

5-YEAR REVIEW

Short Form Summary

Species Reviewed: *Chamaesyce rockii* ('akoko)

Current Classification: Endangered

Federal Register Notice announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2009. Endangered and threatened wildlife and plants; initiation of 5-year reviews of 103 species in Hawaii. Federal Register 74(49):11130-11133.

Lead Region/Field Office:

Region 1/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaii

Name of Reviewer(s):

Marie Bruegmann, Plant Recovery Coordinator, PIFWO

Jess Newton, Recovery Program Lead, PIFWO

Assistant Field Supervisor for Endangered Species, PIFWO

Methodology used to complete this 5-year 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 March 16, 2009. The review was based on final critical habitat designation for *Chamaesyce rockii* and other species from the island of Oahu (USFWS 2003), as well as a review of current, available information. The National Tropical Botanical Garden 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 Tamara Sherrill, biological consultant, was reviewed by the Plant Recovery Coordinator. The document was then reviewed by the Recovery Program Lead and the Assistant Field Supervisor for Endangered Species before submission to the Field Supervisor for approval.

Background:

For information regarding the species listing history and other facts, please refer to the Fish and Wildlife Service's Environmental Conservation On-line System (ECOS) database for threatened and endangered species (http://ecos.fws.gov/tess_public).

Application of the 1996 Distinct Population Segment (DPS) Policy:

This Policy does not apply to plants.

Review Analysis:

Please refer to the final critical habitat designation for *Chamaesyce rockii* published in the Federal Register on June 17, 2003 (USFWS 2003) for a complete review of the species' status (including biology and habitat), threats, and management efforts. No new threats and no significant new information regarding the species biological status have come to light since listing to warrant a change in the Federal listing status of *C. rockii*.

Chamaesyce rockii was listed as endangered in 1996 (USFWS 1996). At that time, there were 200 to 400 individuals in 11 populations. By the time critical habitat was designated in 2003, the total number of individuals was estimated to be between 641 and 773 in 20 populations (USFWS 2003).

Fruits in Euphorbieae subfamily are generally dry capsules, exploding their seed only a few meters from their source. However, there are a few cases of long-distance dispersal within Euphorbieae, which include the genus *Chamaesyce*. Molecular evidence supports that this group probably originated in the New World. Because many *Chamaesyce* species possess mucilaginous seeds, their long-distance dispersal may have been accomplished by adhering to animals. This helps to explain why *Chamaesyce* is one of the few taxa within Euphorbiinae that has transoceanic distribution (Steinmann and Porter 2002).

There are approximately 30 taxa of *Chamaesyce* in Hawaii that have radiated from a single colonizer. A graduate student at University of Hawaii at Manoa, Maggie Sporck, has been focusing her research on the relationship between leaf structure and habitat in the Hawaiian *Euphorbia*. In 2007, a population of *Chamaesyce rockii* accessible from the Koolau Summit Trail on Oahu, ranging from 615 to 714 meters (2,018 to 2,343 feet) elevation, was characterized for habitat and leaf functional traits. The large leaf area, high leaf mass per area, and low nitrogen concentration indicated that this species is adapted to establish in forested, shady habitat. These traits also indicate that this species exhibits slow respiration and growth, and the production of long-lived leaves (Maggie Sporck, University of Hawaii, pers. comm. 2010). Hawaiian taxa of *Chamaesyce* are uniquely classified as C4 photosynthetic (having a biochemical pathway that prevents photorespiration). C4 plants usually have a leaf anatomy that allows the plant to grow in high light conditions with low moisture availability, and are usually characterized as grasses. The taxa within the Hawaiian *Chamaesyce* are the only trees with C4 photosynthetic leaves known to science (Maggie Sporck pers. comm. 2010; University of Hawaii 2010).

