit and 26 individuals grow in the very low fire risk zone in the Ohikilolo Management Unit within the Makua action area. By maintaining 200 m (656 ft) of shrub vegetation between the grass-dominated areas in Makua Valley and the Pahole Management Unit (see Project Description section 3.1.3), the Army minimized the risk that a fire will spread from the valley into the management unit (see General Effect – Fire Suppression). All 42 plants in the action area are at risk of being burned in a fire ignited by a misfired long-range, live-fire weapon such as the TOW, and spot fires resulting from an intense grass fire in the Makua Valley. Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could enable these fires to burn more than 40 ha (100 ac) in a 48-hr period (see General Effects).

Stabilization actions proposed by the Army, including outplanting, ungulate and rat control, Army wildland fire suppression assistance, and genetic storage, are likely to result in increased probability that this species will persist on Oahu. By assisting the City and County of Honolulu with the protection of Honouliuli Preserve from wildland fire, the Army will ensure the maintenance of the largest population of this species on Oahu. By constructing the Palikea and Ekahanui fences and removing ungulates from these areas, increased vigor and recruitment of *Plantago princeps* var. *princeps* plants. The Army has successfully propagated this species in greenhouses and the National Park Service has successfully outplanted *Plantago princeps* var. *laxiflora* on Maui (U.S. Army Garrison 2006c). Therefore, augmentations proposed to increase the number of mature, successfully reproducing individuals growing in four population units in threat-controlled areas to 50 are expected to be successful.

Conclusion

Despite the ongoing exposure of *Plantago princeps* var. *princeps* to wildland fire impacts associated with the proposed project, Army conservation and stewardship programs will improve its baseline condition in the action area and range-wide. Weapons restrictions, fire detection and fire suppression helicopter staffing and maintenance of the 200-m (656-ft) wide shaded fuelbreak adjacent to Pahole Management Unit will minimize the risk of training-related wildland fire to the *P. princeps* var. *princeps.* Ungulate and rodent control, ecosystem management, and genetic storage activities conducted by the Army over the next 30 years will increase population numbers of *P. princeps* var. *princeps* in four population units, including three outside the action area that will not be exposed to training-related wildland fire. Therefore, based on our analysis of the effects of the actions outlined in the Project Description, including training-related fire minimization measures, the Service concludes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

Effects of the Action on *Plantago princeps* var. *princeps* Critical Habitat

There are two critical habitat units in the Makua action area for *Plantago princeps* var. *princeps* that represent only two percent (62 ha; 153 ac) of the total critical habitat designated for this species (see Figure E 24). Located in the northeastern portion of the action area, all critical habitat is within the two low fire risk zones with 3.4 ha (8.3 ac) in the low fire risk area and 58.3 ha (144.2 ac) in the very low fire risk area. Critical habitat unit A (15 ha; 37 ac) was designated, in combination with critical habitat unit B, to provide habitat for the conservation of one population of at least 300 mature, reproducing individuals of *P. princeps* var. *princeps*(68 FR 35950). Critical habitat unit B is part of a larger 53 ha (130 ac) critical habitat unit that extends outside the Makua action area. The primary constituent elements essential for this species include, but are not limited to, slopes or ledges in *Metrosideros polymorpha* (ohia) lowland mesic forest or shrubland (68 FR 35950). The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within an ohia lowland mesic forest or shrubland community on Oahu. It is estimated that the majority of the critical habitat is in areas comprised of greater than 50 percent native plant cover, indicating that there has been some habitat degradation in these units. Portions of this critical habitat may have been impacted by past fire events, which diminishes the conservation value of the habitat by removing the vegetative primary constituent elements. Non-native plant species subsequently outcompete the native plants so that natural recruitment is precluded. In the absence of habitat management, additional fires resulting from future training actions could add to the degradation of this critical habitat unit by removing the remaining vegetative primary constituent elements.

The western boundaries of critical habitat units A and B are approximately 0.2 km (0.1 mi) and 1 km (0.6 mi), respectively, from the fire source and there is a risk that a fire started in the impact area could move east and impact these units. The loss of vegetative primary constituent elements within these two units would remove their ability to provide for the conservation of a portion of one population of *Plantago princeps* var. *princeps*. Most of the western edges of the two critical habitat units are immediately adjacent to low and very low fire risk areas. Approximately 72 percent (35 ha; 86 ac) of the critical habitat in the action area is found within management units (Pahole, Upper Kapuna, West Makaleha, Central and East Makaleha, and Kahanahaiki). To

reduce the risk of fire to listed species and their habitat, the Army is preparing wildland fire management plans for the Kahanahaiki and Ohikilolo management units. Implementation of these plans will reduce the risk of fire to *P. princeps* var. *princeps* critical habitat due to construction of fuel modification zones between the impact area and the Kahanahaiki Management Unit, adjacent to critical habitat unit A; and, between the impact area and the Ohikilolo Management Unit, adjacent to critical habitat unit B. Fuel modification will buffer the Kahanahaiki Management Unit from fires that spread outside the impact area and in turn buffer the critical habitat unit A in the adjacent Pahole Management Unit.

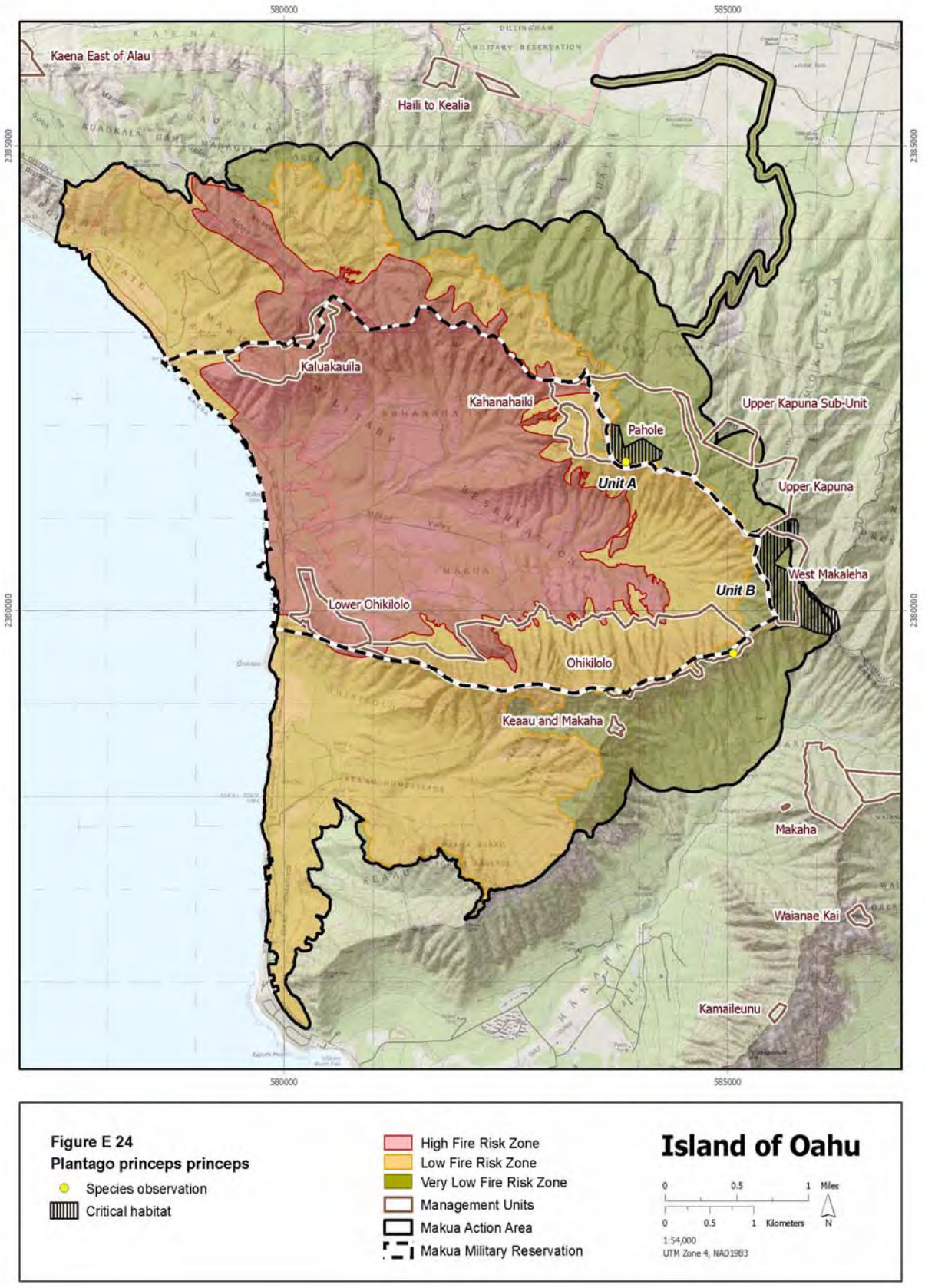
Implementation of the Ohikilolo fire management plan and fuel reduction actions, such as removal of non-native plants in the West, and East and Central Makaleha management units will reduce the risk of fire impacting portions of critical habitat unit B outside the management units. The Army is implementing other threat abatement measures in the management units, such as removal of non-native plants, to enhance the habitat in the management units. The Pahole and Kahanahaiki management units are fenced, and the Army has fenced portions of the West Makaleha Management Unit. Fences are planned for the Central and East Makaleha and Upper Kapuna management units, pursuant to the Makua Implementation Plan. Ungulates will be removed from these fenced areas. The Army is working to reduce non-native plants in all of these management units. The Army is conducting rat control in the Kahanahaiki and West Makaleha management units to reduce their impacts on listed and associated native plants. All of these conservation actions within the management units, pursuant to the Makua Implementation Plan, will enhance the conservation value of the two critical habitat units. Some actions, such as removal of non-native plants, decrease the risk of fire in part by reducing the fuel load in these management units. The portion of critical habitat unit B that is outside the management units (27 ha; 71 ac) is separated from the impact area by low and very low fire risk areas and by the Ohikilolo and West Makaleha management units. Spatial separation from the impact area, adjacent low and very low fire risk area along the western boundary of critical habitat unit B, fuel modification actions that will be implemented for the Ohikilolo Management Unit, and the aforementioned activities implemented by the Army for species stabilization in the West Makaleha Management Unit will further reduce the risk of fire to the portion of critical habitat outside management units.

To reduce the negative impacts to this critical habitat unit from any fire that escapes the firebreak road, the Army has committed to revegetate burned areas with native plant species to restore the area to pre-burn conditions. The revegetation plan will address restoration of burned areas by replanting native plant species (primary constituent elements) and controlling non-native, competitive plant species. While there may be a temporal loss of the function of the critical habitat units in the action area, in conjunction with the portion that extends outside the action area, the ability of these units to provide habitat essential for the conservation of four populations of *Plantago princeps* var. *princeps* will be retained in the long-term.

Conclusion

The two critical habitat units for *Plantago princeps* in the Makua action area are entirely within the low and very low fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire will be reduced due to the construction of

fuel modification zones between the impact area and the Kahanahaiki and Ohikilolo management units. In addition, fuel reduction within the management units will further buffer the critical habitat units from fire. The portions of critical habitat within the Pahole, West, East and Central Makaleha, and Upper Kapuna management units will be managed to improve their baseline quality, pursuant to the Makua Implementation Plan. Without this management, these critical habitat units would eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to these habitats *(*e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *P. princeps* var. *princeps* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *P. princeps* var. *princeps* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *P. princeps* var. *princeps*.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Kaena East of Alau
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Kahanahaiki
Upper Kapuna Sub-Unit
Pahole
Unit A
Upper Kapuna
West Makaleha
Unit B
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 24
Plantago princeps princeps
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
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1:54,000
UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Pritchardia kaalae* (Loulu)

A total of 841 *Pritchardia kaalae* plants (92 percent of the 911 total range-wide individuals) grow in the Ohikilolo and West Makaleha population units in the action area (Figure E 25). *P. kaalae* is a palm tree, endemic to Oahu's Waianae Mountains. Three hundred fifty six (39 percent of all plants) *P. kaalae* occur as a result of Army propagation and outplanting efforts. Little natural recruitment has been observed where rat fruit predation and ungulate herbivory occur (U.S. Army Garrison 2006c). This species may also be vulnerable to lethal yellowing, a palm disease transmitted by a sap-sucking plant hopper, *Myndus crudus*, which is prevalent in many tropical and subtropical zones worldwide although it is not yet found in Hawaii (Murakami 1999). *Pritchardia kaalae* has a high background risk of extinction due to its very low numbers and lack of recruitment due to ungulate and rat threats. The Army is managing this species as a stabilization species pursuant to the Makua Implementation Plan Addendum because of its limited abundance and restricted distribution.

