

Tetramolopium arenarium
(No common name)

**5-Year Review
Summary and Evaluation**

**U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Honolulu, Hawaii**

5-YEAR REVIEW

Species reviewed: *Tetramolopium arenarium* (No common name)

TABLE OF CONTENTS

1.0	GENERAL INFORMATION	3
1.1	Reviewers.....	3
1.2	Methodology used to complete the review:.....	3
1.3	Background:.....	3
2.0	REVIEW ANALYSIS	5
2.1	Application of the 1996 Distinct Population Segment (DPS) policy.....	5
2.2	Recovery Criteria.....	5
2.3	Updated Information and Current Species Status	7
2.4	Synthesis.....	17
3.0	RESULTS	19
3.1	Recommended Classification:.....	19
3.2	New Recovery Priority Number:.....	19
3.3	Listing and Reclassification Priority Number:	19
4.0	RECOMMENDATIONS FOR FUTURE ACTIONS	20
5.0	REFERENCES	21
	Signature Page.....	25

5-YEAR REVIEW
***Tetramolopium arenarium* (No common name)**

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office:

Region 1, Endangered Species Program, Division of Recovery, Jesse D'Elia,
(503) 231-2071

Lead Field Office:

Pacific Islands Fish and Wildlife Office, Loyal Mehrhoff, Field Supervisor, (808)
792-9400

Cooperating Field Office(s):

N/A

Cooperating Regional Office(s):

N/A

1.2 Methodology used to complete the review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office of the U.S. Fish and Wildlife Service (USFWS), beginning on April 8, 2010. The review was based on the proposed designation of critical habitat for *Tetramolopium arenarium* and the recovery plan for the Big Island plant cluster (USFWS 2002, 1996), as well as a review of current, available information. The Bernice Pauahi Bishop Museum provided an initial draft of portions of the review and recommendations for conservation actions needed prior to the next five-year review. The evaluation of Samuel Aruch, biological consultant, was reviewed by a recovery biologist and the Plant Recovery Coordinator. The document was then reviewed by the Recovery Program Leader and the Assistant Field Supervisor for Endangered Species before submission to the Field Supervisor for approval.

1.3 Background:

1.3.1 Federal Register (FR) Notice citation announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; 5-year review status of 69 species in Idaho, Washington, Hawaii, Guam, and the Commonwealth of the Northern Mariana Islands. Federal Register 75(67):17947-17950.

1.3.2 Listing history

Original Listing

FR notice: USFWS. 1994. Endangered and threatened wildlife and plants; determination of endangered or threatened status for 21 plants from the island of Hawaii, State of Hawaii; final rule. Federal Register 59(43):10305-10325.

Date listed: March 4, 1994

Entity listed: Species

Classification: Endangered

Revised Listing, if applicable

FR notice: N/A

Date listed: N/A

Entity listed: N/A

Classification: N/A

1.3.3 Associated rulemakings:

USFWS. 2003a. Endangered and threatened wildlife and plants; designation of critical habitat for 60 plant species from the islands of Maui and Kahoolawe, Hawaii; final rule. Federal Register 68(93):25934-26165.

USFWS. 2003b. Endangered and threatened wildlife and plants; final designation and nondesignation of critical habitat for 46 plant species from the island of Hawaii, Hawaii; final rule. Federal Register 68(127):39624-39761.

No critical habitat was designated for the multi-island species *Tetramolopium arenarium* in the Hawaiian Islands. On Maui, information on the physical and biological features essential to the conservation of this species on the island was unknown, so no critical habitat designation was possible (USFWS 2003a). On Hawaii Island, no critical habitat was designated for *T. arenarium* because all of the habitat containing the physical and biological features essential to the conservation of this species occurred on federally-owned land at Pohakuloa Training Area, which were excluded from critical habitat designation because an agreement with the U.S. Army Garrison of Hawaii to continue its excellent track record of natural resource stewardship at Pohakuloa Training Area (USFWS 2003b).

1.3.4 Review History:

Species status review [FY 2011 Recovery Data Call (August 2011)]:

Declining

Recovery achieved:

1 (0-25%) (FY 2007 Recovery Data Call)

1.3.5 Species' Recovery Priority Number at start of this 5-year review:

5

1.3.6 Current Recovery Plan or Outline

Name of plan or outline: USFWS. 1996. Recovery plan for the Big Island plant cluster. U.S. Fish and Wildlife Service, Portland, Oregon. 176 pages + appendices. Available online at <http://www.fws.gov/pacificislands/recoveryplans.html>.

Date issued: September 26, 1996

Dates of previous revisions, if applicable: N/A

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

Yes
 No

2.1.2 Is the species under review listed as a DPS?

Yes
 No

2.1.3 Was the DPS listed prior to 1996?

Yes
 No

2.1.3.1 Prior to this 5-year review, was the DPS classification reviewed to ensure it meets the 1996 policy standards?

Yes
 No

2.1.3.2 Does the DPS listing meet the discreteness and significance elements of the 1996 DPS policy?

Yes
 No

2.1.4 Is there relevant new information for this species regarding the application of the DPS policy?

Yes
 No

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes
 No

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

Yes
 No

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?

