105 mm Artillery

This weapon is a 1,814 kg (4,000 lb) cannon, generally towed by vehicles or airlifted into firing position, which is used for direct and indirect fire support of troops (Figure PD 20). The weapon has an average crew of seven Soldiers. It is capable of firing a wide range of standard NATO ammunition. At Makua, it will fire high explosive and inert rounds. The 105 mm inert round has no explosion upon impact, while the 105 mm high explosive has a large explosion. This 105 mm weapon has a range of 19.2 km (11.9 mi) when rocket assistance and eight charge bags are used. The number of charge bags and firing angles will be limited so that the weapon's maximum range or "Distance X" on the developed surface danger zone is 2,400 m (1.5 mi) or less at Makua. This maximum range will be limited by enforcing strict limits on the charge used and the angle that the weapon is fired (Figure PD 21). The amount of powder in each charge bag and the number of charge bags used is closely controlled. Charges are counted out separately and inserted in the tube, and double checked prior to firing the weapon by at least four different personnel. Artillery will only be fired from the designated spot in the irrigated green and mowed grass area in the north lobe of the firebreak road. Artillery will only be targeted at Objective Deer.

Figure PD 20. Photograph of 105 mm artillery.

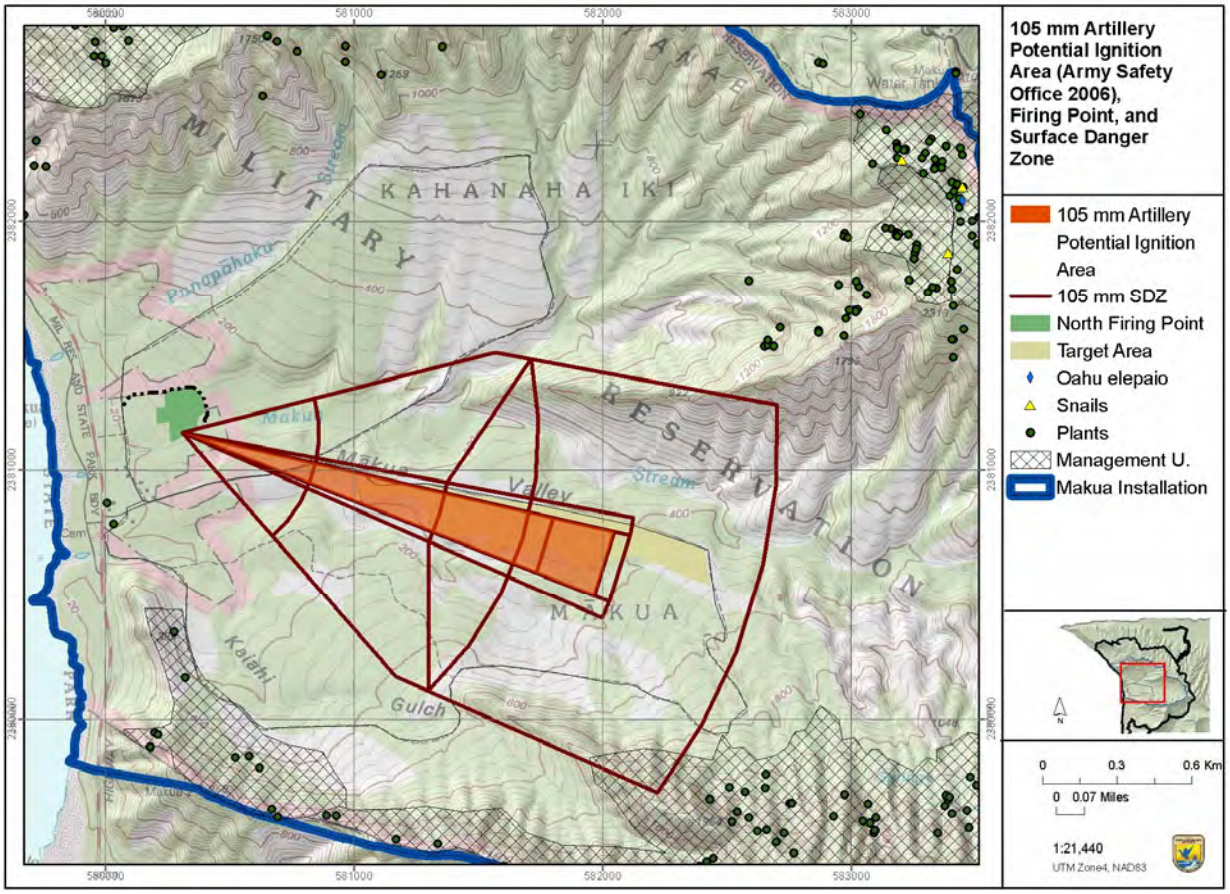

Figure PD 21. Surface danger zone and potential ignition area for 105 mm artillery.

<u>155 mm Artillery</u>

This weapon is a 7.1 kg (15,758 lb) cannon, generally towed by vehicles or airlifted into firing position, and used for direct and indirect fire support of troops (Figure PD 22). It is capable of firing a wide range of standard NATO ammunition. The 155 mm howitzer barrel can be fitted with a sleeve so that it fires 105 mm ammunition. At Makua, it will fire high explosive and inert rounds. The 155 mm inert round has no explosion upon impact, while the 155 mm high explosive has a large explosion with fragments and blast effects confined to the surface danger zone. The maximum effective range of this weapon is 22.4 km (13.9 mi) with conventional ammunition and 30 km (18.6 mi) using a rocket-assisted projectile. The maximum and sustained rates of fire are four and two rounds per minute, respectively. The howitzer is transported and operated by a crew of nine. The number of charge bags and firing angles will be limited so that the weapon's maximum range or "Distance X" on the developed surface danger zone is 2,600 m (1.6 mi) or less at Makua (Figure PD 23). The maximum range for this weapon, given three bags of powder is 6,100 m (12.4 mi). To minimize the distance the 155 mm round can travel, the Army will enforce strict left and right limits, limit the angle that the weapon is fired, enforce use of the safety card (specifies the limitations of using at the range), and complete the firing solution (adjusting the direction of fire of the weapon) by two different methods, by hand and by computer, to ensure the two match up before firing. The amount of powder in each charge bag and the number of charge bags used is closely controlled. On Oahu, the charge bags are limited to no more than two to limit the distance the ammunition can

travel. Upon preparation for firing, the projectile and propellant are loaded into the howitzer in two separate operations. Separate loading ammunition propellants are issued as a separate unit of issue in sealed canisters to protect the propellant. The amount of propellant to be fired with artillery ammunition varies with the number of propellant increments. The charge selected is based on the range to the target and the tactical situation.

Restrictions

Illumination and white phosphorus (smoke) rounds will not be fired at Makua. Charges are counted out separately and inserted in the tube, and double-checked prior to firing the weapon by at least four different personnel. Artillery will only be fired from the designated spot in the irrigated green and mowed grass area in the north lobe of the firebreak road. Artillery will only be targeted at Objective Deer.

Figure PD 22. 155 mm artillery. (Photos: Department of Defense: www.defenselink.mil)

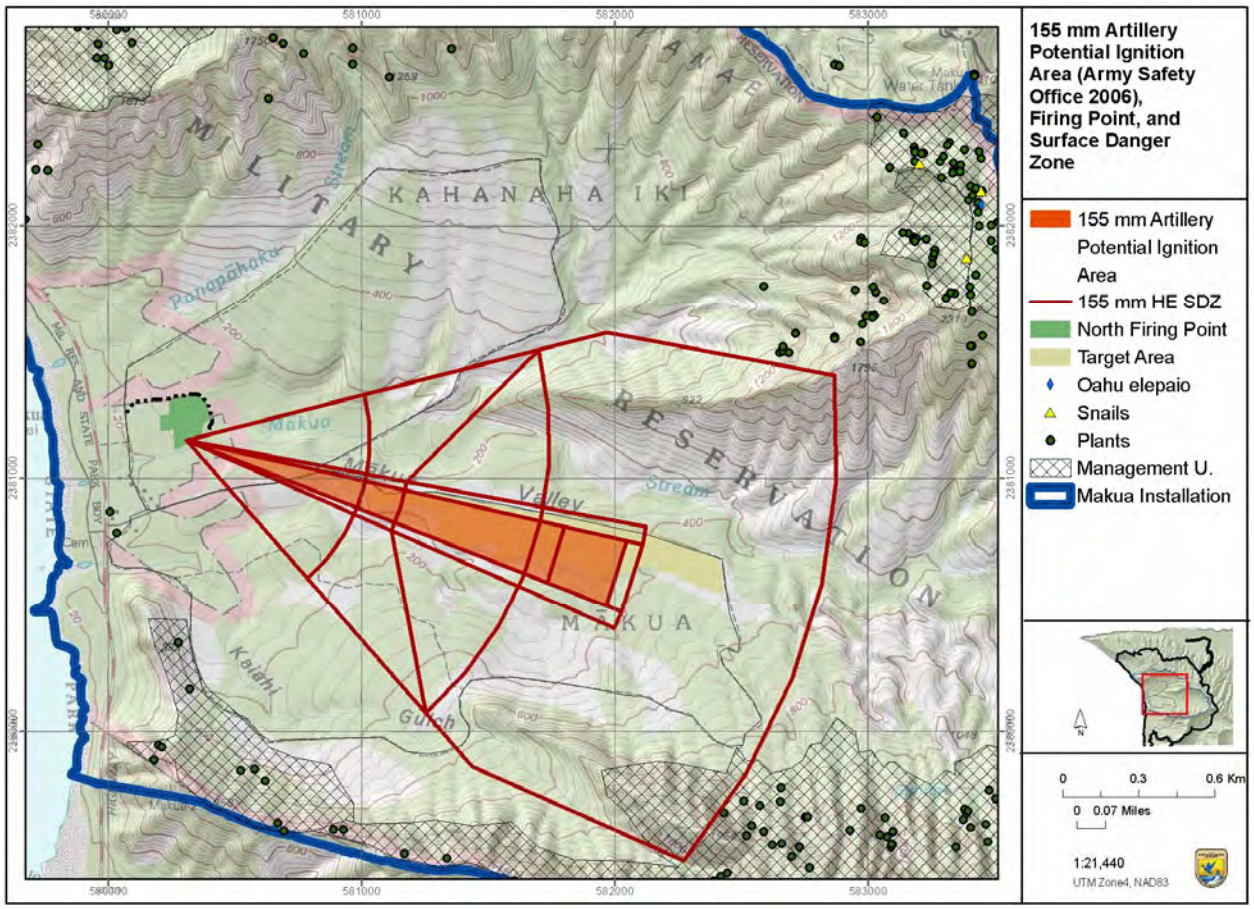

Figure PD 23. Potential ignition area, firing point, and surface danger zone for 155 mm artillery.

AT-4 Anti-Armor Weapon

The AT-4 is a lightweight, shoulder-fired, anti-armor weapon. Each AT-4 is pre-packaged and sealed with only one round of ammunition. It fires a rocket-type cartridge consisting of a fin-stabilizing assembly with a tracer element and a warhead consisting of an 84 mm, shaped, high-explosive warhead. Although the M136 AT-4 can be employed in limited visibility, the firer must be able to see and identify the target and estimate the range to it. The maximum range for the rocket is 2.1 km (1.3 mi). The AT-4 will be fired only from within the designated firing point in the north lobe of the firebreak road, a minimum of 50 m (164 ft) from the outer edge of the 7-ac (2.8-ha) mowed firing point with a minimum clearance of 95 m (311 ft) from any flammable vegetation. The designated firing point in the north lobe of the firebreak road will either be kept bare of vegetation or it will be mowed and irrigated, so that live herbaceous fuel moisture of the grass in all areas remains above 200 percent. The firing point will be bounded directly along its north and east edges by a new improved firebreak road, 469 m (1,539 ft) long and following the route of an area historically used as an access road, maintained with bare ground to a width not less than 6 m (19.7 ft) (Figure PD 24). The AT-4 will be targeted at Objective Deer (EJ 8190-8070). The AT-4 will not be fired until after the Kaluakauila, Kahanahaiki and Ohikilolo fuelbreaks and firebreaks are constructed and the expedited stabilization of three endangered plant species is completed (see Table PD 2).

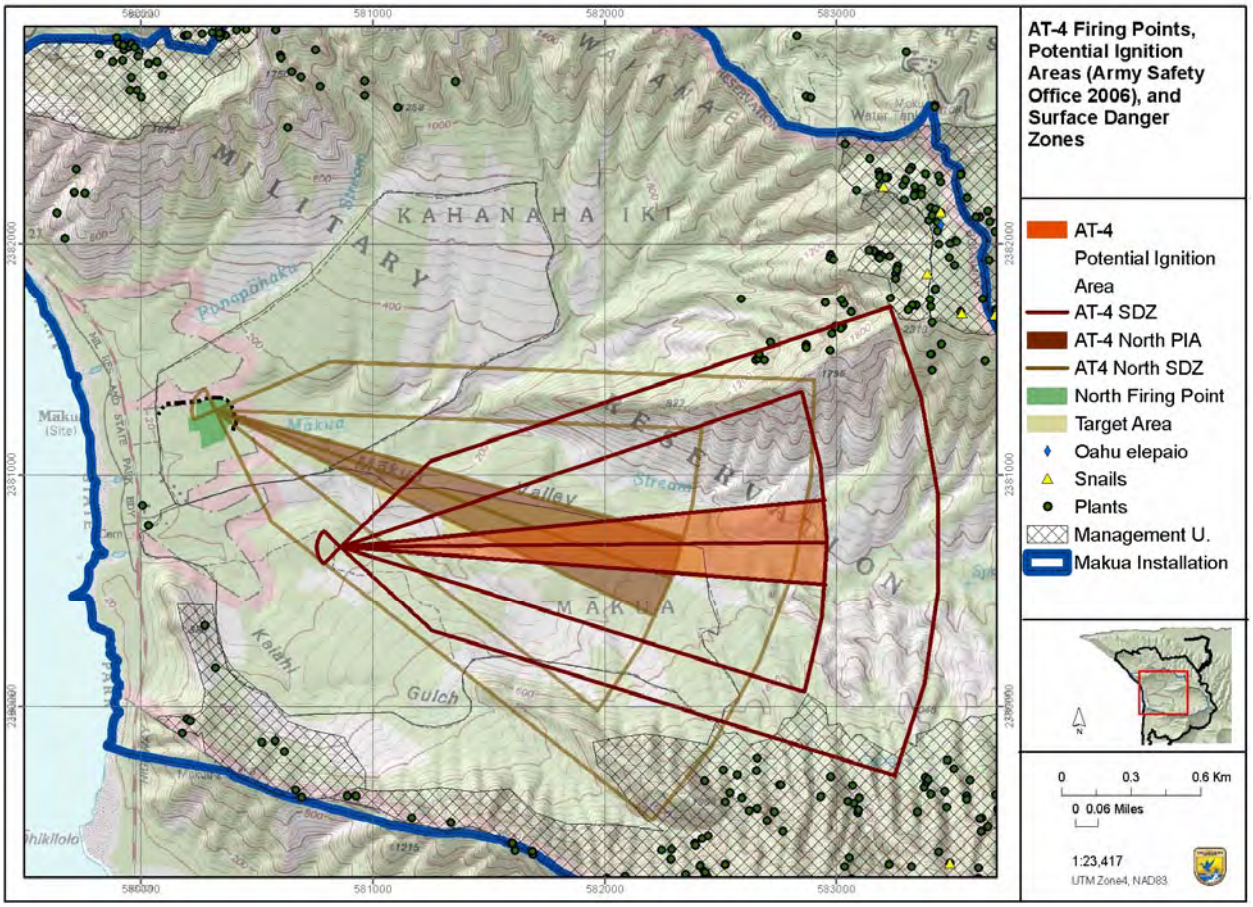

Figure PD 24. AT-4 surface danger zone, designated irrigated firing point, and maintained firebreak locations.

SMAW

The Launcher Assault Rocket 83 mm (SMAW) is a hand held fiberglass launch tube with a mounted sight and a maximum range of 2.0 km (1.2 mi). There is a 30-m (98-ft) back-blast area behind the firing point where hot flying debris could land, so this weapon will only be fired from the designated firing point in the north lobe of the firebreak road. The weapon will only be fired at a target in Objective Deer. This weapon is used at Makua by the Marine Corps. No surface danger zone is available for the SMAW, but its range and effects are similar to the AT-4. The SMAW will not be fired until after the Kaluakauila, Kahanahaiki and Ohikilolo fuelbreaks and firebreaks are constructed and the expedited stabilization of three endangered plant species is completed (see Table PD 2).

Tracers

Tracer ammunition is used to illuminate a shooter's line of fire at night or during the day, depending on the type of tracer used. A bright-burning pyrotechnic compound is added to a specially formed cup in the rear of the jacket of a given ammunition type. When the powder is ignited, it in turn ignites the tracing compound. This leaves a bright luminescent trail behind the bullet in flight, allowing the shooter to see the path of the projectile. Tracers are used primarily in machine gun and rifle applications, where every fourth or fifth round is a tracer. Only 5.56 mm, 7.62 mm, and .50 caliber M1 tracers will be fired from ground and Stryker-based locations and only 5.56 mm and 7.62 mm tracers will be fired from helicopters. Tracer burnout distances are as follows: 5.56 mm is 900 m (0.6 mi) (HQDA FM 23-14), 7.62 mm is 900 to 1,000 m (0.6 to 0.62 mi), and .50-caliber M1 is 1,800 m (1.1 mi) (HQDA FM 23-65) (Figure PD 25).

Restrictions

Use of all other tracers, including M17 tracers, is prohibited at Makua. Tracers will be fired by ground troops and from Strykers. Small arms tracers will be fired from various locations within the south lobe of the firebreak road, at various targets within the south lobe of the firebreak road. All firing points, including firing points for tracers fired from helicopters, will be within the south lobe of the firebreak road, east of UTM 581,400. M1 tracers will not be fired from any point farther east than the UTM 581,400 line within Objective Deer. Tracer ammunition will be used in accordance with the weapons restrictions specified in Table PD 2. Tracers will not be fired until after the Kaluakauila, Kahanahaiki and Ohikilolo fuelbreaks and firebreaks are constructed and expedited stabilization of three endangered plant species is completed. Prior to completion of expedited stabilization of 12 species, tracer ammunition will be used only when live herbaceous fuel moisture, calculated at the Makua Range WIMS weather station, is 120 percent or higher and when fire danger is low (Green). After expedited stabilization of 12 species is completed, tracers will only be fired when live herbaceous fuel moisture is 100 percent and higher when fire danger is low (Green). Fire suppression forces will be staffed pursuant to fire suppression staffing requirements described in Section 3 of the Project Description.