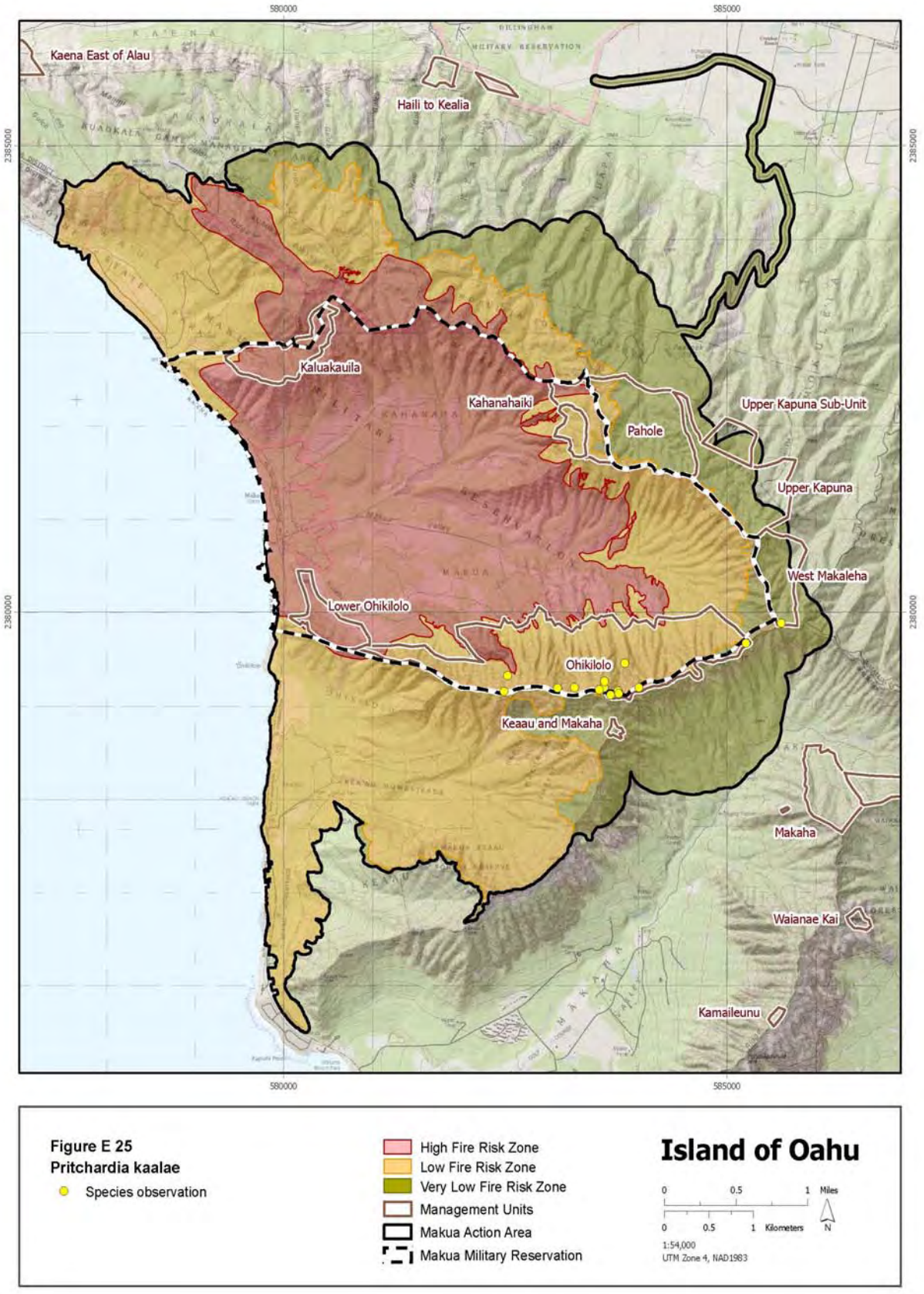
Species Response to the Proposed Action

The proposed action of increased Army training with long-range, incendiary weapons could result in injury and death of *Pritchardia kaalae* individuals in the action area. Approximately 75 mature and 694 immature *P. kaalae* plants grow in the low fire risk zone where they may be burned by an Army-caused fire and 72 immature individuals grow in the very low fire risk zone where fire is less likely to occur. Nine of the plants in the low fire risk zone grow on Ohikilolo Ridge, within approximately 50 m (164 ft) of previously burned grass slopes. The rest of the plants occur higher on the ridges of Makua Valley, where a fire could be ignited by a misfired long-range, live-fire weapon such as the TOW, and burn due to a spot fire from an intense grass fire in the valley. Fire detection and suppression response is designed to prevent a fire ignited in forest and shrub areas from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could enable these fires to burn more than 40 ha (100 ac) in a 48-hr period (see General Effects - Fire Suppression). Fire resistance of this species is not documented, but seedlings of other palm species are often killed by fire, while mature palms often survive even high intensity fires (Abrahamson 1984a, Abrahamson 1984b, and Menges and Kohfeldt 1995). Army weapons restrictions, fire suppression staffing, and fuels management are designed to minimize the fire threat to the *P. kaalae* growing within the action area.

Pritchardia kaalae are particularly vulnerable to seedling predation by goats and pigs, and fruit predation by rats (Makua Implementation Team 2003, U.S. Army Garrison 2005b, U.S. Army Garrison 2006c). Substantial increases in seedling numbers have occurred in the Ohikololo population unit where rat control and fencing with ungulate removal have been completed by Army Natural Resources Staff. Only one germinating fruit and no seedlings were observed in the Ohikilolo population unit in 1999. Due to Army fencing, ungulate eradication, and rat control, the number of seedlings has increased from 221 in 2005 to 410 in 2006 (U.S. Army Garrison 2006c). The Makaha, Makaleha to Manuwai, and Waianae Kai population units will benefit from the Army's rat control efforts and ungulate removal, slated for completion at these sites by 2012. Genetic storage and habitat conservation actions proposed by the Army increase the likelihood that this species will persist.

Conclusion

Ninty-two percent of the 911 known *Pritchardia kaalae* occur in the action area and are located in the low and very low fire risk zones. Weapons restrictions, fire detection, fire suppression helicopter staffing, and implementation of suppression actions by skilled NWCG-qualified fireline supervisors will minimize the risk of a fire burning *P. kaalae* in the action area. The potential damage or loss of *P. kaalae* individuals from wildland fires associated with live-fire training will be offset by the ongoing efforts of the Army's Natural Resources Staff as they implement stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Three hundred fifty six (39 percent of the total) *P. kaalae* occur as a result of Army propagation and outplanting efforts, and ungulate removal and rat control appear to have resulted in an increase in seedling numbers from zero (in 1999) to 410 (in 2006) in the Ohikilolo Population Unit (U.S. Army Garrison 2006c). Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service concludes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.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Kahanahaiki
Pahole
Upper Kapuna Sub-Unit
Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 25
Pritchardia kaalae
Species observation
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
0 0.5 1 Kilometers
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UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Schiedea kaalae* (No Common Name)

There are approximately 22 (three naturally occurring and 19 outplanted) *Schiedea kaalae* in the action area located in the Pahole Management Unit (Figure E 26). There are a total of 235 total individuals (43 naturally occurring, 192 outplanted) of this Oahu endemic species, located in 10 population units the Waianae and Koolau Mountains. One plant occurs in the Schofield Barracks West Range action area. Eighty one percent of *S. kaalae* plants exist because of propagation and outplanting efforts by the Army and The Nature Conservancy (U.S. Army Garrison 2005 and 2006c). *Schiedea kaalae* has a high background risk of extinction due to its very low numbers, low isozyme variability (Wagner et al 2005), and vulnerability to slug and snail herbivory (U.S. Army Garrison 2005b). The Army is managing this species as a stabilization species, pursuant to the Makua Implementation Plan Addendum, because of its limited abundance and restricted distribution.

Species Response to the Proposed Action

The proposed action of increased Army training with long-range, incendiary weapons could result in injury and death of *Schiedea kaalae* individuals in the action area. The three naturally occurring and 19 outplanted *S. kaalae* in the Pahole Management Unit grow in the very low fire risk zone of the action area where they may be burned in a fire ignited by misfired long-range, live-fire weapon such as the TOW, and a spot fire resulting from an intense grass fire in the valley. Fire detection and suppression response is designed to prevent fires ignited in forested areas by misfired weapons from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could enable these fires to burn more than 40 ha (100 ac) in a 48-hr period (see General Effects - Fire Suppression).

The potential damage to or loss of *Schiedea kaalae* individuals due to Army-caused fires will be offset by ongoing efforts by the Army to complete stabilization actions for this species. Stabilization will result in four population units of 50 reproducing individuals in areas where there are currently only 0, 3, 14, and 16 naturally occurring plants (U.S. Army Garrison 2006c). Army-funded slug control research may lead to techniques that will increase natural recruitment of this species. Ungulate removal and ecosystem scale weed control will also benefit this species. The Army has collected seeds from 19 founders in five population units and will complete and maintain genetic storage for all 42 wild individuals.

Conclusion

Weapons restrictions, fire detection, fire suppression helicopter staffing, and implementation of suppression actions by skilled NWCG-qualified fireline supervisors will minimize the risk of a fire burning *Schiedea kaalae* in the action area. The potential damage or loss of *S. kaalae* individuals from wildland fires associated with live-fire training will be offset by the ongoing efforts of the Army's Natural Resources Staff as they implement stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Stabilization actions proposed by the Army, including augmentations, ungulate control, slug control research, and genetic storage, increase the probability that this species will persist. Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, we conclude that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

Effects of the Action on *Schiedea kaalae* Critical Habitat

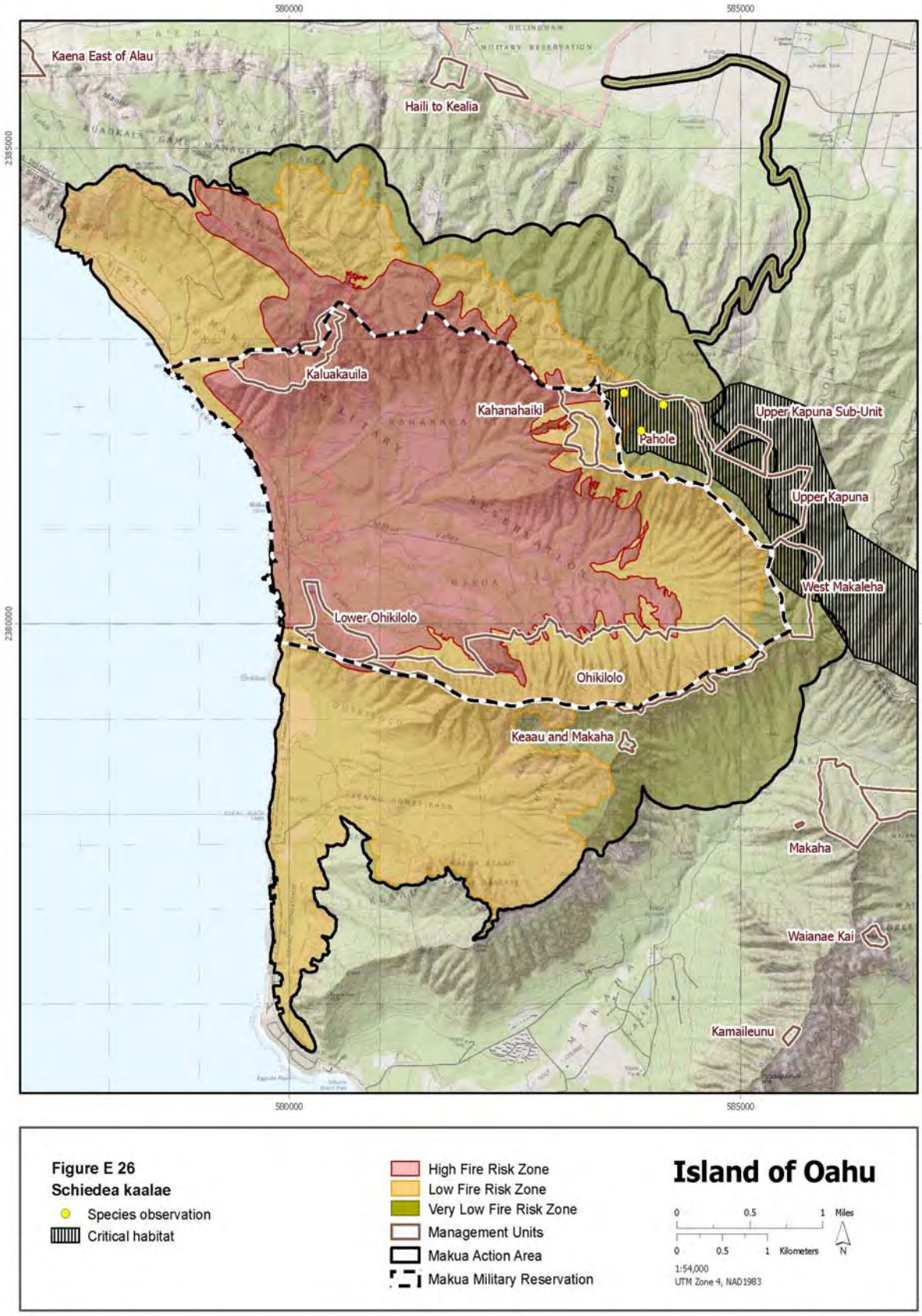
Critical habitat for *Schiedea kaalae* comprises 14 percent (151 ha; 372 ac) of the total critical habitat for this species in the Makua action area (see Figure E 26). The unit for *S. kaalae* is located in the northeastern portion of the action area within the two low fire risk zones, with 7.4 ha (18.2 ac) in the low fire risk area and 143 ha (353.6 ac) in the very low fire risk area. This critical habitat, together with 123 ha (304 ac) outside the action area, was designated to provide habitat for the conservation of two populations of *S. kaalae* in order to meet the recovery goals for this species. At least 300 mature, reproducing individuals will comprise each population (68 FR 35950). The primary constituent elements essential for this species include, but are not limited to, steep slopes, cliffs, stream banks, or deep shade in diverse mesic or wet forests. The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within diverse mesic or wet forests. It is estimated that almost one-half of the critical habitat is located in forest habitat with less than 50 percent native plant cover (U.S. Army Garrison 2003b; K. Kawelo, pers. comm. 2004; 68 FR 35950; 68 FR 35950). This indicates that this critical habitat unit is somewhat degraded due to non-native plant encroachment.

There is a risk that a fire could impact this unit. Fire could spread east from the impact area or from discharge of a weapon outside of the impact area. Eighty-seven percent, or 131 ha (325 ac), of the critical habitat is located in the Upper Kapuna, Upper Kapuna Sub-unit, Pahole and West Makaleha management units. Due to the similarities of this critical habitat unit to *Schiedea obovata*, please see *S. obovata* for the detailed effects analysis regarding Army actions in this portion of Makua. Overall, the risk of fire to this critical habitat unit is reduced due to the spatial separation from the fire source, the low flammability of the surrounding vegetation (mesic or wet forests), and the beneficial resource management actions conducted by the Army in the management units, pursuant to the Makua Implementation Plan Addendum. The remaining critical habitat (20 ha; 47 ac) outside of the management units is buffered from the impact area by the management units themselves.

Conclusion

The critical habitat unit for *Schiedea kaalae* in the Makua action area is located almost entirely in the low and very low fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside of the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire to the critical habitat unit will be reduced due to the construction of a fuel modification zone between the impact area and the Kahanahaiki Management Unit that is adjacent to the Pahole Management Unit. Fuel reduction within the management units will further buffer the critical habitat unit from fire. The critical habitat that is within the Central and East Makaleha, Upper Kapuna Sub-unit, Pahole, Upper Kapuna, and the West Makaleha management units will be managed to improve its baseline quality, pursuant to the Makua Implementation Plan. Without this management, this critical habitat unit could eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *S. kaalae* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a

temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *S. kaalae* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *S. kaalae*.


580000
585000
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Kaena East of Alau
Haili to Kealia
Kaluakauila
Kahanahaiki
Pahole
Upper Kapuna Sub-Unit
Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 26
Schiedea kaalae
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
0 0.5 1 Kilometers
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UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Tetramolopium filiforme* (No Common Name)

Of the 3,500 total range-wide individuals of *Tetramolopium filiforme*, 3,428 (98 percent) grow within the Makua action area (Figure E 27). *Tetramolopium filiforme* is a diminutive perennial shrub that occurs in two morphologically differentiated varieties: *T. filiforme* var *filiforme* and *T. filiforme* var *polyphyllum*. Forty five individuals grow on the north aspect of C-Ridge below the Kahanahaiki Management Unit, 1,000 plants (primarily var. *polyphyllum*) grow at the lower, dry, western end of the Ohikilolo Management Unit, 2,298 plants of both varieties grow farther up on Ohikilolo Ridge, and 88 occur in the Keaau population unit. Three small population units (containing 9, 25, and 39 *T. filiforme* individuals) occur in the northern Waianae Mountains, southeast of the action area. The smallest population unit, Kalena, containing nine plants, occurs in the upper reaches of the action area for the Schofield Barracks West Range, where it is exposed to threats associated with Army training covered on that range (Service 2003). Recent declines, apparently due to feral ungulate pressure to plants growing south (outside) of the Ohikilolo ungulate exclusion fence, have been marked. The Army is managing this species as a stabilization species because of its restricted distribution outside the action areas. Numerical criteria for stability are four population units containing 50 reproducing individuals each. Currently only the Ohikilolo population meets the numerical stabilization criteria. *Tetramolopium filiforme* has a high background risk of extinction due to its low numbers, occurrence in dry fire-prone areas, ungulate impacts, and possibly, infestation by non-native scale insects (see General Effects).