Yes
 No

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

A synthesis of the threats (Listing Factors A, B, C, D, and E) affecting this species is presented in Section 2.3.2 and Table 2.

Stabilizing, downlisting, and delisting objectives are provided in the recovery plan for the Big Island plant cluster (USFWS 1996), based on whether the species is an annual, a short-lived perennial (fewer than ten years), or a long-lived perennial. *Tetramolopium arenarium* is a short-lived perennial, and to be considered stabilized, which is the first step in recovering the species, the taxon must be managed to control threats (*e.g.*, fenced) and be represented in an *ex situ* (off-site) collection. In addition, a minimum of three populations should be documented on the Big Island (Hawaii Island). For the species to be considered stable, each of these populations must be naturally reproducing and increasing in number, with a minimum of 50 mature individuals per population.

This recovery objective has not been met.

For downlisting, a total of five to seven populations of *Tetramolopium arenarium* should be documented on the island of Hawaii. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 300 mature individuals per population. Each population should persist at this level for a minimum of five consecutive years before downlisting is considered.

This recovery objective has not been met.

For delisting, a total of eight to ten populations of *Tetramolopium arenarium* should be documented on the island of Hawaii. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with 300 mature individuals per population. Each population should persist at this level for a minimum of five consecutive years before delisting is considered.

This recovery objective has not been met.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Flowering has been observed in January, April, and August (Douglas and Shaw 1989), and in the fall and early winter (Center for the Environmental Management of Military Lands [CEMML] 2003a), and seed production has been observed in late winter and spring (CEMML 2003a). Douglas and Shaw (1989) noted that the occurrence of juveniles indicated that viable seed was being produced and that environmental conditions necessary for seed germination and seedling establishment occurred periodically.

In germination studies of the genus *Tetramolopium*, Falkner *et al.* (1997) noted that *T. arenarium* demographically appeared to be of unimodal size-class distribution, suggesting that the population was a single cohort moving through time, with little recruitment. The authors theorized that *T. arenarium* might have reduced competitive abilities, and might require periodic disturbance, such as that associated with fire, to create the necessary regeneration sites to ensure its long-term survival; fire adaptation would also help explain the even-aged population structure observed in the field (Falkner *et al.* 1997). While soil moisture and seedbed characteristics were important for germination, light intensity was the primary factor controlling successful establishment and growth of *Tetramolopium* species under greenhouse conditions. Translated to the arid Pohakuloa Training Area environment, it would require a prolonged period of high rainfall followed by a sunnier period with adequate moisture, and would occur even less frequently if these conditions had to be shortly preceded by a disturbance event, such as a fire (Falkner *et al.* 1997). A period of prolonged, above-average precipitation at Pohakuloa Training Area in 1989 to 1990, however, was not followed by successful recruitment in either *T. arenarium* or *T. lepidotum*, and only a small amount of recruitment in *T. consanguineum*, showing the complexity of rare plant seed biology (Falkner *et al.* 1997). Young plants were noted from germinating seeds following the 1994 Kipuka Kalawamauna fire (CEMML 2003a), although Beavers and Burgan (2002) noted that seed regeneration following fire was slow.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family

size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Historically, *Tetramolopium arenarium* was found on Maui on the western slope of Haleakala and on Hawaii Island from the Kohala Mountains, the northwestern slopes of Mauna Kea and Mauna Loa, and the slopes of Hualalai (USFWS 1994, 1996, 2002; CEMML 2003a). Wagner *et al.* (1999) considered the species to be extinct since it had not been collected since the late 1800s, and its habitats had little remaining native vegetation. However, Douglas and Shaw (1989) reported the rediscovery of *T. arenarium* subsp. *arenarium* on Hawaii Island within Kipuka Kalawamauna, located on the northwestern side of the U.S. Army's Pohakuloa Training Area, where it grew near three other endangered species: *Haplostachys haplostachya*, *Stenogyne angustifolia*, and *Lipochaeta venosa* (now known as *Melanthera venosa*). Two groups of individuals about 100 meters (328 feet) apart were found, totaling 114 mature individuals and 14 juvenile or seedlings. This remains as the only extant locality for the species (USFWS 2010).

At the time of listing (USFWS 1994), the only known population in Kipuka Kalawamauna (January 1993 census) consisted of 29 mature and 79 juvenile individuals within a 200 by 60 meter (660 by 200 foot) area. However, a devastating wildfire swept through Kipuka Kalawamauna in 1994, virtually extirpating the extant population, with only two individuals surviving the fire and no seedlings reestablished after the fire (USFWS 1996). In the same year, two new populations were discovered in the unburned portion of Kipuka Kalawamauna, comprising about 382 individuals (no breakdown of mature or juvenile's was given); these were the census numbers reported in the recovery plan for the taxon (USFWS 1996). During the Hawaii Island critical habitat review, two populations comprising less than 400 individuals were reported (USFWS 2002). In a biological assessment for the transformation of the 2nd Brigade 25th Infantry Division (Light) to a Stryker Brigade Combat Team, census totals for *Tetramolopium arenarium* were 160 mature and 106 juveniles (266 total individuals) in 25 locations (CEMML 2003a).

