5-YEAR REVIEW

Short Form Summary

Species Reviewed: *Diellia falcata* (no common name)

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 *Diellia falcata* 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 5-year review and recommendations for conservation actions needed prior to the next five-year review. The evaluation of Tamara Sherrill, a 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 *Diellia falcata* 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 *D. falcata*.

Diellia falcata was listed as endangered in 1991 (USFWS 1991). A recovery plan was prepared for this species in 1998 (USFWS 1998). Critical habitat was designated for this species in 2003 in four separate units on Oahu on State land (Pahole Natural Area Reserve and Mokuleia Forest Reserve), Federal land (Lualualei Naval Reservation), and private land (Honouliuli Preserve) (USFWS 2003).

Detailed observations of the life cycle and population dynamics of *Diellia falcata* have been made over the course of a decade of annual visits to the Hawaiian Islands by Estonian researcher, Ruth Aguraiuja. Her work is outlined in a number of publications (Aguraiuja 2001; Aguraiuja 2005; Aguraiuja and Wood 2002; Aguraiuja *et al.* 2004). The development of ferns from one reproductive stage to the next is apparently quite variable, probably in response to the differences in climate from year to year. Fronds bearing sori (groups of spores) have been observed year-round on *D. falcata.* Aguraiuja observed that the Kahanahaiki, Oahu population of *D. falcata* contained significantly fewer sporelings and premature individuals, and contained more mature individuals than expected. The peak of gametophyte (immature sporeling) establishment and vegetative growth was in April. In the South Palawai drainage, *D. falcata* was observed in small groups and various life stages. Premature stages formed about 60 percent of the population (Aguraiuja 2001; Aguraiuja and Wood 2002; Aguraiuja *et al.* 2004).

Historically, *Diellia falcata* was known from almost the entire length of the Waianae Mountains, from Manini Gulch to Palehua Iki, as well as from the Koolau Mountains of Oahu, from Kaipapau Valley to Aiea Gulch (USFWS 1991). Currently, *D. falcata* is locally common in the Waianae Range, but it is probably extirpated from the Koolau Range. Botanists have not made accurate counts of the number of individuals as it is locally common in some areas of the Waianae Mountains. In 1998, fourteen larger populations (containing 40 to 2,000 individuals each) were known and 8 populations contained fewer than 10 individuals (USFWS 1998). In 2005, it was known from at least 22 populations comprising between 5,540 and 6,540 individuals (USFWS 2007). Currently, there are 15 populations with a total of thousands of individuals but no single population is known to contain more than 230 mature individuals. However, at least three populations contain more than 50 individuals (USFWS 2007). It is sparsely distributed throughout the whole of the Waianae Mountains (Aguraiuja and Wood 2002; Aguraiuja 2001). *Diellia falcata* is the only species in the genus that seems to be maintaining viable populations (Aguraiuja 2005; USFWS 2007).

At Pahole Gulch, between 2 to 50 or more individuals were seen from 1993 to 1996, at 640 meters (2,100 feet) elevation (Perlman 2009; Wood 2009). In central Makaleha Gulch, 10 or more individuals were seen in 1996 at 555 to 600 meters (1,820 to 1,970 feet) elevation (Perlman 2009; Wood 2009). At Palikea, 100 or more individuals were reported in 1996 at 732 meters (2,400 feet) elevation. Fifty or more individuals were observed at Puu Pane in Palikea in 1998, at 671 meters (2,200 feet) elevation, and 50 or more were observed there in 2000 (Perlman 2009; Wood 2009). At Kahanahaiki in1999, approximately 250 to 500 individuals were seen at 555 meters (1,820 feet) elevation (Perlman 2009; Wood 2009) , and between 230 and 1,035 individuals were estimated to

occur there in 2007. At Huliwai between 35 and 163 individuals were estimated in 2004. At South Ekahanui, six individuals were observed in 2004. A few scattered individuals were seen in Honouliuli, Puu Kaua, Ekahanui Gulch at 686 meters (2,250 feet) elevation in 2005 (National Tropical Botanical Garden 2010). At Waianae Kai, scattered individuals were seen in 1994 at 701 to 762 meters (2,300 to 2,500 feet) elevation. Between 15 and 20 individuals were seen at 686 to 698 meters (2,250 to 2,290 feet) elevation in 2000 at Waianae Kai (Perlman 2009; Wood 2009), and between 62 and 211 individuals were estimated in 2004. At South Palawai, between 3 and 13 individuals were seen in 2004. At North Palawai, over 100 individuals were seen in 1991 at 750 to 850 meters (2,461 to 2,789 feet) elevation, and between 15 and 35 individuals were known in 2002 (National Tropical Botanical Garden 2010). An estimate for Pualii in 2004 was between 3 and 5 individuals and for Makaha the estimate in 2002 was between 300 to 700 individuals. An earlier estimate from Makaha in 1986 was hundreds to 1,000 or more individuals in 1999 at 732 to 783 meters (2,400 to 2,570 feet) elevation (Perlman 2009; Wood 2009). Most recently, the total number of populations identified by the U.S. Army Garrison in 2005 was 22, and in 2007 it was 15 populations comprising thousands of individuals (USFWS 2007).