Species Response to the Proposed Action

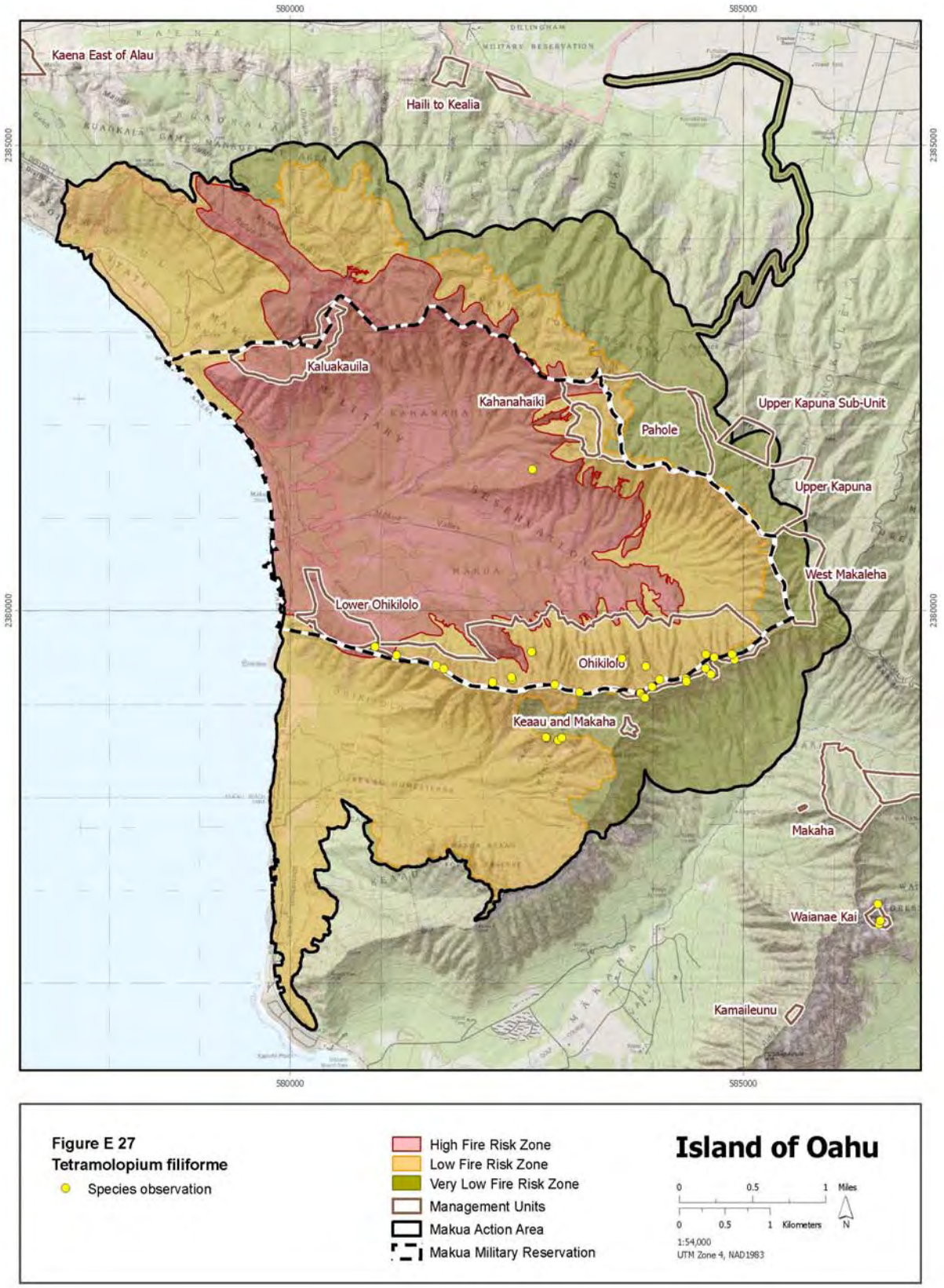
The proposed action of increased Army training with long-range, incendiary weapons could result in injury and death of *Tetramolopium filiforme* individuals in the action area. Thirty percent of all existing *T. filiforme* individuals grow within the high fire risk zone in the Makua action area. A fuelbreak will be completed, prior to the implementation of Column C weapons restrictions, to protect the 1,000 *T. filiforme* growing at the junction of Ohikilolo and Lower Ohikilolo management units from fires burning outside the firebreak road at Makua (see Figure PD 11). In the last 30 years, an Army-caused fire is recorded to have burned the site occupied by the 1,000 *T. filiforme* in the lower area of Ohikilolo Management Unit (see Figure E 1). Proposed weapons and prescribed burning restrictions, fire suppression staffing requirements, and increased grass mowing around the interior of the south lobe of the firebreak road minimize the likelihood that a fire will threaten the *T. filiforme* in the Ohikilolo area prior to the implementation of Column C weapons restrictions.

The 45 plants growing on the north aspect of C-Ridge, outside the Kahanahaiki Management Unit, grow in cracks on a near vertical rock cliff (S. Ching, pers. comm. 2007) that is likely to remain unburned, even though it is within the high fire risk zone. The vegetation in the drainage below the cliff is composed primarily of Kukui and is therefore not conducive to fire spread. The other 2,383 *T. filiforme* individuals growing within the Makua action area grow in locations high on the cliffs in the Ohikilolo Management Unit, and in the Keaau population unit, in the low and very low fire risk zone, where they are unlikely to be burned as a result of the proposed action. Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could permit these fires to burn more than 100 acres in a 48-hr period (see General Effects - Fire Suppression).

Stabilization actions proposed by the Army, including augmentations, ungulate control, Army fire suppression assistance, and genetic storage, increase the probability that this species will persist. Eighteen of the 28 mature individuals outplanted by Army Natural Resources Staff at the Puhawai population unit (where only six naturally occurring plants grow) survived after four months in the field (64 percent survival rate). The Ohikilolo stabilization population unit, which contains 87 percent of all individuals of this species, is fenced and the entire Makua Valley will be fenced and ungulate free within 5 years. Fencing and ungulate control scheduled for the Waianae Kai population unit in 2011 are expected to result in increases in numbers and vigor of *in situ* plants at that site. Army fire suppression aid, particularly helicopter support, on State and City and County wildland fires that threaten the Puhawai and Waianae Kai population units will help ensure the persistence of *T. filiforme* at these sites.

Conclusion

Thirty percent of all existing *Tetramolopium filiforme* individuals grow within the high fire risk zone in the Makua action area. Weapons restrictions, fire suppression staffing, and new fuelbreaks and firebreaks will minimize the risk of a fire burning many of these *T. filiforme* plants. One thousand of them will be protected with a fuelbreak and the rest grow on a near vertical rock cliff which is likely to remain unburned. The potential damage or loss of *T. filiforme* individuals from fire will be offset by the ongoing efforts of the Army's Natural Resources Staff as they implement stabilization actions for this species pursuant to the Makua Implementation Plan Addendum. Stabilization actions, including population unit augmentations, ungulate control, and genetic storage, in addition to fire suppression aid which the Army will be providing, increase the probability that this species will persist. The overall effect of the proposed action's stressors and subsidies will result in a net increase in the numbers, distribution, and reproductive success of *T. filiforme* in and adjacent to the action area over the next 30 years. Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service concludes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.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Kaena East of Alau
Haili to Kealia
Kaluakauila
Kahanahaiki
Pahole
Upper Kapuna Sub-Unit
Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 27
Tetramolopium filiforme
Species observation
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
0 0.5 1 Kilometers
N
1:54,000
UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Viola chamissoniana* ssp. *chamissoniana* (Pamakani)

Viola chamissoniana ssp. *chamissoniana* is a short-lived perennial endemic to the Waianae mountain range on Oahu. The estimated range-wide abundance of *V. chamissoniana* ssp. *chamissoniana* is 620 individuals (595 mature and 25 immature) with approximately 80 percent (500 plants) located in the action area, primarily in the Ohikilolo and Keaau Management Units (Figure E 28). All of these individuals are exposed to the suite of threats as described and analyzed in the General Effects section. *Viola chamissoniana* ssp. *chamissoniana* has a high background risk of extinction due to its low numbers and multiple threats. The Army is managing this species as a stabilization species.

Analysis of Effects of the Proposed Action

Over the next 30 years, *Viola chamissoniana* ssp. *chamissoniana* individuals could be exposed to the indirect and direct effects of a training-related wildland fire. The majority of the naturally occurring *V. chamissoniana* ssp. *chamissoniana* (approximately 450 mature and 20 immature) are located in the low fire risk zone with 25 individuals found in the very low fire risk zone. Three of the eight population units of *V. chamissoniana* ssp. *chamissoniana* are located along the higher reaches of the Ohikilolo Ridge (731 m; 2,400 ft elevation) distributed across 3.2 km (2 mi). The result of a wildland fire could be the direct loss of any plants in the path of the fire. Indirect effects include heat, ash, erosion and post recruitment of non-native plants. The loss of topsoil due to fire-induced erosion could be very detrimental to plants growing on steep, vertical crevices. A wildland fire could spread into Ohikilolo Ridge from the valley floor, or a fire may ignite on the ridge by a misfired long-range, live-fire weapon such as the TOW, or from a spot fire resulting from an intense grass fire in the valley. Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac). Inadequate detection and suppression response could enable these fires to burn more than 40 ha (100 ac) in a 48-hr period (see General Effects - Fire Suppression).

The risk assessment for this species includes several factors such as plant location, distribution and distance from the impact area. The risk of a wildland fire spreading from the valley floor (impact area) up the ridge is very low due to the distance from the impact area and the fire suppression measures that will be enacted that will slow or stop the fire prior to impacting Ohikilolo Ridge (see General Effects – Fire Suppression). In addition, the spread of a wildland fire would be limited due to the discontinuous fuels on the cliffs and therefore, the risk of affecting all plants in this area is minimal.

Approximately 300 *Viola chamissoniana* ssp. *chamissoniana* in the action area are protected from ungulates by the recently installed Ohikilolo Ridge fence. These individuals benefit from the exclusion of ungulates, which reduces grazing pressure. Other individuals of *V. chamissoniana* ssp. *chamissoniana* not in fenced exclosures are relatively inaccessible to ungulates due to their location on steep cliffs. The Army is actively attempting to control threats to this species with additional fencing in the Makaha Management Unit. The Ohikilolo population unit in the action area has reached numeric stabilization goals with approximately 400 mature individuals; however, all threats have not been abated. Other population units are showing an increasing trend in mature individuals.

Conclusion

Eighty percent of the known *Viola chamissoniana* ssp. *chamissoniana* plants occur in the action area and are located in the low to very low fire risk zones. The Army's training related impacts to this species will be offset by completing stabilization actions including outplanting, weed management, fence installation and reducing potential ongoing threats from ungulates and other invasive species. The Army's management actions for this species are expected to increase the abundance and distribution of this species in the Waianae Mountain Range over time. Army weapons restrictions, fire suppression staffing, and the fuels management program are designed to minimize the risk of fire damage to the *V. chamissoniana* ssp. *chamissoniana* growing within the action area. While there is a risk of a training related wildland fire affecting *V. chamissoniana* ssp. *chamissoniana*, the risk is considered minimal. While any loss of individual plants will be significant to the survival of *V. chamissoniana* ssp. *Chamissoniana* as a taxon, genetic storage, and other proposed fire management and stabilization actions, will offset such loss. Based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service believes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

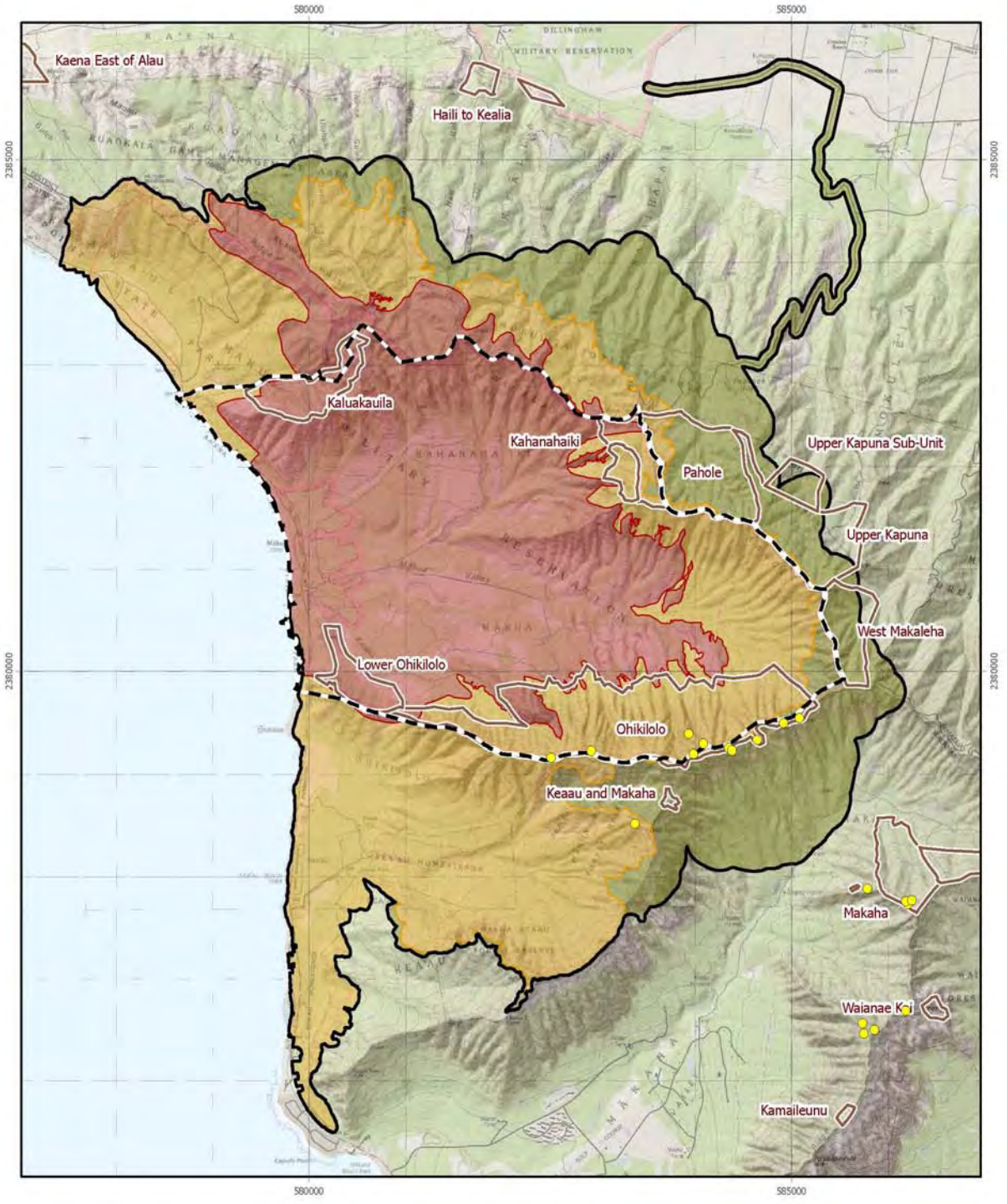


Figure E 28
Viola chamissoniana chamissoniana
Species observation

EFFECTS OF THE ACTION ON AT-RISK (EXPEDITED) TAXA

The 12 taxa listed below have been identified as particularly at risk of extinction in the action area, based primarily on their overall status, environmental baseline within the action area, and exposure to the risk of training-related wildland fire (Table E 10). These at-risk taxa were identified in late 2005 and early 2006, when the Service and the Army agreed to expedite stabilization as a conservation measure to protect these taxa from extinction while full stabilization measures are being implemented. Current data may reflect increases in abundance since 2003 as a result of the Army's ongoing efforts to stabilize these taxa. In 2005, at least 50 percent of all known remaining individuals and/or mature individuals of each of these at-risk taxa were located within the action area. Location within the action area by definition means these individuals are vulnerable to training-related wildland fire. Taxon-specific information supporting this group effects analysis for the 12 at-risk taxa are detailed in this section.

