Kadua fluviatilis
(kamapua‘a)

5-Year Review
Summary and Evaluation

U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Honolulu, Hawai‘i

5-YEAR REVIEW

Species reviewed: *Kadua fluviatilis* (kamapua‘a)

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5-YEAR REVIEW
Kadua fluviatilis (kamapua‘a)

1.0 GENERAL INFORMATION

1.1 Reviewers:

Cheryl Phillipson, Biologist, Pacific Islands Fish and Wildlife Office (PIFWO)
Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
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Lead Regional Office:
Interior Region 12, Portland Regional Office

Lead Field Office:
Pacific Islands Fish and Wildlife Office

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 (Service), beginning in October 2020. The review was based on the final rule listing this species; peer reviewed scientific publications; unpublished field observations and species status report by the Service, State of Hawai‘i, and other experienced biologists; unpublished survey reports; notes and communications from other qualified biologists; as well as a review of current, available information. The evaluation by Cheryl Phillipson, Biologist, was reviewed by Lauren Weisenberger, Plant Recovery Coordinator, and Megan Laut, Conservation and Restoration Team Manager.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2019. Endangered and threatened wildlife and plants; initiation of 5-year status reviews for 91 species in Oregon, Washington, Hawai‘i, and American Samoa. Federal Register 84 (112): 27152–27154, June 11, 2019.

1.3.2 Listing history:

Original Listing
FR notice: [USFWS] U.S. Fish and Wildlife Service. 2016. Endangered and Threatened Wildlife and Plants; endangered status for 49 species from the

Hawaiian Islands; final rule. Department of the Interior, Federal Register 81 (190): 67786–67860, Friday, September 30, 2016.

Date listed: September 30, 2016
Entity listed: *Kadua fluviatilis*
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:
N/A

1.3.4 Review History:
This is the first 5-year review for *Kadua fluviatilis*.

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: Recovery Outline for the Multi-Island Species
Date issued: August 2020
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**
__X_**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
__X_ 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?

____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.

The recovery plan is currently being drafted. However, the Hawai‘i and Pacific Plants Recovery Coordinating Committee (HPPRCC) has outlined the actions and goals for stages leading towards recovery (2011). These stages are described below.

Current information is lacking for many Hawaiian plant species on the status of the species and their habitats, breeding systems, genetics, and propagule storage options. The following downlisting and delisting criteria for plants have therefore been adopted from the revised recovery objective guidelines developed by the HPPRCC (2011). Many of the Hawaiian plant species are at very low numbers, so the Service also developed criteria for avoiding imminent extinction and an interim stage before downlisting, based on the recommendations of the HPPRCC, to assist in tracking progress toward the ultimate goal of recovery. These criteria are assessed on a species-by-species basis, especially as additional information becomes available.

In general, long-lived perennials are those taxa either known or believed to have life spans greater than 10 years; short-lived perennials are those known or believed to have life spans greater than one year but less than 10 years; and annuals are those known or believed to have life spans less than or equal to one year. When it is unknown whether a species is long- or short-lived, the Service has erred on the side of caution and considered the species short-lived. This will be revised as more is learned about the life histories of these species. Narrow extant range and broad contiguous range are recognized as not needing different numbers of individuals or populations, but that the populations will be distributed more narrowly or more broadly, respectively, across the landscape. Obligate outcrossers are those species that either have male and female flowers on separate plants or otherwise require cross-pollination to fertilize seeds, and therefore require equal numbers of individuals contributing to reproduction as males and females, doubling the number of mature individuals. Species that reproduce vegetatively may reproduce sexually only on occasion, resulting in the majority of the genetic variation being between populations, therefore requiring additional populations. Species that have a tendency to fluctuate in number from year to year require a larger number of mature individuals on average to allow for decline in years of extreme habitat conditions and recuperation in numbers in years of more normal conditions.

