

***BIDENS WAILELE* (ASTERACEAE: COREOPSIDEAE): A NEW CRITICALLY ENDANGERED SPECIES FROM KAUAI, HAWAIIAN ISLANDS**

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Premise of research. The explosive diversification of Hawaiian *Bidens* is considered one of the premier examples of plant adaptive radiation in the native Hawaiian flora. Botanical exploration, especially in remote areas, continues and sometimes results in the discovery of new species. Most of these new discoveries are narrowly distributed endemics, and some are evaluated to be threatened or endangered, sometimes critically so, as is the case for *Bidens wailele*.

Methodology. *Bidens wailele* K.R. Wood & Knope (Asteraceae/Compositae) is (1) described and illustrated from Kauai, Hawaiian Islands; we also (2) provide a diagnostic key distinguishing characters that separate *B. wailele* from all other native Kauai *Bidens*, (3) present a summary of its distribution, ecology, and threats; and (4) provide a formal Red List assessment utilizing the International Union for Conservation of Nature (IUCN) criteria for endangerment. This discovery is part of ongoing floristic research and exploration conducted by the National Tropical Botanical Garden Science and Conservation Department.

Pivotal results. This new species occurs in extremely wet conditions around the waterfalls of Waialeale and Wainiha, central Kauai. Morphologically, it is most similar to *Bidens valida*, a Kauai endemic species naturally occurring around windswept ridges and cliffs of southeastern Kauai (as on Haupu, Hulua, and Kahili Mountains).

Conclusions. This rare new species is presently known from only 700–800 individuals and restricted to three remote locations; *B. wailele* has been evaluated under the IUCN Red List criteria and proposed as critically endangered. A fourth population on a wet cliff where the new species historically occurred (i.e., Kamanu, Kauai) was destroyed by a landslide after its discovery in 2008, most likely caused by torrential rains and demonstrating the species' vulnerability for extinction.

Keywords: Compositae, conservation, single-island endemic, IUCN Red List category, Oceania.

Introduction

The Asteraceae (or Compositae) family is one of the most species-rich families of flowering plants, with approximately 25,000 extant species that can be found in terrestrial habitats around the globe (Funk et al. 2009; Palazzesi et al. 2022). Recent advances in molecular phylogenomics have resulted in a fully resolved backbone phylogeny at the subfamily and tribe levels (Mandel et al. 2019), but many generic and species-level relationships remain unresolved. In addition, discovery and description of species are ongoing in this hyperdiverse and globally distributed angiosperm family. Within the family, the genus *Bidens* L. (subfamily Asteroideae; tribe Coreopsideae) is estimated to be composed of 150–235 species (Sherff 1937; Strother and Weedon 2006), but recent evidence suggests that the genus is not monophyletic, and the

current circumscription of the genus needs revision (Kim et al. 1999; Kimball and Crawford 2004; Knope et al. 2020b). Keeping these broader taxonomic and phylogenetic uncertainties in mind, it is now apparent that *Bidens* has dispersed into the Pacific islands and radiated into a monophyletic clade of 42 currently recognized species within Polynesia (Knope et al. 2020b), with an additional taxon of enigmatic origin and uncertain taxonomic status on Starbuck Island (*Bidens* sp. “Starbuck Is.”) in the Line Islands (Sayre 2001) and a separate lineage that has given rise to a single species (*B. socorroensis* Moran & G.A. Levin) endemic to Socorro Island near the Pacific coast of mainland Mexico (Knope et al. 2020b). The Polynesian radiation is currently composed of 19 species endemic to the Hawaiian Islands (Ganders and Nagata 1984), 10 species endemic to the Marquesas Islands (Wagner et al. 2014), nine species endemic to the Society Islands (Welsh 1998), two species endemic to the Austral Islands (Funk and Wood 2014), and two species endemic to the Pitcairn Islands (Florence et al. 1995), of which many are threatened or endangered and are of high conservation concern. The entire radiation of Polynesian *Bidens* has occurred within the past ~1.6 Myr and

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appears to be one of the most rapid and explosive plant diversification events in the Pacific (Knobe et al. 2012, 2020b).