Chamaesyce herbstii (small tree)
Cyanea grimesiana ssp. *obatae* (shrub)
Cyanea longiflora (shrub)
Cyanea superba ssp. *superba* (small tree)
Delissea subcordata (shrub)
Gouania vitifolia (woody vine)
Hibiscus brackenridegei ssp. *mokuleianus* (shrub)
Neraudia angulata (shrub)
Phyllostegia kaalaensis (perennial herb)
Sanicula mariversa (perennial herb)
Schiedea nuttallii (subshrub)
Schiedea obovata (subshrub)

Status Summary of At-Risk Taxa

Abundance, distribution, and reproduction data for the 12 at-risk taxa are generally inadequate to predict changes in their baseline conditions over the next 30 years, with or without the proposed action. All taxa, except *Gouania vitifolia,* are limited in distribution to a few known population units on Oahu. When the Service and the Army agreed to expedited stabilization measures for these at-risk taxa in 2006, the range-wide total of known individuals of all taxa except *Hibiscus brackenridgei* ssp. *mokuleianus* consisted of less than 350 naturally occurring, *in situ* individuals. The total number of known individuals of *Chamaesyce herbstii, Gouania vitifolia, Phyllostegia kaalaensis,* and *Schiedea nuttallii* is less than 100. For 10 of the at-risk taxa none of the population units outside the action area meet or exceed stabilization targets for number of mature individuals, and five have no such population units at any location. Due to the low number of mature, reproducing individuals and lack of sufficient population units that meet or exceed the required number of individuals for stabilization populations, all 12 at-risk taxa are considered to have a very high background risk of extinction both in the action area and range-wide. Thus, expedited stabilization is necessary to protect these taxa from extinction while the Army is working to implement improved fire protection and suppression measures, and while long-term conservation measures are being implemented for full stabilization of all 28 plant target taxa.

Gouania vitifolia is the only at-risk species with individuals on another island (two known individuals on the island of Hawaii). About 98 percent of all individuals on Oahu, and about 95 percent of all individuals State-wide, are located within the action area. *Hibiscus brackenridgei* ssp. *mokuleianus* is the only at-risk taxon with a relatively substantial number of *in situ* individuals range-wide. However, only 48 of its total 669 *in situ* (naturally occurring)

Table E 10. Status and Environmental Baseline of at-risk Taxa (U.S. Army Garrison 2006d). **Taxon**	**Total Number of Individuals (mature/immature)**	**Percent of Total Individuals in the Action Area**	**Number of Stabilization Population Units Exceeding Minimum Number of Individuals (existing‡/required)**	**Number of Stabilization Population Units Exceeding Minimum Number of Individuals Outside Action Area (existing‡/required)**	**Population Units with Fences (existing/required)**	**Fire Risk‡**
Chamaesyce herbstii	87 (51/36)	100	1/3	0/2	1/3	V
Cyanea grimesiana ssp. *Obatae*	254 (134/120)	16	1/3	0/2	3/3	V
Cyanea longiflora	171 (80/91)	92	0/3	0/1	1/3	L, V
Cyanea superba ssp. *superba*	311 (171/140)	50	2/4	1/3	2/4	L, V
Delissea subcordata	185 (173/12)	12	1/4	1/3	3/4	L, V
Gouania vitifolia	81 (81/0)*	95	1/3	0/2	0/3	V
Hibiscus brackenridegei ssp. *Mokuleianus*	669 (48/621)†	3	0/4	0/3	1/4	H
Neraudia angulata	380 (227/153)	21	0/4	0/2	2/4	H,L
Phyllostegia kaalaensis	2 (0/2)	100	0/3	0/2	0/3	V
Sanicula mariversa	224 (18/206)	87	0/3	0/1	1/3	L, V
Schiedea nuttallii	94 (83/11)	100	1/3	0/1	1/3	L, V
Schiedea obovata	389 (158/231)	100	2/3	0/1	1/3	L, V

*State-wide
†*in situ* only
‡ Individuals may not be reproducing successfully due to threats which have not yet been abated.
‡Fire Risk: H (high), L (low), V (very low)

individuals are mature plants, and the one existing population unit in the action area represents 33 percent of the total mature individuals for this taxon range-wide. When the Service and the Army first began discussing expedited stabilization for at-risk species, the action area individuals of *H. brackenridgei* ssp. *mokuleianus* represented 50 percent of the mature individuals range-wide. Although there are a considerable number of seedlings at some sites, the survival and eventual reproductive success of these immature plants, especially those in unfenced areas, is uncertain.

Five of the at-risk taxa do not meet stabilization targets for the number of mature individuals for stabilization population units (*Cyanea longiflora*, *Hibiscus brackenridgei* ssp. *mokuleianus*, *Neraudia angulata*, *Phyllostegia kaalaensis*, and *Sanicula mariversa*). Seven taxa (*Chamaesyce herbstii*, *Cyanea grimesiana* ssp. *obatae*, *Cyanea superba* ssp. *superba*, *Delissea subcordata*, *Gouania vitifolia*, *Schiedea nuttallii*, and *Schiedea obovata*) each have at least one population unit that meets or exceeds stabilization targets for the number of mature individuals. However, these population units are not considered fully stabilized because they are not self-sustaining (i.e., there is little natural recruitment), threats are not controlled (e.g., fire, invasive plants, slugs), and *ex situ* genetic storage is not complete.

Seven of the at-risk taxa appear to be increasing in abundance since initiation of the Makua Implementation Plan in 2003. However, the apparent increases of *Chamaesyce herbstii*, *Cyanea grimesiana* ssp. *grimesiana*, *Cyanea longiflora*, *Cyanea superba* ssp. *superba*, *Neraudia angulata*, *Schiedea nuttallii*, and *Schiedea obovata* are due primarily to Army augmentation and reintroduction efforts. Recruitment in the wild is poor for most of these taxa, primarily because of slugs, for which there is no known feasible control method in natural environments. The apparently increasing trend in abundance of *Chamaesyce herbstii*, *Cyanea longiflora*, *Gouania vitifolia*, and *Neraudia angulata* is likely due in part to new discoveries of previously unknown individuals. Six at-risk taxa are prone to wide fluctuations in population size and have recent histories of decline: *Cyanaea grimesiana* ssp. *grimesiana*, *Cyanea longiflora*, *Delissea subcordata*, *Neraudia angulata*, *Phyllostegia kaalaensis*, and *Schiedea obovata*. All naturally occurring individuals of *Cyanea superba* ssp. *superba* and *P. kaalaensis* have become extirpated in the wild since completion of the Makua Implementation Plan, and all currently existing individuals have been reintroduced from greenhouse-propagated stock.

Hibiscus brackenridgei ssp. *mokuleianus*, *Phyllostegia kaalaensis*, and *Sanicula mariversa* are the only taxa that appear to be decreasing in the total number of individuals, even with stabilization management under the Makua Implementation Plan Addendum. There is not sufficient data to determine a trend in abundance of *S. mariversa*, because population viability data is lacking on long-term survival and reproduction rates. This species undergoes a complex summer dormancy period, from which many individual plants fail to reappear from year to year. In addition, flowering is infrequent and inconsistent, and plants apparently die after flowering only once. Until the life history and population viability of *S. mariversa* are better known, this species must be considered at-risk.

When their threats are managed (ungulate fencing, weed control, predator control) only two at-risk taxa, *Hibiscus brackenridgei* ssp. *mokuleianus* and *Sanicula mariversa*, are thought to successfully recruit in the wild. Nonetheless, reintroductions will be needed to meet stabilization

targets for the number of mature reproducing individuals for these two taxa (U.S. Army Garrison 2006d). Seven at-risk taxa produce seedlings in the wild or at reintroduction sites, but only rarely, and some may have uncontrollable threats (e.g., slugs or black twig borers); all will require reintroduction to establish the required number of mature reproducing individuals: *Chamaesyce herbstii*, *Cyanea longiflora*, *Cyanea grimesiana* ssp. *obatae*, *Delissea subcordata*, *Neraudia angulata*, *Schiedea obovata*, and *Schiedea nuttallii* (U.S. Army Garrison 2006d). Two at-risk taxa, *Cyanea superba* ssp. *superba* and *Phyllostegia kaalaensis*, have never produced any known seedlings in the wild or at reintroduction sites, so reintroduction methods for these taxa will require additional research (U.S. Army Garrison 2006d). Little is known about the recruitment potential of the remaining at-risk taxon, *Gouania vitifolia*.

Due to small population size, restricted distribution in only one population unit, limited recruitment, and declining trends in abundance and distribution, these 12 at-risk taxa already are in a phase of quasi-extinction. The number of individuals has declined to the point where demographic or environmental stochasticity alone can result in extirpation. We infer from these circumstances, conservation biology principles, and examples from other species that these taxa have a very high background extinction risk in the action area and range-wide, and any additional threats associated with training-related wildland fire are likely to eliminate expectation of its long-term persistence.

Analyses for Effects of the Action

Individuals of the 12 at-risk taxa in the action area will be exposed to training-related wildland fire and the ongoing impacts of non-native species. Effects of human disturbance (trampling) are considered minor, except for *Phyllostegia kaalaensis*, which has a root system particularly vulnerable to soil compaction. Life forms of these taxa include an herbaceous plant, a woody vine, partially woody subshrubs, and woody shrubs and small trees of the understory. All individuals and life stages are vulnerable to high and low severity fires throughout the year, depending on phenology and the time of year fire occurs.

Individuals of these 12 taxa will be exposed to the direct and indirect effects of training-related wildland fire over the next 30 years, due to their occurrence within the action area in zones at high, low, or very low risk of training-related wildland fire (Table E 11). All individuals and life stages are vulnerable to high and low severity fires throughout the year. At-risk taxa with individuals located in areas at high risk of fire are *Hibiscus brackenridgei* ssp. *mokuleianus* and *Neraudia angulata*. These plants are likely to be burned under certain conditions. Even full staffing of on-site and standby fire suppression helicopter forces will not guarantee containment of all fires. On approximately 1.5 percent of historical potential training days analyzed, on-site and standby helicopter containment would have failed to contain a fire burning outside the firebreak road, if the fire had not been successfully contained before 1 pm. If additional contingency fire suppression resources are not called, these fires would escape initial attack and burn large acreages. Large fires and fires escaping initial attack are likely to burn into the native forest (see General Effects – Fire Suppression) before additional helicopter support can arrive on-site. In addition, *Hibiscus brackenridgei* ssp. *mokuleianus* plants in the Lower Ohikilolo Management Unit are particularly vulnerable to training-related wildland fire unless fuel

modifications are completed, because they are located on a dry, grassy slope that has burned in the past.

Table E 11. Exposure Area for At-Risk Taxa (U.S. Army Garrison 2006c).

Taxon	Individuals in Fire Risk Zones[†]		
	High	Low	Very Low
Chamaesyce herbstii	0	0	87 (100)
Cyanea grimesiana ssp. *obatae*	0	0	42 (16)
Cyanea longiflora	0	56 (33)	94 (54)
Cyanea superba ssp. *superba*	0	21 (7)	134 (43)
Delissea subcordata	0	20 (11)	2 (1)
Gouania vitifolia	0	0	77 (95)
Hibiscus brackenridgei spp. *mokuleianus*	20 (3)	0	0
Neraudia angulata	32 (8)	48 (13)	0
Phyllostegia kaalaensis	0	0	2 (100)
Sanicula mariversa	0	52 (23)	128 (57)
Schiedea nuttallii	0	84 (89)	10 (11)
Schiedea obovata	0	91 (23)	298 (77)

[†]Total number of individuals (percent of total individuals occurring in fire risk zone).

Plants growing outside the high fire risk zone in the action area are at low risk of burning from training-related wildland fire. At-risk taxa with individuals located in the low fire risk zone include *Cyanea longiflora*, *Cyanea superba* ssp. *superba*, *Delissea subcordata*, *Neraudia angulata*, *Sanicula mariversa*, *Schiedea nuttallii*, and *Schiedea obovata*. These plants can burn in fires that spread from fires that ignite in the high fire risk zone, from misfired or malfunctioning long-range weapons systems and munitions (tracers, AT-4 and SMAW anti-tank weapons, 2.75-caliber rockets, Javelin anti-tank missiles, and TOW missiles), and from spot fires spawned from intense fires in Makua Valley. Under certain adverse conditions (such as an unreported fire during an extreme drought), fires that spread into the low fire risk zones may burn to the outer boundary of the very low fire risk zone within 48 hours.

Plants growing outside the low fire risk zone are at very low risk of burning as a result of training-related wildland fire ignited by a misfired or malfunctioning Javelin or TOW projectile, or a spot fire from an intense fire burning in Makua Valley under certain dry, windy weather conditions. At-risk taxa with individuals located in the very low fire risk zone include *Chamaesyce herbstii*, *Cyanea grimesiana* ssp. *obatae*, *Cyanea longiflora*, *Cyanea superba* ssp. *superba*, *Delissea subcordata*, *Gouania vitifolia*, *Phyllostegia kaalaensis*, *Sanicula mariversa*, *Schiedea nuttallii*, and *Schiedea obovata*. These plants can burn within spot fires of various sizes, depending on topography, vegetation cover, weather, and suppression capability. The expected fire size resulting from a misfired long-range Javelin or TOW projectile landing within intact shrub and/or forest vegetation is about 0.1 ha (0.3 ac) with immediate fire suppression response; if a fire is undetected, it could burn over 100 acres in 48 hours.

At-risk taxa were originally identified, in part, because of their rather high risk of training-related wildland fire, as predicted by preliminary fire models (Beavers 2005). Additional fire modeling based on the Army's intention to significantly upgrade its fire-fighting capability shows a serious reduction to the originally predicted fire risk (D. Greenlee, pers. comm. 2007). Based on

improvements to the Army's Wildland Fire Management Plan, which is included as part of the Project Description, the currently predicted fire risk to most of these 12 taxa is low. However, the success of any fire suppression response will depend on rigorous adherence to requirements that include a complex system of weather forecasting, fire danger monitoring, and skilled deployment of fire fighting personnel and equipment. We anticipate fires that ignite or spread outside the firebreak road will be contained as quickly as possible utilizing direct attack with fire suppression helicopters. Nonetheless, we also recognize that unavoidable human errors, accidents, and delays occur on fires, reducing the effectiveness of fire suppression operations (see General Effects - Fire and Fire Suppression). Even a fire that burns only up to a management unit fenceline, without destroying listed plants within the unit, may damage the fence enough to allow a period of ungulate access to at-risk population units. In addition, even with Army management, two at-risk taxa (*Cyanea superba* ssp. *superba* and *Phyllostegia kaalaensis*) have ceased to exist in the wild as naturally occurring plants; all extant individuals were outplanted from greenhouse-propagated stock. Most importantly, the Army is concerned about the long-term adequacy of funding for fire protection and stabilization activities (U.S. Army Garrison 2006d). Therefore, we have retained the designation of at-risk taxa because we consider even a low risk of fire or ungulates as potentially damaging to these critically endangered taxa.