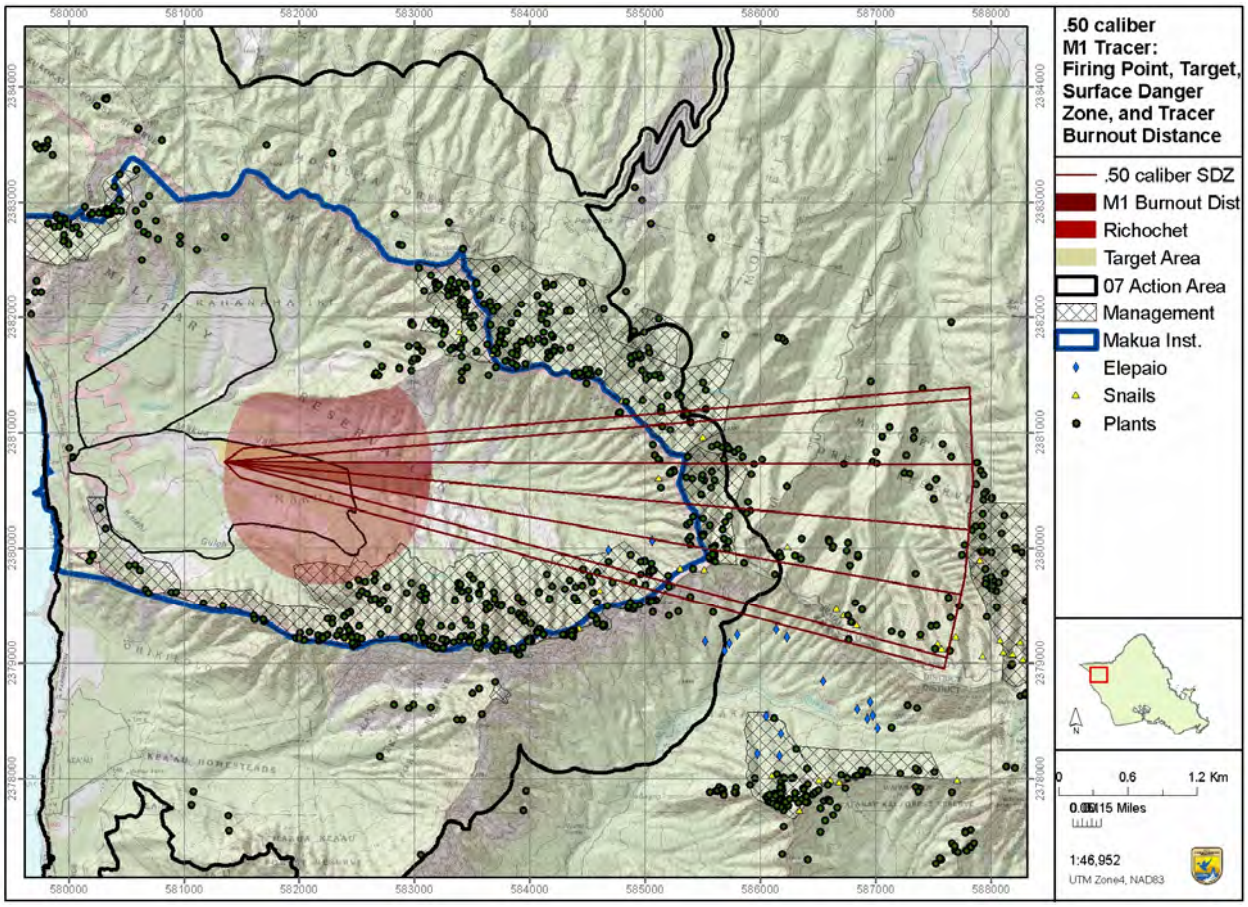

Figure PD 25. M1 tracer static firing point, target, surface danger zone and tracer burnout distance, and possible tracer ricochet dispersion area.

2.75-caliber Rocket

The 2.75-caliber (70 mm) Hydra-70 rocket system proposed for use at Makua consists of a seven-tube M260 launch tube, the MK66 MOD 4 rocket motor, and the blue spear WTU1B inert, ten pound steel training warhead (Figure PD 26). No other warhead or motor will be used at Makua. For use at Makua, the launch tube will be attached to an OH-58 Kiowa or similar helicopter. Only pilots with current qualifications in the use of 2.75-caliber rockets will fire these helicopter-mounted weapons in support of ground troops during CALFEX exercises. Makua will not be used for training, recertification, or qualification flights for 2.75-caliber rocket use. Rockets will be used by skilled, qualified pilots in order to provide realistic experience for personnel training on the ground. No more than 56 rockets will be fired during each CALFEX iteration. The rocket will be fired from approximately 1.0 km (0.6 mi) range at a target, which will be located in Objective Deer or Elk. The rocket will be fired from a Kiowa or similar helicopter flying below 134 m (440 ft) altitude, at a minimum of 60 knots airspeed, at a nose down dive, with a nose-down angle of at least 10 degrees. The rocket will never be fired from a helicopter that is not at a nose-down position of at least 10 degrees.

Figure PD 26. Example of 2.75-caliber rocket being fired from a helicopter and 2.75-caliber (70 mm) rocket pod mounted on the side of a helicopter. Unlike the rocket being fired in the photograph, rockets fired at Makua will only be fired from helicopters with nose-down angles of 10 degrees or more.

The Army currently uses a surface danger zone developed for a rocket fired from a level helicopter over flat terrain, in which the rocket has a maximum range of 3.0 km (1.9 mi). Topographic correction to the surface danger zone was completed by the Center for Environmental Management of Military Lands (Beavers 2006). Topographic correction is shown for a surface danger zone created for a rocket fired straight ahead (not nose down) at an altitude of 134 m (440 ft) (see Figure PD 26). At this time, surface danger zones when firing this weapon at a down angle have not been formally adopted by the Army. The maximum range (Distance X) of rockets fired from nose-down helicopters would be shorter than the range shown in Figure PD 27. The chance of a 2.75 rocket landing outside the Makua installation boundary is less than one in a million. An estimated 5,040 rounds will be fired in the next 30 years. Therefore, there is a 1:200 (1,000,000 divided by 5,040) chance of a round escaping from the installation boundary over the next 30 years.

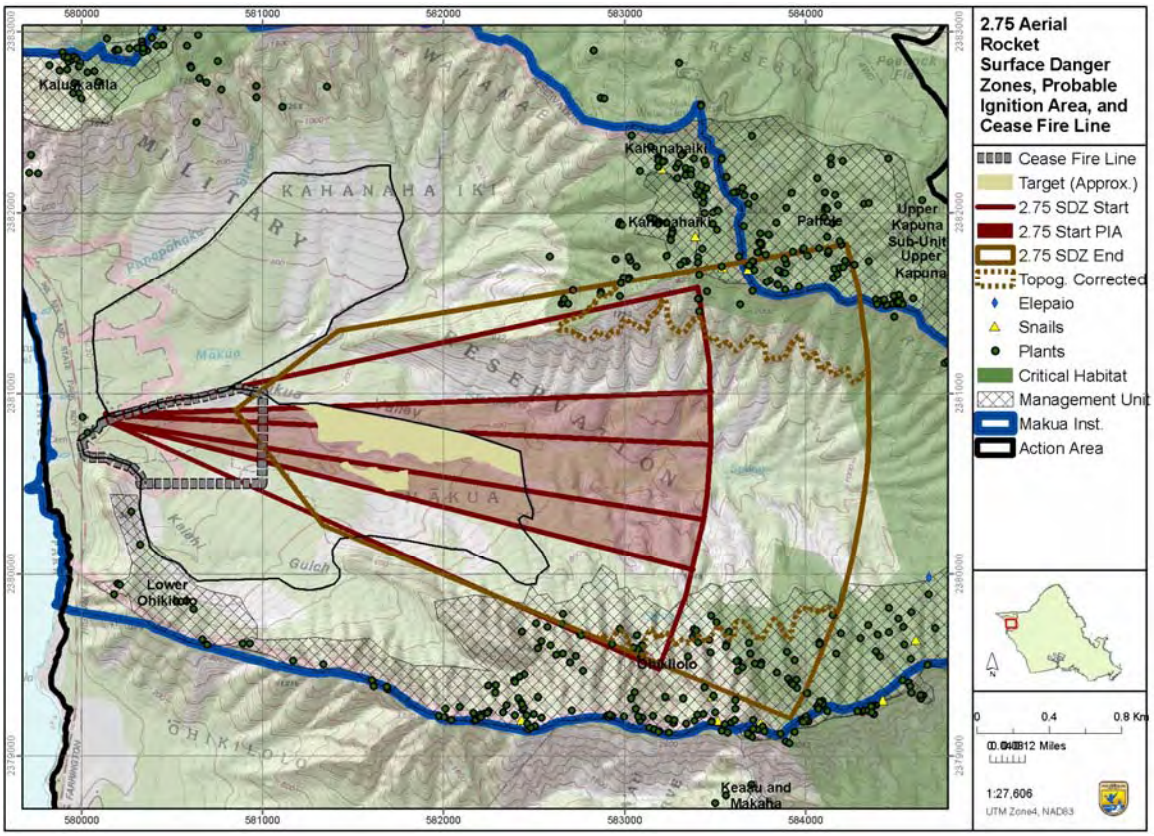

Figure PD 27. Surface danger zones (1: 1 million chance of escapement), an example of an associated probable ignition area, and the perimeter of the live-fire area cease fire lines (581,000 UTM line and roads) to be used for 2.75-caliber aerial gunnery rocket firing.

Restrictions

These rockets will not be fired until after the Kaluakauila, Kahanahaiki and Ohikilolo fuelbreaks and firebreaks are constructed and the expedited stabilization of 12 endangered plant species is completed (see Table PD 2). To ensure that hot residuals associated with the launch of the rocket do not fall outside the south lobe of the firebreak road or into Lower Ohikilolo Management Unit, rockets will not be fired south of 21º 31’ 30’’ North Latitude (the UTM NAD83 2380500 m line). To prevent the topographically corrected surface danger zone from overlapping with the management units on C-Ridge, rockets will not be fired above 122 m (400 ft) above ground level (AGL) and no further east than 158 º 13’ 10’’West Longitude (the UTM NAD83 581,000 m line). These cease fire lines will be visually marked on the ground with a minimum of 10 panels so that pilots can easily identify limits to live fire from the air. Ground markings will be visible to both the pilots and to an observer situated on the tower at the Makua Range office. A passing score for a 2.75 qualification exercise is one out of three, or three out of seven hits within a 100 by 100 m (328 by 328 ft) target box around a tank-sized object (Master Gunner S. Lodge, U.S. Army, pers. comm. 2006). The entire target box will lie inside the south lobe of the firebreak road. Although many rounds are expected to land outside the firebreak road, most of them will be within 800 m (2,624 ft) of the target. The rocket is propelled by burning propellant in a tube-shaped rocket motor. The motor burns out at approximately 450 m (1,476 ft), but the tube remains hot enough that it can ignite vegetation on impact 3.0 km (1.9 mi) down-range (S. Lodge, US Army, pers. comm. 2006).

Errors and malfunctions that have the potential to result in a rocket being fired outside the 3.0 km (1.9 mi) surface danger zone, can be minimized so that this weapon can be used safely at Makua. The maximum range for this weapon, if it were fired at a 45 degree positive angle, is 12.0 km (7.5 mi). To better ensure that rockets are only fired when the helicopter is in a dive, a second certified 2.75-caliber rocket pilot will be in the copilot seat and will arm the weapon only when the helicopter is at least 10 degrees nose down and below 134 m (440 ft altitude) (122 m (400 ft AGL)). Wind gusts affect rocket firing accuracy by affecting the helicopter's movement and by affecting the rocket's flight. Rockets tend to fly into the wind. Operations conducted in conjunction with aerial rocket firing will be suspended (per Army Regulation 385-63, *Range Safety Manual*) for one hour if wind gust is more than 30 knots (35 mph) as indicated by the maximum windspeed measured at the Makua Range weather station during the previous hour (available at http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?hiHMAR). Skilled pilots will take wind into account when positioning their helicopter for firing to ensure that the landing skids running the length of the helicopter will be at a 10 degree front-down angle or greater whenever a rocket is fired at Makua.

Malfunctions of equipment resulting in a hang fire or a substantially misdirected rocket are rare. A hang fire, where the rocket is fired but does not leave the launch tube mounted to the helicopter, can result in a 10 degree "yaw" of the helicopter to the left or right. Our local 125th Battalion master gunners estimate that a hang fire occurs once for every 300,000 rockets fired. It is possible, but unlikely, for the pilot to be firing the trigger in ripple mode (which would enable deployment of 14 rockets in under six seconds), and, in a hang fire situation, a rocket could be fired 10 degrees off of the intended target. During these types of training exercises, pilots are likely to only fire two to four rockets during each pass at the target area so they are unlikely to employ ripple mode. Given a hang fire situation, the pilot may chose to jettison the launch tube assembly from the side of the helicopter. If the propellant in the rocket motor has been cracked, which could occur if it has been mishandled or dropped, the resulting uneven motor burn could potentially result in the rocket deploying at a 45 degree angle, regardless of the helicopter's nose-down position. However, the rocket's range would be reduced to 6.0 km (3.7 mi) (Yuma Proving Ground rocket specialist), and if the rocket contacted the helicopter's rotor blade, its range would be reduced even further. Recent changes in regulations regarding this weapon prohibit the use of any motor that has been dropped any distance. There is also the possibility of a malfunction of the rocket's side fins which could result in the rocket veering off course. However, the malfunction would also create a wobble in the rocket's flight and therefore the range of the malfunctioning rocket would be substantially reduced. A fin malfunction has not happened to any of the 300,000 2.75-caliber unguided rockets the 125th Battalion master gunner or the Yuma Proving Ground rocket specialist has observed. The 2.75-caliber rocket will be fired only when live herbaceous fuel moisture, calculated at the Makua Range WIMS weather station, is 100 percent or higher and when fire danger is low (Green). Fire suppression forces will be staffed pursuant to fire suppression staffing requirements.

Javelin Missile

The Javelin is a portable anti-tank weapon. It is shoulder-fired and can also be installed on tracked, wheeled or amphibious vehicles (Figure PD 28). The Javelin system consists of the Command Launch Unit and the round. The round consists of the Javelin missile and the ATK (Alliant Techsystems) Launch Tube Assembly. Javelin is a fire-and-forget missile with lock-on before launch and automatic self-guidance. The propulsion system is a two stage solid propellant design which provides a minimum smoke soft launch. At 1,000 m (0.6 mi), the flight motor is fully exhausted. Therefore, the surface danger zone, created for flat terrain, overestimates the maximum range of the weapon, given the terrain in the Makua valley. The tandem warhead is fitted with two shaped charges: a precursor warhead to initiate explosive reactive armor and a main warhead to penetrate base armor. At Makua the Javelin will be locked onto and fired at a heat source.

Restrictions

Tracers will not be fired until after the Kaluakauila, Kahanahaiki and Ohikilolo fuelbreaks and firebreaks are constructed and the expedited stabilization of 12 endangered plant species is completed (see Table PD 2). The weapon will be fired no closer than 25 m (82 ft) from the firebreak road to ensure that back blast resulting from activation of the flight motor pressure relief system does not ignite a fire outside the firebreak road. The blast will be contained by bunkers built around the targets. The vegetation within 10 m (32 ft) of the bunker will be maintained at stubble height. The maximum range of the missile is 4.0 km (2.5 mi) (Figure PD 29). The Javelin will be used only when live herbaceous fuel moisture, calculated at the Makua Range WIMS weather station is 100 percent or higher, and when fire danger is low (Green). Fire suppression forces will be staffed pursuant to fire suppression staffing requirements.

Figure PD 28. Javelin missile photographs from www.army-technology.com.

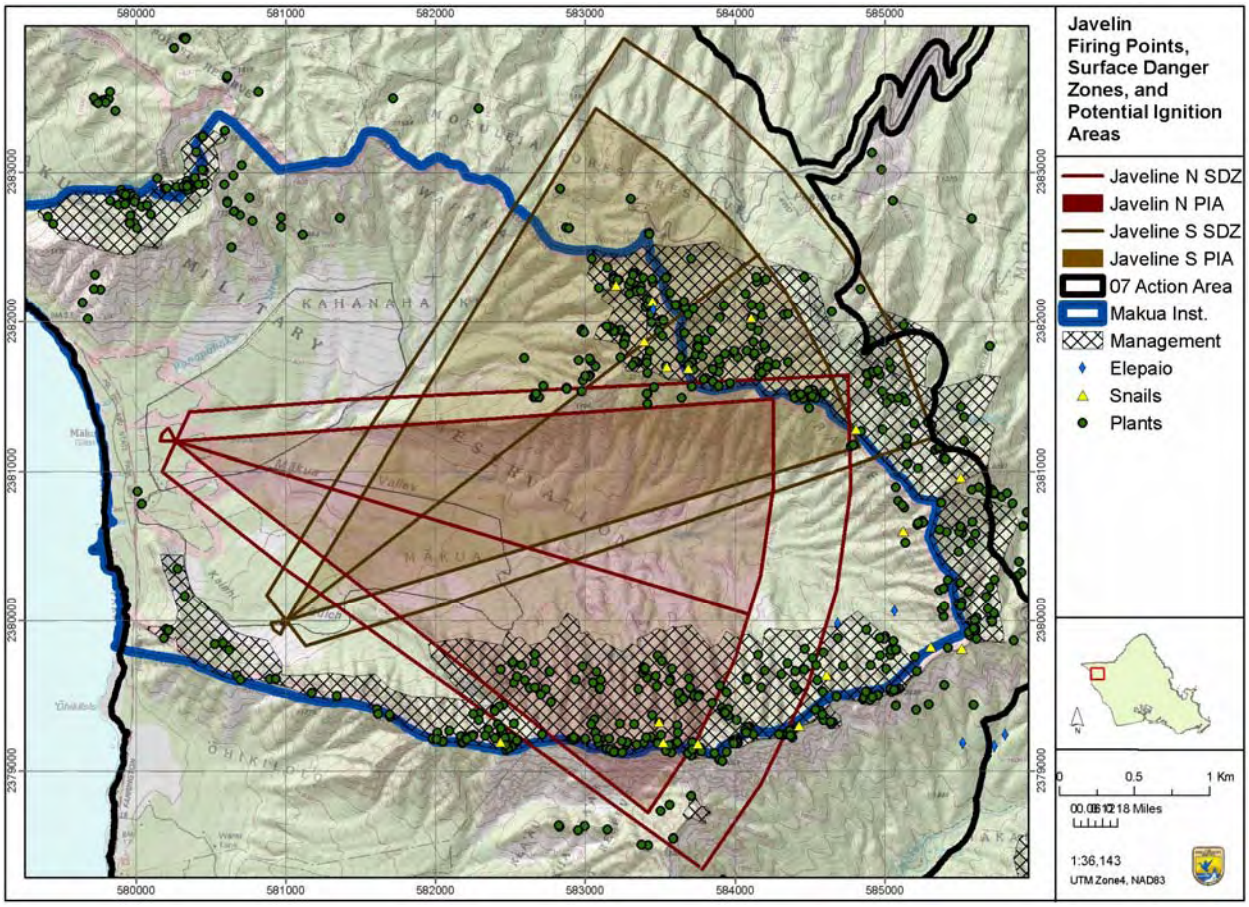

Figure PD 29. Javelin 1:1 million surface danger zones and potential ignition areas for northern and southern firing points.