The native Hawaiian angiosperm flora is composed of ~1020 currently recognized species, all descended from an estimate of just 259 original natural colonists (Price and Wagner 2018). Some of these Hawaiian lineages are world renowned for their adaptive radiations (e.g., Hawaiian silverswords and lobeliads), resulting in both high endemic species richness and extreme ecomorphological differentiation (e.g., Carr 1987; Baldwin and Sanderson 1998; Givnish et al. 2008). Alongside Hawaiian silverswords and lobeliads, Hawaiian *Bidens* are considered a textbook example of plant adaptive radiation, having radiated into a large number of endemic species with extremely divergent ecomorphs in many distinct habitat types across the island chain (e.g., Helenurm and Ganders 1985; Carr 1987; Knobe et al. 2020a). Native *Bidens* occur on all of the main Hawaiian Islands (Kauai, Oahu, Maui, Lanai, Molokai, Kahoolawe, Hawaii, and there are historical records of occurrence on Niihau) and can be found from sea level to 2200 m elevation (elev) in bogs, woodlands, scrublands, rain forests, cinder deserts, sand dunes, sea cliffs, and lava flows, with many taxa displaying extreme differences in growth form across these habitat types (Ganders and Nagata 1984, 1990). Importantly, the widely disparate ecomorphs grow “true to form” under identical environmental conditions in common-garden experiments (Gillett and Lim 1970; Knobe et al. 2013), demonstrating that the morphological differences among native Hawaiian *Bidens* species are not the result of phenotypic plasticity.

Sherff (1937) originally recognized 43 endemic Hawaiian *Bidens* species and more than 20 varieties and forms largely on the basis of leaf characters, which are now considered to be unreliable taxonomic characters for the group (Gillett and Lim 1970; Ganders and Nagata 1984). Current species delineation, which is based on morphology, ecology, and geographical data, describes 19 species and eight subspecies of endemic Hawaiian *Bidens* (Ganders and Nagata 1984, 1990). Knobe et al. (2012) concurred with this taxonomic assessment, despite the limited genetic differentiation and ability for taxa to hybridize in the field and the greenhouse (Gillett and Lim 1970; Ganders and Nagata 1984; Knobe et al. 2013). Furthermore, even though hybrids and “hybrid swarms” can readily form, 70% of taxa are single-island endemics, 85% are further genetically isolated by habitat segregation, and with the shift to bird pollination syndrome in *B. cosmoides* (with all other taxa being presumably insect pollinated), a full 93% of endemic Hawaiian *Bidens* are genetically isolated from one another (Ganders and Nagata 1984).

Kauai is the oldest among the current high islands (collectively referred to as the “main Hawaiian Islands”). It was formed over the stationary Hawaiian magma hot spot ~4.7 mya before drifting to the northwest with the Pacific tectonic plate to its current location (Price and Clague 2002). Since its origin as a shield volcano, Kauai has undergone massive geological change, including subsidence into the Pacific plate and extreme erosion (Price and Clague 2002). Kauai is also home to Mt. Waialeale (1569 m), which is considered one of the rainiest spots on Earth, with summit rainfall averaging >10,000 mm/yr (or >400 in./yr; Kroll 1995; Ahrens 2009).

Kauai has seven currently recognized native Hawaiian *Bidens* species, three of which are endemic to only Kauai and four are multi-island species (Ganders and Nagata 1990; Lorence et al. 1995; Wood and Kirkpatrick 2014). Two of the multi-island spe-

cies of *Bidens* were discovered on Kauai after the publication of the *Manual of the Flowering Plants of Hawai'i* (Wagner et al. 1990), including the discoveries of *B. hillebrandiana* subsp. *polycephala* (Wood and Kirkpatrick 2014) and *B. campylothea* subsp. *campylothea* (Lorence et al. 1995), indicating that there is still much to learn about *Bidens* on Kauai. In addition, herbarium vouchers of what we are now describing as *B. wailele* were sent to Fred Ganders after he and coauthor Kenneth Nagata contributed their treatment for Hawaiian *Bidens* in the first edition of the Hawaiian flora by Wagner et al. (1990). On review of those specimens, Ganders commented that he believed that the *Bidens* was new to science and suspected the closest relative to be *B. valida*. We concur with Ganders that this new *Bidens* is morphologically most similar to *B. valida*, a Kauai endemic that is found 350–900 m elev along and near the windswept summit ridges and cliffs of Haupu and Kahili, southeastern Kauai (Wagner et al. 1990). We hereby describe and name this new species *Bidens wailele*, present a summary of its distribution and ecology, provide a diagnostic key with distinguishing characters that separate *B. wailele* from all other native Kauai *Bidens*, and provide a provisional Red List assessment utilizing the International Union for Conservation of Nature (IUCN) criteria for endangerment (IUCN 2012).