The areas exposed to training-related wildland fire and invasive species in the action area include mixed native and non-native vegetation in mesic forest, dry forest, and dry grassland/shrubland habitats. Population units of several taxa (*Cyanea superba* ssp. *superba*, *Delissea subcordata*, *Hibiscus brackenridgei* ssp. *mokuleianus*, *Neraudia angulata*, *Schiedea nuttallii*, and *Schiedea obovata*) are at high risk of training-related wildland fire within dry, grassy habitats of the Kaluakauila, Lower Ohikilolo, and Kahanahaiki (C-Ridge vicinity) management units. Population units within mesic, forested habitats in the Kahanahaiki, Pahole, Upper Kapuna, and West Makaleha management units are generally at lower risks of fire, except in areas of alien grass encroachment. Population units in the Ohikilolo Management Unit along the south valley rim and in the Keaau area beyond Ohikilolo Ridge are likewise at lesser risks of fire. Mesic conditions in upper-slope forests do not preclude the incidence of fire, however, especially during prolonged drought conditions in disturbed areas with grassy understories. The spread of wildland fire from the northern C-Ridge area into the Kahanahaiki Management Unit, for example, is strongly influenced by grass. The 1995 and 2003 escaped prescribed burns increased the exposure of listed plants near this area to future fires by killing native vegetation and increasing the alien grass cover. Less than half of the population units to be managed for stability of at-risk taxa are located within fenced areas, and not all of them are regularly controlled for invasive weeds. Individuals under mesic forest canopy in weed control areas are probably fairly well protected from rapidly spreading intense fire. Other individuals in locations lacking weed control are not well protected from long-term fire encroachment into native and mixed forest.

To reduce the risk of training-related wildland fire to listed plants, the Army will use certain types of weapons systems and munitions for training at Makua only after completion of specific measures to protect at-risk taxa and augment their numbers in the wild to expedite their stabilization. In addition, as part of the proposed action, the Army will implement conservation and stewardship programs to reduce the risk of ignition and spread of training-related wildland

fire, reduce the loss of plants in wildland fires occurring on State and private land outside the action area, and improve native habitat in population units by excluding feral ungulates and controlling non-native weeds (Makua Implementation Plan Addendum).

Table E 12. Expedited Stabilization Population Units Located on State, City/County, and Private Lands; All Taxa Except *Chamaesyce herbstii*, *Cyanea grimesiana* ssp. *obatae*, *Gouania vitifolia*, and *Phyllostegia kaalaensis* also have population units on Army lands (U.S. Army Garrison 2006d).

Taxon	State Lands	City/County Lands	Private Lands
Chamaesyce herbstii	Upper Kapuna to Pahole* W Makaleha	Makaha	
Cyanea grimesiana ssp. *obatae*	Pahole to W Makaleha*		Central Kaluaa Palikea (S Palawai)
Cyanea longiflora	Upper Kapuna to W Makaleha* Makaha & Waianae Kai Pahole*	Makaha & Waianae Kai	
Cyanea superba ssp. *Superba*	Central & E Makaleha Pahole to Kapuna	Makaha	
Delissea subcordata	Kahanahaiki to Keawapilau*		Ekahanui Kaluaa
Gouania vitifolia	Keaau* Waianae Kai*		
Hibiscus brackenridgei ssp. *mokuleianus*	Keaau*		Haili to Kawaiu Kaimuhole & Palikea Gulch
Neraudia anugulata	Manuwai Waianae Kai Mauka		
Phyllostegia kaalaensis	Keawapilau to Pahole* Manuwai	Makaha	
Sanicula mariversa	Kamaileunu Keaau*		
Schiedea nuttallii	Kahanahaiki to Pahole* Upper Kapuna-Keawapilau Ridge	Makaha	
Schiedea obovata	Kahanahaiki to Pahole* Keawapilau to WMakaleha*	Makaha	

*Entirely or partially inside action area

The risk of fire to listed species occurring inside the action area will be minimized by training restrictions, fire management, and expedited stabilization actions. Fire minimization measures are based on required levels of helicopter staffing to contain fires before they escape the firebreak road. In addition, to reduce the fire risk to *Hibiscus brackenridgei* ssp. *mokuleianus* plants (as well as to the stabilization taxon *Chamaesyce celastroides* var. *kaenana*) in the Lower Ohikilolo Management Unit, the Army will not begin any live-fire or blank-fire training until alien grass cover is removed and controlled within 3 m (9.8 ft) of these plants and to less than 20 percent cover within the Lower Ohikilolo weed control areas. Additional fuels modification within a 60-m (197-ft) swath along the inside perimeter of the south firebreak road, as shown in Figure PD 6 will allow the Army to reduce the level of on-site helicopter staffing required for certain weapons. With these fuel modifications in place, the Army may train using small arms,

demolitions, grenades, mines, simulators, and mortars and artillery, with the use of certain of these weapons systems and munitions restricted to Green fire danger conditions. Within five to 10 years, plants growing in the Kahanahaiki and Kaluakauila management units will be protected by fuels modification and firebreaks; these protections will benefit at-risk taxa noted above. With these management units better protected from fire, and with completion of expedited stabilization of *Cyanea superba* ssp. s*uperba*, *Schiedea nuttalli*, and *Schiedea obovata*, the Army may begin training with more weapons systems and munitions under Yellow fire danger conditions instead of only under Green fire danger conditions; and begin using grenade launchers and AT-4 and SMAW weapons under Green or Yellow fire danger conditions, depending on live herbaceous fuel moisture. Expedited stabilization of the 12 at-risk taxa must be complete before the Army may begin training with tracer ammunition, Javelins, and 2.75-caliber rockets. Thus, all listed species in the action area, including the 16 stabilization taxa, will benefit from training restrictions required until expedited stabilization is complete for all 12 at-risk species. Full stabilization of all 16 stabilization taxa and all 12 at-risk taxa must be complete before the Army may begin training with TOWs.

Species Response to the Proposed Action

The response of individuals of at-risk taxa to training-related wildland fire and invasive species will include the direct and indirect effects of fire injury and death, ungulate grazing and trampling, invertebrate herbivory, and alien plant competition (see General Effects). As a result, the number of mature individuals and numerically stable population units of at-risk taxa in the action area are expected to decline over the next 30 years. The overall response to direct and indirect effects will be a measurable reduction in baseline numbers, distribution, and reproduction of individuals and/or entire occurrences in action area population units due to fire injury and death. Reduced individual fitness in plants that survive will further decrease the viability of population units through a continuing decline in baseline numbers. Without implementation of the Army's conservation and stewardship programs, these effects will worsen the existing condition of at-risk taxa in the action area by constraining their resiliency (recovery rate from disturbance) and exacerbating their risk of extinction due to small population size. We infer from conservation biology principles and examples from related species that these at-risk taxa have very high background extinction risks due to demographic, environmental, and catastrophic events in the action area. We conclude that any additional threats to at-risk taxa are likely to eliminate expectation of their long-term persistence.

The Service anticipates that implementation of fire management and expedited stabilization actions will prevent training-related declines in baseline numbers of individuals and population units of at-risk taxa. Over the next 30 years, expedited stabilization is expected to achieve modified numerical stability of threshold numbers of mature and immature individuals in at least three population units, including one or two outside the action area, for each at-risk taxon. (Full stabilization over the long term will require threshold numbers of mature, reproducing individuals, full threat control, and full *ex situ* genetic storage for all population units.) The Army recently decided to identify four manage for stability population units for some of the at-risk taxa (U.S. Army Garrison 2006d). The criteria used to identify taxa that will be managed at four stabilization population units include (1) presence in both the Makua and Schofield Barracks (Service 2003) action areas (*Delissea subcordata*); (2) presence in high fire threat areas

in the Makua action area (*Hibiscus brackenridgei* ssp. *mokuleianus*); (3) need for reintroduction to achieve stabilization population goals (*Hibiscus brackenridgei* ssp. *mokuleianus, Cyanea superba* ssp. *superba*); and (4) need for an additional population unit to represent the full geographic and morphological diversity of the taxon (*Neraudia angulata, Cyanea grimesiana* spp *superba*).

Expedited stabilization goals can be attained for most of the at-risk taxa within about five to 10 years, while others (particularly *Sanicula mariversa*) may take longer (K. Kawelo, U.S. Army, pers. comm. 2006). Overall, the response of at-risk taxa to project subsidies is expected to result in measurable increases in individual fitness (survival, reproduction, and recruitment), increased total number of mature and immature individuals within population units, and expanded distribution of population units outside the action area. Thus, Army conservation and stewardship programs will protect these taxa from jeopardy over the next 30 years, improve their likelihood of reaching full stabilization goals over the long term, and enhance their probability of persistence.

Responses to project subsidies may involve indirect adverse effects to certain at-risk taxa. In particular, prioritizing augmentation and reintroduction of individuals and population units both inside and outside the action area may deplete seed sources and delay collection of material for *ex situ* genetic storage. In some cases, repeated outplantings to replace individuals that do not survive because of fire, ungulates, weeds, or invertebrate pests may create sink population units where reproduction and recruitment are insufficient to offset mortality. These impacts will be minimized by careful monitoring and addressing limiting factors to survival and recruitment through fuels, weed, and pest control measures. In addition, four at-risk taxa will be managed for stability at only one population unit outside the action area. Army biologists believe that action area locations of these taxa represent their currently known and historical centers of abundance (K. Kawelo, U.S. Army, pers. comm. 2006). For this reason, the Army believes scarce propagule resources should be used to augment current action area locations rather than introducing population units outside their historically documented range. Thus, these four taxa will still have an elevated exposure to training-related wildland fire, even when fully stabilized, because relatively fewer individuals will be located outside the action area. However, because the predicted fire risk to these taxa is low or very low, one population unit outside the action area is believed to be adequate. The Army and the Service will closely monitor these taxa and revise management actions as necessary to achieve and maintain expedited stabilization criteria.

The reasoning outlined above is based on information about the proposed action and the environmental baselines of the at-risk taxa in the action area. In addition, we make general inferences from this set of circumstances according to conservation biology principles regarding small populations and from previous experience regarding threats to the conservation of native vegetation in Hawaii (see General Effects). We also make inferences from examples of other species that are closely related to the at-risk taxa or have a similar life history, and have become unstable, endangered, or extinct.

The genus *Schiedea*, for example, contains the highest proportion of endangered taxa of any species-rich lineage in the Hawaiian Islands, with 19 taxa (about 54 percent) listed as endangered and three designated as candidates for listing (Wagner et al 2005; U.S. Fish and Wildlife Service

2005a). *Schiedea nuttallii* is closely related to *S. amplexicaulis* and *S. implexa*, which are presumed extinct, and to *S. kaalae*, a stabilization species that is endangered and unstable. *Schiedea obovata* is somewhat less closely related to these species but is also endangered and unstable. The declines of *S. nuttalllii*, *S. obovata*, and *S. kaalae* are attributed to habitat degradation by feral pigs and lack of seedling survival due to slug herbivory. According to Wagner et al (2005), loss of native forest in the Waianae Mountains are/were caused in part by military-related fires, and the coincidental high diversity of *Schiedea* in this area, probably have contributed disproportionately to endangerment in this genus. We believe that ongoing threats in the action area, if not addressed, are likely to further imperil at-risk *Schiedea* species to the point of extinction.

Similarly, 28 (49 percent) *Cyanea* taxa are listed as endangered, one is listed as threatened, eight (14 percent) are candidates for listing, and 17 (30 percent) are considered species of concern (U.S. Fish and Wildlife Service 2006a; Hawaii Biodiversity and Mapping Program 2006). In addition, four (44 percent) of the nine *Delissea* species are listed as endangered and several are presumed extinct. *Cyanea*, one of the largest Hawaiian plant genera, and the closely related genus *Delissea* are classified within the Lobelioideae subfamily of the Campanulaceae (bellflower family). The Hawaiian lobelioids are classic examples of adaptive radiation on isolated, oceanic islands. About 25 percent of lobelioid species have become extinct over the past 100 years (Wagner et al 1999). Six endemic lobelioid genera exhibit morphological diversity that is likely related to the role of endemic Hawaiian honeycreepers as pollinators, many of which are also endangered or extinct. At Makua, naturally occurring individuals of *Cyanea superba* ssp. *superba* have been extirpated since completion of the Makua Implementation Plan in 2003; this taxon (and the unrelated *Phyllostegia kaalaensis*) currently exist in the wild only as Army reintroductions from greenhouse-propagated stock. We infer from such examples that at-risk taxa in the action area are similarly threatened with extinction, given their unstable status, existing threats, and the potential impacts of the proposed action. These examples also illustrate the need to expedite stabilization of at-risk taxa before all naturally occurring individuals disappear.

Conclusion

Based on the analysis above, the Service anticipates that stressors associated with training-related wildland fire, and the introduction and spread of invasive species, are likely to result in decreased fitness of individuals and viability of population units of 12 at-risk taxa by reducing their abundance, distribution, and reproduction in the action area. Action area individuals will be exposed to high, low, and very low risks of burning as a result of a training-related wildland fire over the next 30 years. The response of at-risk taxa to a training-related wildland fire range from direct effects of injury and death to indirect effects of physiological stress, increased mortality, habitat degradation, and competition with non-native species. The overall effect of training-related wildland fire and spread of invasive species will be a further decline in individual fitness, baseline numbers, and viability of population units within the action area. The number of individuals in the action area population units represent from 12 to 100 percent of all known remaining individuals of each of these 12 at-risk taxa. With so few individuals remaining, these

taxa have a greater risk of extinction, however, expedited stabilization greatly minimizes this risk for these 12 taxa.

We develop our opinion using the best available scientific and commercial information, giving benefit of the doubt to the species if significant information gaps preclude determination of quantifiable effects. For example, the proposed action's training-related wildland fire risk could be estimated more accurately with additional modeling to predict long-term fire frequency and encroachment into native forest, and with collection of adequate demographic data for population viability analysis of listed plants. Lacking that information, we infer from restricted distribution, small population size, and limited recruitment that at-risk taxa in the action area have a very high background risk of extinction. We believe any additional threats, including training-related wildland fire and habitat degradation by invasive species, are likely to eliminate expectation of their long-term persistence. Accordingly, we consider expedited stabilization of population units outside the action area, where they will not be exposed to training-related wildland fire, essential to persistence of these at-risk taxa in the wild. The reduced viability of action area population units, in the absence of stabilization population units outside the action area, may be sufficient to appreciably reduce the likelihood these species will persist.