TOW Missile

This is a line-of-sight, tube-launched, optically-tracked, wire-guided (TOW) missile system. This system is composed of a reusable launcher, a missile guidance set and sight system (Figure PD 30). The system can be tripod mounted; however, because it is heavy, it is generally employed from a high mobility multi-purpose wheeled vehicle. TOW missiles will not be fired from helicopters at Makua. TOW missiles are used primarily in anti-tank warfare to engage and destroy enemy armored vehicles and other targets such as field fortifications. The maximum range of the missile, fired from a ground position, is 5.0 km (3.1 mi) (Figure PD 31). Only inert TOWs with concrete warheads will be shot at Makua. TOW missile blast effect simulators may also be used. The missile's movement is fueled by burning propellant, which can remain ignited for a distance up to the maximum range of 5.0 km (3.1 mi). The TOW is optically-tracked and wire-guided by the person firing the weapon. If the wire snags or detaches from the TOW, the warhead is no longer controllable, often quickly plummeting into the ground. However, in other instances, it flies erratically for some distance and there is the potential, although extremely limited, for the malfunctioning weapon to travel up to 5 km (3.1 mi). Malfunction rate information for the TOW was not readily available for use in this consultation. 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, 18 percent missed their target, including seven percent which missed their target due to a malfunction (http://www.redstone.army.mil/history/tow/tow_chronology.htm.).

Restrictions

TOWs will only be used after full stabilization of all Makua Implementation Plan species has occurred, including control of major threats. TOW missiles will not be fired until after the Kaluakauila, Kahanahaiki and Ohikilolo fuelbreaks and firebreaks are constructed (see Table PD 2). The TOW use will be limited to periods when live herbaceous fuel moisture is 100 percent or greater, and will only be fired when fire danger is low (Green) and when grass and forest fuels are less flammable. If an average of approximately 40 TOW missiles are fired each year for 30 years, then approximately 1,200 TOWs will be fired over the life of the project. At a malfunction rate of seven percent, 84 TOW malfunctions would occur over the life of the project. If a TOW malfunction results in a wildland fire outside of the impact area, the TOW will not be used at Makua again until all shrub and forest vegetation within the burned area is restored to its pre-fire species composition or better, and all Makua Implementation Plan species are at full stabilization.

Figure PD 30. Photograph of a TOW missile launch (The Warfighter's Encyclopedia http://wrc.navair-rdte.navy.mil/warfighter_enc/weapons/landlnch/m220tow.htm)

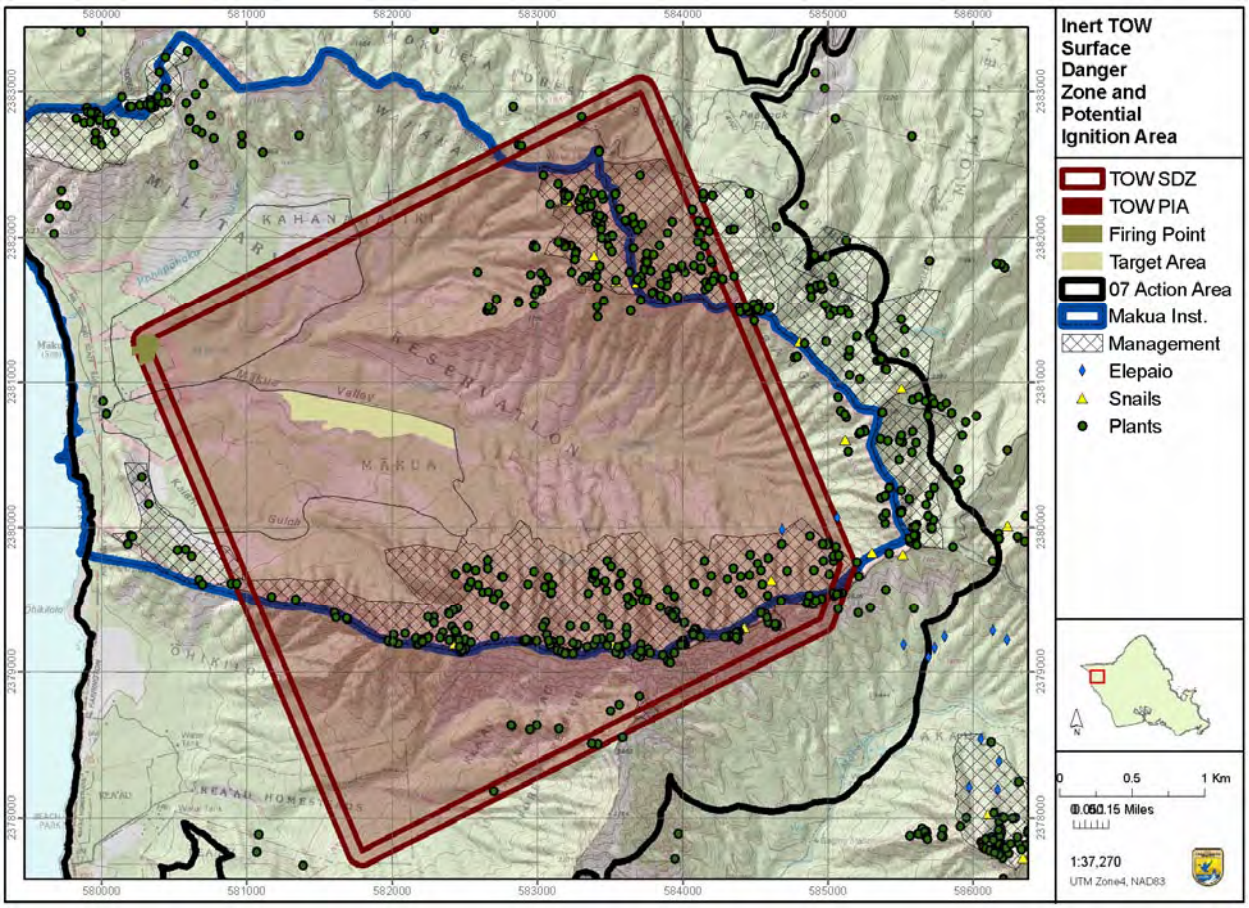

Figure PD 31. Surface danger zone and potential ignition area for inert TOW with concrete warhead, fired from within north lobe of firebreak road, targeted at Objective Deer.

9. Guinea Grass Fuel Model and Anticipated Fire Behavior Details

The CONTAIN module of the fire behavior model BehavePlus is the standard tool used by the National Wildfire Coordinating Group agencies for determining the number and type of fire suppression resources necessary to suppress fires under particular fuel moisture and weather conditions. It is used for both the development of prescribed fire contingency resource requirements and it is used for wildland fire suppression planning. BehavePlus compares the expected perimeter growth per unit time of a fire with the speed at which suppression forces are working to put out designated lengths of the perimeter during that time. A fire is "contained" when the suppression resources put out the perimeter of the fire. A fire "escapes" when the fire grows so fast, that the fire suppression resources are not able to contain the perimeter. The guinea grass (*Panicum maximum*), fuel model is a custom model which has received attention from the Center for Environmental Management of Military Lands (Beavers 2001), the US Forest Service (Wright et al 2002 and Scott and Burgan 2005), and the Service (D. Greenlee, unpublished 2006).

Fire behavior predictions for fires burning outside the firebreak road at Makua were based on a custom fuel model for local ungrazed stands of guinea grass originally developed by Beavers (2001), further described by Scott and Burgan (2005) and Wright et al (2002), and refined by Greenlee (unpublished 2006). Guinea grass fuel dominates the area between the firebreak road and the native vegetation surrounding Makua Valley (see Figure PD 2). Guinea grass is native to Africa and was cultivated and probably naturalized in Hawaii prior to 1871 as perennial forage for cattle (Wagner et al. 1999). Throughout its range, the grass reaches heights of 70 to 300 cm (2.3 to 9.8 feet). At Makua, the grass outside the firebreak road has an average height of 1.8 m (6 ft). One-third to 0.6 m (1 to 2 ft) of dead grass leaves form a thick thatch near ground level. Fuel loading is described in Beavers (2001). Of the 40 new fuel models described in Scott and Burgan (2005), guinea grass is heavier than all except for the four slash fuel models and four other heavy fuel models (SH7 Chaparral, SH9 Florida Scrub, TU5 and TL9 heavy forest understory or litter). Guinea grass fuel load estimates range from 8.8 to 11 tons per acre with fuel bed depth estimates between 0.5 m (1.8 ft) and 1.5 m (5 ft) (Beavers 2001, Wright et al 2002, and Scott and Burgan 2005). Kauffman (U.S. Forest Service) has extensive experience burning guinea grass pastures in Mexico and South America (Kauffman et al 1998, Guild et al 1998).

Fire rate of spread 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, State Division of Forestry and Wildlife, 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 spread of the fire. Guinea grass growth and grass greenness appears 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 National Fire Danger Rating System algorithm for calculating live herbaceous fuel moisture based on precipitation.

Beavers et al (1999) GRASS2 fuel model appears to most accurately predict rate of spread of guinea grass head fires burning during the summer of 2006, when live herbaceous fuel moistures were lower than 99 percent, when the original fuel bed depth of 0.6 m (1.9 ft) is adjusted to 1.3 m (4.1 ft) (the fuel bed depth suggested by Wright et al 2002 and Scott and Burgan 2005). The complete halt in fire rate of spread predicted by the dynamic fuel models in Scott and Burgan 2005 for live herbaceous fuel moistures greater than 120 percent, predicted to occur in the Scott and Burgan (2005) model, due to a complete transfer of dead fuel to the live herbaceous fuel category does not occur in guinea grass stands due to a persistent layer of thatch in the understory. On a prescribed burn at Schofield Barracks on September 29, 2006 (live herbaceous fuel moisture 150 percent) and at Makua on December 8, 2006 (live herbaceous fuel moisture 163 percent) green grass adjacent to herbicide-treated grass was found with the thatch layer underburned, with the green grasses laying over unconsumed. In both instances, a hot head fire hit the green grass and fingers of the green grass burned 10 to 50 m (32.8 to 164 ft). Rate of spread has not been accurately measured on fires burning in green grass in part because when the headfire hits the green grass, the smoke turns to heavy steam due to the moisture content of the grass, obscuring the fire. Preliminary fuel model parameters, which the Army and the Service agree are likely to overpredict fire rate of spread in guinea grass with live herbaceous fuel moistures greater than 120 percent, will be used until the fuel model can be updated to the satisfaction of the Army and the Service (Table PD 10). It is anticipated that updates to the fuel model and helicopter staffing guidelines may be made periodically and cooperatively by the Army and the Service as new information about fire rate of spread under various conditions becomes available. New information would not necessarily trigger reinitiation of formal consultation, as long as fire suppression helicopter staffing adjustments are made, to maintain equal or greater protection to the resources.

Table PD 10. Guinea grass fuel model parameters to be used to adjust Beavers (2001) GRASS 2 fuel model until future adjustments to the fuel model are made and accepted by the Army and Service.

Live Herbaceous Fuel Moisture (WIMS)	Wind Adjustment Factor	Fuel Bed Depth
120 % or higher	0.5	1.88 feet
100 – 120 %	0.5	2.71 feet
99% or lower	0.5	4.1 feet

At the time when the helicopter staffing requirements table was developed, limited fire behavior information was available for fires burning in guinea grass, particularly for grass with WIMS-calculated live herbaceous fuel moisture greater than 100 percent. Army wildland fire management staff are collaborating with fire behavior researchers from the U.S. Forest Service Pacific Southwest Research Station, the State, and the Center for Environmental Management of Military Lands to gather rate of spread data for headfires burning in mature guinea grass under various live herbaceous fuel moisture conditions. Actual rates of spread are expected to be lower than the rates of spread used to develop these helicopter staffing requirements under

high live herbaceous fuel moisture conditions. When the Army has documented guinea grass rates of spread with various WIMS-calculated live herbaceous fuel moistures, particularly under high live herbaceous fuel moisture conditions, the Army will forward the updated fuel model information to the Service for review. Given mutually agreed upon fuel model parameters, the Army will develop updated fire suppression helicopter staffing requirements which provide for the containment of fires outside the firebreak road at acreages equal to or smaller than those which are predicted to occur given the current helicopter staffing requirements. The CONTAIN module of BehavePlus will be used to compare predicted fire acreages using the new fuel model and helicopter staffing, to the acreages in Table PD 11. Fire acreages at all wind speeds and fuel moisture conditions would be equal to or less than those presently predicted in Table PD 11. The updated helicopter staffing requirements will be submitted to the Service for review and concurrence. Updated helicopter staffing requirements, agreed to in writing by the Service field supervisor, will be appended to the Biological Opinion and will replace the requirements currently specified in Table PD 5. Updated helicopter staffing guidelines will not be instituted at Makua without this prior written approval of the Service.

We have been conservative in our application of the fuel model and Behave/CONTAIN fire spread model in some areas, but this is counterbalanced by some of the model's other limitations. Some of the assumptions we used result in predicted acreages larger than what we anticipate will occur. For instance, the smallest initial fire acreage permitted in the Behave/CONTAIN model is 0.04 ha (0.1 ac). Because fire spread will be slow in the winter, we anticipate that you will initiate suppression when fires are smaller than 0.04 ha (0.1 ac). Behave/CONTAIN assumes that the fire is burning over a homogeneous landscape of guinea grass. When the fire hits breaks in topography (i.e., when fires hit the top of C-Ridge) they slow. Larger fires will hit shrub/forest vegetation, which burns more slowly. There are large, continuous expanses of grass fuels in Makua Valley which would support large fire development. Fire acreages and suppression success are similar on flat ground to those in the fire acreage tables. On the other hand, BehavePlus/CONTAIN does not provide for changes in wind direction, spot fires (which are likely to occur when live herbaceous fuel moisture is less than 100 percent), or for multiple simultaneous fire ignitions (which may occur when tracers are being fired).

The predicted helicopter staffing appears to closely match the numbers of helicopters that were historically used to suppress fires at Makua outside the firebreak road. This included: zero helicopters: 14 percent of fires (fires close to road were suppressed by hand), one helicopter: 41 percent of fires, two helicopters: 10 percent of fires, three helicopters: 14 percent of fires, four helicopters: 7 percent of fires, 5 helicopters: 10 percent of fires, 7 helicopters: 3 percent of fires. In summary, 35 percent of Army-caused fires outside the firebreak road took four or more helicopters to suppress and almost all helicopters were UH-60 and CH-47 helicopters with 660 to 1,000 gallon buckets.

Anticipated Fire Acreage Examples: For planning purposes the CONTAIN module of BehavePlus fire behavior software was used to predict anticipated fire acreages for fires burning in guinea grass under various slope, fuel moisture and wind conditions. FireFamily Plus' NFDRS Calculator program was used to estimate Burning Index and tables were color-coded to indicate the fire danger which was most likely to occur under various fuel moisture

and weather conditions. Examples of the results from these simulations are presented in Table PD 11.

Table PD 11: Examples of anticipated final acreages of fires outside the firebreak road, burning in thick guinea grass, burning under various fuel moisture and weather conditions, with standby helicopter response times of one full hour, based on CONTAIN module of BehavePlus fire behavior model.

Color shading in tables:

	Likely to be Green
	May be green or yellow, depending on other weather and fuel moisture factors
	Likely to be Yellow
	May be yellow or red, depending on other weather and fuel moisture factors
	Likely to be Red

Guinea grass fire: Live Herbaceous Fuel Moist 200%, Live Woody Fuel Moisture 200%, 10-hr = 1hr+1, WAF = .5, wind across 60% slope
Fire Suppression Helicopter staffing: 22 ch/hr (0-5 mph winds), 33 ch/hr (6-10 mph), 41 ch/hr (11-15 mph), 42 ch/hr (>16 mph)

	1-hour fuel moisture				
20-ft wind	**6%**	**8%**	**10%**	**12%**	**14%**
0 mph	**Contained 6.1 ac**	**Contained 5.4 ac**	**Contained 4.8 ac**	**Contained 4.4 ac**	**Contained 4.0 ac**
2 mph	**Contained 6.4 ac**	**Contained 5.7 ac**	**Contained 5.1 ac**	**Contained 4.6 ac**	**Contained 4.2 ac**
4 mph	**Contained 7.6 ac**	**Contained 6.6 ac**	**Contained 5.9 ac**	**Contained 5.4 ac**	**Contained 4.9 ac**
6 mph	**Contained 7.7 ac**	**Contained 6.8 ac**	**Contained 6.1 ac**	**Contained 5.6 ac**	**Contained 5.2 ac**
8 mph	**Contained 9.7 ac**	**Contained 8.6 ac**	**Contained 7.7 ac**	**Contained 7.1 ac**	**Contained 6.5 ac**
10 mph	**Contained 12.4 ac**	**Contained 10.8 ac**	**Contained 9.7 ac**	**Contained 8.8 ac**	**Contained 8.1 ac**
12 mph	**Contained 13.8 ac**	**Contained 12.2 ac**	**Contained 11.0 ac**	**Contained 10 ac**	**Contained 9.1 ac**
14 mph	**Contained 17.0 ac**	**Contained 14.9 ac**	**Contained 13.3 ac**	**Contained 12.1 ac**	**Contained 11.0 ac**
16 mph	**Contained 20.4 ac**	**Contained 17.7 ac**	**Contained 15.8 ac**	**Contained 14.4 ac**	**Contained 13.0 ac**
18 mph	**Escaped**	**Contained 21.7 ac**	**Contained 18.9 ac**	**Contained 17.0 ac**	**Contained 15.4 ac**
20 mph	**Escaped**	**Escaped**	**Escaped**	**Contained 20.8 ac**	**Contained 18.2 ac**

Guinea grass fire: Live Herbaceous Fuel Moist 150%, Live WDY FM 150-200%, 10-hr = 1hr+1, WAF = .5, wind across 60% slope
Fire Suppression Helicopter staffing: 28 ch/hr (0-5 mph winds), 42 ch/hr (6-10 mph), 50 ch/hr (11-15 mph), 52 ch/hr (>16 mph)