Material and Methods

All measurements were taken from dried herbarium specimens and field notes and are presented in the descriptions as length × width with units of measurements (mm or cm). We have examined all specimens cited. The extent of occurrence and area of occupancy for *Bidens wailele* were calculated by using ArcMap version 10.2 in relation to coordinates recorded while collecting herbarium specimens or making field observations.

Results

Taxonomic Treatment

Bidens wailele K.R. Wood & Knobe sp. nov. (Figs. 1, 2)

Type. USA, Hawaiian Islands, Kauai, Lihue District, north fork of Wailua River, Blue Hole, lat. 22.062559°N, long. –159.494114°W, 622 m elev, 29 Sep 2021, Wood et al. 18820 (holotype: PTBG-87744!; isotypes: BISH!, NY!, UC!, US!).

Diagnosis. *Bidens wailele* is most similar to *B. valida* but can be differentiated by its suberect, diffuse habit, nodding heads 2–4 cm in diameter, outer involucre bracts linear and 0.5–1 mm wide, ray florets 8–18 mm × 3–5 mm, achenes glabrous, and its habitat preference for saturated sites around waterfalls.

Description. Perennial herb, suffrutescent, suberect, diffuse, 0.5–1 m tall, usually lithophytic on cliffs near waterfalls or occasionally terrestrial on nearby volcanic soils, two to seven branched, stems green to tan brown or red tinged, glabrous. Leaves simple or compound and trifoliate, 5–15 cm long including petiole, leaflets lanceolate, 3–11 cm × 1–3 cm, glabrous, margins serrate, apex attenuate. Inflorescence with peduncles (4–)8–17 cm, glabrous, heads (1–)2–3 in simple to compound cymes, terminating on main stem and lateral branches, 2–4 cm in diameter including ray florets; outer involucre bracts linear, 9–12(–18) mm ×