Our conclusion is based on our best professional judgment of the likely response of at-risk taxa to both stressors and subsidies of the proposed action. Military training restrictions and conservation management to attain expedited stabilization will ensure that at least three population units at modified numerical thresholds for stability are maintained for each at-risk taxon, including one or two population units for each taxon outside the action area that will not be exposed to training-related wildland fire. We anticipate that expedited stabilization will protect at-risk taxa from jeopardy over the next 30 years while fire protection and suppression measures are being improved and long-term actions for full stabilization are being implemented. Therefore, after reviewing the current status of the 12 at-risk taxa, the environmental baseline for these taxa in the action area, and the effects of the proposed action and the cumulative effects, it is the Service's biological opinion that the proposed action is not likely to jeopardize the continued existence of the following 12 at-risk taxa in the wild by reducing their reproduction, numbers, and distribution: *Chamaesyce herbstii*, *Cyanea grimesiana* ssp. *obatae*, *Cyanea longiflora*, *Cyanea superba* ssp. *superba*, *Delissea subcordata*, *Gouania vitifolia*, *Hibiscus brackenridegei* ssp. *mokuleianus*, *Neraudia angulata*, *Phyllostegia kaalaensis*, *Sanicula mariversa*, *Schiedea nuttallii*, and *Schiedea obovata*.

EFFECTS OF THE ACTION – *Chamaesyce herbstii* (Akoko)

All 87 individuals of the Waianae endemic tree, *Chamaesyce herbstii*, are part of the Kapuna to Pahole population unit located in the Makua action area (Figure E 29). These individuals are growing in the Pahole (20) and Upper Kapuna (67) management units. The Kapuna to Pahole population unit is not considered stabilized (defined as 25 mature, reproducing individuals) because threats are not controlled and the plants are not naturally self-sustaining. *Chamaesyce herbstii* has been identified as particularly at risk in the action area, based primarily on their overall status, environmental baseline within the action area, and exposure to the risk of training-related wildland fire. *Chamaesyce herbstii* was identified as an expedited stabilization species as a conservation measure to protect these taxa from extinction while full stabilization measures are

being implemented over the long term. *Chamaesyce herbstii* has a high background risk of extinction due to its very low numbers, low vigor, and apparent lack of pollinators. Due to small population size, restricted distribution, limited recruitment, and declining trends in numbers and distribution, *C. herbstii* already is in a phase of quasi-extinction with numbers that have declined to the point where demographic or environmental stochasticity alone can result in extirpation. We infer from these circumstances, conservation biology principles, and examples from other species that *C. herbstii* has a very high background extinction risk, and any additional threats associated with training-related wildland fire are likely to eliminate expectation of its long-term persistence.

Species Response to the Proposed Action

Over the next 30 years, *Chamaesyce herbstii* individuals in the Kapuna to Pahole population unit will be exposed to the direct and indirect effects of training-related wildland fire in the very low fire risk zone. However, the proposed action of increased Army training with long-range, incendiary weapons could result in injury and death of *C. herbstii* individuals in the action area. As a small tree, mature and immature individuals are vulnerable to high and low severity fires throughout the year. *Chamaesyce herbstii* in the action area also will be exposed to the direct and indirect impacts of non-native invasive plants, which have significantly altered the mesic habitat where this species occurs. The direct and indirect effects of non-native weeds and invertebrates will reduce the vigor, reproduction, recruitment, and survival of individual plants.

All *Chamaesyce herbstii* plants growing in the action area may be impacted by spot fires spawned by intense fires burning in Makua valley, or by fires ignited by a misfired long-range, live-fire weapon such as the TOW. Fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac) (see General Effects - Fire Suppression). In addition, reaching expedited stabilization goals (see Expedited Group Effects) will improve the likelihood that *C. herbstii* will attain full stabilization and enhance its probability of persistence over the long term. Implementation of all fire suppression measures incorporated into this action, as well as the Army's Standard Operating Procedures reduce the risk of *C. herbstii* destruction by fire over the next 30 years. Any loss of action area plants will reduce baseline numbers and available propagule material for augmentation and reintroduction, and prolong the time needed to achieve expedited and full stabilization.

The Pahole Management Unit is fenced to exclude feral ungulates, and weeds are partially controlled throughout the population unit. Because of their occurrence in mesic forest, *Chamaesyce herbstii* individuals are somewhat protected from the spread of fire. Moreover, no long-range weaponry will be used until expedited stabilization thresholds are achieved for all stabilization population units. Expedited stabilization will involve continued augmentation to maintain at least 25 individuals of *C. herbstii* in the Kapuna to Pahole population unit inside the action area. Outside the action area, the West Makaleha and Makaha population units will be established through reintroduction, after fence exclosures are constructed. *Chamaesyce herbstii* plants have been grown from wild-collected seed and successfully outplanted by State biologists since 1995.

Conclusion

Despite the ongoing exposure of *Chamaesyce herbstii* to project wildland fire impacts, Army conservation and stewardship programs will improve its baseline condition in the action area and range-wide. Weapons restrictions, fuels management, fire suppression, invasive species control, and expedited stabilization actions minimize the risk of wildland fire to *C. herbstii.* Expedited and full stabilization pursuant to the Makua Implementation Plan Addendum will increase the number of *C. herbstii* to stability thresholds in three population units, including two outside the action area that will not be vulnerable to training-related wildland fire. Thus, the overall effect of the proposed action's stressors and subsidies will result in a net increase in population numbers, distribution, and reproduction of *C. herbstii* in and adjacent to the action area. Therefore, based on our analysis of the effects of the actions outlined in the Project Description including fire minimization measures, the Service concludes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

Effects of the Action on *Chamaesyce herbstii* Critical Habitat

Forty-one percent or 205 ha (506 ac) of the total critical habitat designated for *Chamaesyce herbstii* is located in the Makua action area (see Figure E 29). It is located in the eastern portion of the action area and is almost entirely located in within the low fire zones with 19.7 ha (48.8 ac) in the low, 184.8 ha (456.6 ac) in the very low, and only 0.02 ha (0.06 ac) in the high fire risk area. The critical habitat in the action area, together with 224 ha (554 ac) outside the action area, was designated to provide habitat for the conservation of five populations of *C. herbstii*. Each population should be represented with a minimum of 300 mature individuals in order to attain recovery goals for this species (68 FR 35950). The primary constituent elements essential for this species include, but are not limited to, shaded gulch bottoms and slopes in mesic *Acacia koa-Metrosideros polymorpha* (koa-ohia) lowland forests or diverse mesic forests. The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within mesic koa-ohia lowland forests or diverse mesic forests. It is estimated that only 30 percent of the critical habitat is in an area of greater than 75 percent native plant cover (K. Kawelo, pers. comm. 2004; 68 FR 35950). This indicates that this unit has been impacted by the encroachment of non-native plants. In the absence of habitat management, fires from military actions could add to the ongoing degradation of this critical habitat unit by removing the remaining vegetative primary constituent elements.

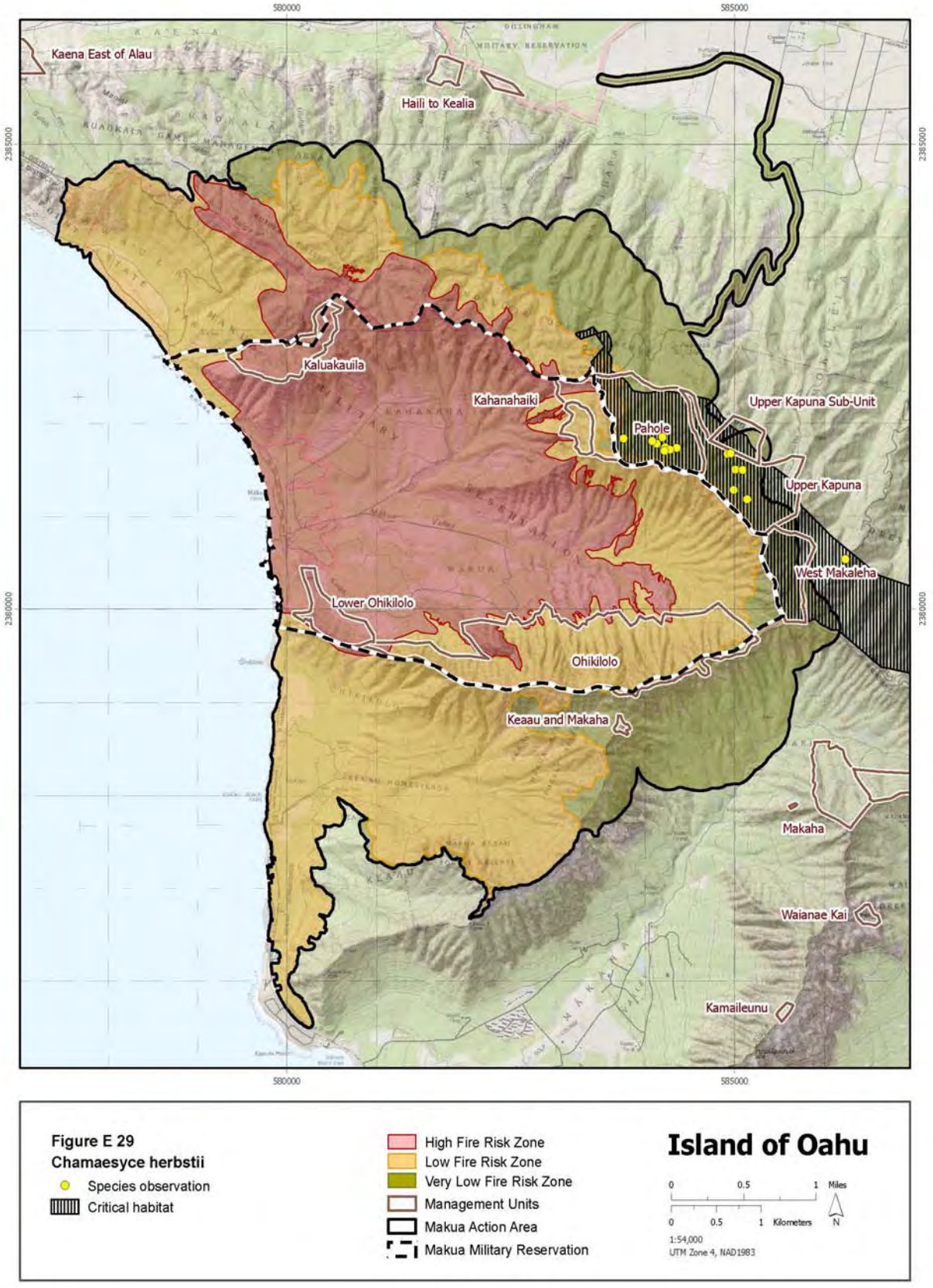
There is a risk that if a fire started in the impact area, it could move east and impact this unit or that a misfired round could ignite outside of the firebreak road and burn into this unit. However, this risk is reduced due to the beneficial resource management actions conducted by the Army in the management units, the low flammability of the surrounding vegetation (mesic forest), and spatial separation from the impact area. Eighty-five percent of this critical habitat unit that lies in the Makua action area is located in Kahanahaiki, Pahole, Upper Kapuna, Upper Kapuna Sub-Unit and West Makaleha management units.

Please see *Schiedea obovata* for a more detailed discussion on the beneficial Army actions in the aforementioned management units. All of these conservation actions being conducted or

planned for implementation in these management units will enhance the conservation value of the critical habitat for *Chamaesyce herbstii*. The remaining critical habitat (31 ha; 77 ac) outside of the management units is separated from the impact area by the management units themselves. The fuel modification activities plus other conservation measures implemented by the Army for species stabilization will further reduce the risk of fire to the portion of the critical habitat outside of the management unit.

Conclusion

The critical habitat unit for *Chamaesyce herbstii* in the Makua action area is located mostly within the low fire risk area. Less than one percent of the unit is in the high fire-risk zone. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside of the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire will be reduced due to the construction of a fuel modification zone between the impact area and the Kahanahaiki Management Unit. In addition, fuel reduction within the management units will further buffer the critical habitat unit from fire. The portions of critical habitat that is within Kahanahaiki, Pahole, Upper Kapuna, Upper Kapuna Sub-Unit and West Makaleha management units will be managed to improve their baseline quality pursuant to the Makua Implementation Plan. Without this management, this critical habitat unit could eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *C. herbstii* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *C. herbstii* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *C. herbstii*.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Kaena East of Alau
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Kahanahaiki
Upper Kapuna Sub-Unit
Pahole
Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 29
Chamaesyce herbstii
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
0 0.5 1 Kilometers
N
1:54,000
UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Cyanea grimesiana* ssp. *obatae* (Haha)

Cyanea grimesiana ssp. *obatae* is a short-lived perennial with approximately 254 total individuals in existence range-wide. There are an estimated 42 individuals in the action area located in Pahole (16 individuals) and West Makaleha (26 individuals) management units (Figure E 30). The population unit in the action area has not met stabilization goals (defined as 100 mature, reproducing individuals) since threats are not controlled, and numbers are currently being maintained primarily through augmentation. Currently, the action area contains about 16 percent of all remaining *C. grimesiana* ssp. *obatae* individuals. *C. grimesiana* ssp. *obatae* has a high background risk of extinction due to its very low numbers, low vigor, and extreme susceptibility to rat and slug predation. *C. grimesiana* ssp. *obatae* was identified as an expedited stabilization species as a conservation measure to protect these taxa from jeopardy while full stabilization measures are being implemented over the long term.

Analysis of Effects of the Proposed Action

Over the next 30 years, *Cyanea grimesiana* ssp. *obatae* individuals in the Pahole to West Makaleha population unit will be exposed to direct and indirect effects of training-related wildland fire in the low and very low fire risk zones. As an understory shrub, all individuals and life stages are vulnerable to the risk of high and low severity wildland fires that will result in injury and death. All *C. grimesiana* ssp. *obatae* plants growing in the low and very low fire risk area in the Pahole Management Unit may be impacted by spot fires spawned by intense fires burning in Makua Valley, or by fires ignited by a misfired long-range, live-fire weapon such as the TOW. However, fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac) (see General Effects - Fire Suppression). The individuals in the West Makaleha Management Unit are almost 3.2 km (1.9 mi) from the training impact area and are buffered by the steep western cliffs of Ohikilolo Ridge. These individuals are at a very low risk of impact from training-related wildland fires.

In addition, reaching expedited stabilization goals (see Expedited Group Effects) prior to the use of incendiary weapons from Column C (see Table PD 2) will offset the risk of extinction while full stabilization measures are being implemented. Expedited stabilization improves the likelihood that *Cyanea. grimesiana* ssp. *obatae* will attain full stabilization and enhance its probability of persistence over the long term. No long-range weaponry will be used until expedited stabilization thresholds are achieved in all stabilization population units (see Expedited Group Effects).

Other Risk Reduction Factors

In addition to wildland fire, *Cyanea grimesiana* ssp. *obatae* will also be exposed to the direct and indirect impacts of non-native plants, slugs, rats, and ungulates. Slug damage is particularly threatening to the survival and recovery of this species (see Status and Baseline section) because no feasible control methods are available for field situations. The direct and indirect effects of non-native weeds and invertebrates will reduce the vigor, reproduction, recruitment, and survival of individual plants. The Army Natural Resources Staff are working to develop slug control

techniques to address predation of *Cyanea* species in Makua (U.S. Army Garrison 2006c). Full stabilization will require development of slug control techniques to increase survival and recruitment.