The Center for the Environmental Management of Military Lands (CEMML 2006) updated the census (as of December 2005) to 601 individuals located within two Intensive Management Units (IMU): IMU 8 with 600 individuals and IMU 12 containing a single individual, protected by emergency exclosures. At Intensive Management Unit 8, 13 new locations were recorded, adding 84 to 104 new individuals, for a grand total of 27 locations (CEMML 2003a). Above average rainfall helped to produce this large increase in the population between 2004 and 2005. Surveys in 2007 within the primary population at Kipuka Kalawamauna (now located in Area of Species Recovery 8) using a

complete census method located 12 additional individuals, bringing a grand total of 577 individuals of *Tetramolopium arenarium* (464 mature, 113 juveniles), compared to the 2006 census of 693 individuals (245 mature, 448 juveniles) (CEMML 2008).

At Kipuka Kalawamauna, there was a marked change in population demographics between 2006 and 2007 (CEMML 2008). Total numbers declined from 693 individuals to 577 individuals (a 17 percent decline); there were 75 percent fewer juveniles and 89 percent more mature individuals in 2007 compared to 2006; and the life stage composition of the population changed from 65 percent juvenile and 35 percent mature in 2006, to 20 percent juvenile and 80 percent mature in 2007 (CEMML 2008). This population shift followed above average rainfall during the winter of 2004 and 2005, resulting in a large flush of juvenile *Tetramolopium arenarium*. The unbalanced proportion of mature individuals in 2007 apparently was the result of a large cohort of juveniles growing to maturity. It was pointed out that in rare plant communities in this particular demographic stage, with a lack of juveniles to compose a stable base for the population, it was crucial that mature individuals remained healthy so that they could restore the soil seed bank for subsequent generations to germinate and recruit (CEMML 2008).

The latest estimate for *Tetramolopium arenarium* listed two populations containing more than 350 individuals (USFWS 2010). Lackey (2010), however, reported a dangerous drop in numbers due to extreme drought conditions in the Hawaiian Islands. Rainfall between January and July 2010 in the Pohakuloa Training Area habitat of *T. arenarium* totaled 1.19 centimeters (0.47 inches), about 3 percent of the normal annual average. As a result, *T. arenarium* numbers dropped from a high of 693 individuals in 2006 to just 27 individuals in June 2010, and just a single individual was considered healthy. This prompted an emergency management response to provide supplemental water until normal rainfall levels returned. Fifteen more individuals died by October 2010, leaving just 12 individuals (8 mature and 4 juveniles) of which 11 were considered healthy.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

No new information.

2.3.1.4 Taxonomic classification or changes in nomenclature:

Tetramolopium arenarium is a short-lived, erect perennial shrub in the sunflower family (Asteraceae) endemic to Maui and Hawaii. It was originally described as *Vittadinia arenaria* by Asa Gray in 1861 from

material collected during the United States Exploring Expedition of 1840 and 1841 (USFWS 1994, 1996; CEMML 2003a). Hillebrand (1888) transferred the species into the genus *Tetramolopium* and, at the same time, described a new infraspecific taxon, *T. arenarium* var. *dentatum*, which is endemic to Maui (USFWS 1994, 1996; CEMML 2003a). In 1934, Sherff described *T. arenarium* subsp. *arenarium* var. *confertum* from material collected at Nohonaohae near Waimea on Hawaii Island (Sherff 1934). In a revision of Hawaiian members of the genus, Lowrey (1986) described *T. arenarium* subsp. *laxum*, a Maui endemic known from Kula (East Maui) and “the sandhills of Maui,” and in the process synonymized *T. arenarium* var. *dentatum* under it. Lowrey’s taxonomic arrangement, which recognized three infraspecific taxa, was accepted in Wagner *et al.* (1999): *T. arenarium* subsp. *arenarium* var. *arenarium*; *T. arenarium* subsp. *arenarium* var. *confertum*; and *T. arenarium* subsp. *laxum*. All three infraspecific taxa were included in the final rule determining endangered species status for *T. arenarium* (USFWS 1994).

Tetramolopium arenarium subsp. *arenarium* var. *confertum* and *T. arenarium* subsp. *laxum* have not been observed since the late 1800s (Hawaii Biodiversity and Mapping Program 2010a, 2010b; Bishop Museum 2011) and are considered to be extinct (USFWS 2003a); they will not be further discussed in this review. Currently, a check of the *Flora of the Hawaiian Islands* website (Smithsonian Institution 2011) suggests that var. *confertum* is synonymized under *T. arenarium* subsp. *arenarium*. Because only *T. arenarium* subsp. *arenarium* is thought to still be extant (Plant Extinction Prevention Program 2010; USFWS 2010), references to *T. arenarium* throughout the remainder of this report will be referred under the new taxonomic changes as *T. arenarium* subsp. *arenarium*.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species’ within its historic range, etc.):

No new information.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

The habitat of *Tetramolopium arenarium* subsp. *arenarium* on Hawaii Island is lowland and montane dry shrublands dominated by *Dodonaea viscosa* (aalii), at 1,362 and 1762 meters (4,470 to 5,780 feet) elevation on very old Mauna Kea lava flows (greater than 10,000 years old) (USFWS 2002; Shaw 1997). Associated native plant taxa are *Leptecophylla tameiameiae* (pukiawe), *Dubautia linearis* (naenae), *Chamaesyce*

olowaluana (akoko), *Sida fallax* (ilima), *Chenopodium oahuense* (aheahea), and *Haplostachys haplostachya* (honohono) (USFWS 1996, 2002; CEMML 2003a). The populations on Maui were restricted to mesic forests (USFWS 1996).