Preventing Extinction

Stabilizing (interim), downlisting, and delisting objectives have been updated according to the draft revised recovery objective guidelines developed by the HPPRCC (2011). The HPPRCC identifies an additional initial objective, the Preventing Extinction Stage, in addition to the Interim Stabilization, Delisting, and Downlisting objectives. Furthermore, life history traits such as breeding system, population size fluctuation or decline, and reproduction type (sexual or vegetative), have been included in the calculation of goals for the number of populations and reproducing individuals for each stage. The goals for each stage remain grouped by life span defined as annual, short-lived perennial (fewer than 10 years), or long-lived perennial.

Kadua fluviatilis is a short-lived perennial shrub and considered a mostly obligate outcrosser. To prevent extinction, which is the first milestone in recovering the

species, the taxon must be managed to control threats (e.g., fenced) and have 50 individuals (or the total number of individuals if fewer than 50 exist) from each of three populations represented in *ex situ* (secured off-site, such as a nursery or seed bank) collections that are well managed. In addition, a minimum of three populations total should be documented on O‘ahu and/or Kaua‘i where they now occur or occurred historically. Each of these populations must be naturally reproducing (i.e., viable seeds, seedlings) with a minimum of 100 mature individuals per population.

This recovery objective has not been met (see Table 1).

Interim Stage

To meet the interim stage of recovery of *Kadua fluviatilis*, 600 mature individuals are needed in each of three populations and all major threats must be controlled around the populations designated for recovery at this stage. Multi-island species should be represented by at least one population on each of the islands from which they were known historically as long as suitable habitat exists. There should also be demonstrated regeneration of seedlings and growth to at least sapling stage for woody species and documented replacement regeneration within each of the target populations. The populations must be adequately represented in an *ex situ* collection as defined in the Center for Plant Conservation’s guidelines (Guerrant et al. 2004, entire) that is secure and well managed. Adequate monitoring must be in place and conducted to assess individual plant survival, population trends, trends of major limiting factors, and response of major limiting factors to management.

This recovery objective has not been met (see Table 1).

Downlisting Criteria

In addition to achieving 5 to 10 populations with 1,000 mature individuals per population and all of the goals of the interim stage, all target populations must be stable, secure, and naturally reproducing for a minimum of 10 years. Multi-island species should be represented by at least three populations on each of the islands from which they were known historically as long as suitable habitat exists. Species-specific management actions are not ruled out. Downlisting should not be considered until an adequate population viability analysis (PVA) has been conducted to assess needed numbers more accurately based on current management and monitoring data collected at regular intervals determined by demographic parameters of the species, although they should only be one of the factors used in making a decision to downlist. Information necessary for the PVA that should be available through monitoring (ideally annually) includes major limiting factors, breeding system, population structure and density, and proven management methods for major threats.

This recovery objective has not been met (see Table 1).

Delisting Criteria
In addition to achieving 5 to 10 populations with 1,000 mature individuals per population and all of the goals of the interim and downlisting stages, all target populations must be stable, secure, naturally reproducing, and within secure and viable habitats for a minimum of 20 years. Multi-island species should be represented by at least three populations on each of the islands from which they were known historically as long as suitable habitat exists. Species-specific management actions must no longer be necessary, but ecosystem-wide management actions are not ruled out if there are long-term agreements in place to continue management. These numbers are initial targets, but may be revised upward as additional information is available, including adequate PVAs for individual species based on current management and monitoring data collected at regular intervals determined by demographic parameters of the species, although they should only be one of the factors used in making a decision to delist. Genetic analyses should be conducted to ensure that adequate genetic representation is present within and among populations compared to the initial variation assessed in the interim stage. Numbers need to be considered on a species-by-species basis.

This recovery objective has not been met (see Table 1).