Chamaesyce rockii is recorded from scattered locations in the northern and central Koolau Mountains. The species has been found as far south as the northern edge of Kalihi Valley. Most populations are located on or near the Koolau Summit Ridge, although there are a few records of it occurring up to 2.4 kilometers (1.5 miles) below the summit. Documented populations of *C. rockii* range from 564 to 847 meters (1,850 to 2,780 feet) elevation. The range of *C. rockii* has been diminishing as populations of this species are declining (U.S. Army Garrison 2008). Many plants were seen in Punaluu Valley, past the summit of Castle Trail, on top of the meadow, at 827 meters (2,100 feet) elevation in 1984 (Perlman 2009). *Chamaesyce rockii* was seen at the top of the Halawa Trail on a hike from Aiea Trail summit to Halawa in 1985 (Perlman 2009); at the summit of the Waimano Trail on the way to the Manana Trail in 1985 (Perlman 2009); and between the Eleao and Waimano Trail, where approximately 6 individuals were seen, at 858 meters (2,180 feet) elevation in 1995 (Perlman 2009). In 1987 and 1991, *C. rockii* was observed at the summit bogs of Peahinaia Trail and Poamoho Trail from 1,043 to 1,102 meters (2,650 to 2,800 feet) elevation (Perlman 2009). In 1997, 50 individuals were seen in sloping shrubland below Peahinaia Summit at 823 meters (2,700 feet)

elevation (Wood 2009). In 1993, in the Waialua District, at Kawailoa, south of Puu Kainapuaa, *C. rockii* was seen at 827 to 945 meters (2,100 to 2,400 feet) elevation (Wood 2009). *Chamaesyce rockii* was also observed in the Koolauloa District; on the windward side of Poamoho, at 945 to 984 meters (2,400 to 2,500 feet) elevation in 1995 (Wood 2009). It was also observed on steep slopes of the west rim of Kaipapau, which divides Koloa Gulch, on the Kaipapau side, at 564 meters (1,850 feet) elevation in 1998 (Wood 2009). In 2000, 25 individuals of *C. rockii* were seen at Manana Stream at 811 meters (2,060 feet) elevation (Perlman 2009; National Tropical Botanical Garden 2010).

In 2006, the U.S. Army reported occurrences of *Chamaesyce rockii* in the Kawailoa Training Area and the Schofield Barracks Military Reservation (U.S. Army Environmental Center 2006). On the summit ridge south of Schofield Waikane Trail, 20 individuals were observed in 1996 at 671 meters (2,200 feet) elevation (Wood 2009). One colony was observed in 1989 in Waikakalua Gulch, at the southern boundary of the East Range of Schofield Barracks Military Reservation, and was estimated to contain 40 to 50 individuals. It was revisited in 2004, and only seven individuals were found (U.S. Army Garrison 2008).

In 2008, the U.S. Army estimated populations occurring within their training areas include approximately seven mature and one immature individuals in Helemano, no individuals in Kaluanui-Maakua, 28 mature and two immature individuals in Kaukonahua-Kipapa, 48 mature and two immature individuals in Kawaiiki, and 48 mature and 29 immature individuals in Kawainui-Koloa-Kaipapau. Outside Army lands, they reported 15 mature individuals at Waiawa and Waimano and no individuals at Halawa summit, with no recent monitoring of Halawa summit (U.S. Army Garrison 2008). In 2009, the U.S. Army reported a reduction of the Kawainui-Koloa-Kaipapau population to 43 mature and 19 immature individuals; no monitoring had been made in that year to update the 2008 report. Outside Army lands, they reported the same 15 individuals at Waiawa and Waimano, with no monitoring there or at Halawa summit in the last year (U.S. Army Garrison 2009). These U.S. Army observations are the only current observations made since 2003, for a total of 141 mature and 24 immature individuals in six populations.

The subtribe Euphorbiinae of the Euphorbiaceae family consists of the single, very large and widely distributed and diverse genus *Euphorbia*. Three of the subgenera, *Chamaesyce*, *Esula*, and *Euphorbia*, are found almost worldwide, suggesting a great age and wide radiation within *Euphorbia* (Bruyns *et al.* 2006). In an earlier study, *Chamaesyce* was shown to have evolved from within the subgenus *Agaloma*. The monophyletic subgenus *Agaloma* was revised to include both *Chamaesyce* and *Euphorbia* including the subgenus *Poinsettia*, which is now referred to as the *Agaloma* alliance. *Chamaesyce* is now recognized as an ancient lineage that diverged early in the evolution of the *Agaloma* alliance. The relationship of all the members of the family Euphorbiaceae are complex, and subject to ongoing controversy among taxonomists and geneticists (Steinmann and Porter 2002).