20-ft wind	**1-hour fuel moisture**				
wpeed	**6%**	**8%**	**10%**	**12%**	**14%**
0 mph	**Contained 9.1 ac**	**Contained 7.9 ac**	**Conatined 7.1 ac**	**Conatined 6.5 ac**	**Contained 6.1 ac**
2 mph	**Contained 9.6 ac**	**Contained 8.3 ac**	**Conatined 7.5 ac**	**Conatined 6.8 ac**	**Contained 6.4 ac**
4 mph	**Contained 11.3 ac**	**Contained 9.8 ac**	**Conatined 8.8 ac**	**Conatined 8 ac**	**Contained 7.5 ac**
6 mph	**Conatined 14.5 ac**	**Contained 9.6 ac**	**Contained 9.1 ac**	**Conatined 8.4 ac**	**Contained 7.9 ac**
8 mph	**Contained 21.2 ac**	**Contained 12.1 ac**	**Contained 11.5 ac**	**Contained 10.6 ac**	**Contained 9.9 ac**
10 mph	**Contained 10.1 ac**	**Contained 15.3 ac**	**Contained 14.6 ac**	**Contained 13.3 ac**	**Contained 12.4 ac**
12 mph	**Contained 21.5 ac**	**Contained 18.8 ac**	**Contained 16.8 ac**	**Contained 15.4 ac**	**Contained 23.3 ac**
14 mph	**Contained 26.5 ac**	**Contained 23 ac**	**Contained 20.5 ac**	**Contained 18.8 ac**	**Contained 14.4 ac**
16 mph	**Contained 31.9 ac**	**Contained 27.4 ac**	**Contained 24.3 ac**	**Contained 22.2 ac**	**Contained 20.7 ac**
18 mph	**Escaped**	**Contained 35.3 ac**	**Contained 29.3 ac**	**Contained 26.5 ac**	**Contained 24.5 ac**
20 mph	**Escaped**	**Escaped**	**Escaped**	**Escaped**	**Contained 29.5 ac**

Guinea grass fire: Live Herbaceous Fuel Moist 120%, Live WDY FM 120-190%,10-hr = 1hr+1, WAF = .5, wind across 60% slope
Fire Suppression Helicopter Staffing: 34 ch/hr (0-5 mph winds), 49 ch/hr (6-10 mph), 60 ch/hr (11-15 mph), 62 ch/hr (>16 mph)

	1-hour fuel moisture				
20-ft wind	**6%**	**8%**	**10%**	**12%**	**14%**
0 mph	**Conatined 12.3 ac**	**Conatined 10.6 ac**	**Conatined 9.4 ac**	**Contained 8.6 ac**	**Contained 8.2 ac**
2 mph	**Contained 13 ac**	**Contained 11.2 ac**	**Conatined 9.9 ac**	**Conatined 9 ac**	**Contained 8.6 ac**
4 mph	**Contained 15.4 ac**	**Contained 13.2 ac**	**Conatined 11.7 ac**	**Conatined 10.6 ac**	**Contained 10.1 ac**
6 mph	**Contained 16.1 ac**	**Contained 13.9 ac**	**Contained 2.5 ac**	**Conatined 2 ac**	**Contained 1.8 ac**
8 mph	**Contained 20.6 ac**	**Contained 17.8 ac**	**Contained 15.8 ac**	**Contained 14.4 ac**	**Contained 13.3 ac**
10 mph	**Contained 26.4 ac**	**Contained 22.7 ac**	**Contained 20 ac**	**Contained 18.1 ac**	**Contained 16.8 ac**
12 mph	**Contained 29.9 ac**	**Contained 25.8 ac**	**Contained 22.9 ac**	**Contained 20.8 ac**	**Contained 19.2 ac**
14 mph	**Contained 37 ac**	**Contained 31.7 ac**	**Contained 28 ac**	**Contained 25.4 ac**	**Contained 23.5 ac**
16 mph	**Contained 44.7 ac**	**Contained 37.9 ac**	**Contained 33.4 ac**	**Contained 30.1 ac**	**Contained 27.8 ac**
18 mph	**Escaped**	**Contained 49 ac**	**Contained 40.2 ac**	**Contained 36 ac**	**Contained 33 ac**
20 mph	**Escaped**	**Escaped**	**Escaped**	**Escaped**	**Contained 39.4 ac**

Guinea grass fire: Live Herbaceous Fuel Moist 100%, Live WDY FM 100-170%, 10-hr = 1hr+1, WAF = .5, wind across 60% slope Fire Suppression Helicopter Staffing: 86 ch/hr (0-10 mph winds), 104 ch/hr (11-15 mph), 107 ch/hr (16 mph and higher)					
20-ft wind	1-hour fuel moisture				
wpeed	6%	8%	10%	12%	14%
0 mph	Contained 30.7 ac	Contained 26.2ac	Contained 23.0 ac	Contained 20.6 ac	Conatined 3.7 ac
2 mph	Contained 32.7 ac	Contained 27.9 ac	Contained 24.4 ac	Contained 21.9 ac	Conatined 20.0 ac
4 mph	Contained 40 ac	Contained 34.0 ac	Contained 29.6 ac	Contained 26.5 ac	Conatined 24.2 ac
6 mph	Contained 42.3 ac	Contained 36.0 ac	Contained 4.7 ac	Contained 4.0 ac	Conatined 3.6 ac
8 mph	Contained 55.6 ac	Contained 47.1 ac	Contained 41.4 ac	Contained 37.2 ac	Conatined 34.1 ac
10 mph	Contained 72.7 ac	Contained 61.2 ac	Contained 53.6 ac	Conatined 48 ac	Conatined 43.9 ac
12 mph	Contained 83.3 ac	Contained 71.3 ac	Contained 62.7 ac	Conatined 56.3 ac	Contained 51.5 ac
14 mph	Contained 104.2 ac	Contained 88.7 ac	Contained 77.6 ac	Conatined 69.5 ac	Conatined 63.5 ac
16 mph	Contained 127.7 ac	Contained 107.3 ac	Contained 93.4 ac	Conatined 83.5 ac	Conatined 76.1ac
18 mph	Escaped	Contained 144.4 ac	Contained 113.4 ac	Conatined 100.3 ac	Conatined 91.1 ac
20 mph	Escaped	Escaped	Escaped	Escaped	Contained 109.1 ac

Guinea grass fire: Live Herbaceous Fuel Moist 80%, Live WDY FM 80-150%, 10-hr = 1hr+1, WAF = .5, wind across 60% slope Fire Suppression Helicopter staffing: 98 ch/hr (0-5 mph winds), 150 ch/hr (6-10 mph), 182 ch/hr (11-15 mph), 197 ch/hr (>16 mph)					
	1-hour fuel moisture				
20-ft wind	6%	8%	10%	12%	14%
0 mph	Contained 87.3 ac	Contained 74.0 ac	Contained 64.3 ac	Contained 9.9 ac	Contained 7.9 ac
2 mph	Contained 94.4 ac	Contained 79.8 ac	Contained 69.3 ac	Contained 61.4 ac	Contained 9.6 ac
4 mph	Contained 119.8 ac	Contained 100.8 ac	Contained 87.1 ac	Contained 77.0 ac	Contained 69.4 ac
6 mph	Contained 129.2 ac	Contained 110.3 ac	Contained 96.4 ac	Contained 86.0 ac	Contained 78.0 ac
8 mph	Contained 175.0 ac	Contained 148.8 ac	Contained 129.6 ac	Contained 115.3 ac	Contained 104.3 ac
10 mph	Contained 234.3 ac*	Contained 197.8 ac	Contained 171.5 ac	Contained 152.0 ac	Contained 137.2 ac
12 mph	Contained 274.3 ac*	Contained 232.9 ac*	Contained 202.6 ac*	Contained 180.1 ac	Contained 162.9 ac
14 mph	Contained 349.3 ac*	Contained 293.8 ac*	Contained 254.4 ac*	Contained 225.4 ac*	Contained 203.4 ac*
16 mph	Contained 417.6 ac*	Contained 348.8 ac*	Contained 301.5 ac*	Contained 267.0 ac*	Contained 240.9 ac*
18 mph	Escaped	Contained 453.7 ac*	Contained 367.8 ac*	Contained 322.7 ac*	Contained 289.9 ac*
20 mph	Escaped	Escaped	Escaped	Contained 406.7 ac*	Contained 347.7 ac*

* BehavePlus/CONTAIN assumes headfire burning in guinea grass on a 60% slope over the entire fire area. The south aspect of C-Ridge has an average percent slope of 60%, but it is only 200 acres in area. Fires larger than 200 acres will hit fuelbreaks and turn into flanking and backing fires once they crest C-Ridge. Therefore, fire acreages larger than 200 acres, and acreages of fires ignited close to the top of C-Ridge are overestimated by the model.

Guinea grass fire: Live Herbaceous Fuel Moist 60%, Live WDY FM 60-130%, 10-hr = 1hr+1, WAF = .5, wind across 60% slope Fire Suppression Helicopters: 120 ch/hr (0-5 mph winds), 183 ch/hr (6-10 mph), 223 ch/hr (11-15 mph), 236 ch/hr (>16 mph)					
	1-hour fuel moisture				
20-ft wind	6%	8%	10%	12%	14%
0 mph	Contained 128.6 ac	Contained 108.6 ac	Contained 93.3 ac	Contained 13.4 ac	Contained 10.7 ac
2 mph	Contained 139.0 ac	Contained 117.2 ac	Contained 101.2 ac	Contained 89.3 ac	Contained 12.6 ac
4 mph	Contained 176.6 ac	Contained 148.1 ac	Contained 127.5 ac	Contained 112.0 ac	Contained 100.2 ac
6 mph	Contained 191.2 ac	Contained 162.8 ac	Contained 141.7 ac	Contained 125.7 ac	Contained 113.1 ac
8 mph	Contained 259.5 ac*	Contained 219.9 ac*	Contained 190.7 ac	Contained 168.7 ac	Contained 151.5 ac
10 mph	Contained 347.9 ac*	Contained 292.8 ac*	Contained 252.8 ac*	Contained 222.8 ac*	Contained 199.6 ac
12 mph	Contained 406.6 ac*	Contained 344.3 ac*	Contained 298.4 ac*	Contained 263.9 ac*	Contained 237.0 ac*
14 mph	Contained 518.2 ac*	Contained 434.6 ac*	Contained 374.9 ac*	Contained 330.4 ac*	Contained 296.0 ac*
16 mph	Contained 620.5 ac*	Contained 516.7 ac*	Contained 445 ac*	Contained 391.9 ac*	Contained 351 ac*
18 mph	Escaped	Contained 668.7 ac*	Contained 542.8 ac*	Contained 473.7 ac*	Contained 422.5 ac*
20 mph	Escaped	Escaped	Escaped	Contained 587.1 ac*	Contained 505.9 ac*

* BehavePlus/CONTAIN assumes headfire burning in guinea grass on a 60% slope over the entire fire area. The south aspect of C-Ridge has an average percent slope of 60%, but it is only 200 acres in area. Fires larger than 200 acres will hit fuelbreaks and turn into flanking and backing fires once they crest C-Ridge. Therefore, fire acreages larger than 200 acres, and acreages of fires ignited close to the top of C-Ridge are overestimated by the model.

Guinea grass fire: Live Herbaceous Fuel Moist 50%, Live WDY FM 50-100%, 10-hr = 1hr+1, WAF = .5, wind across 60% slope Fire Suppression Helicopters: 135 ch/hr (0-5 mph winds), 206 ch/hr (6-10 mph), 250 ch/hr (11-15 mph), 270 ch/hr (>16 mph)					
	1-hour fuel moisture				
20-ft wind	6%	8%	10%	12%	14%
0 mph	Contained 160.5 ac	Contained 135.4 ac	Contained 117.0 ac	Contained 103.1 ac	Contained 92.2 ac
2 mph	Contained 173.5 ac	Contained 146.2 ac	Contained 126.1 ac	Contained 111.0 ac	Contained 99.3 ac
4 mph	Contained 220.7 ac*	Contained 184.9 ac	Contained 158.9 ac	Contained 139.4 ac	Contained 124.3 ac
6 mph	Contained 239.1 ac*	Contained 203.4 ac*	Contained 176.8 ac	Contained 156.6 ac	Contained 140.6 ac
8 mph	Contained 324.7 ac*	Contained 274.9 ac*	Contained 238.2 ac*	Contained 210.3 ac*	Contained 188.5 ac
10 mph	Contained 435.4 ac*	Contained 366.2 ac*	Contained 315.8 ac*	Contained 277.9 ac*	Contained 248.5 ac*
12 mph	Contained 510.4 ac*	Contained 431.7 ac*	Contained 373.8 ac*	Contained 329.9 ac*	Contained 295.6 ac*
14 mph	Contained 650.9 ac*	Contained 545.3 ac*	Contained 469.8 ac*	Contained 413.3 ac*	Contained 369.5 ac*
16 mph	Contained 780.4*	Cantained 648.9 ac*	Contained 558.0 ac*	Contained 490.6 ac*	Contained 438.4 ac*
18 mph	Escaped	Contained 851.3 ac*	Contained 681.0 ac*	Contained 593.3 ac*	Contained 527.8 ac*
20 mph	Escaped	Escaped	Escaped	Contained 736.8 ac*	Contained 632.2 ac*
* BehavePlus/CONTAIN assumes headfire burning in guinea grass on a 60% slope over the entire fire area. The south aspect of C-Ridge has an average percent slope of 60%, but it is only 200 acres in area. Fires larger than 200 acres will hit fuelbreaks and turn into flanking and backing fires once they crest C-Ridge. Therefore, fire acreages larger than 200 acres, and acreages of fires ignited close to the top of C-Ridge are overestimated by the model.					

The Army will invite the Service to a meeting or after action review within one week of the occurrence of all fires burning outside the firebreak road at Makua or any fire burning any area within any of the on-site or off-site Makua Implementation Plan management units. The Army will evaluate the fire suppression response and final fire acreage of all fires in relation to the fire size predicted by the CONTAIN module of BehavePlus. If the sizes of fires suppressed outside the firebreak road at Makua are larger than the sizes predicted by the Contain module of BehavePlus (see Table PD 11), or fire rate of spread is faster than predicted, the Army will work with the Service to develop new, increased, helicopter staffing requirements which are acceptable to both agencies. If rate of spread data indicates that guinea grass burns more slowly than the fuel model predicts, helicopter staffing decreases may be considered. Adjustments to the guinea grass fuel model and fire suppression helicopter staffing requirements may be appended to this Biological Opinion, for use at Makua, given the concurrence of both the Army and the Service.

STATUS AND ENVIRONMENTAL BASELINE OF SPECIES AND CRITICAL HABITAT - OVERVIEW

Introduction

This section presents the biological and ecological information relevant to formulating the Service's Biological Opinion covering 38 plant taxa, Oahu tree snail, and Oahu elepaio. We also include information on designated critical habitat for 36 endangered and threatened plant taxa and for the Oahu elepaio. These listed resources are present within the action area on Army-owned or leased lands on Makua, and on adjacent State, city/county, and private lands.

For the "status" descriptions for each species, we discuss life history, habitat, distribution, abundance, threats, conservation needs, constituent elements of critical habitat, and other factors necessary for survival, as the basis for analyses in later sections. For the "environmental baseline" descriptions, we document this information for species and critical habitats within the action area. We also attempt to rank the background risk of extinction for each covered species, as a basis for evaluating project effects on individual fitness, population viability, and the likelihood of species persistence. Demographic data is utilized where available to generally indicate whether a species is increasing, declining, or maintaining its numbers. For most of the species covered in this Biological Opinion, little is known about the critical factors that determine status, such as intrinsic rates of population increase or decline, survivorship, minimum viable population size, and estimated mean time to extinction.

Owing to the lack of population viability data for the covered species, we qualitatively categorize whether baseline conditions for plant species are currently at a moderate, high, or very high risk of extinction. By definition, any species listed as endangered is "in danger" of extinction throughout all or a significant portion of its range. The Army's proposed Makua Implementation Plan Addendum identifies 28 endangered plant taxa in need of stabilization (Table SB 1). For the purposes of this Biological Opinion, these species are considered to have a high background extinction risk because intensive management is needed to ensure their persistence. Of these target taxa, 12 taxa are considered even more "at risk" due to their restricted distribution (i.e., only or mostly on Oahu), low numbers, and limited reproduction. As such, these 12 species have been identified for expedited stabilization (see Table SB 1). These expedited stabilization taxa are defined as those with (1) fewer than 100 total individuals remaining; or (2) more than 100 individuals, but with fewer than half of their mature individuals needed to fulfill numerical stabilization criteria; or (3) more than 100 individuals, but with half or more of their mature individuals within the action area (i.e., at risk of training-related wildfire). Expedited stabilization taxa were identified in 2006, during inter-agency negotiation of conservation measures to avoid jeopardy, and are based on the Army's 2005 Status Update Report (U.S. Army Garrison 2005b). Expedited stabilization taxa are also characterized by fewer than three population units not exceeding numeric criteria for stabilization, no population units outside the action area exceeding numeric criteria for stabilization, and a declining number of individuals or maintenance of numbers primarily through augmentation; in addition, they may face uncontrollable threats, such as rat and slug predation or black twig borer infestation. There are 12 non-stabilization species, (i.e., species that are not included for stabilization management in the Makua Implementation PlanAddendum, owing to relatively large range-wide numbers and some occurrences with larger individual numbers, are considered at "moderate" risk of extinction) (see Table SB 1).

Table SB 1. Status of Plant Taxa Within the Action Area

Species	Status						
	Critical Habitat & Plants	Plants Only	Critical Habitat Only	Stabilization	Expedited Stabilization	Non-Stabilization	Kaluakauila-Punapohaku Fire Minimization Measures
Abutilon sandwicense		●				●	
Alectryon macrococcus var. *macrococcus*		●		●			
Bonamia menziesii	●					●	●
Cenchrus agrimonioides var. *agrimonioides*	●			●			
Chamaesyce celastroides var. *kaenana*	●			●			●
Chamaesyce herbstii	●				●		
Colubrina oppositifolia			●				
Ctenitis squamigera		●				●	
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 brackenridegei ssp. *mokuleianus*	●				●		
Isodendrion laurifolium			●				
Isodendrion longifolium			●				
Isodendrion pyrifolium			●				

Table SB 1 (Continued). Status of Plant Taxa Within the Action Area

Species	Status						
	Critical Habitat & Plants	Plants Only	Critical Habitat Only	Stabilization	Expedited Stabilization	Non-Stabilization	Kaluakauila-Punapohaku Fire Minimization Measures
Lepidium arbuscula		●				●	
Lobelia niihauensis		●				●	
Mariscus pennatiformis			●				
Melanthera tenuifolia		●		●			
Melicope pallida			●				
Neraudia angulata	●				●		
Nototrichium humile	●			●			●
Peucedanum sandwicense		●				●	
Phyllostegia kaalaensis	●				●		
Plantago princeps var. *princeps*	●			●			
Pritchardia kaalae		●		●			
Sanicula mariversa	●				●		
Schiedea hookeri	●					●	●
Schiedea kaalae	●			●			
Schiedea nuttallii	●				●		
Schiedea obovata		●			●		
Silene lanceolata		●				●	
Solanum sandwicense			●				
Spermolepis hawaiiensis	●					●	
Tetramolopium filiforme		●		●			
Viola chamissoniana ssp. *chamissoniana*		●		●			

Five endangered taxa, *Nototrichium humile, Chamaesyce celastroides* var. *kaenana, Bonamia menziesii, Euphorbia haeleeleana* and *Schiedea hookeri* occur in the Kaluakauila Management Unit or in adjacent areas (see Table SB 1). This management unit and the areas in close proximity are surrounded by the high fire risk zone. The dominant vegetative cover of this area is non-native fire prone grasses. A significant percentage of the known individuals (State-wide and/or island-wide) of these taxa occur within, or near to, this management unit. Therefore, the loss of individuals of these taxa from within and around the Kaluakauila Management Unit would significantly reduce the probability these taxa would persist over the long-term. For some taxa, the probability of persistence across their total range would be reduced, for other taxa the continued persistence in a significant portion (Oahu) of their range would be reduced.