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:

Kadua fluviatilis, a member of the Rubiaceae (coffee) family, is a scandent (climbing) shrub, fetid (bad smelling) when bruised; with cylindrical, but slightly flattened, stems, 0.3 to 2.5 meters (1 to 8 feet) long, glabrous (hairless), and with short lateral branches. Leaves are widely spaced, papery, elliptic-oblanceolate to elliptic-lanceolate (narrowly oval to lance-shaped), 8 to 17 centimeters (cm) (3.2 to 6.8 inches (in)) long, and 3 to 5 cm (1.2 to 2 in) wide. Flowers are perfect and pistillate (hermaphrodite and female plants), borne in reduced axillary, cymose inflorescences (terminal flowers bloom first). Calyx lobes are deltate (triangular) to narrowly ovate (egg-shaped), 12 to 18 millimeters (mm) (0.5 to 0.7 in) long, 3 to 6 mm (0.1 to 0.2 in) wide, with several small sac-like glands at the indentations between corolla lobes. The corolla is white, fleshy and waxy, with a tube 22 to 30 mm (0.9 to 1.2 in) long. Capsules (dry fruit) are woody, strongly quadrangular or winged, 8 to 13 mm (0.3 to 0.5 in) long, and 9 to 13 mm (0.4 to 0.5 in) in diameter. Seeds are translucent reddish brown, wedge-shaped, and minutely reticulate (net-veined). *Kadua fluviatilis* is very similar to *K. acuminata* but differs by having larger flowers with thicker, waxy, white corollas (Wagner et al. 1999, pp. 1142–1144).

Wagner et al. (1999, p. 1144) suggest that *Kadua fluviatilis* might best be treated as a subspecies of *K. acuminata*. Furthermore, they state plants from Sacred Falls, Oʻahu, described by Degener and Fosberg in 1943 as *Hedyotis* (*Kadua*) *fluviatilis* f. *breviflora*, may represent hybrids with *K. acuminata* as both species occur in the area (Wagner et al. 1999, p. 1144).

The genus *Kadua* in the islands of Hawaiʻi evolved from a hermaphroditic colonizer that speciated into 20 endemic species (Sakai et al. 1995, p. 2519; Wagner et al. 1999, pp. 1133–1156). The majority (66 percent) of these species are dimorphic (two distinct forms) with the majority being gynodioecious; meaning that all of the flowers on an individual plant are female, or all the flowers on an individual are hermaphroditic (flowers with both male and female reproductive parts). This is the case for *Kadua fluviatilis* (Sakai et al. 1995, p. 2519). Therefore, female plants require a mechanism for outcrossing as to receive pollen from hermaphroditic plants in a population.

Kadua fluviatilis flowers sporadically and nearly year round (NTBG 2020). Based on herbarium specimens, this species was observed flowering every month except April (no vouchers collected in April), and fruiting during the months of March, May, and August through December (NTBG 2020), The pale white color and tubular shape of the flowers indicates that moths could be a likely pollinator of *K. fluviatilis* (Pollinator Partnership and NAPPC 2013, p. 11; Sakai et al. 1995, p. 2527). For fruit dispersal, it is possible that the small, winged capsules may be carried by wind or water via floatation and several populations on Kauaʻi and Oʻahu occur along streams. Seed-eating birds may be a dispersal vector and seeds could potentially be carried in mud on the feet of birds (Sakai et al. 1995, p. 2527; Carlquist 1980, p. 314, 327).

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, on Oʻahu, *Kadua fluviatilis* occurred in the Koʻolau mountains at Kaukonahua, Kīpapa, Kaluanui, Helemano, ʻŌpaeʻula, Kawai Iki, Punaluʻu, Maʻakua, Kaipapaʻu, and Kōloa, totaling as many as 550 individuals (HBMP 2010, OANRP 2020, unpublished data). Historically, on Kauaʻi, occurrences ranged from the south at Hāʻupu to Waiʻoli, and ʻIole, and north to Hanakāpīʼai and Limahuli (HBPM 2010; Wood 2005, p. 7, NTBG 2020, Wood 2014, p. 18).