Hawaiian *Euphorbiaceae* taxa have been successfully crossed experimentally in many combinations, demonstrating a lack of genetic barriers among these species. Several cases of apparent hybridization between co-occurring Hawaiian *Chamaesyce* include hybrid swarms between *C. rockii* and *C. clusiifolia* in Kawaihoa at the head of Opaepala Gulch, adjacent to the Peahinaia Trail, and on the ridge between Kawaiiki and Opaepala Gulches. The *Chamaesyce* populations at these two locations consist of very variable individuals, many of which are morphologically intermediate between *C. rockii* and *C. clusiifolia*. It is possible that the formation of hybrid populations between these two *Chamaesyce* species occurred naturally in pre-human times, but it is also possible that the two species did not naturally hybridize due to ecological reproductive barriers which may have broken down following human disturbances, allowing a blurring of species differences. *Chamaesyce clusiifolia*, which is endemic to the Koolau Mountains, is not considered to be a rare plant, and is the only *Chamaesyce* whose range overlaps the range of *C. rockii*. If reintroductions of *C. rockii* are needed, they should be placed away from *C. clusiifolia* populations to minimize the chances of hybridization (U.S. Army Garrison 2008).

The members of the genus *Chamaesyce* have been moved to the genus *Euphorbia*. Earlier there was some consensus among taxonomists to remove *Chamaesyce* from *Euphorbia*. However, Steinmann and Porter (2002) disagreed that *Euphorbia* should be divided, and their conclusions were supported by many taxonomists (Bruyns *et. al.* 2006). Steinmann and Porter's solution to the problem of Euphorbiinae classification was to expand *Euphorbia* to encompass all members of the subtribe, which includes *Chamaesyce*. They favored this solution as being the least disruptive of current usage, and not requiring the creation of new genera to encompass all the *Euphorbia* species not within the subgenus *Euphorbia*, which would be 90 percent of the species currently in the genus (Steinmann and Porter 2002). This is the treatment supported by Wagner, author of the Flora of the Hawaiian Islands (Warren Wagner, Smithsonian Institution, pers. comm. 2009). Therefore, this species will be referred to as *Euphorbia rockii* in the remainder of this review.

In Kawaihoa, south of Puu Kainapuaa and on the rim of Kaipapau in the Koolau Mountains, the habitat is *Metrosideros polymorpha* (ohia) – *Dicranopteris linearis* (uluhe) lowland wet forest with *Cheirodendron trigynum* (olapa), *Clermontia oblongifolia* (oha wai), *C. persicifolia* (oha wai), *Coprosma longifolia* (pilo), *Cyanea* spp. (haha), *Cyrtandra cordifolia* (hahala), *Diplazium sandwichianum* (hoio), *Dubautia laxa* (naena pua mele), *Gardenia mannii* (nanu), *Labordia* sp. (kamakahala), *Melicope clusiifolia* (kolokolo mokihana), *Myrsine lessertiana* (kolea lau nui), *Phyllostegia grandiflora* (kapana), *Pittosporum confertiflora* (hoawa), *Pouteria sandwicensis* (alaa), *Pritchardia martii* (loulu hiwa), *Psychotria* spp. (kopiko), *Rhynchospora sclerioides* (kuolohia), *Scaevola chamissoniana* (naupaka kuahiwi), *Syzygium sandwicensis* (ohia ha), *Tetraplasandra oahuensis* (ohe mauka), *Wikstroemia oahuensis* (akia), and *Zanthoxylum oahuense* (ae) (National Tropical Botanical Garden 2010; Perlman 2009; Wood 2009).

In the Koolauloa District on the windward side of Poamoho, the habitat is cloud-swept

summit vegetation with *Metrosideros polymorpha* – *Dicranopteris linearis* and *Metrosideros polymorpha* mixed lowland wet forest with *Broussaisia arguta* (kanawao), *Euphorbia clusiifolia* (akoko), *Cyrtandra* sp. (haiwale), *Freycinetia arborea* (ie ie), *Labordia* sp., *Machaerina* sp. (uki), and *Phyllostegia* sp. (no common name [NCN]) (Wood 2009).