In the case of four of the taxa, *Nototrichium humile, Chamaesyce celastroides* var. *kaenana, Euphorbia haeleeleana* and *Schiedea hookeri,* a significant portion of the total known number of individuals (approximately 20 percent, 40 percent, 40 percent and 20 percent, respectively) are at considerable risk of being destroyed by training related wildfires, in and around the Kaluakauila Management Unit. In addition, 20 percent of the known individuals of *Bonamia menziesii* on Oahu occur within Kaluakauila Management Unit and thus stand a significant risk of being destroyed by training related wildfires.

The environmental baseline description for each species documents its status within the action area. For each species, we determine the importance of individual fitness to population viability within the action area, and to the survival and recovery of the species as a whole. The threat of training-related wildfire in the action area is estimated according to the location of individuals within zones of high, low, and very low fire risk. For many species, the available GIS database information is too coarse to enumerate all individuals that will be exposed to fire within these zones. For example, data points located on map boundaries between fire risk zones may represent individuals within either or both of the zones. In these cases, the Service and the Army have agreed that all individuals at zone boundaries will be counted within the higher fire risk zone.

The consultation period for this Biological Opinion has required significant inter-agency negotiation of complex fire protection and impact minimization measures over about 18 months. During that time, we periodically received updated information about the proposed action from the Army. The new information required continual revision of our fire model simulations to delineate the action area and recommend appropriate conservation measures. Also during the consultation period, the Army continued to implement stabilization measures and monitor target species. The Army's 2006 status report, which was distributed in October 2006 and reviewed by the inter-agency Makua Implementation Team, is the best available information on the status and baseline of the 29 species that need stabilization covered in this opinion. Problems arise because the action area for this consultation differs from that used in 2003 to develop the Makua Implementation Plan, and the Army monitors stabilization species within that 2003 action area. The current action area excludes some parts of the 2003 action area that encompassed population units of stabilization species, and elsewhere expands to new areas that contain additional occurrences of listed species (e.g., *Gouania vitifolia*). Few covered species are affected by the change in action area boundaries, and the numbers of individuals that are included or excluded based on differences in the 2003 and 2007 action areas are not significant.

For stabilization species, our baseline determinations are based on current status within the action area monitored in the Army's 2006 status report, even though this creates inaccuracies for some species that have fewer individuals or population units within the current action area than in the 2003 action area. In some cases, detailed analysis of GIS information and reference to Army Natural Resources field data sheets was used to determine numbers of individuals within various areas, and in these cases, these additional sources of data are cited. Many listed plants, especially many of the most highly at-risk taxa, occur along the Makua Valley rim and beyond, in mixed native and non-native forest that has been excluded from the new action area. Thus, baselines for some species are slightly overestimated for the action area considered in this opinion. To the best of our knowledge, the action area baseline has not been underestimated for any of the covered species. In addition, the reader also should note that status/baseline tables in this opinion do not allow for direct comparison of numbers due to varying survey effort across years.

General Environmental Baseline Factors

General environmental baseline factors that are uniform for all species and critical habitats in the action area are summarized jointly below. These factors include past and present impacts of all Federal, State, or private actions, and other human activities in the action area; anticipated impacts of all proposed Federal projects in the action area that have already undergone formal consultation; and impact of State or private actions that are contemporaneous with the consultation. Details on unique or important factors for particular species or critical habitats are discussed more fully in the species-specific status and baseline descriptions that follow.

Past and present impacts of all human activities in the action area include historical land use in the Makua and Kahanahaiki valleys (now located within Makua) and adjacent lands, as described in the Army's draft environmental impact statement for the proposed action (U.S. Army Corps of Engineers 2005). Before human settlement on Oahu, vegetation in leeward lowland areas such as Makua probably consisted of dry grasslands and shrublands, and shrublands and forests in some areas may have extended all the way to the coast (Cuddihy and Stone 1990). In leeward Oahu valleys, native Hawaiians altered lowland vegetation by cultivation of sweet potato, taro, and other crops using shifting cultivation (slash-and-burn) and extensive irrigation systems (Cuddihy and Stone 1990). In the 1800s, non-native Hawaiian farmers grew watermelon, pumpkin, cucumber, tobacco, and cotton in the Makua and Kahanahaiki valleys (U.S. Army Corps of Engineers 2005). Ranching impacted all or parts of Makua and Kahanahaiki, and the adjacent Keawaula and Kuaokala areas, from 1864 until the Army took over control of the area in 1941. At that time, the Army relocated residents before using Makua and Kahanahaiki valleys for "simulated battle training." The Army has been training at Makua ever since.

Other past and present human activities in the action area include fires set by human carelessness and arson, habitat lost to development, and trampling of native vegetation along roads and trails. Major threats to listed resources in the action area related to human activities are non-native plants and animals introduced by Polynesian and Euro-American settlers. These invasive species include ungulates (pigs, goats, cattle, and sheep), rodents (rats and mice), insects (black-twig borer, Chinese rose beetle, two-spotted leaf hopper, long-legged ant, white fly, and scales), other invertebrates (snails and slugs), disease pathogens (avian malaria and avian pox), and hundreds of invasive weed species that compete with native plants for growing space, light, water, and soil

nutrients. These threat factors are tabulated for each species in Appendix E and are discussed in the "General Effects" section. Details on unique or particularly dangerous threats are discussed as appropriate in the species-specific status and baseline descriptions.

Anticipated impacts of all proposed Federal projects in the action area that have already undergone formal consultation include activities covered by existing Biological Opinions that are still in effect (Service 1999b, 2001a, 2001b, 2003a, 2004a). The actions covered by these opinions are similar to the proposed action except for the inclusion of the following weapon systems in this opinion; tracers, TOWs, 155 mm HE howitzer artillery, 2.75-caliber helicopter-launched rockets, and Javelin anti-tank missiles. As a result of previous Biological Opinions, the Army developed and began implementing a Wildland Fire Management Plan and fire danger rating system to reduce the risk of fire ignition and spread, and a Makua Implementation Plan to stabilize 29 target taxa. Impacts associated with Army training were expected to continue indefinitely while the Army continued to implement these conservation measures. Ongoing stabilization actions for target taxa are based on management of species-level population units and ecosystem-level management units, and include ungulate exclusion, weed control, rat control at elepaio nesting sites, augmentation and reintroduction of endangered plants, propagule collection for *ex situ* genetic storage, and captive propagation of *Achatinella mustelina* tree snails. During 1999-2003, the Army implemented certain "urgent actions" needed to address threats to listed resources while the Makua Implementation Plan was being developed, and has been monitoring and managing non-stabilization species in the action area since 1999.

The fire history of military training at Makua is described in the General Effects – Fire Suppression section of this Biological Opinion. Training at Makua was suspended in 1998 due to a third-party lawsuit but was resumed in October 2001 under a settlement agreement and stipulated order. Under the settlement agreement, limited live-fire training (18 CALFEXs and other training exercises) was conducted between October 2001 and October 2005, in conformance with the Service's existing Biological Opinions. During the 2001-2005 limited training period, four fires were ignited. Two small fires, caused by an AT-4 anti-tank rocket and oxidation of old white phosphorus rounds, were immediately extinguished without damage to listed resources (U.S. Army Corps of Engineers 2005). An approximately 640-ha (2,100-ac) fire from an escaped July 2003 prescribed burn, jumped the firebreak road and burned uncontrolled for three days damaging several listed species and critical habitats. An approximately 121-ha (300-ac) fire attributed to white phosphorus ignition escaped the firebreak road in August 2005, but did not affect listed resources. Thus, even with reduced training levels since 1998, fires associated with military activities have continued to impact Makua.

The impacts of State or private actions that are contemporaneous with the consultation include conservation programs on State-owned lands within and adjacent to the action area (Kuoakala Forest Reserve, Mokuleia Forest Reserve, Makua-Keaau Forest Reserve, and Pahole Natural Area Reserve). Population units of listed species, management units for ecosystem-level stabilization actions, and critical habitat units are also located on city/county and private lands. Some State lands within and adjacent to the action area are public hunting areas where non-native ungulates are impacting native plants. In addition, city/county and private lands contain endangered species population units and management units, including Honolulu Board of Water Supply lands and lands managed by The Nature Conservancy of Hawaii. Other privately owned lands are not managed for endangered species conservation and are threatened by pigs, goats,

and invasive weeds. All non-Army lands within and adjacent to the action area have been impacted by agricultural and ranching activities, habitat loss and development, trampling of native vegetation along roads and trails, and fires set by carelessness and arson.

Critical Habitat This section also presents the biological and ecological information relevant to formulating the Service's Biological Opinion covering designated critical habitat for 36 endangered and threatened plant taxa and for the Oahu elepaio. Specific areas within the geographical area occupied by a species were designated as critical habitat because they contain physical or biological features essential to species conservation that may require special management considerations or protection. In some cases, specific areas outside the geographical area occupied by the species were also designated as critical habitat because they are essential to species conservation. Critical habitat is designated within the action area on State, city/county, and private lands. Critical habitat for plants is not designated on Army lands owing to various exclusions pursuant to sections 3 and 4 of the Endangered Species Act. However, critical habitat for the Oahu elepaio is designated on Army lands within Makua, as well as on State, city/county, and private lands within the action area.

Army-controlled (owned or leased) lands on Oahu and the island of Hawaii were excluded from plant critical habitat designation because they were covered by Integrated Natural Resource Management Plans that adequately address the species' needs, and because the benefit of exclusion outweighed the benefit of inclusion. According to the Sikes Act Improvement Amendments of 1997, each military installation must develop an Integrated Natural Resource Management Plan that reflects a mutual agreement between the Service and the State concerning conservation, protection, and management of fish and wildlife resources. Although the Service determined that lands within Makua were essential for the conservation of many plant species, management and conservation of these lands were already addressed in the Makua Integrated Natural Resource Management Plan.

For the critical habitat status and environmental baseline descriptions, we discuss the constituent elements necessary for species conservation as the basis for analyses in later sections. The status sections describe the entire designated critical habitat in terms of the biological and physical features that are essential to the conservation of the species, with emphasis on critical habitat units designated on Oahu. Although the primary constituent elements of the critical habitat are identified, little information is available on the current condition of these constituent elements. The environmental baseline sections describe these issues for critical habitat units within the action area, the relationship of action area critical habitat to the entire designated critical habitat, and the conservation value of the critical habitat to the species. The environmental baseline descriptions also address the ability of action area critical habitat to provide a portion of the habitat essential for the conservation of one or more populations. The general environmental baseline factors for critical habitat in the action area are the same as those discussed above for covered species.

For the critical habitats covered in this Biological Opinion, the best available scientific and commercial information is insufficient to determine their current condition within the action area and range-wide. In general, however, most native Hawaiian ecosystems are threatened by the same suite of factors related to habitat loss and the introduction and spread of non-native invasive species. Because these threats are fairly uniform, they are described in general below

and are not discussed in the species-specific status and baseline descriptions. Likewise, conservation needs of critical habitat are much the same for all covered species, and are not discussed in the species-specific descriptions.

Threats to Critical Habitat The major threats to all covered species, including plants and the Oahu elepaio, are similar within the action area as well as range-wide. Herbivory (including fruit and seed predation) of listed plants and associated native plants by non-native ungulates, rats, snails, slugs, and insects reduce the overall ecosystem health of critical habitat. Feral ungulates (cattle, goats, sheep, pigs, and deer) also degrade critical habitat by trampling and uprooting vegetation, increasing erosion, and spreading seeds of invasive plants. Some critical habitats also are vulnerable to occasional random environmental disturbances such as landslides, rockfalls, erosion, hurricanes, and flooding, and to human-related disturbances such as fire, military training, and trampling along trails. For some species of multi-island distribution, threats to critical habitat vary slightly among island units; for example, non-native deer and mouflon sheep (absent from Oahu) may threaten the status of critical habitat units on other islands.

Non-native plants that compete with and replace native plants are a major threat to critical habitat through exploiting and pre-empting available light, growing space, water, and nutrients. Competition by aggressive non-native plants for primary constituent elements results in habitat degradation and reduced vigor of native plants. Although the particular invasive plant species differ in various critical habitat units, some of the major invasive plants affecting listed species and critical habitats throughout the action area include *Ageratina riparia*, *Aleurites moluccana*, *Blechnum appendiculatum*, *Clidemia hirta*, *Ficus macrophylla*, *Ficus microcarpa*, *Grevillea robusta*, *Kalanchoe pinnata*, *Lantana camara*, *Melinis minutifolia*, *Paspalum conjugatum*, *Passiflora suberosa*, *Psidium* sp., *Rivina* sp., *Schinus terebinthifolius*, *Syzygium cumini*, and *Toona ciliata* (Makua Implementation Team 2003; 68 FR 35950).

Conservation Needs for Critical Habitat The conservation needs for plant and elepaio critical habitats in the action area are fairly uniform. Restoration of fire-altered native habitats to native vegetation is the primary need to prevent further invasion of fire-tolerant invasive grasses. The removal and control of ungulates, rats, and invasive plants would eliminate a major threat to the conservation value of critical habitat and would enhance the quantity, quality, and availability of primary constituent elements. Ungulate control usually requires fence construction and removal of animals from fenced exclosures. Rat control currently involves establishing and monitoring individual toxicant bait stations and trapping grids, which is labor intensive and expensive. Aerial broadcast of rodenticide baits would facilitate cost-effective treatment of large areas. The Environmental Protection Agency is evaluating the approval of a label registration for aerial rodenticide broadcast in Hawaii. Research and implementation of control techniques for non-native invertebrates such as slugs, snails, black twig borer, two-spotted leafhopper, and Chinese rose beetle would reduce habitat degradation by these pests. Invertebrate control is complicated by the need to develop methods that do not also harm native tree snails and insects but is mandatory to aide in the persistence of these native threatened populations.

Status of the Species– *Abutilon sandwicense* (No Common Name)

Species Description *Abutilon sandwicense* is a member of the Malvaceae (mallow) family. It is a shrub that grows to 3 m (9 ft) in height. Leaf blades are pale green, shallowly dentate, and covered with sparse pubescence. Flowers are solitary and pendulous and located in the leaf axils. The fruit develops into a capsule that matures in about six weeks. The sepals are greenish yellow in color, with the petals being bright green to reddish brown with green venation. This species is distinguished from others in the genus by its green or reddish-brown tipped petals that exceed the sepals (Wagner et al 1999).

Listing Status *Abutilon sandwicense* was federally listed as endangered on October 29, 1991 (56 FR 55770), and was state listed as endangered at the same time. A recovery plan for Waianae plants included this species (Service 1995a), and critical habitat was designated on June 17, 2003 (68 FR 35950).

Historic and Current Distribution *Abutilon sandwicense* is endemic to the island of Oahu. Historically, *A. sandwicense* was known from nearly the entire length of the Waianae Mountains, from Makaleha Valley to Nanakuli Valley (Service 1998a). When the species was listed in 1991, there were 14 occurrences with 300 to 400 individuals. Currently there are 14 occurrences with approximately 400 individuals on Federal, State, private, city, and county lands. Trends in numbers and distribution are difficult to discern, 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, only one stabilization population has more than 50 mature, reproducing individuals.

Table SB 2. Range-wide Distribution of *Abutilon sandwicense.*

Population Units	**Number of Known Individuals**					
	1991 (1)	**1995** (2)	**2003** (3)	**2003** (4)	**2005** (5)	**2006** (6)
Kahanahaiki	--	--	--	1-2	0	0/1[‡]
Keaau	--	--	--	1	1	1/10
Kaluakauila	--	--	--	--	0/6 [0/6][§]	0/22
Palikea Gulch portion of Kaawa to Puulu[¶]	--	--	--	63-83	10/3	--
West Makaleha	--	--	--		0/2	--
East Makaleha	--	--	--	--	2/2	--
Halona	--	--	--	1	1/ 4	--
Ekahanui and Huliwai	--	--	--	17	17/15 [0/65]	--
Kaawa to Puulu	--	--	--	--	34/84	--
Makaha Mauka	--	--	--	50-100	40/100	--
Makaha Makai	--	--	--		50/7	--
Nanakuli	--	--	--	30	30	--

North Mikilua	--	--	--	2	2	--
South Mikilua	--	--	--	4	4	--
Waianae Kai	--	--	--	6	6	--
Total Individuals	**300-400**	**<300**	**253-263**	**180-246**	**407** (189/212)[†] [0/71]	**424** (166/258)

Shaded population units are inside the action area.
[‡]Mature/immature individuals
[¶]Schofield Barracks Military Reservation
[§][Augmented and or reintroduction]
[†]Total (mature/immature)

(1) Listing rule (56 FR 55770)
(2) Recovery plan (Service 1998a)
(3) Critical habitat rule (68 FR 35950)
(4) Oahu Biological Opinion (Service 2003a)
(5) Army re-initiation request (U.S. Army Garrison 2005c)
(6) Army database (U.S. Army Garrison 2006d)

Ecology *Abutilon sandwicense* typically grows on steep slopes in dry forests between 300 and 600 m (1,000 and 2,000 ft) elevation. Associated native species include *Antidesma pulvinatum, Diospyros sandwicensis, Elaeocarpus bifidus, Eugenia reinwardtiana, Hibiscus arnottianus, Metrosideros polymorpha, Myrsine lanaiensis, Nestegis sandwicensis, Pipturus albidus, Pisonia* sp., *Pittosporum* sp., *Pleomele* sp., *Psydrax odorata, Rauvolfia sandwicensis, Reynoldsia sandwicensis,* and *Sapindus oahuensis* (Hawaii Natural Heritage Program 2001). *Abutilon sandwicense* has been observed flowering in winter and spring. Although seedlings are often initially abundant, few plants appear to survive to maturity for unknown reasons. Little else is known about the phenology, pollinators, seed dispersal agents, longevity, specific environmental requirements, or limiting factors for this species (59 FR 32932).

Threats to the Species *Abutilon 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 unique threats to *A. sandwicense* are the black twig borer (*Xylosandrus compactus*) and the Chinese rose beetle (*Adoretus sinicus*). Human activity along a trail in Honouliuli Preserve also threatens individuals in a nearby occurrence. There is one population with more than 50 mature, reproducing individuals (the suggested minimum number for stabilization populations for this species (Service 1995a) of *A. sandwicense* on Makaha Makai.