The genus *Diellia* is endemic to Hawaii and includes six species, which may all have originated from a single common ancestor (Palmer 2003). It is believed that *Diellia* ferns may have been some of the earliest colonists on the Hawaiian Islands, some 23 to 24 million years ago (Aguraiuja 2005). Three of the six species of *Diellia* are endemic to Oahu (Palmer 2003). *Diellia falcata* hybridizes with *D. unisora* to form an endemic hybrid *D. lauii*, which was described as locally common when found by J. Lau in 1991 (USFWS 2007). The area where most of these hybrids occur is in South Palawai (Aguraiuja 2001).

It is believed that with its high dispersability of spores, *Diellia* may have had collections of interacting populations in the past which have been disrupted by habitat degradation and fragmentation (Aguraiuja 2001).

In their molecular analyses of *Diellia*, Schneider et al. (2005) resolved the genus as being monophyletic (evolved from a single ancestor), nested within *Asplenium.* They concluded that continued recognition of *Diellia* as an independent genus would render *Asplenium* as paraphyletic (evolved from multiple introductions), and suggest following Viane and Reichstein (1991), who transferred all species of *Diellia* to *Asplenium*. In addition, the species is now considered *Asplenium dielfalcatum* (Schneider *et al.* 2005). Therefore, *Diellia falcata* will be referred to as *A. dielfalcatum* throughout the remainder of this review.

Asplenium dielfalcatum grows in deep shade or open understory on moderate to moderately steep slopes and gulch bottoms in diverse mesic forest containing associated native plant species including *Acacia koa* (koa), *Alyxia stellata* (maile), *Antidesma* sp. (hame), *Asplenium kaulfussii* (kuau), *Carex meyenii* (no common name [NCN]), *Charpentiera* sp. (papala), *Claoxylon sandwicense* (poola), *Coprosma foliosa* (pilo), *Diospyros hillebrandii* (lama), *D. sandwicensis* (lama), *Diplazium sandwichianum* (hoio),

Doodia kunthiana (okupukupu), *Dryopteris unidentata* (akole), *Elaeocarpus bifidus* (kalia), *Freycinetia arborea* (ie ie), *Kadua affinis* (manono), *Hibiscus arnottianus* (hau hele, kokio), *Melicope* sp. (alani), *Metrosideros polymorpha* (ohia), *Myrsine lanaiensis* (kolea lau nui), *Nephrolepis exaltata* (nianiau), *Nestegis sandwicensis* (olopua), *Nothocestrum* sp. (aiea), *Pipturus albidus* (mamake), *Pisonia sandwicensis* (papala kepau), *Pouteria sandwicense* (alaa), *Psychotria* sp.(kopiko), *Psydrax odorata* (alahee), *Sapindus oahuensis* (lonomea), *Selaginella arbuscula* (lepe lepe a moa), *Sophora chrysophylla* (mamane), and *Xylosma* hawaiiense (au) (USFWS 2007).

In Makaha Valley the habitat where *Asplenium dielfalcatum* occurs is *Acacia koa – Metrosideros polymorpha* mesic forest and relictual *Diospyros sandwicensis* forest with *Alectryon macrococcus* (mahoe), *Antidesma pulvinatum* (hame), *Bidens torta* (kookoolau), *Carex meyenii*, *Coprosma foliosa*, *Cyanea angustifolia* (haha), *Diospyros sandwicensis*, *Diplazium sandwichianum*, *Dubautia plantaginea* (naenae), *Flueggea neowawraea* (mehamehame), *Isodendrion laurifolium* (aupaka), *Leptecophylla tameiameiae* (pukiawe), *Melicope makahae* (alani), *Myrsine lessertiana*, *Pipturus albidus* (mamake), *Pisonia* sp. (papala kepau), *Pouteria sandwicensis*, *Psychotria hathewayi* (kopiko), *Psydrax odorata, Rauvolfia sandwicensis* (hao), *Viola chamissoniana* (pamakani), and *Xylosma hawaiiense* (au) (Perlman 2009; Wood 2009).

