5-YEAR REVIEW

Short Form Summary

Species Reviewed: *Hedyotis cookiana* (awiwi)

Current Classification: Endangered

Federal Register Notice announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; initiation of 5-year status reviews of 70 species in Idaho, Montana, Oregon, Washington, and the Pacific Islands. Federal Register 73(83):23264-23266.

Lead Region/Field Office:

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

Name of Reviewer(s):

Marie Bruegmann, Pacific Islands Fish and Wildlife Office, Plant Recovery Coordinator
Marilet A. Zablan, Pacific Islands Fish and Wildlife Office, Assistant Field Supervisor for Endangered Species
Jeff Newman, Pacific Islands Fish and Wildlife Office, Acting Deputy Field Supervisor

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 April 29, 2008. The review was based on the final critical habitat designation for *Hedyotis cookiana* and other species from the island of Kauai (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 Assistant Field Supervisor for Endangered Species and Acting Deputy Field Supervisor 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 *Hedyotis cookiana* published in the Federal Register on February 27, 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 *H. cookiana*.

Hedyotis cookiana was known historically from the islands of Hawaii, Molokai, and Oahu, and in 1976 it was discovered on Kauai. It is extirpated from all islands except Kauai (USFWS 1994). Thought to exist in only one location on the Napali coast of Kauai when last reviewed by the USFWS in 2003, *H. cookiana* is now found in two valleys on the Napali Coast (USFWS 2003; Wood 2008).

At the time of listing, only one population of about 50 to 100 individuals of *Hedyotis cookiana* was believed to exist (USFWS 1994). Recent observations show that its distribution is restricted to Hanakoa and Waiahuakua Valleys on the Na Pali coast of Kauai. Ken Wood of the National Tropical Botanical Garden estimates there are approximately 100 to 122 individuals remaining in the wild. The Waiahuakua population occurs at 335 meters (1,100 feet) elevation, and is composed of 50 to 70 individuals along the lower margins of the main falls and extends approximately 25 to 30 meters (80 to 100 feet) along the sides of the waterfall. In addition, two individuals were observed about 200 meters (650 feet) downstream of Waiahuakua along its spring-fed banks. The Hanakoa Valley population occurs at 366 meters (1,200 feet) elevation, at the end of the main trail, along the west falls of the east fork. About 50 individuals are found along the margins of the main falls and can be observed for a distance of 25 to 30 meters (82 to 98 feet) up the falls (Wood 2008).

The Hawaiian and other Polynesian species formerly included in the genus *Hedyotis* are currently placed in the genus *Kadua* (Terrell *et al.* 2005). Therefore, this species will be referred to as *Kadua cookiana* for the remainder of this review.

Habitat requirements for *Kadua cookiana* are areas around cool, clean flowing water such as streams, springs, and especially perennial waterfalls (Wood 2008). In Waiahuakua Valley, about 50 to 70 individuals of *Kadua cookiana* grow as sub-shrubs in fissures of seeping basalt along the margins of the lower falls and up the falls. It grows with *Artemisia australis* (ahinahina), *Bidens forbesii* (kookoolau), *Carex meyenii* (no common name [NCN]), *Chamaesyce celastroides* var. *hanapepensis* (akoko), *Christella cyatheoides* (kikawaio), *Kadua elatior* (awiwi), and *Machaerina angustifolia* (uki), in an area dominated by alien vegetation. Other native associated plants include *Eragrostis variabilis* (kawelu), *Selaginella arbuscula* (lepelepe a moa), *Lipochaeta connata* var. *acris* (nehe), and *Metrosideros polymorpha* (ohia) (National Tropical Botanical Garden 2009a; Wood 2008).

In Hanakoa Valley, *Kadua cookiana* grows along the main waterfall and pools on seeping vertical basalt cliffs with riparian vegetation. About 50 individuals occur along the sides of the falls at 366 meters (1,200 feet) elevation. Cliff habitat is relic *Metrosideros polymorpha* var. *glaberrima* (ohia) lowland mesic forest. Adjacent is *Aleurites moluccana* (kukui) introduced forest associated with relic mesic *Diospyros sandwicensis* (lama) and *Psydrax odorata* (alahee). Native associated species include *Asplenium unilaterale* (pamoho), *Boehmeria grandis* (akolea), *Carex meyenii* (NCN), *Chamaesyce celastroides* var. *hanapepensis* (akoko), *Deparia cataracticola* (NCN), *Eragrostis variabilis* (kawelu), *Hibiscus kokio* subsp. *saintjohnianus* (kokio ula), *Isachne pallens* (NCN), *Kadua elatior* (awiwi), *Lipochaeta connata* (nehe), *Machaerina angustifolia* (uki), *Nototrichium sandwicensis* (kului), *Pipturus kauaiensis* (mamake), *Plantago*

princeps (laukahi kuahiwi), *Pleomele aurea* (hala pepe), *Pouteria sandwicensis* (alaa), *Psydrax odorata* (alahee), *Rauvolfia sandwicensis* (hao), *Selaginella arbuscula* (lepelepe a moa), and *Sphenomeris chinensis* (palapalaa) (National Tropical Botanical Garden 2008a; Wood 2008).