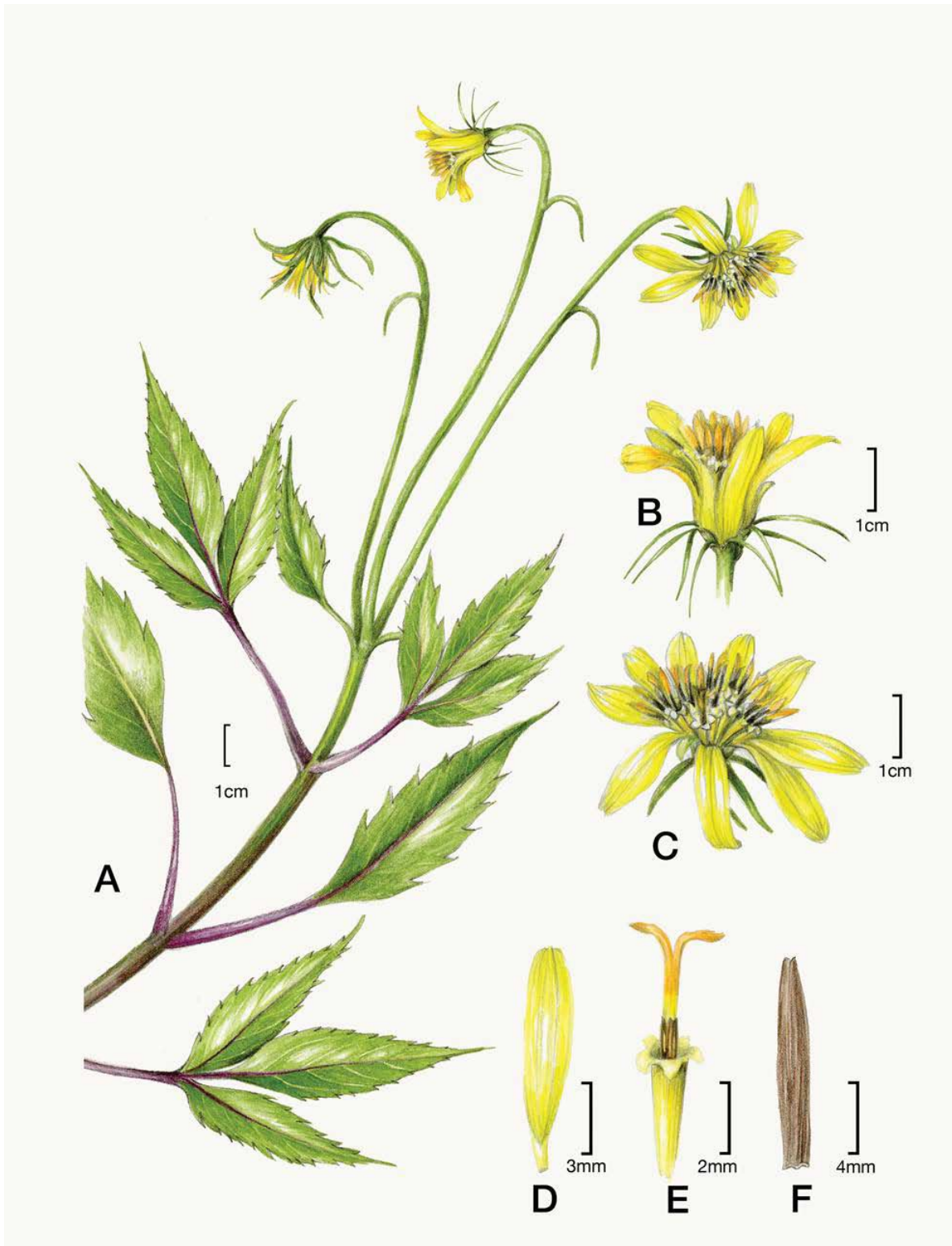


Fig. 1 *Bidens wallele* K.R. Wood & Knope. **A**, Habit. **B**, Head, view from side, highlighting involucre bracts. **C**, Head, view from above, highlighting ray and disk florets. **D**, Ray corolla. **E**, Disk corolla. **F**, Achene. Drawn from Wood et al. 18913 (paratype, PTBG).



Fig. 2 *Bidens waialele* K.R. Wood & Knope, showing suberect, diffuse habit with nodding heads on long peduncles. In situ image of Wood et al. 18820 (holotype, PTBG), Blue Hole, Kauai, Hawaii.

0.5–1 mm, glabrous, inner ones distinct; ray florets usually 8–10 per head, sterile, rays yellow, 8–18 mm × 3–5 mm; disk florets 20–40 per head, perfect, corollas yellow, anther thecae dark, pollen yellow, style branches yellow, exerted 2–4 mm beyond the anthers; pappus absent or rarely with two awns 0.8–1.0 mm long. Achenes black-brown, straight or slightly twisted, wingless, 7.5–12 mm × 0.8–2.2 mm, glabrous, mature achenes not enveloped by subtending chaffy receptacular bracts.

Specimens examined (paratypes). USA. Hawaiian Islands, Kauai, Lihue District, headwaters of the north fork of Wailua River, just below Kawaikini and Waialeale, Blue Hole, 600–700 m elev, 10 Aug 1988, Wood et al. 0099 (BISH, PTBG, US); loc cit, 600–700 m elev, 23 Aug 1990, Lorence et al. 6588 (PTBG); loc cit, 700 m elev, 4 Nov 1991, Wood & Perlman 1351 (PTBG, UBC, US); loc cit, 680–700 m elev, 19 Aug 1992, Lorence et al. 7266 (PTBG, UBC); loc cit, 670–700 m elev, 9 Aug 1999, Perlman et al. 16744 (AD, HAST, NY, PTBG, WU); loc cit, 646 m elev, 12 Aug 2000, Perlman & Nishek 17296 (AD, HAST, MO, NY, PTBG, US); loc cit, 617 m elev, 30 Sept 2014, Perlman & Williams 24159 (BISH, PTBG, US); loc cit, 610 m elev, 21 Feb 2017, Wood et al. 17262 (BISH, PTBG, UC, US); loc cit, 634 m elev, 28 Jan 2021, Wood et al. 18627 (BISH, CAS, NY, PTBG, UC, US); loc cit, 640 m elev, 4 Feb 2022, Wood et al. 18913 (PTBG); Lihue District, Waialeale summit, saturated rim south of rain gauge, 1524 m elev, 31 Dec 2005, Wood & Nishek 11692 (BISH, PTBG, UBC, US); Lihue District, below Kamanu, south of north fork of Wailua River, 732 m elev, 12 Jan 2008, Wood 12776 (PTBG); Hanalei District, Wainiha, back of valley below Hinalale, 700 m elev, 9 Jan 1993, Wood et al. 2237 (PTBG); loc cit, 579–671 m elev, 5 Feb 1998, Wood et al. 7121 (PTBG, UBC, US); loc cit, 686 m elev, 8 Sept 2004, Wood & Menard 10930 (BISH, NY, PTBG, US); loc cit, 670 m elev, 10 Feb 2015, Wood et al. 16304 (BISH, PTBG).