At Pahole Gulch, in Kahanahaiki Valley, near Pahole Gulch rim, and at Makaleha Gulch the habitat where *Asplenium dielfalcatum* occurs is *Acacia koa – Metrosideros polymorpha* mesic forest and *Diospyros hillebrandii* lowland forest with *Alectryon macrococcus*, *Antidesma pulvinatum*, *Charpentiera tomentosa* (papala), *Diospyros hillebrandii*, *Dryopteris unidentata*, *Hibiscus arnottianus* (kokio keokeo), *Kadua affinis*, *Leptecophylla tameiameiae*, *Melicope peduncularis* (alani), *Morinda trimera* (noni kauhiwi), *Perrottetia sandwicensis, Pipturus albidus*, *Pouteria sandwicensis*, *Psychotria hathewayi*, *P. mariniana* (kopiko), *Syzygium sandwicense* (ohia ha), and *Urera glabra* (opuhe) (Perlman 2009; Wood 2009).

The habitat in Palikea where *Asplenium dielfalcatum* occurs is *Acacia koa – Metrosideros polymorpha* mesic forest with *Alyxia stellata*, *Antidesma pulvinatum*, *Bobea sandwicensis* (akahea), *Broussaisia arguta* (kanawao), *Canavalia galeata* (awikiwiki), *Carex meyenii*, *Claoxylon sandwicensis*, *Coprosma foliosa*, *C. longifolia* (pilo), *Cyanea membranacea* (haha), *Diospyros sandwicensis*, *Dodonaea viscosa* (aalii), *Dubautia plantaginea*, *Labordia kaalae* (kamakahala), *Leptecophylla tameiameiae*, *Melicope peduncularis*, *Neraudia* sp., *Nestegis sandwicensis*, *Perrottetia sandwicensis*, *Phyllostegia parviflora* var. *lydgatei* (NCN), *Pipturus albidus*, *Pittosporum glabrum* (hoawa), *Plantago princeps* (laukahi kuahiwi), *Pouteria sandwicensis*, *Pritchardia* sp. (loulu), *Psychotria hathewayi, P. mariniana*, *Pteralyxia macrocarpa* (kaulu), *Silene perlmanii* (NCN), *Solanum sandwicense* (popolo), *Syzygium sandwicense*, and *Urera kaalae* (opuhe) (National Tropical Botanical Garden 2010; Perlman 2009; Wood 2009).

At Waianae Kai the habitat where *Asplenium dielfalcatum* occurs is *Acacia koa – Metrosideros polymorpha* mesic forest with *Alectryon macrococcus, Alyxia stellata, Antidesma pulvinatum, Coprosma foliosa, Cyanea angustifolia, Diospyros sandwicensis,*

Diplazium sandwichianum, Doodia kunthiana, Dryopteris unidentata, Flueggea neowawraea, Hibiscus arnottianus, Isodendrion laurifolium, Morinda trimera, Myrsine lessertiana, Neraudia sp., *Nestegis sandwicensis, Nothocestrum longifolium* (aiea), *Pipturus albidus, Pisonia* sp., *Pouteria sandwicensis, Psychotria hathewayi, Psydrax odorata, Rauvolfia sandwicensis, Streblus pendulinus, Toona ciliata, Viola chamissoniana*, and *Xylosma hawaiiense* (National Tropical Botanical Garden 2010; Perlman 2009; Wood 2009).

In Honouliuli the habitat where *Asplenium dielfalcatum* was observed is *Acacia koa-Metrosideros polymorpha* lowland mesic forest with *Urera glabra*, *Streblus pendulinus* (aiai), *Cyanea membranacea*, *Bidens* sp. (kookoolau), *Dubautia* sp. (naenae), *Viola* sp., *Claoxylon* sp., *Dianella sandwicensis* (uki uki), *Pittosporum* sp. (hoawa), *Psychotria* sp., and *Pteralyxia macrocarpa* (National Tropical Botanical Garden 2010).