2.3.1.7 Other:

No new information.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

Threats:

- Ungulate degradation of habitat – Rooting by feral ungulates (Douglas and Shaw 1989; USFWS 1994, 1996, 2002; Shaw 1997; CEMML 2003a)
 - Goats (*Capra hircus*)
 - Pigs (*Sus scrofa*)
 - Sheep (*Ovis aries*)
- Established ecosystem-altering invasive plant species degradation of habitat (Douglas and Shaw 1989; USFWS 1994, 1996, 2002; Shaw 1997; CEMML 2003a)
 - *Pennisetum setaceum* (fountain grass) which also increases the probability and intensity of fire
 - *Senecio madagascariensis* (fireweed)

Current conservation efforts:

- Ungulate exclosure:
 - At the end of 2005, the two Intensive Management Units in Pohakuloa Training Area containing all known wild individuals of *Tetramolopium arenarium* subsp. *arenarium* were still unprotected and being impacted by a herd of 50 to 100 feral goats, which were consistently seen within the weed control buffers and surrounding area (CEMML 2006). Browse damage decreased due to the construction of emergency exclosures around unprotected individuals, but these provided limited protection and are not considered long-term solutions (CEMML 2006). A 17 percent drop in the *T. arenarium* subsp. *arenarium* population between 2006 and 2007 was primarily attributed

to ungulate herbivory, with 34 percent of all individuals exhibiting evidence of browse, while no browse was recorded in 2006 (CEMML 2008). In 2007, permanent six-foot fencing was installed around the entire population of *T. arenarium* subsp. *arenarium* (CEMML 2008), which should minimize threats to this species from ungulate damage (U.S. Army Garrison 2009).

- As of 2009, fenced units at Pohakuloa Training Area containing *Tetramolopium arenarium* subsp. *arenarium* included the Kipuka Kalawamauna Endangered Plants Habitat, Kipuka Kalawamauna Fence Unit, and temporary emergency exclosures (using hog wire, concertina wire, and/or plastic construction fencing) (U.S. Army Garrison 2009).
- An effort is underway to complete Large Fence Units around the concentration of federally listed plant species on the west and southwest side of Pohakuloa Training Area; these contiguous fenced units will enclose about 7,921 hectares (19,572 acres) and consist of 101 kilometers (63 miles) of fencing to protect the greatest number of threatened and endangered individuals and their habitats from the destructive impact of feral ungulates and other feral animals (U.S. Army Garrison 2009). The fence is scheduled for completion in 2012 (U.S. Army Garrison 2009).
- As of 2007, the two reintroduction sites for *T. arenarium* subsp. *arenarium* on State lands are fenced including Puu Huluhulu and Puu Waawaa (Plant Extinction Prevention Program 2007).
- Ecosystem-altering invasive plant species control:
 - Intensive Management Unit 8, where the bulk of the *T. arenarium* subsp. *arenarium* population resides, was the first Intensive Management Unit to conduct comprehensive, large-scale weed control at Pohakuloa Training Area (CEMML 2006).
 - Fifty-meter radius weed control buffers were established around existing *T. arenarium* subsp. *arenarium* locations, in which all weedy individuals are removed by hand clearing around individuals, spraying, and weed whacking; a total of 15 hectares (37 acres) were under active weed control. If new individuals of *T. arenarium* subsp. *arenarium* were discovered within these buffers, the buffer was expanded to encompass the new habitats, and emergency exclosures were erected to provide temporary

protection to the rare plants in the area. The cleared habitat provides space for regeneration of rare taxa, as well as the components of the native plant community that will enhance regeneration of *T. arenarium* subsp. *arenarium* (CEMML 2006).

- Weed control efforts also help to reduce fire threat in the community. At Intensive Management Unit 12, mostly located within the Kipuka Kalawamauna Fence Unit, a single wild individual of *T. arenarium* subsp. *arenarium* was located outside the fence, but within an emergency enclosure. This Unit had 2.4 hectares (6.0 acres) under intensive weed control efforts and primarily provided habitat for the endangered *Stenogyne angustifolia* and *Silene lanceolata*. *Tetramolopium arenarium* subsp. *arenarium* was more commonly recorded from this area prior to and following the Puu Anahulu/Kipuka Kalawamauna fires in 1994 and 1999, and weed management efforts should aid in the regeneration of *T. arenarium* subsp. *arenarium* at the site (CEMML 2006).

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

None reported.