Currently, on Oʻahu, there are two populations, one at Kaipapaʻu totaling 20 individuals and a second (two subpopulations) at Kaluanui, one subpopulation totaling five to 10 individuals and the second subpopulation with only one individual (Ching Harbin 2020, pers. comm.). On Kauaʻi,

there are five populations (Limahuli-Mānoa, Hoʻolulu, Hanakāpīʼai, ʻIole, and Hulēʻia) totaling 78 to 128 individuals. More surveys are needed on both islands to better determine the status of these populations and to determine if others may still exist (Ching Harbin 2020, pers. comm.).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
Several phylogenetic studies have investigated the relationships of species within the family Rubiaceae. *Kadua fluviatilis* may be most closely related to *K. acuminata* based on studies on of seed morphology (Terrell et al. 2005, p. 822) and chloroplast and nuclear DNA markers (Kårehed et al. 2008, p. 851). However, Groeninckx et al. (2009, p. 121) analyzed chloroplast data and found that the relationships within the genus *Kadua* remain mostly unresolved. Furthermore, they suggest broader sampling including more *Kadua* species and additional molecular markers are needed to discuss molecular evolution in the light of the seed morphological observations of Terrell et al. (2005). Wikstrom et al. (2018) conducted Bayesian phylogenetic analyses of *Kadua* using plastid (*rps16*, *petD*) and nuclear (ITS, ETS) sequence data to test former taxonomic hypotheses. Their results suggest *K. fluviatilis* and *K. parvula,* a rare, small shrub only found on cliffs of the Waiʻanae mountain range on Oʻahu, are the most closely related.

2.3.1.4 Taxonomic classification or changes in nomenclature:
First described as *Kadua fluviatilis* by Forbes (1911-1913, p. 6), this species was moved to the genus *Hedyotis* by Fosberg (1943, p. 90) and was recognized as a distinct taxon in Wagner *et al*. (1999, pp. 1142–1144). However, a recent scanning electron microscope study (Terrell *et al*. 2005, entire) and molecular phylogeny studies by Motley *et al*. (1998, abstract) of the tribe Hedyotideae, to which all 22 Hawaiian native *Hedyotis* belonged, suggested nomenclatural changes were necessary. Terrell et al.'s (2005) study of seed and fruit characters, and Kårehed et al.'s 2008 study of the phylogeny of the Rubiaceae tribe, revealed that the Hawaiian species were distinct from Asian and Pacific species of *Hedyotis* subgenus *Hedyotis* and from North American specimens of tribe Hedyotideae. In light of these morphological changes, the oldest available genus name, *Kadua*, was resurrected and applied to all Hawaiian species. The new combination for *Hedyotis fluviatilis* is *Kadua fluviatilis* and is the currently accepted taxonomy (Wagner et al. 2012, p. 64).

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.):
See section 2.3.1.2 and 2.3.1.4 above for spatial distribution of the species.

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

Typical habitat for *Kadua fluviatilis* includes lowland mesic to wet shrubland and forest, including stream banks and cliffs, at 229 to 783 m (750 to 2,569 ft) on Oʻahu and Kauaʻi (HBMP 2010; Wood 2005, pp. 7–8; Wood 2014, p. 18).

On Oʻahu, *Kadua fluviatilis* occurs in wet *Metrosideros* (ʻōhiʻa) forest on rocky streambanks with the associated native species *Psychotria* spp. (kōpiko), *Pritchardia martii* (loulu hiwa), *Rhynchospora sclerioides* (kuolohia), *Scaevola chamissoniana* (naupaka kuahiwi), and *Syzygium sandwicensis* (ʻohiʻa hā), and *Dicranopteris linearis* (uluhe) and other native ferns, at 250 to 607 m (820 to 1,990 ft) (HBMP 2010).