Feral pigs (*Sus scrofa*) and goats (*Capra hircus*) disturb the ground and significantly contribute to erosion (Listing Factor A), and together represent the single greatest threat to this species. Invasive introduced plants also degrade the habitat and invade openings created by disturbance, and crowd areas which might otherwise support recruitment of new sporelings (Aguraiuja 2005). These invasive introduced plant species include *Adiantum hispidulum* (rough maidenhair fern), *Blechnum appendiculatum* (NCN), *Bryophyllum pinnatum* (airplant), *Buddleia asiatica* (dog tail), *Casuarina equisetifolia* (ironwood), *Christella parasitica* (downy wood fern), *Clidemia hirta* (Koster's curse), *Coffea arabica* (coffee), *Erigeron karvinskianus* (daisy fleabane), *Grevillea robusta* (silk oak), *Lantana camara* (lantana), *Melinis minutiflora* (molasses grass), *Passiflora suberosa* (corkystem passionflower), *Psidium guajava* (common guava), *P. cattleianum* (strawberry guava), *Rubus argutus* (blackberry), *Schinus terebinthifolius* (Christmas berry), and *Toona ciliata* (cedar) (Listing Factors A and E) (Aguraiuja 2005; Perlman 2009; Wood 2009). In Makaha landslides (Listing Factor E) are also a threat (Wood 2009).

Goats and rats (*Rattus* spp.) are believed to eat these ferns (Listing Factor C) (Perlman 2009). In cultivation, greenhouse thrips (*Heliothrips haemorrhoidalis*) have been observed on these plants and in one case, at Kahanahaiki, approximately 10 percent of the population was damaged (Listing Factor C) (Aguraiuja 2001).

Climate change may also pose a threat to this species (Listing Factor A and E). 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.

Approximately 1,500 individuals (22 percent) of this species occur in the fenced Kahanahaiki and Ohikilolo management units of the Makua Military Reservation, where invasive ungulates and weeds are controlled. In addition, fuel load modification along the Kaluakauila ridgeline reduces the risk of fire (USFWS 2007). *Asplenium dielfalcatum* is represented in an *ex situ* (at other than the plant's natural location, such as

a nursery or arboretum) collection in micropropagation from spores at the Center for Conservation Research and Training Seed Storage Lab (2009). Spores collected in 2007 from Pahole are in long term storage at the National Tropical Botanical Garden (National Tropical Botanical Garden 2009a, 2009b).

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. *Asplenium dielfalcatum* is a short-lived perennial, and to be considered for downlisting, the taxon must be managed to control threats (*e.g.*, fenced) and be represented in an *ex situ* collection. In addition, a minimum of five to seven 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 300 mature individuals per population. Each population should persist at this level for a minimum of five consecutive years before downlisting is considered.

The downlisting goals for this species have not been met (Table 1), because although there are 15 known populations with thousands of individuals, surveys from 1999 to 2007 reported only two populations containing more than 300 mature individuals (USFWS 2007). Therefore, *Asplenium dielfalcatum* meets the definition of endangered as it remains in danger of extinction throughout its range.

Recommendations for Future Actions:

- Monitor all populations and determine the current status of the species; survey to determine numbers of mature individuals in each population.
- Fence remaining populations to protect against the negative impacts from feral ungulates.
- Control invasive introduction of plant species around all populations.
- Control rats in the vicinity of these populations.
- Develop and implement an effective method to control greenhouse thrips.
- Update the listed entity on 50 CFR 17 to match the currently recognized taxonomy.
- Collect material for genetic storage and propagation for reintroduction.
- Work with Hawaii Division of Forestry and Wildlife, U.S. Navy, Hawaii State Parks, 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.

References:

Aguraiuja, R. 2001. Population status of five Hawaiian endemic taxa within the genus *Diellia* (Aspleniaceae). CBM:s Skriftserie 3:7-24.

Aguraiuja, R. 2005. Hawaiian endemic fern lineage *Diellia* (Aspleniaceae): distribution, population structure and ecology. Dissertationes Biologicae Universitatis Tartuensis 112. Tartu University Press. 78 pages.

Aguraiuja, R. and K.R. Wood. 2002. The critically endangered endemic fern genus *Diellia* Brack. in Hawaii: its population structure and distribution. Fern Gazette 16:6-8.

Aguraiuja, R., M. Moora, and M. Zobel. 2004. Population stage structure of Hawaiian endemic fern taxa of *Diellia* (Aspleniaceae): implications for monitoring and regional dynamics. Canadian Journal of Botany-Revue Canadienne De Botanique 82(10):1438-1445.

Center for Conservation Research and Training Seed Storage Laboratory. 2009. Seed storage lab database report. University of Hawaii at Manoa, Honolulu, Hawaii. Unpublished.