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Abutilon sandwicense* 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). Conservation actions required for stabilization are described in the "Stabilization" section of the project description for this opinion. However, *A. sandwicense* is not included as a target taxon for stabilization under the Makua Implementation Plan Addendum. Currently, the Army does not actively manage this species in the Makua and

Schofield Barracks action areas (Service 2003a). Surveys should be conducted to identify and assess the effects of the black twig borer and/or Chinese rose beetle on this species.
Ongoing Conservation Actions Various conservation management actions have been implemented for *Abutilon sandwicense* since it was listed as endangered. About 22 individuals (four percent of all remaining individuals) of this species occur in the fenced Kaluakauila Management Unit where they will benefit from population unit and/or ecosystem-level protection. 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, in order to recover rare species and restore native habitats; this plan will benefit any *A. sandwicense* within the preserve. This species is represented in the following *ex situ* collections: 45 leaf samples in micropropagation (Harold L. Lyon Arboretum), 42 plants in botanical garden collections (Amy Greenwell Ethnobotanical Garden and Waimea Valley Audubon Center), 457 seeds in seed storage (Lyon Arboretum Seed Storage Facility), and five seedlings in a nursery (Harold L. Lyon Arboretum) (Service 2005b, U.S. Army Garrison 2005d).

Environmental Baseline of the Species

Status of the Species in the Action Area The three occurrences of *Abutilon sandwicense* in the action area total approximately 35 individuals or about 8 percent of the for this species total population (U.S. Army Garrison 2005c) (see Table SB 2). One occurrence with approximately 22 immature individuals is located within the Kaluakauila fenced unit. The other two occurrences are not fenced and these occurrences are not actively managed by the Army. *Abutilon sandwicense* plants in the action area are located in areas at risk from training-related wildfire. About 22 individuals occur in the high fire risk zone, one in the low fire risk zone and 12 individuals occur in the very low fire risk zone. About four percent of the species' totals range-wide are located in the high fire risk zone.

Threats to the Species The primary threats to *Abutilon 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. All individuals of *A. sandwicense* are at risk from training-related wildfires. Particularly the 22 immature plants in the Kaluakauila Management Unit since this unit is located in the high fire risk zone. One mature plant occurs in the low fire risk zone and 12 individuals occur in the very low fire risk zone.

Conservation Needs of the Species *Abutilon sandwicense* does not require stabilization by the Army because less than 50 percent of all remaining individuals are located within the action area. A post-fire revegetation plan and site-specific fuels modification plan are needed where *A. sandwicense* 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 No conservation actions are currently being implemented specifically for *Abutilon sandwicense* in the Makua action area. However, this species benefits from ecosystem-level management in the fenced Kaluakauila Management Unit 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; Service 2004a). This species is represented in the following *ex situ* collections: 45 leaf

samples in micropropagation (Harold L. Lyon Arboretum), 42 plants in botanical garden collections (Amy Greenwell Ethnobotanical Garden and Waimea Valley Audubon Center), 457 seeds in seed storage (Lyon Arboretum Seed Storage Facility), and five seedlings in a nursery (Harold L. Lyon Arboretum) (Service 2005b, U.S. Army Garrison 2005d).

Status of the Species – *Alectryon macrococcus* var. *macrococcus* (Mahoe)

Species Description *Alectryon macrococcus* var. *macrococcus* is a tree in the soapberry family (Sapindaceae) that reaches heights of 11 m (34 ft). Fully mature trees are usually multi-trunked with a sinewy appearance and reddish-brown branches. The leaves are compound, with two to five pairs of leaflets, each of which measures 10 to 28 cm (3.9 to 10.9 in) long. The undersides of the leaves of a young *A. macrococcus* var. *macrococcus* plant have dense brown hairs. The flowers are borne in panicles up to 30 cm (11.7 in) long. Flowers are either perfect (possessing male and female reproductive parts) or staminate (possessing only male reproductive parts). The roundish fruits are 2.5 to 7 cm (0.9 to 2.7 in) in diameter and, when ripe, the hard rind of the fruit will open to expose the contents. The hard rind consists of the aril, or the fleshy part of the fruit, and a single flattish seed (Wagner et al 1999).

Listing Status *Alectryon macrococcus* var. *macrococcus* was federally and State listed as endangered on May 15, 1992 (57 FR 20772). A recovery plan was prepared for this species in 1997 (Service 1997). Critical habitat was designated for *A. macrococcus* var. *macrococcus* on Kauai; February 27, Molokai; March 18, Maui; May 14, and Oahu on June 17, 2003 (60 FR 51398).

Historic and Current Distribution *Alectryon macrococcus* var. *macrococcus* is endemic to the Hawaiian Islands and is known from Kauai, Oahu, Molokai, and Maui. Trends in distribution indicate approximately 79 plants are thought to remain on Kauai on the western side of the island from Olokele Canyon to Kalalau Valley. *Alectryon macrococcus* var. *macrococcus* has always been considered relatively rare on Molokai (10 individuals) and Maui (approximately 21 individuals). On Oahu, it is known primarily from the Waianae Mountains, where it has been recorded throughout the mountain range on both windward and leeward sides. There are two historical records of the taxon in the Koolau Mountains where it is no longer found. *Alectryon macrococcus* var. *macrococcus* is present throughout its historic range except for the Koolau Mountains. Currently, there are approximately 372 wild mature plants, 10 wild immature plants, and 14 augmented immature plants State-wide. Known locations on Kauai include: Haeleele (three wild mature plants), Kalalau (11 wild mature plants), and Koaie (65 wild mature plants), totaling 79 individuals. There are 21 individuals located on Maui at Haena Nui (15 wild mature plants), Honokowai (two wild mature plants), Iao (two wild mature plants), Launiupoko (one wild mature plant), and Waikapu (one wild mature plant). Ten individuals are located on Molokai at Kahuaawi (one wild mature plant), Kaunakakai to Kawela (eight wild mature plants), and Kawela and Makolelau (one wild mature plant). Approximately 244 plants remain in the Waianae Mountains in the following locations: Kahanahaiki to West Makaleha (42 wild mature, four wild immature, plus four augmented immature plants), Makua (33 wild mature plants), South Mohiakea (six wild mature plants), Central Kaluaa to Central Waieli (46 wild mature and 10 wild immature plants), Makaha (63 wild mature, five wild immature, and two seedlings), and Waianae Kai (six wild mature plants) (U.S. Army Garrison 2006c) (Table SB 3). It is estimated that the residual plants for this species reside only on Federal and State lands. On Oahu, demographic data reveals 90 percent of *Alectryon macrococcus* var.

macrococcus individuals are mature plants, and one percent are immature augmentations. Thus, *A. macrococcus* var. *macrococcus* on Oahu is characterized by only two populations units with more than 25 mature reproducing individuals and several other occurrences with fewer than 25 mature reproducing individuals that represent about 80 percent of all State-wide individuals.

Table SB 3. Range-wide Distribution of *Alectryon macrococcus* var. *macrococcus.*

Population Units	**Number of Known Individuals**					
	1992 (1)	**1997** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Kahanahaiki*	--	--	2	43/4 [0/6] §	42/4 [0/6]	1/0 [0/4]
Kapuna*			6			0/0
Pahole*			7			4/0
West Makaleha*			40/4‡			37/4
Makua*	--	--	15	17	20	33/0
Central Kaluaa to Central Waieli*	--	--	50/3	50/1	56/2 [0/8]	20(7)/10
South Mohiakea (SBMR)	--	--	16/1	15/1	6	6/0
Makaha*	--	--	75/2	35	62/7	63/7
Waianae Kai	--	--	16	16	5	6/0
Other Surveyed Locations	--	--	--	--	--	48/4
Total Individuals on Oahu	**~500**	**~500**	**347** (337/10)†	**188** (176/6) [0/6]	**218** (191/13) [0/14]	**247** (218/25) [0/4]
Total Individuals on Other Islands	<110	~100	110	--	--	--
Total Individuals State-wide	**610**	**600**	**447/10**	--	--	**357**

Shaded Population Units are inside the action area.
*Stabilization population units (Kahanahaiki, Kapuna, Pahole, and West Makaleha are considered one stabilization population unit.)
‡Mature/immature individuals
¶Schofield Barracks Military Reservation
§[Augmented and or reintroduced]
†Total (mature/immature)

(1) Listing rule (57 FR 20772)
(2) Recovery plan (Service 1997)
(3) Critical habitat rule (68 FR 35969), Makua Implementation Plan (Makua Implementation Team 2003) and 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)
(6) 2006 status update (U.S. Army Garrison 2006c, 2006d)
(7) S. Ching (U.S. Army Garrison, pers. comm. 2007).

Ecology *Alectryon macrococcus* var. *macrococcus* is a relatively slow-growing, long lived tree that grows in xeric to mesic sites and is adapted to periodic drought. Despite appearing

relatively healthy, a substantial percentage of the trees flower but never bear fruit. Although the cause of this is not known, it may be that some trees only bear flowers that are functionally male. There is little information on growth rates of wild plants and their age of maturation. However, two trees in cultivation have been observed to flower for the first time when they were about 15 years old. At that age they were approximately 6 m (20 ft) tall and were single-trunked, with the trunks measuring about 14 cm (5.5 in) in diameter. Wild trees undoubtedly live for decades, based on observed growth rates and tree sizes. Pollination of the taxon is probably carried out by insects. No recruitment has been observed and most remaining individuals are likely to be old, senescent individuals that will die without replacement. Flowering cycles, seed dispersal agents, and specific environmental requirements are unknown (Makua Implementation Team 2003). Other demographic information for *A. macrococcus* var. *macrococcus* in the wild is unknown. *Alectryon macrococcus* var. *macrococcus* grows on slopes, ridges, or in gulches within mesic lowland forests between elevations of 367 and 941 m (1,204 and 3,086 ft) (Service 2003b).

Threats to the Species *Alectryon macrococcus* var. *macrococcus* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described under "General Status and Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. In addition, *A. macrococcus* var. *macrococcus* is vulnerable to rat predation on seeds, fruits and other plant parts; depressed reproductive vigor; loss of pollinators; and stochastic events (Service 1999b; Hawaii Natural Heritage Program 2001; Service 2003b).

The primary threat to *Alectryon macrococcus* var. *macrococcus* on Oahu is an invasive insect, the black twig borer (*Xylosandrus compactus*), which was introduced in 1961. The black twig borer burrows into the branches and introduces a pathogenic fungus. The end result is severe pruning of the host that often kills branches or the whole plant. All known plants of this species suffer from slight to severe defoliation and reduced vigor due to the infestation of this non-native insect. The Chinese rose beetle, introduced in 1896, also defoliates portions of the plant and could result in death once the tree is weakened by other threats (Mau and Kessing 2004; Nelson and Davis 1972; Hara and Beardesly 1979).

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Alectryon macrococcus* var. *macrococcus* 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 recovery plan for this species identifies several conservation actions necessary to recover this species such as fencing, weed control, outplanting of local genetic material and rodent control (perhaps only seasonally during fruiting season). Surveys and monitoring should be initiated to determine the detrimental effects of the black twig borer and rodents to this species. Sites that are relatively free from these invasive pests should be considered prime candidates for protection. Extreme care should be taken not to introduce the black twig borer into a pest-free area with propagated material of *A. macrococcus* var. *macrococcus* species (Service 2003b). At least 50 mature, reproducing individuals are needed per population unit to attain stability for long-lived individuals.

Ongoing Conservation Actions Since listing, the Makua Implementation Team (2003) has developed stabilization protocols for *Alectryon macrococcus* var. *macrococcus, w*hich are

incorporated in the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). The U.S. Navy is conducting non-native plant control in areas where *A. macrococcus* var. *macrococcus* is located at the Naval Magazine Lualualei. Recreational hunting is allowed on Navy lands to control feral pigs. Feral ungulate control is being conducted on both Army and State lands in the Waianae Mountains. This species is being propagated at the Army Environmental nursery and the Lyon Arboretum on Oahu, the Hawaii Division of Forestry and Wildlife nursery on Kauai, and the National Tropical Botanical Garden on Maui and Kauai. Introductions/augmentations have been conducted over the last ten years into Kahanahaiki Gulch. Seeds are in storage facilities at the Lyon Arboretum and the National Tropical Botanical Garden. The Service is not currently aware of any other conservation efforts for this species (Service 2003b; L. Durand, pers. comm. 2004; Hawaii and Pacific Plant Recovery Committee. 2007; Service 2005a).

Alectryon macrococcus var. *macrococcus* is represented in several *ex situ* collections, including nine embryos in micropropagation (Harold L. Lyon Arboretum), one apical or lateral vegetative bud in micropropagation (Harold L. Lyon Arboretum), two cuttings in a nursery (Army Environmental Division, Oahu), three plants in a botanical garden (Waimea Valley Audubon Center), six seeds in a nursery (Harold L. Lyon Arboretum), 174 seeds in seed storage (Lyon Arboretum Seed Storage Facility), and 10 seedlings in a nursery (Harold L. Lyon Arboretum) (Service 2005b, U.S. Army Garrison 2005d). *Alectryon macrococcus* var. *macrococcus* can be successfully propagated from seed, air layers and cuttings.

Environmental Baseline of the Species

Status of the Species in the Action Area Approximately 30 percent of all known individuals of *Alectryon macrococcus* var. *macrococcus* are located within the action area in the Ohikilolo and Kahanahaiki to West Makaleha population units. Trends in numbers suggest an overall decline in numbers of this species since the 1990s. *Alectryon macrococcus* var. *macrococcus* individuals have increased since 2003 due to augmentation of immature plants and discovery of new mature individuals in the wild (U.S. Army Garrison 2004a). Approximately 90 percent of the total individuals in the action area are mature and 10 percent are augmented immature individuals.

Of the approximately 40 *Alectryon macrococcus* var. *macrococcus* individuals in the action area, almost all are located outside of the high fire risk zone. *Alectryon macrococcus* var. *macrococcus* is characterized by 18 occurrences, each with fewer than 25 mature, reproducing individuals.

Threats to the Species in the Action Area The primary threats to *Alectryon macrococcus* var. *macrococcus* 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. Additional threats that affect this species include rat predation and reduced plant vigor due to infestation of the black twig borer (U.S. Army Garrison 2003b). *Alectryon macrococcus* var. *macrococcus* has a background risk of species extinction and these additional threats decrease its potential for long-term persistence.

Conservation Needs of the Species in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) includes *Alectryon macrococcus* var. *macrococcus*

because no populations meet the minimum requirement for plant stabilization. To be considered stable, *A. macrococcus* var. *macrococcus* must meet the criteria required for stability of a long-lived perennial. Stabilization measures include habitat and population management of three population units, augmentation of existing populations, collection of full *ex situ* representation of wild stock on Oahu, rat control, and research and implementation of black twig borer control methods (U.S. Army Garrison 2003b). 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 Makaha and Makua population units are being managed for stabilization as specified by the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). Twenty-four individuals of *A. macrococcus* var. *macrococcus* are within fenced units and benefit from ungulate exclosure. Most of the trees in the Kahanahaiki to West Makaleha population unit show a significant amount of black twig borer damage. Some of the Kahanahaiki trees are fenced, while none of the Upper Kapuna or West Makaleha trees are fenced. Weed control has only occurred around the Kahanahaiki reintroductions. Seven air layers were set up on two different trees in the Makua population unit in February 2005. As of June, only one of the air layers exhibited any sign of callusing. Rats are controlled in the vicinity of some trees in Makaha and central Kalua'a in conjunction with Oahu elepaio management, and have activated baiting grids in 2006 around small fruited populations in lower Makua (U.S. Army Garrison 2006b). Natural Resources Staff had observed a significant decline in the numbers of known trees in the South Mohiakea population unit. Controlling rats with bait is not feasible at this site due to problems with access. Air layers have been done with some success and the propagules are established at the Army Nursery (U.S. Army Garrison 2005c).

The Army has prepared a fire management plan for the Kaluakauila Management Unit. Rats are controlled within the exclosure. Fuel modification is being conducted along the ridgeline between the management unit and the installation boundary to reduce the risk of fire and to protect the plants in this management unit. In addition, the Natural Resources Staff has begun collecting genetic material for *Alectryon macrococcus* var. *macrococcus* and has sent seeds to Lyon Arboretum for a propagation experiment. Unfortunately, genetic storage goals for *A. macrococcus* var. *macrococcus* are less than one percent complete (1/300) (U.S. Army Garrison 2003b).

Status of the Species and Critical Habitat – *Bonamia menziesii* (No Common Name)

Species Description *Bonamia menziesii*, a member of the Convolvulaceae (morning-glory) family, is a vine with twining branches up to 10 m (33 ft) long that are fuzzy when young. The leathery, oblong to oval leaves measure 3 to 9 cm (1.2 to 3.5 in) in length and 1 to 4-cm (0.4 to 1.6 in) in width. The upper leaf surface is usually hairless or covered with sparse hairs and the lower surface is covered with tomentose. The white to greenish funnel-shaped flowers are produced singly or in clusters of three on stalks with tiny bracts (modified leaves) at the base of each stalk. Stamens usually have glandular hairs at their bases. The flower has two styles, which are separate or partly fused. The fruits are tan or yellowish brown and contain one or two oval seeds imbedded in black pulp. This species is the only member of the genus that is endemic

to the Hawaiian Islands and differs from other genera in the family by its two styles, longer stems and petioles, and rounder leaves (Wagner et al 1999; Austin 1990).

Listing Status *Bonamia menziesii* was federally listed as endangered on November 10, 1994 (59 FR 56333), 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).

Historic and Current Distribution Historically, *Bonamia menziesii* was known from scattered locations on Kauai, the Koolau and Waianae Mountains of Oahu, several locations on Molokai, one location on west Maui, and eastern Hawaii. Currently, this species is extant on Kauai, Oahu, Lanai, Maui, and Hawaii. *Bonamia menziesii* is known from many occurrences on these five islands with the largest number of extant individuals located on Kauai comprising several thousand individuals. At least a dozen occurrences are known from Kalalau, upper Waioli Valley, scattered across the north coast from Limahuli, Hanakapiai to Milolii, Kawaiula Valley, Hipalau Valley, Paaiki Valley, Mount Kahili, and Hono O Na Pali Natural Area Reserve on State and private land, and Wahiawa drainage on private land totaling more than 1,000 individuals. There are 12 occurrences on Oahu that total fewer than 60 plants located both the Waianae and the Koolau Mountains (U.S. Army Garrison 1999a). These occurrences are found in Niu Valley, Makaleha Valley, Makua-Keaau Ridge, Wailupe, Waialae Nui-Kapakahi Ridge and Kapakahi Gulch, Kaluakauila Gulch, Keawaula, Hawaii Loa Ridge and Kului Gulch, Nanakuli Valley, Kuaokala, Halona, Waialae Iki, Kapuna Gulch, Mikilua, Waianae Kai, and Alaiheihe Gulch on Federal, State, and private lands (EDA Database 2001; GDSI 2001; Hawaii Natural Heritage Program 2001). On Lanai, *B. menziesii* is known from three scattered occurrences: about six individuals at Kaa, two individuals on Puhielelu Ridge, and four individuals at Paomai, on private land. On Maui, one occurrence of a single individual is known from private land on the western slopes of West Maui, and three to five occurrences with nine to 14 individuals are located on private and State land on East Maui. On the island of Hawaii, a single occurrence of at least three individuals is located at Kaupulehu on private land (Hawaii Natural Heritage Program 1995; Lorence and Flynn 1991; S. Perlman and K. Wood, pers. comm. 1997). Recent survey data from the island of Oahu suggests the number of individuals and occurrences is decreasing on the island. There are no stabilization population units exceeding minimum numerical criteria (i.e., greater than 50 reproducing individuals) on Oahu. Even though there are thought to be several thousand individuals on the island of Kauai, these populations are not managed or monitored so their status is unknown.