On Kauaʻi, *Kadua fluviatilis* occurs in mixed native shrubland and wet *Metrosideros polymorpha* forest with the associated native species *Bidens* spp. (koʻokoʻolau), *Boehmeria grandis* (ʻākōlea), *Dicranopteris linearis*, *Diplazium sandwichianum* (hōʻiʻo), *Hibiscus waimeae* subsp. *hannerae* (kokiʻo keʻokeʻo), *Isodendrion longifolium* (aupaka), *Lobelia niihauensis* (no common name), *Machaerina angustifolia* (ʻuki), *Perrottetia sandwicensis* (olomea), *Pipturus albidus* (waimea) (HBMP 2010); and in open shrubland with sparse tree cover of *Metrosideros polymorpha* and the associated native species *Antidesma platyphyllum* var. *hillebrandii* (hame), *Bidens valida* (koʻokoʻolau), *Bobea brevipes* (ʻahakea lau liʻi), *Cheirodendron fauriei* (ʻōlapa), *Cibotium glaucum* (hāpuʻu), *Dicranopteris linearis*, *Diplopterygium pinnatum* (uluhe lau nui), *Eragrostis variabilis* (kāwelu), *Freycinetia arborea* (ʻieʻie), *Kadua affinis* (manono), *Melicope feddei* (alani), *Polyscias* spp. (ʻohe), *Psychotria mariniana* (kōpiko), *Sadleria pallida* (ʻamaʻu), and *Xylosma hawaiiense* (maua) (Wood 2005, pp. 7–8). Associated native plants in mesic habitat at Hāʻupu include *Pisonia* spp. (pāpala), *Diospyros sandwicensis* (lama), *Acacia koa* (koa), *Kadua acuminata* (au), *Pipturus* spp. (mamaki), *Psychotria* spp., *Cyanea hardyi* (hāhā), and *Bidens* spp. (Wood 2005, p. 6; Lorence et al. 2010, p. 140).

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 (Factor A):

Ungulate destruction and degradation of habitat—Evidence of the activities of feral pigs (*Sus scrofa*) are observed at Punaluʻu, Kaluanui, and Kaipapaʻu on Oʻahu and the activities of feral pigs and goats (*Capra hircus*) are observed at Hāʻupu, Hanakāpīʼai, Hoʼolulu, ʻIole, and Mānoa on Kauaʻi (Lorence et al. 2010, p. 140; HBMP 2010). Feral ungulates modify and degrade habitat by disturbing and destroying vegetative cover,

trampling plants and seedlings, reducing or eliminating plant regeneration by damaging seeds and seedlings, and increasing erosion by creating large areas of bare soil (Loope 1998, pp. 747–774; van Riper and van Riper 1982, pp. 34–35).

Established ecosystem-altering invasive plant modification and degradation of habitat, and competition—Invasive introduced plant species modify habitats occupied by native plant species by changing the availability of light, altering soil-water regimes, modifying nutrient cycling, and changing the fire characteristics of the native plant community (Cuddihy and Stone 1990, p. 74). Habitat modification and destruction by invasive nonnative plants negatively affects all occurrences of *Kadua fluviatilis* (HBMP 2010; Wood 1998, p. 2). Nonnative plants with the greatest impacts on *K. fluviatilis* include *Adiantum raddianum* (maidenhair fern), *Ageratina riparia* (Hāmākua pāmakani), *Axonopus fissifolius* (narrow-leaved carpetgrass), *Christella parasitica*, *Clidemia hirta* (Koster's curse), *Cyperus meyenianus* (flatsedge), *Deparia petersenii* (lady fern), *Hedychium gardnerianum* (kāhili ginger), *Heliocarpus popayanensis* (moho), *Juncus planifolius* (rush), *Lantana camara* (lantana), *Melastoma septemnervium* (Asian melastome), *Melinis minutiflora* (molasses grass), *Oplismenus hirtellus* (basket grass), *Paederia foetida* (maile pilau), *Passiflora tarminiana* (banana poka), *Psidium guajava* (guava), *P. cattleianum* (strawberry guava), *Rubus rosifolius* (thimbleberry), *Sacciolepis indica* (glenwood grass), *Schinus terebinthifolius* (Christmas berry), *Schizachyrium condensatum* (little bluestem), *Setaria palmifolia* (palmgrass), *S. parviflora* (yellow foxtail), *Spathoglottis plicata* (Philippine ground orchid), *Sphaeropteris cooperi* (Australian tree fern), and *Tibouchina herbacea* (glorybush) (Wood 1998, p. 2; Wood 2005, p. 3).