2.3.2.3 Disease or predation:

Threats:

- Ungulate predation or herbivory (Douglas and Shaw 1989; USFWS 1994, 1996, 2002; Shaw 1997; CEMML 2003a)
 - Goats (*Capra hircus*)
 - Sheep (*Ovis aries*)

2.3.2.4 Inadequacy of existing regulatory mechanisms:

No new information.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Threats:

- Ungulate trampling (Douglas and Shaw 1989; USFWS 1994, 1996, 2002; Shaw 1997; CEMML 2003a)
 - Goats (*Capra hircus*)

- Pigs (*Sus scrofa*)
- Sheep (*Ovis aries*)
- Fire (Douglas and Shaw 1989; USFWS 1994, 1996, 2002; Shaw 1997; CEMML 2003a)
- Military activities – Habitat disturbance and damage (Douglas and Shaw 1989; USFWS 1994, 1996, 2002; Shaw 1997; CEMML 2003a)
- Drought – Lackey (2010) documented a severe drought (see Section 2.3.1.2 for more details) during the 2009 to 2010 wet season in the Hawaiian Islands, which the National Weather Service called the driest in the past 30 years, resulting in a precipitous drop in the number of *T. arenarium* subsp. *arenarium* individuals in June 2010.
- Climate change may pose a threat to this species. However, current climate change analyses in the Pacific Islands lack sufficient spatial resolution to make predictions on impacts to this species. The Pacific Islands Climate Change Cooperative (PICCC) has currently funded climate modeling that will help resolve these spatial limitations. We anticipate high spatial resolution climate outputs by 2013.

Current conservation efforts:

- Captive propagation for genetic storage and reintroduction:
 - Seeds are collected for storage at the National Seed Storage Laboratory at Colorado State University, and occasionally used for seed germination tests (CEMML 2006).
 - The National Tropical Botanical Garden (2011) reported 25 seeds in genetic storage from Pohakuloa Training Area.
 - U.S. Army Garrison Pohakuloa Training Area (2011) reported no seeds in storage for 2011. In 2010 they reported 1,092 seeds in genetic storage, representing 9 wild individuals [in previous years, Pohakuloa Training Area totals were: 2009, 5,700 seeds in genetic storage, representing 77 wild individuals; 2008, 9,786 seeds in storage, representing 118 wild individuals; 2007, 4,990 seeds in storage, representing 41 wild individuals; 2006, 4,800 seeds in storage, representing 30 wild individuals (U.S. Army Garrison Pohakuloa Training Area 2006, 2007, 2008, 2009, 2010)].
 - Center for Conservation Research and Training Seed Storage Laboratory (2010) recorded 5,740 seeds in their facilities (2,400 sown, 3,340 in storage).

- Harold L. Lyon Arboretum (2010) reported no individuals in micropropagation.
- Volcano Rare Plant Facility (2008) last reported 1,000 seeds in genetic storage, representing a single wild individual, but nothing reported since.
- Statistically, Pohakuloa Training Area records from 2007 provide an idea of the available genetic material being stored; about 4,000 seeds were collected from 42 individuals in the natural population in 2007, representing about 9 percent of the adult population, and around 25 percent of the population was represented in storage (CEMML 2008).
- Captive propagation protocol development – Seeds of *Tetramolopium arenarium* subsp. *arenarium* are easily germinated and established in the greenhouse (USFWS 1996; Shaw 1997). There are no special germination requirements (CEMML 2006); seeds are soaked in water for one-hour prior to surface sowing on vermiculite/perlite (1:1), and usually germinate within 8 to 10 days, with germination percentages of 15 to 72 percent. The individuals are ready for reintroduction within 6 to 8 months, but are susceptible to aphids (CEMML 2006).
- Reintroduction / translocation protocol development – The Pohakuloa Training Area houses a climate-controlled greenhouse and a plant holding compound to acclimate individuals scheduled for reintroduction to conditions more similar to those they will encounter in the wild (USFWS 2003a).
- Reintroduction / translocation site identification:
 - Six reintroduction sites have been established, including three on State lands managed by the Hawaii Division of Forestry and Wildlife—Puu Huluhulu (fenced habitat), Puu Waawaa (fenced habitat), and Kipuka Oweowe (fenced habitat)—and three sites bordering Kipuka Kalawamauna (Plant Extinction Prevention Program 2007; CEMML 2008).
 - In 2005, the Pohakuloa Training Area identified three reintroduction sites bordering Kipuka Kalawamauna called TAOP02/TAOP05 (IMU 216), KKOP05 (IMU 210), and KKOP06 (IMU 211) [TAOP presumably an acronym for *Tetramolopium Arenarium Out Planting*, KKOP meaning *Kipuka Kalawamauna Out Planting*] (CEMML 2006).
- Reintroduction / translocation implementation:

- Since 2003, about 330 individuals of *Tetramolopium arenarium* subsp. *arenarium* have been reintroduced at these Puu Huluhulu, Puu Waawaa, and Kipuka Oweowe, and three sites bordering Kipuka Kalawamauna (Plant Extinction Prevention Program 2007; CEMML 2008).
- In 2005, 175 individuals of *Tetramolopium arenarium* subsp. *arenarium* were reintroduced at three sites within Pohakuloa Training Area bordering Kipuka Kalawamauna, 42 individuals survived, a 24 percent survival rate (CEMML 2006).
- In 2007, the Pohakuloa Training Area reported that 115 individuals were reintroduced: 32 at Puu Huluhulu, 65 at Puu Waawaa, and 18 at Kipuka Oweowe (U.S. Army Garrison Pohakuloa Training Area 2007).
- Compliance and enforcement:
 - The U.S. Army's land stewardship is governed by the Sikes Act of 1997, which statutorily requires all military installations with land and/or water suitable for the conservation and management of natural resources to complete an Integrated Natural Resources Management Plan (INRMP), to be updated every five years, which integrates implementation of the military mission of the installation with stewardship of the natural resources found there (USFWS 2003b). At Pohakuloa, the USFWS is a major cooperater in the implementation of this INRMP.
 - In a biological assessment for the transformation of the 2nd Brigade, 25th Infantry Division (Light) at Pohakuloa Training Area to incorporate Stryker Brigade Combat Team activities, attendant threats to the existing federally listed species at Pohakuloa Training Area (15 plants, 5 birds, 1 mammal) were assessed (CEMML 2003a). Within its restricted range in Kipuka Kalawamauna, in a fenced area inside Training Area 19, threats to *Tetramolopium arenarium* subsp. *arenarium* from Stryker Brigade Combat Team activities were considered to be very low, insignificant, or discountable for military use, fire, and dust, and low for the effects of invasive introductions (CEMML 2003a). Although 22 of the 25 *T. arenarium* subsp. *arenarium* locations were in the proposed off-road mounted maneuver area, they would be buffered by at least 100 meters (328 feet); bivouacking would only be allowed at pre-approved sites; troops would be educated on the need to protect federally-listed endangered or threatened species; and fencing was planned for some of the locations

(CEMML 2003a).

- Fire protection – In 2003, the Pohakuloa Training Area completed an Integrated Wildland Fire Management Plan to reduce the threat of wildfires (CEMML 2003b). In June 2012, Pohakuloa Training Area drafted a revision of their 2003 Integrated Wildland Fire Management Plan (CEMML 2012).
- Existing population management and restoration – Lackey (2010) documented a severe drought (see Section 2.3.1.2 for more details) during the 2009 to 2010 wet season in the Hawaiian Islands, resulting in a precipitous drop in the number of *T. arenarium* subsp. *arenarium* individuals to 27 in June 2010, only 4 percent of which were considered in good condition. Natural resources staff at Pohakuloa Training Area determined that the viability of this last known natural population would be unsustainable without taking action, and initiated a supplemental watering program until such time that normal rainfall levels returned. A half-gallon of water per plant was provided once a week for eight weeks, and reduced to once every two weeks thereafter. Monitoring is continuing, as supplemental watering has created novel conditions in the habitat. Invasive ants and scale, previously unobserved, were found on 62 percent of the individuals after four days of supplemental watering. Added soil trampling and compaction due to the need for hand watering may have unforeseen impacts. Intensive management will continue until it is determined that natural rainfall is adequate to reduce or cease supplemental watering; a rain gauge has been installed at the site to help with that determination (Lackey 2010).
- Population viability monitoring – At least two of the Kipuka Kalawamauna reintroduction sites (TAOP02/TAOP05, KKOP05) had been documented as containing natural populations of *T. arenarium* subsp. *arenarium*, which has since died (CEMML 2006). One observation of reintroductions was that they were able to reach reproductive status, but appeared to be much shorter lived than adult individuals in the natural population (CEMML 2006). Sparse recruitment was noted at the Kipuka Kalawamauna reintroduction sites, and no survival past the juvenile stage (CEMML 2008).

2.4 Synthesis

The interim stabilization goals for this species have not been met. There is only a single population containing more than 12 individuals with an unstable status (Table 1), and all threats are only being partially managed (Table 2). Therefore, *Tetramolopium arenarium* subsp. *arenarium* meets the definition of endangered as it remains in danger of extinction throughout its range.

Table 1. Status of *Tetramolopium arenarium* subsp. *arenarium* from listing through 5-year review.

Date	No. wild individuals	No. outplanted	Stabilization Criteria identified in Recovery Plan	Stabilization Criteria Completed?
1994 (listing)	108	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	No
1996 (recovery plan)	<400	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	No
2003 (critical habitat)	<400	330	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	No
2012 (5-year review)	12	Unknown	All threats managed in all 3 populations	Partially (see Table 2)
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	No

Table 2. Threats to *Tetramolopium arenarium* subsp. *arenarium* and ongoing conservation efforts.

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Ungulates – Degradation of habitat, herbivory, trampling	A, C, E	Ongoing	Partially: Ungulate exclosures at Pohakuloa Training Area, Puu Waawaa, and Puu Huluhulu.
Established ecosystem-altering invasive plant species degradation of habitat	A	Ongoing	Partially: Ecosystem-altering invasive plant species control
Fire	E	Ongoing	Partially: Fire protection
Military activities	E	Ongoing	Partially: Compliance and enforcement at Pohakuloa Training Area
Drought	E	Ongoing	Partially: Existing population management and restoration with supplemental watering during droughts at Pohakuloa Training Area
Climate change	A, E	Increasing	No

3.0 RESULTS

3.1 Recommended Classification:

Downlist to Threatened

Uplist to Endangered

Delist

Extinction

Recovery

Original data for classification in error

No change is needed

3.2 New Recovery Priority Number:

Brief Rationale:

3.3 Listing and Reclassification Priority Number:

Reclassification (from Threatened to Endangered) Priority Number: _____

Reclassification (from Endangered to Threatened) Priority Number: _____

Delisting (regardless of current classification) Priority Number: _____

Brief Rationale:

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Captive propagation for genetic storage and reintroduction:
 - Continue to collect seeds from all existing populations and send to at least two or three different venues for propagation.
 - Collect cuttings or seed from tagged individuals, keeping close track of the maternal source for use in *ex situ* propagation
- Reintroduction / translocation site identification – Continue efforts to establish reintroduction sites outside of Pohakuloa Training Area to achieve the goal of establishing two more viable populations.
- Ungulate exclosures:
 - Complete the Large Fence Units at Pohakuloa Training Area and continue to construct fenced exclosures around each population.
 - Monitor all fenced exclosures for any signs of breaching.
- Ungulate control – Protect all populations against disturbances from feral ungulates and ensure ungulates are not present within fenced exclosures.
- Ecosystem-altering invasive plant species control – Continue to control invasive introduced plant species around all populations and around expansion control buffers at Pohakuloa Training Area, as appropriate.
- Fire protection:
 - Continue to implement the Wildland Fire Management Plan at Pohakuloa Training Area.
 - Develop and implement fire management plans for all reintroduced populations at Puu Waawaa, Puu Huluhulu, and Kipuka Oweowe.
- Site / area / habitat protection – Develop and implement effective measures to reduce the impact of military activities.
- Existing population management and restoration – Continue emergency hand watering of the extant population at Pohakuloa Training Area as needed, until it is deemed that natural rainfall conditions are adequate.
- Threat monitoring and control – Monitor newly established reintroduced and wild populations for evidence of plant disease and insect predation. If threats are found implement effective control methods.
- Population biology research:
 - Study the reproductive biology of the species in the field to determine pollinators.
 - Study the causes of low survivability at these sites.

- Population viability monitoring – Continue to monitor reintroduction sites at Kipuka Kalawamauna.
- Alliance and partnership development – Continue to work with the Hawaii Division of Forestry and Wildlife, U.S. Army Garrison Hawaii, and other land managers to initiate planning and contribute to implementation of ecosystem-level restoration and management to benefit this species.
- Threats research – Assess the modeled effects of climate change on this species, and use to determine future landscape needed for the recovery of the species.

5.0 REFERENCES

Beavers, A.M., and R.E. Burgan. 2002. Analysis of fire history and management concerns at Pohakuloa Training Area. TPS 02-02. Center for Environmental Management of Military Lands, Fort Collins, Colorado. 32 pages + appendices. Unpublished.

Bishop Museum. 2011. Herbarium Pacificum database. Available online at <http://nsdb.bishopmuseum.org/>. Accessed March 2011.

Center for Conservation Research and Training Seed Storage Laboratory. 2010. Seed bank inventory. Honolulu, Hawaii. Microsoft Access database. Unpublished.

[CEMML] Center for the Environmental Management of Military Lands, Colorado State University. 2003a. Programmatic biological assessment for transformation of the 2nd Brigade 25th Infantry Division (light), U.S. Army, Island of Hawaii. Colorado State University, Fort Collins, Colorado, prepared for the U.S. Army Corps of Engineers, Honolulu, Hawaii. 376 pages.

[CEMML] Center for the Environmental Management of Military Lands, Colorado State University. 2003b. Integrated wildland fire management plan, Pohakuloa and Oahu Training Areas, U.S. Army, Hawaii and 25th Infantry Division (light). 22 August 2003. 436 pages.

[CEMML] Center for the Environmental Management of Military Lands, Colorado State University. 2006. Report for the ecosystem management program at Pohakuloa Training Area, Island of Hawaii; July 2003 to December 2005. U.S. Army Garrison, Pohakuloa Training Area, Hawaii. 144 pages.

[CEMML] Center for the Environmental Management of Military Lands, Colorado State University, Pohakuloa Training Area Natural Resources Staff. 2008. Report for the ecosystem management program Pohakuloa Training Area, Island of Hawaii, year 2007. U.S. Army Garrison, Pohakuloa Training Area, Hilo, Hawaii, prepared for the U.S. Army Garrison, Hawaii. 85 pages + appendices.