In Waiahuakua, threats to this species are feral animals including pigs (*Sus scrofa*) and goats (*Capra hircus*) (Factor A); and hurricanes, landslides, and floods (Factor E). Dominant invasive introduced plant species (Factor E) include *Adiantum raddianum* (NCN), *Ageratina riparia* (Hamakua pamakani, spreading mist flower), *Ageratum conyzoides* (maile hohono), *Blechnum appendiculatum* (NCN), *Clidemia hirta* (Koster's curse), *Elephantopus mollis* (elephant's-foot), *Erigeron karvinskianus* (daisy fleabane), *Lantana camara* (lantana), *Melinis minutiflora* (molasses grass), *Oplismenus hirtellus* (basketgrass, honohono), *Pluchea carolinensis* (sourbush, marsh fleabane), *Psidium guajava* (guava), *Setaria parviflora* (yellow foxtail), and *Syzygium cumini* (java plum) (Wood 2008).

The population at Hanakoa Valley is threatened by landslides, hurricanes (Factor E), pigs and goats (Factor A). Waterfall vegetation is dominated by invasive introduced plant species (Factor E). The general area below the falls has a 14 meter (46 foot) overstory of *Aleurites moluccana* (30 to 50 percent cover) and *Mangifera indica* (mango) (5 to 30 percent cover). The understory includes *Psidium guajava, Zingiber zerumbet* (awapuhi), *Oplismenus hirtellus* (honohono),*Christella dentata* (pai i iha), and *Coffea arabica* (Arabian coffee).Along with scattered non-native trees, shrubs and ferns including *Ageratina riparia* (spreading mist flower), *Blechnum appendiculatum* (NCN), *Kalanchoe pinnata* (airplant), *Clidemia hirta* (Koster's curse), *Cyperus meyenianus* (NCN), *Elephantopus mollis* (elephant's-foot), *Melinis minutiflora* (molasses grass), *Pluchea carolinensis* (sourbush), *Sacciolepis indica* (Glenwood grass), *Setaria palmifolia* (yellow foxtail), *Syzygium cumini* (java plum), and *Syzygium malaccense* (mountain apple) (National Tropical Botanical Garden 2008a).

Climate change may also pose a threat to *Kadua cookiana* (Factors A and E). However, current climate change models do not allow us to predict specifically what those effects, and their extent, would be for this species.

In addition to all of the other threats, species like *Kadua cookiana* that are endemic to small portions of a single island are inherently more vulnerable to extinction than widespread species because of the higher risks posed to a few populations and individuals by random demographic fluctuations and localized catastrophes such as hurricanes, landslides, flooding, and disease outbreaks (Factor E). The effects of these processes on this single-island endemic are exacerbated by anthropogenic threats, such as habitat loss for human development or predation by introduced species (Factor E) (USFWS 1995).

In the spring of 2008, at the nursery of the National Tropical Botanical Garden on Kauai researchers studied the pollination system of *Kadua cookiana* from Waiahuakua and Hanakoa Valley. It was concluded that *K. cookiana* is gynodioecious, *i.e.*, a population containing individuals that have either all female flowers or all hermaphroditic (bisexual)

flowers. Hermaphrodism is incomplete, in that while many flowers are female, very few produce pollen. In the Hanakoa population, flowers from hermaphroditic individuals are mostly female, with some individuals never producing pollen. By contrast, hermaphroditic individuals of the Waiahuakua population had more flowers that produced pollen, with a few producing abundant sources of pollen. This pollen was viable, but weak. The central flower in the cyme (flowering stalk) was more likely to show strong stigma receptivity, yet less likely to produce pollen. The next pair of flowers on that cyme, the side flanking flowers, was more likely to produce pollen. Other individuals observed, which were apparently second generation cultivated plants from Waiahuakua, had highly variable pollen production (D. Vogler, SUNY College Oneonta, pers. comm. 2008). Further studies are needed to better understand these variations in breeding strategies which will have implications for conservation methods.

Conservation of this species is hindered by the difficulty of outplanting or augmenting populations in locations that are relatively inaccessible, and hard to monitor or manage. *Kadua cookiana* have been grown from seeds and cuttings at the National Tropical Botanical Garden Nursery and outplanted for genetic storage at both the Limahuli Garden on Kauai's north shore and at the McBryde Garden on the south shore. They seem to survive better at Limahuli, which has a wetter environment (National Tropical Botanical Garden 2008b). About 1,000 seeds from each valley (Waiahuakua and Hanakoa) are currently stored at the National Tropical Botanical Garden nursery (National Tropical Botanical Garden 2009b). There is no other known *ex situ* (at other than the plant's natural location, such as a nursery or arboretum) collections known for this species.