In Schofield, Waikane, and Kawaihoa areas *Euphorbia rockii* occurs with *Antidesma platyphyllum* (mehame), *Bidens macrophylla* (kookoolau), *Bobea elatior* (ahakea lau nui), *Broussaisia arguta*, *Cibotium* spp. (hapuu), *Clermontia persicifolia*, *Coprosma longifolia*, *Diplopterygium pinnatum* (uluhe lau nui), *Dubautia laxa*, *Labordia sessilis* (kamakahala), *Kadua affinis* (manono), *K. fosbergii* (manono), *Metrosideros polymorpha* (ohia), *Machaerina angustifolia* (uki), *Melicope* spp. (alani), *Myrsine* spp. (kolea), *Pritchardia martii*, *Psychotria* spp., *Syzygium sandwicensis*, and *Wikstroemia oahuensis* (U.S. Army Garrison 2008; Wood 2009).

In the Peahinaia summit area, the species occurs in *Metrosideros polymorpha* – *Cheirodendron trigynum* lowland wet forest with windswept shrublands and dissecting riparian headwater drainages with associated species including *Bidens macrocarpa* (kookoolau), *Dicranopteris linearis*, *Dubautia laxa*, *Kadua fosbergii*, *Melicope clusiifolia*, *M. hosakae* (alani), and *Pritchardia martii* (Wood 2009).

The habitat on Castle Trail, Halawa Trail, Waimano to Manana Summit Trail, Elaeao to Waimano Trail, and Manana Stream includes *Metrosideros polymorpha* wet forest with *Broussaisia arguta*, *Freycinetia arborea*, *Cheirodendron trigynum*, *Cibotium* spp., *Clermontia oblongifolia*, *C. persicifolia*, *Coprosma longifolia*, *Cyrtandra cordifolia*, *C. paludosa* (moa), *Diplazium sandwichianum*, *Dubautia laxa*, *Gardenia mannii*, *Kadua affinis*, *Labordia waiolani* (kamakahala), *Machaerina* sp., *Myrsine lessertiana*, *Phyllostegia grandiflora*, *Pipturus* sp. (mamake), *Pittosporum confertiflora*, *Pouteria sandwicensis*, *Pritchardia martii*, *Sadleria* sp. (amau or apuu), *Scaevola* sp. (naupaka), *Tetraplasandra oahuensis*, *Wikstroemia oahuensis*, and *Zanthoxylum oahuense* (National Tropical Botanical Garden 2009; Perlman 2009).

Threats to *Euphorbia rockii* include feral pigs (*Sus scrofa*) that degrade the habitat, and invasive introduced plant species such as *Axonopus fissifolius* (narrow-leaved carpetgrass), *Clidemia hirta* (Koster's curse), *Leptospermum scoparium* (New Zealand tea tree), *Psidium cattleianum* (strawberry guava), *Hedychium gardnerianum* (kahili ginger), *Paspalum conjugatum* (Hilo grass), *Pterolepis glomerata* (NCN), and *Rubus rosifolius* (thimbleberry) (National Tropical Botanical Garden 2009; Perlman 2009; Wood 2009; U.S. Army Garrison 2008).

Threats from human activities, such as trail clearing, recreational hiking, and foot traffic in the course of military training maneuvers include trampling and the possible introduction of seeds of nonnative invasive species (U.S. Army Garrison 2008).

Seed predation by rats (*Rattus* sp.) and consumption of leaves and stems by slugs (unidentified species) are threats to *Euphorbia rockii* (Perlman 2009; U.S Army Garrison

2008).

Climate change may also 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.

Three management areas were selected by the U.S. Army for focusing its conservation efforts for *Euphorbia rockii*. They are Kaipapau-Koloa-Kawainui, Helemano, and Waiawa-Waimano (U.S. Army Garrison 2008). Within those areas the Army will survey existing populations, collect propagules, fence against ungulates and remove invasive introduced plants (U.S. Army Garrison 2008). As of 2009, the U.S. Army was still awaiting a license agreement to construct the Koloa management unit (U.S. Army Garrison 2009). The Center for Conservation Research and Training Seed Storage Laboratory (2009) has 28 seeds from one collection at Kawailoa in storage. Samples for population genetic studies were collected by the University of Hawaii from 12 individuals located in Koloa gulch (U.S. Army Garrison 2009).