Table SB 4. Range-wide Distribution of *Bonamia menziesii*.

Population Units	**Number of Known Individuals**						
	1991 (1)	**1999** (2)	**1999** (3)	**2002** (4)	**2003** (5)	**2005** (6)	**2006** (7)
Kaluakauila	--	--	--	--	--	10/0‡	10/0
Makua	--	--	--	--	--	1/0	--
Keaau	--	--	--	--	--	1/0	--
Alaiheihe	--	--	--	--	--	5/0	--
Kaawa	--	--	--	--	--	10/0	--
Kapuna	--	--	--	--	--	5/0	--
Kaumokunui	--	--	--	--	--	1/0	--

Keawaula	--	--	--	--	--	5/0	--
Kuaokala	--	--	--	--	--	10/0	--
Lualualei	--	--	--	--	--	2/0	--
Nanakuli	--	--	--	--	--	10/0	--
Waianae Kai	--	--	--	--	--	1/0	--
Total Individuals Oahu	**<150**	**100-150**	**100-150**	**<100**	**<100**	**~60**	**28** (27/1)[†]
Total Population Units State-wide	--	31-44	>31	--	--	--	--
Total Individuals State-wide	**~200**	**1,000s**	**1,000s**	**1,000s**	**1,000s**	**1,000s**	--

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

(1) Listing rule (56 FR55770)
(2) Recovery plan (Service 1999a)
(3) Makua Biological Opinion (Service 1999b)
(4) Critical habitat rule (67 FR 37108)
(5) Critical habitat rule (68 FR 35950)
(6) Army re-initiation request (U.S. Army Garrison 2005c)
(7) Army database (U.S. Army Garrison 2006d)

Ecology *Bonamia menziesii* is found on steep slopes as well as on level ground in dry to mesic forest and sometimes in wet forest, between the elevations of 150 and 625 m (490 and 2,050 ft). Associated species include *Metrosideros polymorpha*, *Psydrax odorata*, *Diospyros sandwicensis*, *Dodonaea viscosa*, *Myoporum sandwicense*, *Nestegis sandwicensis*, *Pisonia umbellifera*, and *Sapindus oahuensis.* Little is known about the life history, flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors of this species (Service 1999a).

Threats to the Species *Bonamia menziesii* 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. An alien beetle (*Physomerus grossipes*), which has recently become established on Oahu, is potentially a significant threat to *B. menziesii* (D. Orr, pers. comm. 1999).

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Bonamia menziesii* 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). Conservation actions required for stabilization are described in the "Stabilization" section of the project description for this opinion. However, *B. menziesii* 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). Surveys should be conducted to identify and assess the effects of the alien beetle on this species.

Ongoing Conservation Actions The *Bonamia menziesii* plant on the Navy's Lualualei Naval Reservation has been fenced for protection from cattle. A program of alien plant removal within the exclosure is ongoing (J. Moribe, pers. comm. 1997). Most of the *B. menziesii* at Kanepuu Preserve on Lanai are found within fenced exclosures. In addition, the Nature Conservancy of Hawaii has implemented a fuel reduction treatment strategy for the Kanepuu Preserve on Lanai that includes mowing, at least yearly, portions of the seven distinct fenced units (C. Cory, pers. comm. 1999). The Kanepuu Preserve fire protection plan is updated each year and incorporates the participation of local, State, and private agencies (A. Remec, pers. comm. 1999). It is expected that these actions may enhance conservation of the *B. menziesii* plants found there. *Bonamia menziesii* has been successfully propagated at the Lyon Arboretum's micropropagation laboratories, at the Waimea Arboretum, and the National Tropical Botanical Garden (Koob 1996; M. Chapin, pers. comm.1997; G. Koob pers. comm. 1997; D. Orr, pers. comm. 1997). Currently, approximately 25 individuals exist in cultivation (Koob 1996; M. Chapin, pers. comm. 1997; D. Orr, pers. comm. 1997). Reintroduction of cultivated individuals to the wild has not been attempted.

Critical Habitat Description A total of 1,795 ha (4,415 ac) has been designated as critical habitat for *Bonamia menziesii* and is separated into nine distinct units on four Hawaiian Islands. Two critical habitat units are located on Kauai and include approximately 513 ha (1,267 ac), one is on Maui and includes 536 ha (1,325 ac), five units are on Oahu and include 608 ha (1,503 ac), and one is on Hawaii and includes 163 ha (402 ac). Critical habitat has been designated primarily on State lands (e.g., Lihue-Koloa Forest Reserve on Kauai, Kanaio Natural Area Reserve on Maui, and Kaena Point State Park and Nanakuli Forest Reserve on Oahu). Each of the critical habitat units provides habitat for one population of at least 300 mature, reproducing individuals of *B. menziesii* (68 FR 9116, 68 FR 25934, 68 FR 35950, 68 FR 39624).

The primary constituent elements of the units on Oahu include steep slopes or level ground in dry or mesic forest in open or closed canopy containing one or more of the following associated native plant species: *Acacia koa*, *Alyxia oliviformis*, *Dianella sandwicensis*, *Diospyros sandwicensis*, *Dodonaea viscosa*, *Erythrina sandwicensis*, *Hedyotis terminalis*, *Leptecophylla tameiameiae*, *Melicope* sp., *Metrosideros polymorpha*, *Myoporum sandwicensis*, *Nestegis sandwicensis*, *Pisonia* sp., *Pittosporum* sp., *Pleomele* sp., *Pouteria sandwicensis*, *Psydrax odorata*, *Rauvolfia sandwicensis*, *Sapindus oahuensis*, *Sicyos* sp., *Sida fallax*, or *Waltheria indica;* at elevations between 81 and 658 m (266 and 2,158 ft). 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 that 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 Currently, less than one percent of the known *Bonamia menziesii* plants are found within the Makua action area. Ten individuals are located in Kaluakauila and two individuals are found on the lower end of Ohikilolo Ridge (U.S. Army Garrison 2005c). None of these occurrences exceed minimum numerical criteria for a stabilization population unit. The individuals within the action area represent approximately 43 percent of the individuals on the island of Oahu. The Kaluakauila population unit with the highest density (10 individuals) is located in the high fire risk zone.

Status of the Critical Habitat in the Action Area Two percent (28 ha; 69 ac) of the critical habitat for *Bonamia menziesii* on the island of Oahu is located in two units within the Makua action area. Eight ha (20 ac) are in the high fire risk zone and 20 ha (49 ac) are in the low fire risk zone. These critical habitat units together provide habitat for the conservation of one population of at least 300 mature, reproducing individuals of *B. menziesii*. It is estimated that only one-quarter of the critical habitat within the Makua action area for this species has a native plant component of more than 75 percent (U.S. Army Garrison 1999a; K. Kawelo, pers. comm. 2004).

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Bonamia menziesii* 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. There are roughly 60 individuals of *B. menziesii* remaining on the island of Oahu with 12 in the Makua action area. There is a risk of losing a significant proportion of this species from the island of Oahu since 10 individuals of *B. menziesii* are located in the high fire risk zone. Less than one percent of the designated critical habitat on Oahu for this species is located in the high fire risk zone.

Conservation Needs of the Species and Critical Habitat in the Action Area Conservation actions that should be implemented for the recovery of *Bonamia menziesii* 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). Conservation actions required for stabilization are described in the "Stabilization" section of the project description for this opinion. However, *B. menziesii* 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).

Ongoing Conservation Actions for the Species and Critical Habitat within the Action Area A portion (less than one percent) of critical habitat in the Makua action area is in the Kaluakauila Management Unit. The Army has prepared a fire management plan for this management unit to reduce the vulnerability of these plants from training related fires. In addition, the unit is fenced, and non-native plants and rats are controlled within the exclosure. Individuals within these fenced units will benefit from ungulate enclosure and from ecosystem level management.

Status of the Species and Critical Habitat – *Cenchrus agrimonioides* var. *agrimonioides* (Kamanomano)

Species Description *Cenchrus agrimonioides* var. *agrimonioides* is a perennial bunchgrass in the Poaceae (grass) family. An individual plant usually consists of few to many stems originating from a common base. Stems have been observed in the Waianae Mountains with lengths up to 2 m (6.6 ft), but they are usually only 0.5 m (1.6 ft) in length. Initially upright or at an angle, the stems recline on the ground as they lengthen. The flowers are encased in spiny burs borne on slender spikes that measure 5 to 10 cm (2 to 4 in) long. Each bur contains two flowers, one fertile and one sterile. The fertile flowers are perfect (possessing male and female reproductive parts) (Wagner et al 1999).

Listing Status *Cenchrus agrimonioides* var. *agrimonioides* was federally listed as endangered on October 10, 1996 (61 FR 53108), and state listed as endangered in Hawaii at the same time. A recovery plan was prepared for this species in July 1999 (Service 1999b), and critical habitat was designated on June 17, 2003 (68 FR 35950).

Historic and Current Distribution *Cenchrus agrimonioides* var. *agrimonioides* is endemic to the Hawaiian Islands. Historically, *C. agrimonioides* var. *agrimonioides* occurred on Oahu, Maui, Lanai, and Hawaii. It has been collected from four general areas: the Waianae Mountains of Oahu, West Maui (where it was recently discovered in 1996), the south slope of Haleakala on East Maui, and the island of Lanai. It was reported from the island of Hawaii in the 1800s, but no specimens from that island are known to exist in herbarium collections today. When this species was listed in 1996, there were six occurrences totaling fewer than 100 individuals State-wide, including one occurrence from the Kanaio Natural Area Reserve on Maui and the remainder on Oahu. Trends in numbers indicate an increase since listing State-wide (Service 2004b). In the U.S. Army Garrison status report (2005c), the Army lists 529 plants from four population units in the Waianae Mountains. These population units include: Kahanahaiki and Pahole (71 mature, 31 immature, and 47 seedlings, plus 192 augmented mature, 47 augmented immature and one augmented seedling), Central Ekahanui (30 mature, three immature, and 16 seedlings, plus 56 augmented mature plants), Makaha and Waianae Kai (14 mature plants), and South Huliwai (21 mature plants) (Table SB 5). State-wide occurrences of *Cenchrus agrimonioides* var. *agrimonioides* are known from Federal, State, city/county, and private lands (61 FR 53108).

On Oahu, about 85 percent of the total *Cenchrus agrimonioides* var. *agrimonioides* individuals are mature plants, seven percent are naturally recruited seedlings or immature plants, and seven percent are immature augmentations (U.S. Army Garrison 2006c). *Cenchrus agrimonioides* var. *agrimonioides* is characterized by one stabilization population unit on Oahu (Kahanahaiki and Pahole population unit) that exceeds the 50 mature, reproducing individuals threshold, representing about 60 percent of all individuals from the island.

Table SB 5. Range-wide Distribution of *Cenchrus agrimonioides* var. *agrimonioides*.

Population Units	**Number of Known Individuals**					
	1996 (1)	**1999** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Kahanahaiki and Pahole*	--	23	28/9[‡]	66/23 [182/57][§]	71/75 [202/42]	71/31 [245/54]

East Makaleha	--	6	--	--	--	--
Makaha*	--	10	5/3	9/2	13/4	14/0
Waianae Kai*	--		4			
Central Ekahanui*	--	--	20	30/3	30/19 [6/27]	30/19 [56/0]
South Huliwai	--	--	27	18	21	21/0
Kaluaa	--	--	--	--	--	[0/163]
Total Individuals on Oahu	**<100**	**<100**	**103** (91/12)†	**390** (123/28) [182/57]	**510** (135/98) [208/69]	**704** (136/50) [301/217]
Total Individuals on Other Islands	--	--	**7** (7/0)	--	--	--
Total Population Units State-wide	--	--	--	--	--	--
Total Individuals State-wide	**610**	**600**	**457** (447/10)	--	--	--

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

(1) Listing rule (61 FR 53108)
(2) Recovery plan (Service 1999a)
(3) Critical habitat rule (68 FR 35950) and MIP (MIT 2003)
(4) MIP Addendum and 2004 status update (U.S. Army Garrison 2005a, 2004)
(5) 2005 status update (U.S. Army Garrison 2005b)
(6) 2006 status update (U.S. Army Garrison 2006c, 2006d)

Ecology *Cenchrus agrimonioides* var. *agrimonioides* is usually found on ridges and on upper gulch slopes, often in the understory of mesic forests. Recorded elevations for this taxon range from 560 to 872 m (1,830 to 2,860 ft) (61 FR 53108). A specimen collected in 1912 from the "Leilehua Plain" indicates that the taxon may also have occurred in lower and drier locations than where it is known today (U.S. Army Garrison 2003b).

Cenchrus agrimonioides var. *agrimonioides* reproduction appears to be mostly sexual as reproduction of the plants by vegetative means is seldom observed. As with most grasses, *C. agrimonioides* var. *agrimonioides* is wind-pollinated. Isolated cultivated plants have been observed to self-pollinate and produce viable seeds. Flowering has been reported from January through July. The spiny burs that contain the seeds of this taxon stick to the fur of mammals or the feathers of birds. With the complete absence of ground mammals in pre-human Hawaii, it is hypothesized that these burrs may have been dispersed by the many now-extinct species of flightless Hawaiian birds (Makua Implementation Team 2003). Certain plants currently in cultivation are four years old and still vigorous. Other demographic information for *C. agrimonioides* var. *agrimonioides* in the wild is unknown, including the species' longevity in the wild, which is assumed to be less than 10 years since it is a relatively small, non-woody plant (U.S. Army Garrison 2003b).

Threats to the Species *Cenchrus agrimonioides* var. *agrimonioides* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described under the "General

Status and Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. In addition, the Makaha and Waianae Kai occurrences are threatened by trampling from hikers, as most of the plants in this area are found along the edge of a major trail. Additional threats to plants include cattle and axis deer grazing on Maui (U.S. Army Garrison 2003b).

Conservation Needs of the Species Conservation actions that should be implemented for the recovery of *Cenchrus agrimonioides* var. *agrimonioides* 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 recovery plan for this species identifies important conservation actions which include protection from fire, maintenance of adequate genetic stock, fencing, non-native plant control, and outplanting of local genetic material to enhance existing populations and establish new populations. In addition, surveys of the northwestern Hawaiian Islands of Laysan, Kure, and Midway and collection of genetic material from any discovered plants should be conducted (Service 1999b).

Ongoing Conservation Actions Since listing, the Makua Implementation Team (2003) has developed stabilization protocols for *Cenchrus agrimonioides* var. *agrimonioides* which are incorporated in the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). One stabilization population (Kahanahaiki and Pahole population unit) with approximately 300 individuals now occurs largely through the efforts of outplanting by the U.S. Army. This species is represented in the following *ex situ* collections: 134 cuttings in a nursery (Army Environmental Division, Oahu), seven mature fruits in storage or awaiting processing at a nursery (Army Environmental Division, Oahu), three plants in a botanical garden (Waimea Valley Audubon Center), 937 ungerminated seeds in nurseries (Army Environmental Division, Oahu and Harold L. Lyon Arboretum), and 8,471 seeds in seed storage (Lyon Arboretum Seed Storage Facility) (Service 2005b; U.S. Army Garrison 2005d). A long-range management plan for Honouliuli Preserve has been drafted, which will include actions for non-native plant management, ungulate control, fire control, rare species recovery, and native habitat restoration. It is expected that these actions will benefit *C. agrimonioides* var. *agrimonioides* within the preserve (Makua Implementation Team 2003; Service 2005b; U.S. Army Garrison 2005d).

Critical Habitat Description Critical habitat was designated for this species on May 14, 2003, on Maui and on June 17, 2003, on Oahu. A total of 1,242 ha (3,069 ac) in six separate units has been designated for *Cenchrus agrimonioides* var. *agrimonioides*. Two critical habitat units totaling 355 ha (878 ac) were designated on the island of Maui and include State (Kanaio Natural Area Reserve, West Maui Forest Reserve) and private lands. A total of 886 ha (3,068 ac) in four units was designated on Oahu on State (Mokuleia Forest Reserve, Waianae Forest Reserve, Kaala Natural Area Reserve) and private lands (Honouliuli Preserve). Each of the critical habitat units on Maui and three of the units on Oahu provide habitat for one population, and one critical habitat unit on Oahu provides habitat for four populations of *C. agrimonioides* var. *grimonioides*. To meet recovery goals, each population should be represented by at least 300 mature, reproducing individuals (68 FR 35950).

The primary constituent elements for the units on Oahu include dry ridges, upper slopes, or ridges in lowland mixed mesic forest containing one or more of the following associated native plant species: *Acacia koa*, *Alyxia oliviformis*, *Bobea* sp., *Carex wahuensis*, *Chamaesyce multiformis*, *Coprosma*

foliosa, *Diospyros sandwicensis*, *Eragrostis variabilis*, *Gahnia beecheyi*, *Leptecophylla tameiameiae*, *Metrosideros polymorpha*, *Nestegis sandwicensis*, *Psychotria* sp., or *Psydrax odorata*. *Cenchrus agrimonioides* grows on Oahu at elevations between 357 and 874 m (1,171 and 2,867 ft). 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 that 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 "Status and Environmental Baseline of the Species and Critical Habitat" section. An additional threat to this species is trampling by humans (68 FR 35950).

Environmental Baseline of the Species and Critical Habitat

Status of the Species in the Action Area Approximately 57 percent of all known individuals of *Cenchrus agrimonioides* var. *agrimonioides* on the island of Oahu are located within the action area, within the Kahanahaiki to Pahole population units. Trends in total number of individuals indicate an overall increase in the population from approximately 25 to approximately 400 individuals from 1999 to 2006. Of the approximately 400 individuals in the action area, approximately 300 have been planted as augmentations (Service 2005b, U.S. Army Garrison 2005c, 2005d). Approximately 194 individuals occur in the low fire risk zone and approximately 207 occur in the very low fire risk zone.