Landslide destruction or degradation of habitat—Landslides are a threat to *Kadua fluviatilis* as this species occurs on cliffs and along streambanks (HBMP 2010; Wood 1998, p. 3; Cuddihy and Stone 1990, pp. 63–64). Landslides, including tree falls and erosion associated with them, can have a significant effect on small populations by destabilizing substrate, altering hydrological patterns, and by damaging and destroying individual plants (Stearns 1985, pp. 99–107, 291–305).

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes (Factor B):
Not a threat.

2.3.2.3 Disease or predation (Factor C):
Herbivory and predation by feral ungulates—Evidence of the activities of feral pigs (*Sus scrofa*) are observed at Punalu‘u, Kaluanui, and Kaipapa‘u on O‘ahu and the activities of feral pigs and goats (*Capra hircus*) are

observed at Hā‘upu, Hanakāpī’ai, Ho’olulu, ‘Iole, and Mānoa on Kaua‘i (Lorence et al. 2010, p. 140; HBMP 2010). These animals damage and destroy plants by direct herbivory, bark stripping, and trampling. Feral pigs have been observed browsing on young shoots, leaves, and fronds of a wide variety of native plants (Diong 1982, p. 144). Feral goats forage in areas of extremely rugged terrain and are instrumental in the decline of native vegetation (Cuddy and Stone 1990, p. 64; van Riper and van Riper 1982, pp. 34–35; Tomich 1986, pp. 153–156).

Herbivory and predation by rats—Field observations indicate that herbivory by rats (*Rattus* sp.) is a threat to species of *Kadua fluviatilis* at Hā‘upu (Lorence et al. 2010, p. 140). Rats impact native plants by eating seeds, flowers, leaves, roots, and other plant parts (Atkinson and Atkinson 2000, p. 23). The effects on plants range from reduced vigor and decreased reproduction to mortality of individuals and complete lack of recruitment (Russell 1980, pp. 269–272.

2.3.2.4 Inadequacy of existing regulatory mechanisms (Factor D): Lack of adequate hunting regulations—*Kadua fluviatilis* occurs within or adjacent to State hunting areas on O‘ahu and Kaua‘i (Department of Land and Natural Resources (DLNR) 2010). Nonnative feral ungulates are an ongoing threat to this species through destruction and modification of habitat and direct predation. Only one occurrence is fenced and feral pigs and goats have been noted as a threat to this species. Public hunting areas are not fenced and game mammals have unrestricted access for most areas across the landscape, regardless of underlying land use designation; therefore, any unfenced populations of *K. fluviatilis* are at risk (DLNR 2010).

Lack of adequate biosecurity legislation—Introduction of nonnative plants—Currently, four agencies are responsible for inspection of goods arriving in Hawai‘i (CGAPS 2009). The Hawai‘i Department of Agriculture (HDOA) inspects domestic cargo and vessels and focuses on pests of concern to Hawai‘i, especially insects or plant diseases. The U.S. Department of Homeland Security-Customs and Border Protection (CBP) is responsible for inspecting commercial, private, and military vessels and aircraft and related cargo and passengers arriving from foreign locations, focusing on non-propagative plant materials, and internationally regulated commercial species under the Convention in International Trade in Endangered Species (CITES). Also included are federally listed noxious seeds and plants, soil, and pests of concern for forests and agriculture. The U.S. Department of Agriculture-Animal and Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ) inspects propagative plant material, provides identification services for arriving plants and pests, and conducts pest risk assessments among other activities (HDOA 2009). The Service inspects arriving wildlife products, enforces

the injurious wildlife provisions of the Lacey Act (18 U.S.C. 42; 16 U.S.C. 3371 et seq.) and prosecutes CITES violations. The State of Hawai‘i allows the importation of most plant taxa, with limited exceptions. Many invasive plants established in Hawai‘i have expanding ranges. Resources available to reduce the spread of these species and counter their negative ecological effects are limited. Control of established nonnative invasive plants is largely focused on a few invasive species that cause significant economic or environmental damage to public and private lands, and comprehensive control of an array of invasive plants remains limited in scope. The introduction of new invasive plant species to the State of Hawaii is a significant risk to federally listed species.