Key to Native Species of *Bidens* on Kauai

1. Styles exerted beyond anthers more than 10 mm; heads nodding; mature achenes enveloped by subtending chaffy receptacular bracts; tubes of disk corollas reddish orange; Kauai *B. cosmoides* (A. Gray) Sherff
1. Styles exerted beyond anthers less than 5 mm; heads erect or nodding; mature achenes not enveloped by subtending chaffy receptacular bracts; tubes of disk corollas yellow (2)
2. Plants either decumbent with fleshy, crenately lobed leaflets on coastal bluffs and sea cliffs; or suberect, diffuse, heads nodding; around interior waterfalls (3)
2. Plants erect, 0.5–4 m tall; leaves and leaflets various but not crenately lobed; heads not nodding; habitat various, not restricted to interior waterfalls (4)
3. (2) Plants decumbent, low and spreading, 0.2–0.3(–0.5) m tall, heads erect; leaves and leaflets fleshy, crenately lobed; on coastal bluffs and sea cliffs; Kauai, Molokai, East Maui *B. hillebrandiana* (Drake) O. Deg. subsp. *polycephala* Nagata & Ganders
3. Plants suberect, diffuse, 0.5–1 m tall, heads nodding; leaves and leaflets not fleshy or crenately lobed; around interior waterfalls; Kauai *B. wailele* K.R. Wood & Knope

4. (2) Inflorescences nearly racemose, heads few (3–)5–20 on widely divergent peduncles (2–)3–19 cm long, borne only on long lateral branches; disk florets 25–45 per head; ray florets (5–)6(–8) per head, 9–17 mm long; Kauai, Oahu, Lanai, Hawaii *B. campylotheca* Sch. Bip. subsp. *campylotheca*
4. Inflorescences compound, rarely simple cymes, heads few to numerous, usually on peduncles 0.1–3(–11) cm long; disk florets either 5–25 per head or ray florets 18–40 mm long (5)
5. (4) Ray florets 8–11 per head, rays 30–40 mm long; peduncles 4–12 cm long; outer involucre bracts (7–)9–13 mm long; achenes straight; Kauai *B. valida* Sherff
5. Ray florets 4–7 per head, rays 8–21 mm long; peduncles 0.1–5 cm long; outer involucre bracts 1.5–5.5 mm long; achenes straight, curved, or coiled (6)
6. (5) Achenes setose all along the margins, straight, not conspicuously long tapered apically, 0.75–1(–1.2) mm wide at widest point, at least 0.5 mm wide just below the apex; Kauai, Oahu *B. sandwicensis* Less
6. Achenes either setose at base only, curved or coiled, or narrow and conspicuously long tapered apically, 0.5–0.8(–1.2) mm wide at widest point, tapering to 0.3–0.5 mm wide just below the apex (9)
7. (6) Inflorescences on lateral branches only; rays 8–13 mm long; stem leaves with (1–)3–7 leaflets; Kauai *B. forbesii* Sherff
7. Inflorescences terminal as well as on lateral branches; rays 15–21(–25) mm long (sometimes shorter on male-sterile plants); stem leaves compound with 5–11(–13) leaflets or bipinnately divided; Niihau, Kauai, Oahu *B. cervicata* Sherff

Discussion

We find few similarities between *Bidens wailele* and other non-Kauai taxa. *Bidens wailele* is most similar to the Kauai endemic species *B. valida*, with both species having similar leaf lengths and simple to compound cymes with relatively long peduncles. However, *B. wailele* can be differentiated from *B. valida* by its suberect, diffuse habit (vs. erect habit of *B. valida*); nodding heads 2–4 cm in diameter (vs. erect heads, (5–)6–7.5 cm); outer involucre bracts linear, 0.5–1 mm wide (vs. outer involucre bracts foliaceous, 2–3(–4) mm wide); ray florets 8–18 mm × 3–5 mm (vs. ray florets 30–40 mm × 10–14 mm); achenes glabrous (vs. achenes moderately setose); and its habitat preference for saturated sites around waterfalls (vs. exposed windswept slopes and ridges). When compared with other Kauai taxa, *B. wailele* can be easily separated from *B. cervicata*, *B. forbesii*, *B. hillebrandiana* var. *polycephala*, and *B. sandwicensis* by its peduncles 8–17 cm long (vs. peduncles less than 5 cm long in all of the aforementioned taxa). *Bidens wailele* can be differentiated from *B. campylotheca* subsp. *campylotheca* by its suberect, diffuse habit 0.5–1 m tall (vs. erect habit 1–4 m tall) and nodding heads of (1–)2–3 (vs. erect heads of 5–20). Last, although *B. wailele* has nodding heads and long peduncles like *B. cosmoides*, it can be easily separated by its significantly smaller heads 2–4 cm wide (vs. 6–8 cm wide on *B. cosmoides*), disk corollas yellow (vs. disk corollas reddish orange), styles exerted beyond anthers 2–4 mm (vs. styles exerted