Status of Critical Habitat in the Action Area 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. 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 the two low fire risk zones with 14.8 ha (36.7 ac) in the low and 174 ha (430 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). It is estimated that more than one-half of the critical habitat is located in an area with a minimum of 50 percent native plant cover (U.S. Army Garrison 2003b; L. Durand, pers. comm. 2004; K. Kawelo, pers. comm. 2004).

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Cenchrus agrimonioides* var. *agrimonioides* 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. In addition, as a grass, *C. agrimonioides* var. *agrimonioides* is vulnerable to grazing pressure from feral ungulates and training related wildfires (U.S. Army Garrison 2003b; K. Kawelo, pers. comm. 2004; 68 FR 35950).

Conservation Needs of the Species and Critical Habitat in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) includes *Cenchrus agrimonioides* var. *agrimonioides* because no stabilization populations that meet minimum numeric criteria exist outside the Makua action area. Three population units have been identified for stabilization. This taxon will be stabilized because fewer than three stabilization population units exist outside of the Army action area. To be considered numerically stabilized *C. agrimonioides* var. *agrimonioides* must meet the criteria required for stability

of a short-lived perennial including 50 mature, reproducing individuals per population and threats abated. Species stabilization measures include: habitat and population management of three population units, augmentation of existing populations, collection of full *ex situ* representation of wild stock on Oahu; non-native plant control, and ungulate control (U.S. Army Garrison 2003b).

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 Within the Action Area Eighty-six percent (235 ha; 581 ac) of the critical habitat for *Cenchrus agrimonioides* var. *agrimonioides* is located in designated management units (Lower and Upper Kapuna, Pahole, and West Makaleha) on Oahu. This species is being managed for stabilization as specified by the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005b). The Kahanahaiki Management Unit is fenced and ungulates are excluded. A portion of Upper Pahole Management Unit is fenced, and fencing is planned for Upper Kapuna and West Makaleha Management Units (U.S. Army Garrison 1999a; U.S. Army Garrison 2003b; K. Kawelo, pers. comm. 2004). Other conservation activities include non-native plant removal, application of rodenticide, fuel modification, habitat restoration, and black twig borer and slug control (U.S. Army Garrison 1999a; U.S. Army Garrison 2003b; K. Kawelo, pers. comm. 2004). There are seven naturally occurring populations, and two large augmentation sites of C. *agrimonioides* var. *agrimonioides* in the Kahanahaiki and Pahole management units. Three of the Kahanahaiki sites are located inside the Kahanahaiki fence; the fourth has one mature, two immature, and one seedling, and is outside the fence. All of the Pahole locations are within the exclosure. This population unit has more than 50 reproducing individuals and all threats have been controlled. Natural Resources Staff and the Natural Area Reserve System specialists collected seeds and conducted weed control in 2005. Seed collected from the two Pahole *in situ* sites will be propagated and outplanted into a new reintroduction site in Pahole in 2006-2007, pending State permission (U.S. Army Garrison 2006c). Natural Resources Staff outplanted 60 plants from the Kahanahaiki stock into Pahole in December 2000. This reintroduction has flourished and 51 F1 generation plants on-site are either immature or have already matured. Genetic storage goals for *C. agrimonioides* var. *agrimonioides* are less than one percent complete. Weed control and monitoring are conducted at reintroduction sites established in Kahanahaiki to Pahole population unit (U.S. Army Garrison 2006c).

Status of the Species and Critical Habitat – *Chamaesyce celastroides* var. *kaenana* (Akoko)

Species Description *Chamaesyce celastroides* var. *kaenana*, a member of the spurge family (Euphorbiaceae), is a low-growing prostrate or upright shrub approximately 1 to 2 m (3.3 to 6.6 ft) tall. The stems have milky sap and are thick and knobby. The leaves, which fall off during the dry season, are mostly hairless and are arranged in two opposite rows along the stem; they are 20 to 65 mm (0.8 to 2.6 in) long, 8 to 20-mm (0.3 to 0.8 in) wide, and are widest at the tip. The flowers are borne on compact side branches, each of which bears 5 to 10 cyathia (specialized flower-like inflorescences with a single central female flower surrounded by much-reduced male flowers). Each flower cluster (cyathia) produces a small, erect capsule which measures 2 to 2.5 mm (0.1 in) long and contains three seeds. Seeds are small, spherical, and gray or white (Wagner et al 1999). A different subspecies, *C. celastroides* ssp. *lorifolia*, located

on the south slope of Haleakala, Maui, has been observed reproducing by vegetative means via root suckers. With *C. celastroides* var. *kaenana*, however, vegetative reproduction has not been reported (Sherff 1938; Kimura and Nagata 1980; Koutnik 1987; Koutnik and Huft 1990; U.S. Army Garrison 2003b).

Listing Status *Chamaesyce celastroides* var. *kaenana* was federally and State listed as endangered on October 29, 1991 (56 FR 55770). A recovery plan was prepared for this species in 1995 and 1998 (Service 1995a, 1998a). Critical habitat was designated for *C. celastroides* var. *kaenana* on the island of Oahu on June 17, 2003 (68 FR 35950).

Historic and Current Distribution *Chamaesyce celastroides* var. *kaenana* is endemic to the Hawaiian Islands. Historically *C. celastroides* var. *kaenana* occurred in the northwestern portion of the Waianae Mountains as well as the southeastern portion of the Koolau Mountains on the island of Oahu (as indicated from one collection) (Koutnik 1987; Koutnik and Huft 1990; Hawaii Natural Heritage Program 2004). The nine known populations are all located within the vicinity of Kaena Point and Makua Valley on State and Federal lands and contain fewer than 900 individuals (J. Lau, pers.comm. 1990; Hawaii Natural Heritage Program 2004; U.S. Army Garrison 2005c).

About the time of listing this species there were only 300 individuals at five known sites. Today this species appears to be increasing since there are approximately 951 mature plants and 100 immature plants and seedlings in nine occurrences (Service 2006c) (Table SB 6). Thirty-six individuals of this species burned during a prescribed burn the Army conducted in July 22, 2003, (35 within North Kahanahaiki and one plant in the East Kahanahaiki population). The individual impacted by the prescribed burn in East Kahanahaiki appears to be recovering, although not reproducing (L. Durand, pers. comms. 2003, 2004; U.S. Army Garrison 2004a; U.S. Army 2005c). Recent survey data indicates numbers for this species is fairly stable to increasing from population estimates of 545 in 1995 to population estimates over 950 in 2006 (Service 1999b; U.S. Army Garrison 2005c, 2006c). However, particular decreases in populations in Kaluakauila and Waianae may indicate a change in the robust nature of this species. *Chamaesyce celastroides* var. *kaenana* populations are located on Federal, State, city/county, and private lands. Approximately 90 percent of the Oahu *C. celastroides* var. *kaenana* individuals are mature plants with 10 percent populations represented by immature augmentations. Thus, *C. celastroides* var. *kaenana* is characterized by four population units (three of which exceed the 25 mature, reproducing individuals stabilization criteria) on Oahu that represent about 56 percent of all individuals.

Table SB 6. Range-wide Distribution of *Chamaesyce celastroides* var. *kaenana*.

Population Units	**Number of Known Individuals**					
	1991 (1)	**1995** (2)	**2003** (3)	**2004** (4)	**2005** (5)	**2006** (6)
Kaluakauila	--	--	17/1‡	12/7	12/7	6/4
Makua (Lower Ohikilolo)*	--	--	36/4	55/57	89/65	89/65
North Kahanahaiki	--	--	218	177	177	177/0

Puaakanoa	--	--	147/10	145/10	145/10	160/10
East Kahanahaiki	--	--	2	2	2	2/0
Kaena (East of Alau)*	--	--	21/5	21/4	21/24	21/24
Kaena and Keawalua (Kaena)*	--	--	300	300	300	300/0
Kaena and Keawalua (Keawaula)	--	--	69/6	24/1	24/1	56/4
Waianae Kai*	--	--	48	33	33	33/0
Total Individuals on Oahu	**<300**	**545**	**884** (858/26)†	**848** (769/79)	**910** (803/107)	**951** (844/107)

Shaded population units are inside the action area.
*Stabilization population units
‡Total mature/immature individuals
†Total (mature/immature)

(1) Listing rule (56 FR 55770)
(2) Recovery plan (Service 1995a)
(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)
(6) 2006 status update (U.S. Army Garrison 2006c)

Ecology *Chamaesyce celastroides* var. *kaenana* typically grows in coastal dry shrubland on windward talus slopes at an elevation of 9 to 640 m (30 to 700 ft) (Hawaii Natural Heritage Program 1990; Koutnik and Huft 1990). *Chamaesyce celastroides* var. *kaenana* is a long-lived perennial that is deciduous in summer. It has been observed flowering and fruiting throughout the year, probably in response to precipitation. Fruits mature in three to four weeks. Little is known about the breeding system of *C. celastroides* var. *kaenana*; however, the genus as a whole is usually monoecious (male and female flowers on different parts of the cyathium) or rarely dioecious (male and female flowers on separate plants). It is not known if the taxon is capable of self-fertilization (U.S. Army Garrison 2003b). Most plants, including the plants in the large colony at Kaena Point, grow on gentle to moderately steep slopes consisting of soil and rock. Others, including many of the plants on the leeward side of the Waianae Mountains, grow on nearly vertical cliff faces. Most sites are now dominated by non-native plants, particularly non-native grasses and *Leucaena leucocephala*. Some sites on the leeward side of the Waianae Mountains still maintain native vegetation. The vegetation on these cliffs is usually sparse, consisting mostly of native shrubs, grasses, and sedges (U.S. Army Garrison 2003b). Other demographic information for *C. celastroides* var. *kaenana* in the wild is unknown.

Threats to the Species *Chamaesyce celastroides* var. *kaenana* was listed as endangered because of major ecosystem-level threats to its survival and recovery, which are described under "General Status and Baseline of the Species and Critical Habitat" section and tabulated in Appendix E. The major threats to *C. celastroides* var. *kaenana* are listed as effects of recreational activities (U.S. Army Garrison 2003b; K. Kawelo, pers. comm. 2004; 68 FR 35950). It is not known if non-native *Chamaesyce* species present in Hawaii could possibly hybridize with the native taxa (Service 1998a; U.S. Army Garrison 2003b). In addition, *C. celastroides* var. *kaenana* is vulnerable to trampling by humans along trails in the Kaena Point Natural Area Reserve and habitat degradation from stochastic events such as landslides, hurricanes, and flooding (68 FR 35950). *Chamaesyce celastroides* var. *kaenana* is vulnerable to extirpation

from naturally occurring events such as landslides, hurricanes, flooding, and/or reduced reproductive vigor due to small population size and limited distribution (56 FR 55770; Service 1999b). Thus, *C. celastroides* var. *kaenana* has a high background risk of 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 *Chamaesyce celastroides* var. *kaenana* 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. At least 300 mature, reproducing individuals are needed per population unit to attain stability for long-lived individuals. The recovery plan identifies actions necessary for this species' conservation. Management actions should include fencing, non-native plant control, protection from fire, and outplanting of local genetic material (Service 1998a).

Ongoing Conservation Actions Since listing, the Makua Implementation Team (2003) has developed stabilization protocols for *Chamaesyce celastroides* var. *kaenana* which are incorporated in the Makua Implementation Plan Addendum (U.S. Army Garrison 2005a). The Hawaii Natural Area Reserves System is managing Kaena Point for the recovery of the native vegetation and bird life. The Division of Forestry and Wildlife has restricted off-road vehicle access to the Kaena Point Natural Area Reserve by constructing a large barrier on the Mokuleia side of the reserve. Access from the Waianae side is prevented by a natural washout. Three individuals were outplanted at the Kaena Point Natural Area Reserve in 1995, and, as of July 1997, only one plant survived. Other management activities in the Kaena Point Natural Area Reserve include outplanting and removal of *Leucaena leucocephala* and *Prosopis pallida* in the vicinity of *C. celastroides* var. *kaenana*.

At Makua, the Army Natural Resources Staff have been conducting fuel management, weed control, firebreaks, and genetic storage for this species pursuant to the Makua Implementation Plan Addendum. Propagation material for this species is currently held at the following institutions: Army Environmental Division on Oahu, Harold L. Lyon Arboretum, Lyon Arboretum Seed Storage Facility, National Tropical Botanical Garden, and Waimea Arboretum. The Waianae populations are monitored by the Natural Resources Staff, but are not actively managed due to their location on steep cliffs. In addition, a State-wide strategic plan is being developed by the Hawaii and Pacific Plant Recovery Coordinating Committee that will address the long-term conservation of *Chamaesyce celastroides* var. *kaenana*. This plan will also include broader landscape actions that are needed for the recovery of this species throughout its range (Service 1998a, 2003b; Hawaii and Pacific Plant Recovery Committee 2007). The *ex situ* collections for *C. celastroides* var. *kaenana* include 16 apical or lateral vegetative buds in micropropagation (Harold L. Lyon Arboretum), 58 cuttings in nurseries (Army Environmental Division, Oahu and Harold L. Lyon Arboretum), nine plants in a botanical garden (Waimea Valley Audubon Center), and 5,516 seeds in seed storage (Lyon Arboretum Seed Storage Facility) (Service 2005b).

Critical Habitat Description A total of 520 ha (1,284 ac) on the island of Oahu has been designated for this species in five separate units. This land was designated to reach the recovery

goal of 8 to 10 populations for this species. Critical habitat has been designated on State land (Kaena Point State Park, Kuaokala Forest Reserve, and Waiane Forest Reserve) and private land. Three of the designated units provide habitat for one population each and two units provide habitat for two populations each of 300 mature, reproducing individuals of *Chamaesyce celastroides* var. *kaenana* (68 FR 35950).

The primary constituent elements for these units include windward talus slopes, leeward rocky cliffs, open grassy slopes, or vegetated cliff faces in coastal dry shrubland containing one or more of the following associated native plant species: *Artemisia australis*, *Boerhavia* sp., *Chamaesyce celastroides* var. *amplectens*, *Dodonaea viscosa*, *Gossypium tomentosum*, *Heteropogon contortus*, *Jacquemontia ovalifolia* ssp. *sandwicensis*, *Lipochaeta lobata*, *Myoporum sandwicense*, *Plumbago zeylanica*, *Psilotum nudum*, *Psydrax odorata*, *Santalum freycinetianum*, *Sida fallax*, or *Waltheria indica*. *Chamaesyce celastroides* var. *kaenana* grows at elevations just above sea level to 862 m (0 to 2,827 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 required for the conservation of this species (68 FR 35950).

Threats to 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 Of the approximately 950 total range-wide individuals of *Chamaesyce celastroides* var. *kaenana*, roughly 511 (54 percent) are located within the Makua action area. Trends in abundance indicate an overall increase in *C. celastroides* var. *kaenana* individuals in the action area since the 1990s due to augmentation with immature plants and discovery of new mature individuals in the wild. The North Kahanahaiki, East Kahanahaiki, Kalaukauila, and Puaakanoa population units are at risk from training-related wildfire. All of these units (550 individuals) are in the high fire risk zone. Demographic data suggests, 85 percent of the individuals in the action area are mature and 15 percent are immature augmentations.

Status of Critical Habitat in the Action Area The action area contains a total of 30 ha (73 ac), or six percent, of the total critical habitat for *Chamaesyce celastroides* var. *kaenana* island-wide. Designated critical habitat is located within three units that either lie in or overlap the action area. One critical habitat unit is approximately 4 ha (10 ac), and less than one-half ha (1 ac) of this unit is located in the Kaluakauila Management Unit. Another critical habitat unit is (4 ha; 10 ac) located south of the Lower Ohikilolo Management Unit. Both of these units abut the high fire risk zone. A third critical habitat unit 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 1 km (0.6 mi) from the high fire risk zone. About six percent of critical habitat for this subspecies is located in an area at risk from training-related wildfire, with less than one percent of the species' range-wide critical habitat located in the high fire risk zone. The other five percent of the species' range-wide critical habitat located in the action area comprises another two percent of the species' total critical habitat. Approximately 75

percent of the critical habitat that is located in an area has 0 to 25 percent native plant coverage, and 25 percent is in an area with 75 to 100 percent native plant coverage (L. Durand, pers. comm. 2003; U.S. Army Garrison 2003b; K. Kawelo, pers. comm. 2004).

Threats to the Species and Critical Habitat in the Action Area The primary threats to *Chamaesyce celastroides* var. *kaenana* 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 and its designated critical habitat are both very vulnerable to training related fires due to xeric conditions and proximity to the impact area (U.S. Army Garrison 2003b; K. Kawelo, pers. comm. 2004). The effects of recreational activities and accidental fires are a major threat to *C. celastroides* var. *kaenana*. Several population units have been affected by fire in the last two decades, namely the units of Kaena (East of Alau), Kaena and Keawaula, Lower Ohikilolo, Punapohaku, and possibly Kaluakauila. In addition, in 2003, a prescribed burn that went out of prescription burned several plants in the Kahanahaiki region within Makua. The increasing amount of non-native grasses in the lowlands of the Waianae Range increases the fire threat to this taxon. It is not known if non-native *Chamaesyce* species present in Hawaii could possibly hybridize with the native taxa (Service 1998a; U.S. Army Garrison 2003b).

Conservation Needs of the Species and Critical Habitat in the Action Area The Makua Implementation Plan Addendum (U.S. Army Garrison 2005a) includes *Chamaesyce celastroides* var. *kaenana* because fewer than three stable population units exist outside of the Army action area. Four population units have been identified for stabilization. To be considered stable, *C. celastroides* var. *kaenana* must meet the criteria required for stability for a short-lived perennial. The stabilization plan for this taxon includes: habitat and population management of three population units, augmentation of existing populations, collection of full *ex situ* representation of wild stock on Oahu, non-native plant control, and ungulate control. Collection of genetic material will be conducted for all individuals plants located within the boundary of the installation boundary (U.S. Army Garrison 2003b). A post-fire revegetation plan should be developed for the Kaluakauila Management Unit. Research regarding the control of slugs, the black twig borer, and the Chinese rose beetle is important for the protection of all endangered and threatened species habitat because these non-native species pose a significant threat to the health of the native habitat. The approval of aerial dispersal of rodenticide within forest habitat is also needed because rats consume many native seeds and plant parts, which contributes to the degradation and destruction of the native forest (K. Kawelo, pers. comm. 2004). 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 Kaena to Keawaula, Kaena, Waianae Kai and Makua population units, which contain approximately 60 percent of the total remaining individuals of *Chamaesyce celastroides* var. *kaenana* on Oahu, are being managed for stabilization as specified by the Army's Makua Implementation Plan Addendum (U.S. Army Garrison 2005b. Of the 41 ha (102 ac) of critical habitat in the action area, five percent (0.4 ha; 1 ac) is within the Kaluakauila Management Unit. Several ongoing actions being conducted by the Army Natural Resources Staff will benefit both the species and the critical habitat in the Makua action area. Fuel modification is being