2.3.2.5 Other natural or manmade factors affecting its continued existence (Factor E):

Reduced viability due to low numbers—Small, isolated populations often exhibit reduced levels of genetic variability, which diminishes the species' capacity to adapt and respond to environmental changes, thereby lessening the probability of long-term persistence (Barrett and Kohn 1991, pp. 3,7; Newman and Pilson 1997, pp. 354–355). The problems associated with small population size and vulnerability to random demographic fluctuations or natural catastrophes are further magnified by synergistic interactions with other threats, such as anthropogenic impacts like habitat loss from human development or predation by nonnative species. Very small plant populations may experience reduced reproductive vigor due to ineffective pollination or inbreeding depression. The number of populations and number of individuals of *Kadua fluviatilis* has been rapidly declining from as many as 900 individuals in 2010 to fewer than 170 in 2021.

Climate change loss or degradation of habitat—Fortini et al. (2013) conducted a landscape-based assessment of climate change vulnerability for native plants of Hawai‘i using high resolution climate change projections. Climate change vulnerability is defined as the relative inability of a species to display the possible responses necessary for persistence under climate change. The assessment concluded that *Kadua fluviatilis* is highly vulnerable to the impacts of climate change with a vulnerability score of 0.506 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). Therefore, additional management actions may be needed to conserve this taxon into the future, such as locating key microsites that overlap with current and future climate envelopes for outplanting efforts.

Current Management Actions:

- Surveys and monitoring—PEPP surveyed for populations of *Kadua fluviatilis* on O‘ahu but no individuals were found (Ching Harbin 2020, pers. comm.).
- Ungulate control—The National Tropical Botanical Garden (NTBG) has fenced Lower Limahuli Preserve to protect outplantings of *Kadua fluviatilis* and other rare species from the effects of feral ungulates (NTBG 2019a, p. 4).
- Ecosystem-altering invasive nonnative plant control—NTBG controls nonnative invasive plants within Lower Limahuli Preserve (NTBG 2019a, p. 4). In addition, *Melastoma septemnervium* is being removed from Hā‘upu (NTBG 2019a, p. 4).
- Captive propagation for genetic storage and reintroduction—NTBG has successfully propagated hundreds of individuals of *Kadua fluviatilis* by seeds and cuttings since 2001 (NTBG 2019b). Several individuals (13) were planted in their living collections at both the McBryde and Limahuli Gardens between 2019 and 2020. There are 3,221 seeds in storage at the NTBG Seed Bank and Laboratory in 16 different accessions representing populations at Kaipapa‘u on O‘ahu and Hanakāpī‘ai, Hā‘upu and Mānoa on Kaua‘i (NTBG 2019b).
- Reintroduction and translocation—NTBG reports a recent outplanting of 15 individuals of *K. fluviatilis* within Lower Limahuli Preserve (NTBG 2019a, p. 4).

Table 1. Status and trends of *Kadua fluviatilis* from listing through 5-year review.

Date	No. wild individuals	No. outplanted	Preventing Extinction Criteria identified by HPPRCC	Preventing Extinction Criteria Completed?
2016 (listing)	20–25 (O‘ahu) ca 500 (Kaua‘i)	1 *inter situ*	All threats managed in all 3 populations	Partially, exclosure at Lower Limahuli Preserve, nonnative plant control at Lower Limahuli Preserve and Hā‘upu
			Complete genetic storage	Partially
			3 populations with 100 mature individuals each	No
2021 (5-year review)	26–36 (O‘ahu) 78–128 (Kaua‘i)	15 *inter situ* Kaua‘i	All threats managed in all 3 populations	Partially, exclosure at Lower Limahuli Preserve, nonnative plant control at Lower Limahuli

				Preserve and Hā‘upu
			Complete genetic storage	Partially
			3 populations with 100 mature individuals each	No
			Each population naturally reproducing	Natural recruitment not reported

Table 2. Threats to *Kadua fluviatilis* and ongoing conservation efforts.