National Tropical Botanical Garden. 2009a. Hawaiian native seed inventory. National Tropical Botanical Garden, Kalaheo, Hawaii. Unpublished.

National Tropical Botanical Garden. 2009b. Report to U.S. Fish and Wildlife Service on controlled propagation of listed and candidate species, as designated under the U.S. Endangered Species Act. National Tropical Botanical Garden, Kalaheo, Hawaii. 15 pages. Unpublished.

National Tropical Botanical Garden. 2010. Herbarium database records for *Diellia falcata*. National Tropical Botanical Garden, Kalaheo, Hawaii. Available online at <http://ntbg.org/herbarium/>. Accessed 24 September2010.

Palmer, D.D. 2003. Hawaii's ferns and fern allies. University of Hawai`i Press, Honolulu, Hawaii. 324 pages.

Perlman, S. 2009. Notes on *Diellia falcata*. National Tropical Botanical Garden, Kalaheo, Hawaii. 3 pages. Unpublished.

Schneider, H., T.A. Ranker, S.J. Russell, R. Cranfill, J.M.O. Geiger, R. Aguraiuja, K.R. Wood, M. Grundmann, K. Kloberdanz, and J.C. Vogel. 2005. Origin of the endemic fern genus *Diellia* coincides with the renewal of Hawaiian terrestrial life

in the Miocene. Proceedings of the Royal Society Biological Sciences 272(1561):455-460.

[USFWS] U.S. Fish and Wildlife Service. 1991. Endangered and threatened wildlife and plants; determination of endangered status for 26 plants from the Waianae Mountains, island of Oahu, Hawaii; final rule. Federal Register 56(209):55770-55786.

[USFWS] U.S. Fish and Wildlife Service. 1998. Recovery plan for Oahu plants. U.S. Fish and Wildlife Service, Portland, Oregon. 207 pages, plus appendices.

[USFWS] U.S. Fish and Wildlife Service. 2003. Endangered and threatened wildlife and plants; final designations or nondesignations of critical habitat for 101 plant species from the island of Oahu, Hawaii; final rule. Federal Register 68(116):35949-36406.

[USFWS] U.S. Fish and Wildlife Service. 2007. Reinitiation of the 1999 biological opinion of the U.S. Fish and Wildlife Service for U.S. Army Military Training at Makua Military Reservation, island of Oahu. 639 + appendices. Unpublished.

Viane R.L.L. and T. Reichstein. 1991. Notes about Asplenium II; some new names and combinations in Asplenium L. (Aspleniaceae and Pteridiophyta). Biologisch Jaarboek - Dodonaea (Belgium) 59:157-165.

Wood, K.R. 2009. Notes on *Diellia falcata*. National Tropical Botanical Garden, Kalaheo, Hawaii. 6 pages. Unpublished.

Table 1. Status of *Asplenium dielfalcatum* from listing through 5-year review.

Date	No. wild indivs	No. outplanted	Downlisting Criteria identified in Recovery Plan	Downlisting Criteria Completed?
1991 (listing)	3,000	0	All threats managed in all 5-7 populations	No
			5-7 populations with 300 mature individuals each	Unknown
			Each population persist for 5 consecutive years	Unknown
1998 (recovery plan)	5,540-6,540	0	All threats managed in all 5-7 populations	No
			5-7 populations with 300 mature individuals each	Unknown
			Each population persist for 5 consecutive years	Unknown
2003 (critical habitat)	>6,000	0	All threats managed in all 5-7 populations	No
			5-7 populations with 300 mature individuals each	Unknown
			Each population persist for 5 consecutive years	Unknown
2010 (5-yr review)	thousands	0	All threats managed in all 5-7 populations	Partially: (Table 2)
			5-7 populations with 300 mature individuals each	No: only two populations more than 300 mature individuals
			Each population persist for 5 consecutive years	Unknown

Table 2. Threats to *Asplenium dielfalcatum*.

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Ungulates – habitat modification and herbivory	A, D	Ongoing	Partially: populations in Kahanahaiki and Ohikilolo are fenced and ungulates controlled
Rats – herbivory	C	Ongoing	No
Greenhouse thrips – herbivory	C	Ongoing	No
Landslides	A, E	Ongoing	No
Invasive introduced plants	A, E	Ongoing	Partially: weeds controlled at populations in Kahanahaiki and Ohikilolo
Climate change	A, E	Increasing	No

U.S. FISH AND WILDLIFE SERVICE
SIGNATURE PAGE for 5-YEAR REVIEW of *Diellia falcata*

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 6/2/11
ACTING