Stabilizing, downlisting, and delisting objectives are provided in the recovery plan for plants from the island of Oahu (USFWS 1998), based on whether the species is an annual, a short-lived perennial (fewer than 10 years), or a long-lived perennial. *Euphorbia rockii* is a short-lived perennial, and to be considered stable, the taxon must be managed to control threats (*e.g.*, fenced) and be represented in an *ex situ* (at other than the plant's natural location, such as a nursery or arboretum) collection. In addition, a minimum of three populations should be documented on the island of Oahu. Each of these populations must be naturally reproducing and increasing in number, with a minimum of 50 mature individuals per population.

The interim stabilization goals for this species have not been met, as only two recently observed populations may contain 50 mature individuals, with the remaining four populations containing less than 50 individuals (Table 1). In addition, though plans are being implemented to control threats in three populations, management units are not yet complete, and thus not all threats are being managed (Table 2). Therefore, *Euphorbia rockii* meets the definition of endangered as it remains in danger of extinction throughout its range.

Recommendations for Future Actions:

- Survey to determine the current status of all wild and reintroduced populations.
- Fence all populations to provide protection against the negative impacts of feral ungulates.
- Implement seed collection for propagation and storage for all populations.
- Propagate for reintroduction augmentation.

- Control invasive introduced plant species in all populations.
- Control rats in the vicinity of these populations.
- Develop and implement an effective method to control slugs.
- Study whether hybridization is occurring among *Euphorbia rockii*
- Work with Hawaii Division of Forestry and Wildlife, U.S. Army, and other land managers to initiate planning and contribute to implementation of ecosystem-level restoration and management to benefit this species.
- Assess the modeled effects of climate change on this species, and use to determine future landscape needed for the recovery of the species.
- Update the listed entity on 50 CFR 17 to match the currently recognized taxonomy.

References:

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Personal Communications:

- Sporck, Maggie J. 2010. Ph.D. candidate, University of Hawaii Botany Department, Honolulu, Hawaii. E-mail to Margaret Clark, National Tropical Botanical Garden, dated December 17, 2009. Subject: 5 year review, summary and evaluation of *Euphorbia* (formerly, *Chamaesyce*) *rockii*; unpublished contributed data.
- Wagner, Warren. 2009. Research Botanist and Curator, Chair of Botany, Smithsonian Institution, Washington, D.C. E-mail to Margaret A. Clark, National Tropical Botanical Garden, dated December 10, 2009. Subject: Chamaesyce to Euphorbia name change.

Table 1. Status of *Euphorbia rockii* from listing through 5-year review.

Date	No. wild indivs	No. outplanted	Stability Criteria identified in Recovery Plan	Stability Criteria Completed?
1996 (listing)	200-400	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	Unknown
1998 (recovery plan)	200-400	0	All threats managed in all 3 populations	No
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	Yes
2003 (critical habitat)	641-773	0	All threats managed in all 3 populations	No
			Complete genetic storage	Unknown
			3 populations with 50 mature individuals each	Unknown
2010 (5-year review)	141	0	All threats managed in all 3 populations	Partially (Table 2)
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	No

Table 2. Threats to *Euphorbia rockii* habitat.

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Ungulates – habitat modification and herbivory	A, D	Ongoing	Partially: U.S. Army developed management units but not yet constructed
Rats – herbivory	C	Ongoing	No
Slugs – herbivory	C	Ongoing	No
Military training activity	A,E	Ongoing	No
Invasive introduced plants	A, E	Ongoing	Partially: U.S. Army developed management units but not yet constructed
Climate change	A, E	Increasing	No


U.S. FISH AND WILDLIFE SERVICE
SIGNATURE PAGE for 5-YEAR REVIEW of *Chamaesyce rockii* ('akoko)

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

Field Supervisor, Pacific Islands Fish and Wildlife Office



Acting

Date 8/2/11