Threat	Listing Factor	Current Status	Conservation/Management Efforts
Destruction and degradation of habitat by ungulates	A	Ongoing	Partial, ungulate exclosure at Lower Limahuli Preserve
Destruction and degradation of habitat by established ecosystem-altering invasive plants	A	Ongoing	Partial, nonnative plant control at Lower Limahuli Preserve and Hā‘upu
Ungulate predation and herbivory	C	Ongoing	Partial, ungulate exclosure at Lower Limahuli Preserve
Inadequacy of regulatory mechanisms	D	Ongoing	Partial, ungulate exclosure at Lower Limahuli Preserve
Low numbers	E	Ongoing	Partial, seed storage and propagation
Climate change degradation or loss of habitat	E	Ongoing	None

2.4 Synthesis

There are 26 to 36 wild individuals of *Kadua fluviatilis* on O‘ahu and 78 to 128 individuals on Kaua‘i. This marks a substantial decline over the last five years of approximately 67 to 80 percent of known individuals. A landscape-based assessment of climate change vulnerability for native plants of Hawai‘i using high resolution climate change projections was made by Fortini et al. (2013) and their analysis showed that *K. fluviatilis* is highly vulnerable to the effects of climate change. The occurrence at Lower Limahuli Preserve *inter situ* planting is protected by an ungulate exclosure. There are seeds and propagules in collections.

Preventing extinction, interim stabilization, downlisting, and delisting objectives are provided in HPPRCC’s Revised Recovery Objective Guidelines (2011). To prevent extinction, which is the first step in recovering the species, the taxon must

be managed to control threats (e.g., fenced) and have 50 individuals (or the total number of individuals if fewer than 50 exist) from each of three populations 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 total should be documented on O'ahu and/or Kaua'i where they now occur or occurred historically and each of these populations must be naturally reproducing (i.e., viable seeds, seedlings) with a minimum of 100 mature, reproducing individuals per population.

The preventing extinction goals for this species have not been met. There are no populations totaling 100 mature individuals and only partial genetic representation (Table 1). In addition, all threats are not being sufficiently managed throughout the range of the species (Table 2). Therefore, *Kadua fluviatilis* meets the definition of endangered as it remains in danger of extinction throughout its range.

3.0 RESULTS

3.1 Recommended Classification:

____Downlist to Threatened
____Uplist to Endangered
____Delist
____*Extinction*
____*Recovery*
____*Original data for classification in error*
__X__**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

- Surveys and inventories—Continue to conduct surveys for *Kadua fluviatilis* in historical locations and potentially suitable habitat.

- Ungulate monitoring and control—Continue to construct and maintain fenced exclosures to protect individuals from the negative impacts of feral ungulates.
- Invasive plant monitoring and control—Continue to control established ecosystem-altering nonnative invasive plant species and those that compete with *K. fluviatilis*.
- Captive propagation for genetic storage and reintroduction—Continue to collect seeds for storage and propagation efforts for maintenance of genetic stock.
- Reintroduction and translocation—Increase numbers of populations and individuals in suitable habitat to build resiliency and redundancy and reduce the impacts of low numbers of populations and individuals and the effects of climate change.
- Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change.
- Alliance and partnership development—Continue to contribute to planning and implementation of ecosystem-level restoration and management to benefit this taxon.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Kadua fluviatilis*
(kamapua‘a)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____Downlist to Threatened
____Uplist to Endangered
____Delist
_X__No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: _____

Review Conducted By:
Cheryl Phillipson, Fish and Wildlife Biologist, PIFWO
Lauren Weisenberger, Plant Recovery Coordinator, PIFWO
Megan Laut, Conservation and Restoration Team Manager, PIFWO

FIELD OFFICE APPROVAL:

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for _____
Field Supervisor, Pacific Islands Fish and Wildlife Office