The Pahole portion of the Pahole to West Makaleha population unit is within the fenced Pahole Management Unit, and the West Makaleha portion is protected by a small ungulate exclosure and rat control grid. The population unit is partially controlled for weeds. The Army will add a fourth stabilization population unit in the Makaha Management Unit (K. Kawelo, Makua Implementation Team meetings 2007). Expedited stabilization will involve continued augmentation of *C. grimesiana* ssp. *obatae* in the Pahole to West Makaleha population unit inside the action area. Outside the action area, the Central Kaluaa and Palikea (South Palawai) population units will continue to receive extensive augmentation. *Cyanea grimesiana* ssp. *obatae* is successfully propagated from seed, which generally can be collected throughout the year. In 2005, supplemental plantings were conducted at existing reintroduction sites adding a total of 36 plants. A year later the Army Natural Resources Staff noted that approximately 75 percent of the reintroduced plants in the Waianae Mountains was still present (U.S. Army Garrison, 2006c). Small plants require a shorter growing time in the nursery, are easier to transport, and can be planted in more locations such as steep slopes where wild plants are known to occur.

The entire current range of *Cyanea grimesiana* ssp. *obatae* occurs on non-Army controlled lands. The Pahole to West Makaleha population unit in the action area is located on State lands, where Army implementation of stabilization actions will be covered by a long-term cooperative agreement. The Central Kaluaa and Palikea population units are located in Honoluliuli Preserve.

Conclusion

Despite the ongoing exposure of *Cyanea grimesiana* ssp. *obatae* to project wildland fire impacts, Army conservation and stewardship programs will improve its baseline condition in the action area and range-wide. Weapons restrictions, fuels management, fire suppression, invasive species control, expedited and eventually full stabilization actions over the next 30 years will increase population numbers of *C. grimesiana* ssp. *obatae* in four population units, including two outside the action area that will not be vulnerable to training-related wildland fire. Thus, the overall effect of the proposed action's stressors and subsidies will result in a net increase in baseline numbers, distribution, and reproduction of *C. grimesiana* ssp. *obatae* in and adjacent to the action area. Reaching expedited stabilization will improve the likelihood that *C. grimesiana* ssp. *obatae* will attain full stabilization and enhance its probability of persistence over the long term. Therefore, based on our analysis of the effects of the actions outlined in the Project Description, including training-related fire minimization measures, the Service concludes that the risks associated with the Army's proposed action are outweighed by the long-term benefits of the Army's stabilization actions and ecosystem management.

Effects of the Action on *Cyanea grimesiana* ssp. *obatae* Critical Habitat

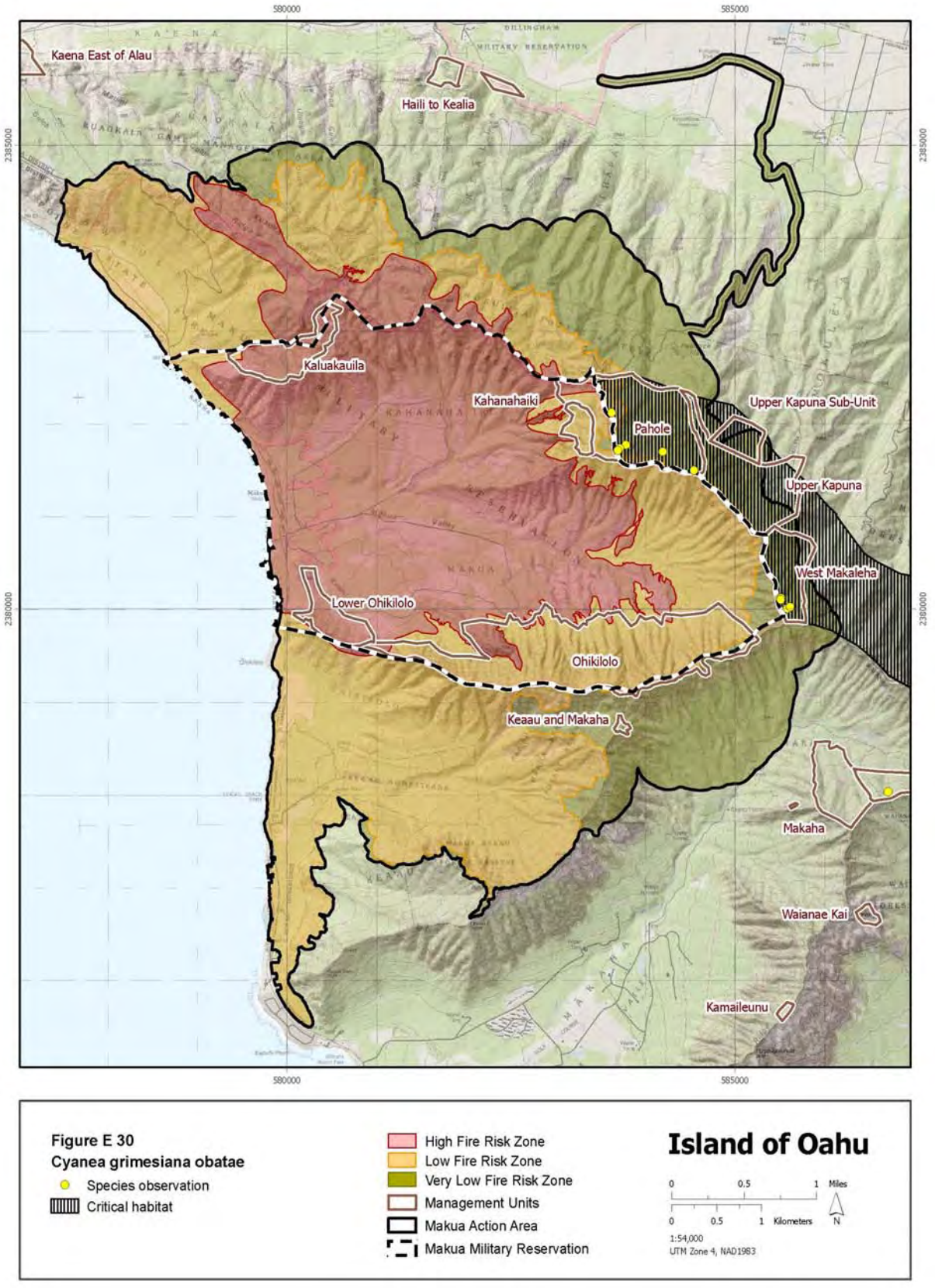
The critical habitat unit within the Makua action area for *Cyanea grimesiana* ssp. *obatae* encompasses 25 percent (209 ha; 512 ac) of the designated critical habitat for this species (see Figure E 30). It is located in the northeastern portion of the action area and is almost entirely within only the very low fire zone 192.7 ha (476.2 ac). The critical habitat unit (area inside and outside of the action area) provides habitat for the conservation of three populations, each comprised of 300 reproducing individuals of *C. grimesiana* ssp. *obatae* (68 FR 35950). The primary constituent elements essential for this species include, but are not limited to, steep, moist, shaded slopes in diverse mesic to wet lowland forests. The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within diverse mesic to wet lowland forests. It is estimated that more than 50 percent of the critical habitat is in an area with greater than 50 percent native plant cover (K. Kawelo, pers. comm. 2004). This indicates some encroachment of non-native plants into this unit. In the absence of resource management, fires from future training actions could add to the degradation of this critical habitat unit by removing the remaining vegetative primary constituent elements.

The risk of a training-related fire to this unit is reduced due to the beneficial resource management actions conducted by the Army in the management units, in combination with the low flammability of the surrounding vegetation (mesic and wet forests), and spatial separation from the impact area. Eighty-eight percent (247 ha; 610 ac) of the critical habitat unit is located in several management units (Pahole, Upper Kapuna, Upper Kapuna Sub-Unit, West Makaleha). These management units and the beneficial actions implemented by the Army are discussed in detail in the effects section for *Schiedea obovata*. The remaining critical habitat (35 ha; 86 ac) for this species located outside of the management units is buffered from the impact area by the management units themselves. The fuel modification activities, plus other conservation measures implemented by the Army for species stabilization, will further reduce the risk of fire to the portion of the critical habitat outside of the management units.

Conclusion

The critical habitat unit for *Cyanea grimesiana* ssp. *obatae* in the Makua action area is almost entirely within the low fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside of the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire to the critical habitat will be reduced due to the low flammability of the surrounding mesic forests, the spatial separation from the impact area, and the beneficial resource management actions conducted by the Army. Fuel reduction within the management units will buffer the critical habitat unit from fire. The critical habitat that is within the Central and East Makaleha, Upper Kapuna Sub-Unit, Pahole, Upper Kapuna, and West Makaleha management units will be managed to improve its baseline quality pursuant to the Makua Implementation Plan. Without this management, this critical habitat unit could eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *C. grimesiana* ssp. *obatae* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though

there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *C. grimesiana* ssp. *obatae* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *C. grimesiana* ssp. *obatae*.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Kahanahaiki
Upper Kapuna Sub-Unit
Pahole
Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 30
Cyanea grimesiana obatae
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
Island of Oahu
0 0.5 1 Miles
0 0.5 1 Kilometers
N
1:54,000
UTM Zone 4, NAD1983

EFFECTS OF THE ACTION – *Cyanea longiflora* (Haha)

The range-wide status of *Cyanea longiflora* is now limited to 171 total individuals in three population units (Figure E 31). In the action area there are an estimated 158 individuals in Upper Kapuna to West Makaleha (56) and Pahole (102) population units. *C. longiflora* in the action area represents 92 percent of the total individuals and is characterized by two population units defined as 75 mature, reproducing individuals.

Cyanea longiflora has been identified as particularly at risk in the action area, based primarily on their overall status, environmental baseline within the action area, and exposure to training-related wildland fires. Because of these factors, it is likely *C. longiflora* is already is in a phase of quasi-extinction with numbers that have declined to the point where demographic or environmental stochasticity alone can result in extirpation (see General Effects – Small Population Size). We infer from these circumstances, conservation biology principles, and examples from other species that *C. longiflora* has a very high background extinction risk in the action area and range-wide, and any additional threats associated with training-related wildland fire are likely to eliminate expectation of its long-term persistence. Therefore, *C. longiflora* was identified as an expedited stabilization species as a conservation measure to protect this taxon from jeopardy while full stabilization measures are being implemented over the long-term.

Analysis for Effects of the Proposed Action

Over the next 30 years, *Cyanea longiflora* individuals in the Kapuna to West Makaleha and Pahole population units will be exposed to the direct and indirect effects of training-related wildland fire in the low and very low fire risk zones. As an understory shrub, all individuals and life stages are vulnerable to the risk of high and low severity wildland fires. The proposed action will result in injury and death of *C. longiflora* individuals in the action area as a result of training-related wildland fire. About 56 individuals occur in the low fire risk zone and 102 in the very low fire risk zone. All *C. longiflora* plants growing in the low and very low fire risk area in the Pahole Management Unit may be impacted by spot fires spawned by intense fires burning in Makua Valley, or by fires ignited by a misfired long-range, live-fire weapon such as the TOW. However, fire detection and suppression response is designed to prevent a fire ignited by misfired weapons landing in forest and shrub areas from burning more than 0.1 ha (0.3 ac) (see General Effects - Fire Suppression). The individuals in the West Makaleha Management Unit are almost 3.2 km (1.9 mi) from the training impact area and are buffered by the steep western cliffs of Ohikilolo Ridge. Mesic forest conditions generally protect *C. longiflora* from the spread of fire, therefore, these individuals are at a very low risk of impact from training-related wildland fires.

Because the action area contains about 92 percent of all remaining individuals, the environmental baseline of *Cyanea longiflora* in the action area is virtually equivalent to the status of the species as a whole. This species is characterized by fluctuating numbers, a trend of local decline, distribution in three unstable population units, limited recruitment, and low numbers that are increasing primarily due to augmentation. To offset the risk of extirpation due to training-related wildland fires, certain weapons systems and munitions will be restricted until fire protection fuelbreaks are in place and expedited stabilization thresholds are achieved (see General Effects –

Fire Suppression). No long-range weaponry will be used until expedited stabilization goals are met for all stabilization population units. In the action area, expedited stabilization actions will involve continued augmentation of *C. longiflora* in the Makua population unit and reintroduction in the Kaluakauila population unit. Outside the action area, the Makaha and Waianae Kai population unit will contain plants that are not exposed to the threat of training-related fires. Three population units will be managed as stabilization population units in order to represent the full, genetic, geographical and morphological complement of this species.

The direct and indirect effects of non-native weeds, invertebrates, and ungulates will reduce the vigor, reproduction, recruitment, and survival of individual plants. *Cyanea longiflora* in the action area also will be exposed to the direct and indirect impacts of non-native plants, slugs, and ungulates. *C. longiflora* is particularly susceptible to slug damage and the Army is sponsoring ongoing research to determine a methodology to control slugs (U.S. Army Garrison 2006c).

Other Risk Reduction Factors

The Pahole population unit in the action area is within the fenced Pahole management unit. Reintroduced plants in the West Makaleha portion of the Kapuna to West Makaleha population unit in the action area are within a small fenced exclosure. Both population units are partially controlled for weeds. In 2005, Natural Resources Staff outplanted 23 immature *Cyanea longiflora* to augment the Kapuna to West Makaleha population unit and in 2006, 20 were still alive (U.S. Army Garrison 2006c). Outside the action area, the Makaha and Waianae Kai population unit also will continue to receive extensive augmentation. *Cyanea longiflora* can be successfully propagated from seed; larger plants survive better when outplanted in the wild than small plants.

Conclusion

Despite the ongoing exposure of *Cyanea longiflora* to training impacts, Army conservation and stewardship programs will improve its baseline condition in the action area and range-wide. Weapons restrictions, fuels management, fire suppression, invasive species control, and expedited stabilization actions over the next 30 years will increase baseline numbers of *C. longiflora* to stability thresholds. However, the risk of training-related wildland fire to plants (158 individuals) within the action area is low or very low and the action area population units are located in manageable habitat where ungulate and weed threats can be controlled. Thus, the overall effect of the proposed action's stressors and subsidies will result in a net increase in baseline numbers, distribution, and reproduction of *C. longiflora* in and adjacent to the action area over the next 30 years. Reaching expedited stabilization will improve the likelihood that *C. longiflora* will attain full stabilization and enhance its probability of persistence over the long term.