Stabilizing, downlisting, and delisting objectives are provided in the recovery plan for the Kauai plant cluster (USFWS 1995), based on whether the species is an annual, a short-lived perennial (fewer than 10 years), or a long-lived perennial. *Kadua cookiana* 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* collection. In addition, a minimum of three populations should be documented on the island of Kauai, and if possible, at least one other island where the species occurred historically (Hawaii, Molokai, or 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 (see Table 1), as there are only two populations with 50 mature individuals each on Kauai, no populations on any other island where it was historically known to occur, and all threats are not being managed. Therefore, *Kadua cookiana* meets the definition of endangered as it remains in danger of extinction throughout its range.

Recommendations for Future Actions:

- Continue collecting material for genetic storage and propagation for reintroduction.

- Work with Hawaii Division of Forestry and Wildlife and Hawaii State Parks to initiate planning and contribute to implementation of ecosystem-level restoration and management to benefit this species.

- Control invasive introduced plant species around wild plants.

- Construct large-scale fences around all naturally occurring and reintroduced individuals to eliminate negative impacts from feral ungulates.

- Assessment of genetic variability within extant population.

- Collect fruit from any outplanted individuals that set seed to add to the genetic diversity of the *ex situ* material.

- Reintroduce individuals into protected suitable habitat within historical range.

- Update the listed entity on 50 CFR 17 to match the currently recognized taxonomy.

- Investigate techniques to improve natural recruitment.

References:

National Tropical Botanical Garden. 2008a. Living collections database. Provenance report accession numbers 000376 and 061168. National Tropical Botanical Garden, Kalaheo, Hawaii. Accessed 1 September 2009. Unpublished.

National Tropical Botanical Garden. 2008b. *Kadua cookiana*, outplant summary from living collections database. National Tropical Botanical Garden, Kalaheo, Hawaii. Unpublished.

National Tropical Botanical Garden. 2009a. Provenance report 930310 for *Kadua cookiana*. National Tropical Botanical Garden, Kalaheo, Hawaii. Accessed on 1 September 2009. Unpublished.

National Tropical Botanical Garden. 2009b. Controlled propagation report to U.S. Fish and Wildlife Service. National Tropical Botanical Garden, Kalaheo, Hawaii. June 30, 2009. Unpublished.

Terrell, E.E., H.E. Robinson, W.L. Wagner, and D.H. Lorence. 2005. Resurrection of genus *Kadua* for Hawaiian Hedyotidinae (Rubiaceae), with emphasis on seed and fruit characters and notes on South Pacific species. Systematic Botany 30(4):818-833.

[USFWS] U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants; determination of endangered or threatened status for 24 plants from the island of Kauai, Hawaii; final rule. Federal Register 59(38):9304-9329.

[USFWS] U.S. Fish and Wildlife Service. 1995. Recovery plan for the Kauai plant cluster. U.S. Fish and Wildlife Service, Portland, Oregon. 270 pages.

[USFWS] U.S. Fish and Wildlife Service. 2003. Endangered and threatened wildlife and plants; final designation or nondesignation of critical habitat for 95 plant species from the islands of Kauai and Niihau, Hawaii; final rule. Federal Register 68(39):9116-9479.

Wood, K.R. 2008. Notes on *Kadua cookiana* Cham. and Schltdl. (Rubiaceae). National Tropical Botanical Garden, Kalaheo, Hawaii. 6 pages. Unpublished.

Personal Communications:

Vogler, Donna. 2008. Associate Professor of Biology, SUNY Oneonta New York. E-mail to Margaret Clark, National Tropical Botanical Garden, dated October 20, 2008. Subject: *Kadua cookiana*, *K. st. johnii*, and *K. hapuuensis*.

Table 1. Status of *Kadua cookiana* from listing through 5-year review.

Date	No. wild indivs.	No. outplanted	Stability Criteria identified in Recovery Plan	Stability Criteria Completed?
1994 (listing)	50-100	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	No
1995 (recovery plan)	50-100	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	No
2003 (critical habitat)	60-80	0	All threats managed in all 3 populations	No
			Complete genetic storage	No
			3 populations with 50 mature individuals each	No
2009 (5-year review)	100-122	0	All threats managed in all 3 populations	No
			Complete genetic storage	Partially
			3 populations with 50 mature individuals each	No

U.S. FISH AND WILDLIFE SERVICE
SIGNATURE PAGE for 5-YEAR REVIEW of *Hedyotis cookiana* (awiwi)

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
__X__ No Change in listing status

Field Supervisor, Pacific Islands Fish and Wildlife Office

Date AUG 2 7 2010