- [CEMML] Center for the Environmental Management of Military Lands, Colorado State University. 2012. Draft integrated wildland fire management plan, U.S. Army Garrison, Hawaii. June 2012. 139 pages + appendices.
- Douglas, P.P., and R.B. Shaw. 1989. Rediscovery of *Tetramolopium arenarium* var. *arenarium* (Asteraceae: Astereae) on the Pohakuloa Training Area, Hawaii. *Annals of the Missouri Botanical Garden* 76:1182–1185.
- Falkner, M.B., R.D. Laven and G.H. Aplet. 1997. Experiments on germination and early growth of three rare and endemic species of Hawaiian *Tetramolopium* (Asteraceae). *Biological Conservation* 80(1):39-47.
- Harold L. Lyon Arboretum. 2010. Micropropagation database. Honolulu, Hawaii. Unpublished.
- Hawaii Biodiversity and Mapping Program. 2010a. Element occurrence record: *Tetramolopium arenarium* var. *confertum*. 2 pages. Unpublished.
- Hawaii Biodiversity and Mapping Program. 2010b. Element occurrence record: *Tetramolopium arenarium* subsp. *laxum*. 4 pages. Unpublished.
- Hillebrand, W. 1888. *Flora of the Hawaiian Islands: a description of their phanerogams and vascular cryptogams*. Carl Winter, Heidelberg, Germany; Williams & Norgate, London; B. Westermann & Co., New York. 673 pages.
- Lackey, T. 2010. Pohakuloa Training Area's Natural Resources Office takes action to preserve the Mauna Kea pamakani during extreme drought. *Ecosystem Management Program Bulletin* 51:1–2.
- Lowrey, T.K. 1986. A biosystematic revision of Hawaiian *Tetramolopium* (Compositae: Astereae). *Allertonia* 4:203-265.
- National Tropical Botanical Garden. 2011. Controlled propagation report to U.S. Fish and Wildlife Service. Unpublished.
- Plant Extinction Prevention Program. 2007. Hawaii Island PEP report, May 2, 2007-June 30, 2007, Plant Extinction Prevention Program. 4 pages. Unpublished.
- Plant Extinction Prevention Program. 2010. Plant Extinction Prevention Program annual report, fiscal year 2010 (July 1, 2009-June 30, 2010). 122 pages. Unpublished.
- Shaw, R.B. 1997. Rare plants of Pohakuloa Training Area, Hawaii. Center for Ecological Management of Military Lands, Fort Collins, Colorado. Unnumbered pages.
- Sherff, E.E. 1934. A study in the genus *Tetramolopium* nees (family: compositae). *Botanical gazette* 95(3):498-502.

- Smithsonian Institution. 2011. Flora of the Hawaiian Islands website. Available online at <<http://botany.si.edu/pacificislandbiodiversity/hawaiianflora/index.htm>>. Accessed 25 March 2011.
- U.S. Army Garrison. 2009. Draft Integrated Natural Resources Management Plan (INRMP), U.S. Army Garrison, Hawai'i, Pohakuloa 2010-2014. 141 pages + appendices.
- U.S. Army Garrison Pohakuloa Training Area. 2006. Controlled propagation report to U.S. Fish and Wildlife Service. Unpublished.
- U.S. Army Garrison Pohakuloa Training Area. 2007. Controlled propagation report to U.S. Fish and Wildlife Service. Unpublished.
- U.S. Army Garrison Pohakuloa Training Area. 2008. Controlled propagation report to U.S. Fish and Wildlife Service. Unpublished.
- U.S. Army Garrison Pohakuloa Training Area. 2009. Controlled propagation report to U.S. Fish and Wildlife Service. Unpublished.
- U.S. Army Garrison Pohakuloa Training Area. 2010. Controlled propagation report to U.S. Fish and Wildlife Service. Unpublished.
- U.S. Army Garrison Pohakuloa Training Area. 2011. Controlled propagation report to U.S. Fish and Wildlife Service. Unpublished.
- [USFWS] U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants; determination of endangered or threatened status for 21 plants from the island of Hawaii, State of Hawaii; final rule. Federal Register 59(43):10305-10325.
- [USFWS] U.S. Fish and Wildlife Service. 1996. Recovery plan for the Big Island plant cluster. U.S. Fish and Wildlife Service, Portland, Oregon. 176 pages + appendices. Available online at <<http://www.fws.gov/pacificislands/recoveryplans.html>>.
- [USFWS] U.S. Fish and Wildlife Service. 2002. Endangered and threatened wildlife and plants; designations of critical habitat for plant species from the Island of Hawaii, Hawaii; proposed rule. Federal Register 67(102):36968-37106.
- [USFWS] U.S. Fish and Wildlife Service. 2003a. Endangered and threatened wildlife and plants; designation of critical habitat for 60 plant species from the islands of Maui and Kahoolawe, Hawaii; final rule. Federal Register 68(93):25934-26165.
- [USFWS] U.S. Fish and Wildlife Service. 2003b. Endangered and threatened wildlife and plants; final designation and nondesignation of critical habitat for 46 plant species from the island of Hawaii, Hawaii; final rule. Federal Register 68(127):39624-39761.

[USFWS] U.S. Fish and Wildlife Service. 2010. Rare plant tracking database. Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii. Unpublished.

Volcano Rare Plant Facility. 2008. Controlled propagation report to U.S. Fish and Wildlife Service. Volcano, Hawaii. Unpublished.

Wagner, W.L., D.R. Herbst and S.H. Sohmer. 1999. Manual of the flowering plants of Hawaii, revised edition. University of Hawaii and Bishop Museum Press, Honolulu, Hawaii. 1,918 pages.

Signature Page
U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Tetramolopium arenarium* (No common name)

Pre-1996 DPS listing still considered a listable entity? N/A

Recommendation resulting from the 5-Year Review:

- Delisting
- Reclassify from Endangered to Threatened status
- Reclassify from Threatened to Endangered status
- No Change in listing status

Appropriate Listing/Reclassification Priority Number, if applicable: _____

Review Conducted By:

Chelsie Javar, Fish and Wildlife Biologist
Marie Bruegmann, Plant Recovery Coordinator
Jess Newton, Endangered Species Recovery Program Leader
Assistant Field Supervisor for Endangered Species

Field Supervisor, Pacific Islands Fish and Wildlife Office

for

Jess Newton

Date 8/28/2012