Effects of Action on *Cyanea longiflora* Critical Habitat

Approximately 177 ha (437 ac), or 24 percent of the total designated critical habitat for *Cyanea longiflora*, is located in the Makua action area (see Figure E 31). The unit is located in the northeastern portion of the action area and is entirely within the low fire zones, with 9.2 ha (22.6

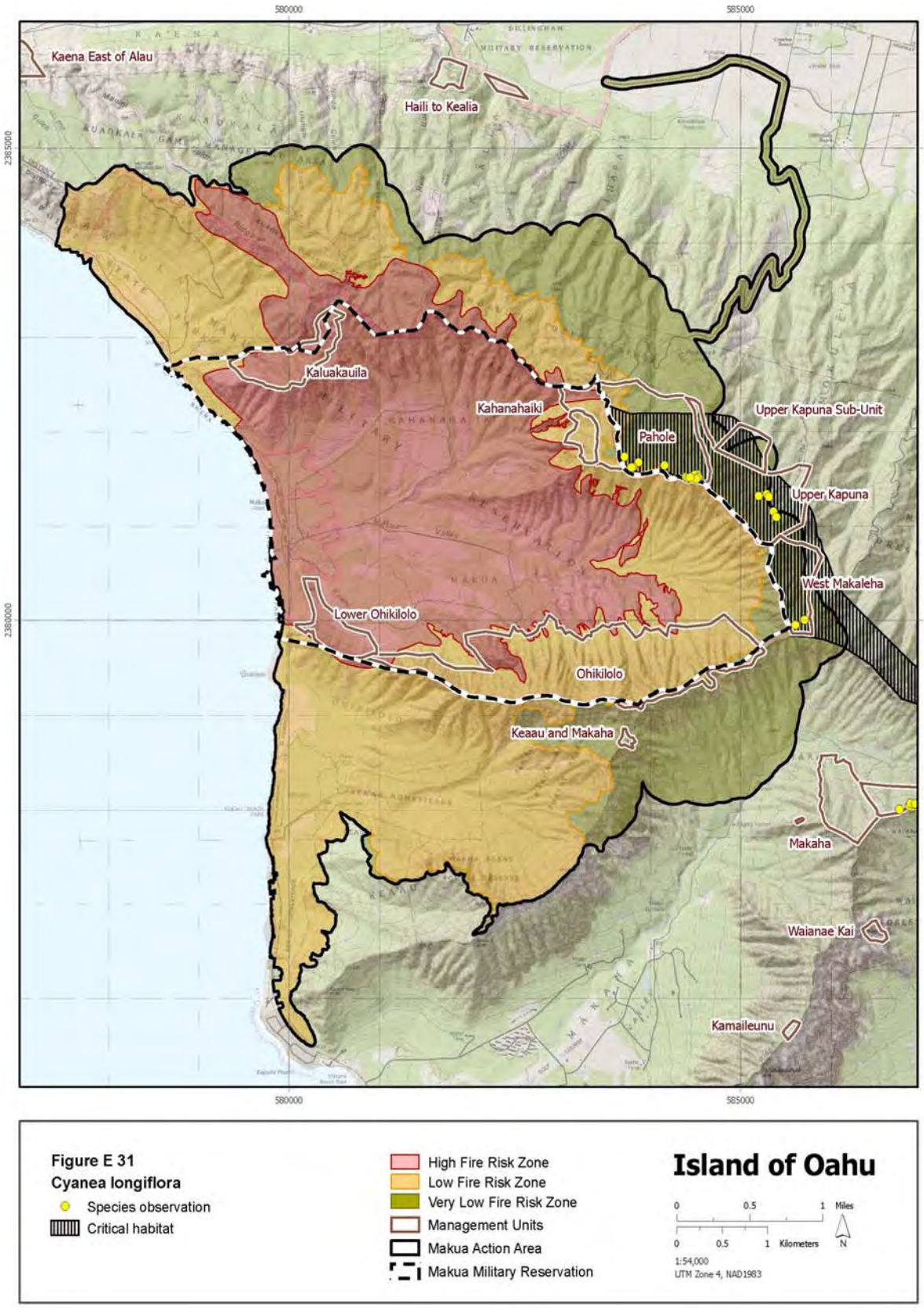
ac) in the low fire risk zone and 167.9 ha (414.8 ac) in the very low zone. This critical habitat unit, together with 185 ha (458 ac) outside of the action area, was designated to provide habitat for the conservation of four populations. Each population is to be represented by at least 300 mature, reproducing individuals of *C. longiflora* (68 FR 35950). The primary constituent elements essential for this species include, but are not limited to, steep slopes, bases of cliffs, or ridge crests in mesic *Acacia koa-Metrosideros polymorpha* (koa-ohia) lowland forest. The primary constituent elements that may be affected by a training-related fire include those associated native plant species found within mesic koa-ohia lowland forest. Almost one-half of the critical habitat is located in an area with 50 to 75 percent native plant cover, and the remainder is in an area that is composed of almost entirely native plant vegetation (U.S. Army Garrison 2003b; L. Durand, pers. comm. 2004; K. Kawelo, pers. comm. 2004; 68 FR 35950). This indicates that these critical habitat units are composed of a high proportion of native plant species. However, in the absence of habitat management, fires could add to the degradation of these critical habitat units by removing the remaining native habitat.

There is a risk that if a fire started in the impact area, it could move east and impact this critical habitat unit or that a misfired round could ignite outside of the firebreak road and burn into this unit. The loss of primary constituent elements within critical habitat unit, together with the 185 ha (458 ac) outside the action area, would remove its ability to provide for the conservation of four populations of *Cyanea longiflora*. However, this risk is reduced by spatial separation from the impact area, low flammability of the surrounding vegetation (mesic forest), and the beneficial resource management actions conducted by the Army in the management units. Approximately 153 ha (378 ac), or 86 percent, of the total critical habitat is located in management units (Pahole, Upper Kapuna, Upper Kapuna Sub-Unit, West Makaleha management units). Please see the discussion for *Schiedea obovata* regarding management units and the beneficial actions occurring within these areas. The remaining critical habitat (24 ha; 59 ac) outside of the management units is buffered from the impact area by the management units themselves. The fuel modification activities and the other threat reduction measures implemented by the Army for species stabilization will further reduce the risk of fire to the critical habitat outside of the management units.

Conclusion

The critical habitat unit for *Cyanea longiflora* in the Makua action area is located entirely in the low fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside of the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire in the critical habitat unit will be reduced due to the construction of a fuel modification zone between the impact area and the Kahanahaiki Management unit that is adjacent to the critical habitat, and the Central and East Makaleha Management Unit. Fuel reduction within the surrounding management units (Pahole, Upper Kapuna, Upper Kapuna Sub-Unit, and West Makaleha) will further buffer the critical habitat unit from fire. Without this management, this critical habitat unit could eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *C. longiflora* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even

though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *C. longiflora* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *C. longiflora*.


580000
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Upper Kapuna Sub-Unit
Pahole
Upper Kapuna
West Makaleha
Lower Ohikilolo
Ohikilolo
Keaau and Makaha
Makaha
Waianae Kai
Kamaileunu
Figure E 31
Cyanea longiflora
Species observation
Critical habitat
High Fire Risk Zone
Low Fire Risk Zone
Very Low Fire Risk Zone
Management Units
Makua Action Area
Makua Military Reservation
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EFFECTS OF THE ACTION – *Cyanea superba* ssp. *superba* (No Common Name)

The range-wide status of *Cyanea superba* ssp. *superba* is now limited to approximately 310 individuals. *Cyanea superba* ssp. *superba* was extirpated from the wild in 2002, and all extant plants were reintroduced from greenhouse stock. Approximately 50 percent of all remaining *C. superba* ssp. *superba* individuals in the Makua action area are located in the Kahanahaiki Population Unit (Figure E 32). After full stabilization, there will be four population units for this species with 50 mature, reproducing individuals.

This subspecies is characterized by a recent history of precipitous decline in the number of individuals, extremely low genetic variability, and extirpation of all naturally occurring plants. Because of these factors, *C. superba* ssp. *superba* already is in a phase of quasi-extinction with numbers declined to the point where demographic or environmental stochasticity alone can result in extirpation (see General Effects – Small Population Size). We infer from these circumstances, conservation biology principles, and examples from other species that *C. superba* ssp. *superba* has a very high background extinction risk in the action area and range-wide, and any additional threats associated with training-related wildland fire are likely to eliminate expectation of its long-term persistence. Therefore, *C. superba* ssp. *superba* has been identified as an at risk species based on its limited population status, restricted distribution, high percentage of individuals in the action area, and risk of training-related wildland fire. *Cyanea superba* ssp. *superba* was identified as an expedited stabilization species as a conservation measure to protect these taxa from extirpation while full stabilization measures are being implemented.

Species Response to the Proposed Action

Over the next 30 years, *Cyanea superba* ssp. *superba* individuals in the Kahanahaiki, Pahole and Upper Kapuna management units (see Figure E 32) will be exposed to the direct and indirect effects of training-related wildland fire in the low and very low fire risk zones. Out of the 310 individuals in the action area approximately 55 to 60 are at a greater risk of impact from a training related wildland fire due to their proximity to previously burned habitat. These 60 plants are located between 140 and 200 m (460 and 656 ft) from the high fire risk area where the historic intrusion of invasive, flammable fuels, increases the risk of a future fire in this area. To offset this risk, the Army will construct either a 20-m (65-ft) wide firebreak, or a 200-m (656-ft) wide shaded fuelbreak in Kahanahaiki Gulch along the Kahanahaiki Management Unit perimeter. In addition, a helispot will be maintained within 500 m (1,640 ft) of the upper reaches of Kahanahaiki Gulch and a safety zone will be established within or adjacent to the management unit so that skilled NWCG-qualified fireline supervisors and firefighters, including red-carded Army Natural Resources Staff, can be safely stationed at the outplanting site when fire threatens the gulch area. These efforts are likely to result in the prevention of loss of *C. superba* ssp. *superba* individuals in the Kahanahaiki Gulch area.

Cyanea superba ssp. *superba* individuals in the Kahanahaiki Management Unit (approximately 120) are also in the low risk area, but due to their more protected location; i.e., further away from the edge of the high fire area, these individuals are at a reduced risk of impact from fire. We estimate that a misfired weapon landing in forest and shrub areas will burn approximately 0.1 ha (0.3 ac) of forest prior to fire suppression measures extinguishing the fire. Inadequate detection

and suppression response could enable these fires to burn more than 40 ha (100 ac) in a 48-hr period. However, to avoid the risk of an undetected fire, the Army will conduct an aerial survey in a helicopter for 1-hour post-training to check for smoke from a misfired round (see General Effects - Fire Suppression).

The remainder of the *Cyanea superba* ssp. *superba* individuals (approximately 130) are located in and adjacent to the Pahole and Upper Kapuna management units in the very low fire risk zone. These plants could be susceptible to a misfired long-range, live-fire weapon such as the TOW. However, as with our determination for the risk of fire in the low risk area, fire detection and suppression response is designed to minimize a fire ignited in mesic forest and shrub areas.

Other Risk Reduction Factors

Cyanea superba ssp. *superba* in the action area also will be exposed to the direct and indirect impacts of non-native plants, slugs, and rats. Slug damage is particularly threatening to the survival and recovery of this species because no feasible control methods are available for field situations. The Kahanahaiki Population Unit is within the fenced Kahanahaiki Management Unit and is regularly controlled for weeds and rats. Certain weapons systems and munitions will be restricted until a fire protection system is in place for the Kahanahaiki Management Unit and expedited stabilization thresholds are achieved for at-risk taxa that occur in that management unit. Expedited stabilization will involve continued augmentation of *C. superba* ssp. *superba* in the Kahanahaiki Population Unit inside the action area. Three additional population units will be established by reintroduction in the Central and East Makaleha, Makaha, and Pahole to Kapuna population units outside the action area. Four population units will be managed for stability for this taxon because all naturally occurring plants have died, and because stabilization must be achieved solely through reintroduction. *Cyanea superba* ssp. *superba* is successfully propagated from seed; outplants grow vigorously and produce ample viable seed. Full stabilization will depend on developing slug control techniques to increase survival and recruitment.

Conclusion

Despite the ongoing exposure of *Cyanea superba* ssp. *superba* to Army-related wildland fires, fire risk to this species is low to very low, and Army conservation and stewardship programs will improve its baseline condition in the action area and range-wide. In this case, *C. superba* ssp. *superba* would be extinct in the wild without the stabilization efforts conducted by the Army's Natural Resources Staff. Weapons restrictions, fuels management, fire suppression, invasive species control, and expedited and full stabilization actions over the next 30 years will increase *C. superba* ssp. *superba* distribution and abundance. The minimal risk of wildland fire is far outweighed by the benefit of stabilization to this species. We further believe this species is unlikely to survive without the Army's expedited and full stabilization efforts.

Effects of the Action on *Cyanea superba* ssp. *superba* Critical Habitat

Twenty-three percent (207 ha; 511 ac) of the State-wide critical habitat for *Cyanea superba* ssp. *superba* is located within the Makua action area. Over 99.9 percent of this critical habitat unit is within the low fire zones, with 17 ha (42.3 ac) in the low fire risk zone and 189.3 ha (467.7 ac) in

the very low zone in the northeastern portion of the action area (see Figure E 32). This critical habitat, together with 96 ha (237 ac) outside the action area, was designated to provide habitat for the conservation of four populations, each consisting of 300 mature individuals of *C. superba* ssp. *superba* (68 FR 35950). The primary constituent elements essential for this species include, but are not limited to, sloping terrain on a well-drained rocky substrate within mesic forest (68 FR 35950). The primary constituent elements that may be affected by a training-related fire include the associated native plant species found within a mesic forest community on Oahu. It is estimated that more than one-half of the critical habitat still contains greater than 50 percent native plant cover, indicating that habitat quality is somewhat compromised due to non-native plant encroachment (U.S. Army Garrison 2003b; K. Kawelo, pers. comm. 2004; 68 FR 35950). Fire removes the vegetative primary constituent elements and non-native plants invasives subsequently outcompete native plants, which prevents post-burn native re-vegetation. In the absence of habitat management, these areas remain degraded and future fires will incrementally encroach into unburned areas, continuing the process of removing vegetative primary constituent elements.

Approximately 88 percent (182 ha; 451 ac) of the critical habitat in the action area is found within the Pahole, Upper Kapuna, Upper Kapuna Sub-Unit, West Makaleha management units. Please see the effects section for *Schiedea obovata* for a more detailed discussion of the effects of the proposed action on this critical habitat unit. The remaining critical habitat for *Cyanea superba* ssp. *superba* outside of the management units (25 ha; approx. 59 ac) is separated from the impact area by low fire risk areas and by the management units themselves.

Conclusion

The critical habitat unit for *Cyanea superba* ssp. *superba* in the Makua action area is located almost entirely within the low fire risk area. Implementation of all fire suppression measures incorporated into this action and the Army's standard operating procedures will reduce the likelihood that a fire will ignite and travel outside of the firebreak road or that a misfired round will ignite outside of the firebreak road. The risk of fire will be reduced due to the construction of fuel modification zones between the impact area and their respective management units. In addition, due to the fuel reduction and other habitat enhancing activities currently ongoing and planned, pursuant to the Makua Implementation Plan, the Kahanahaiki Management Unit will buffer portions of the critical habitat from fires traveling from the impact zone. The critical habitat within the Pahole, Upper Kapuna, Upper Kapuna Sub-Unit, West Makaleha management units will be managed to improve baseline quality, pursuant to the Makua Implementation Plan. Without this management, this critical habitat unit would eventually lose most of the elements essential to the survival and recovery of the species because of the ongoing threats to this habitat (e.g., ungulates and non-native plant encroachment). We considered this continued degradation of *C. superba* critical habitat in the evaluation of the effects of the proposed action. Most importantly, even though there may be a temporal loss of vegetation due to a fire, the restoration of these areas by the Army will provide habitat essential for the conservation of *C. superba* ssp. *superba* and allow for the long-term recovery goals of this species. Therefore, training-related fire events will not result in adverse modification of critical habitat for *C. superba* ssp. *superba.*