Kaua`i, Hawaiian Islands

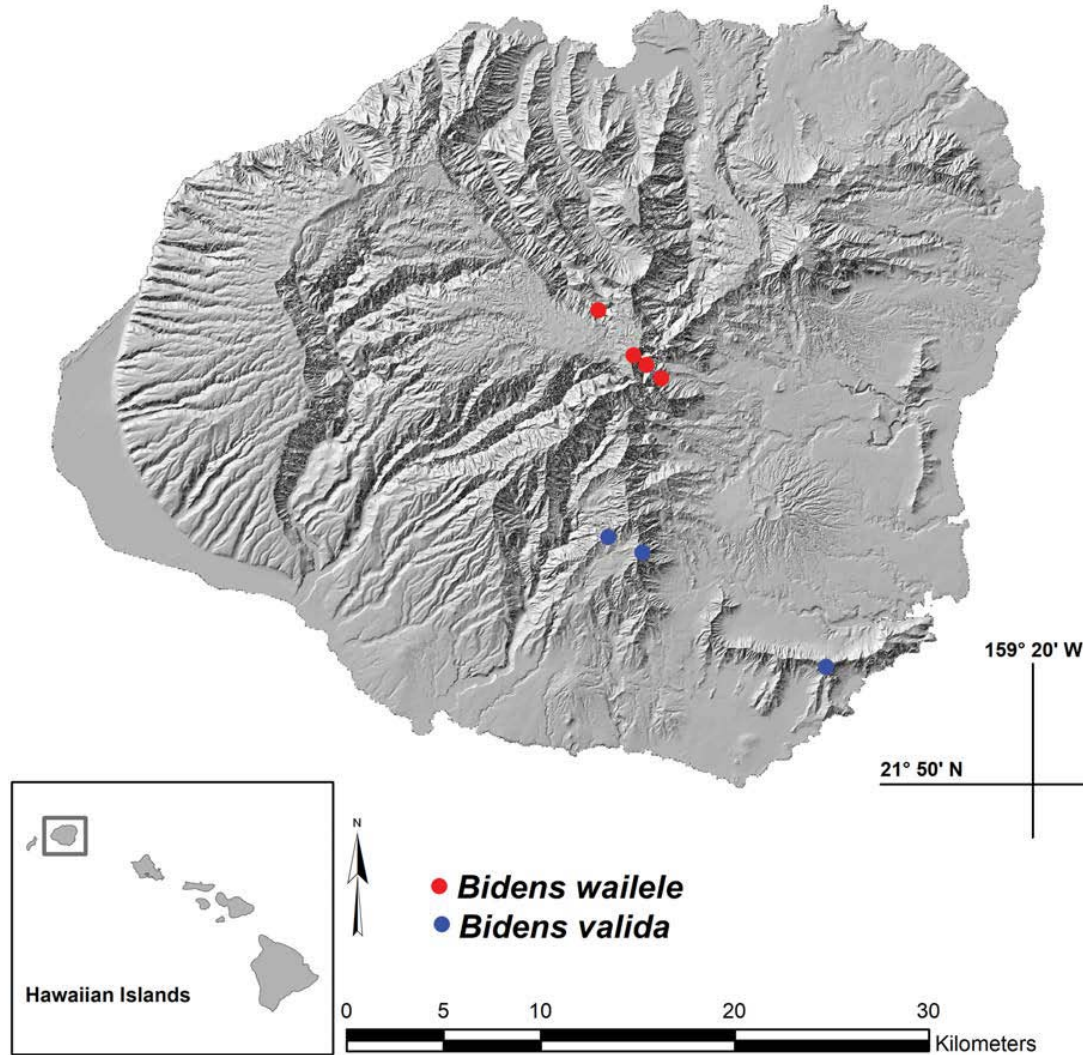


Fig. 3 Distribution of *Bidens wailele* and *Bidens valida* on Kauai, Hawaiian Islands. From left to right, *B. wailele* colonies are Wainiha, Waialeale, Blue Hole, and Kamanu (note that Kamanu colony was destroyed by a landslide ca. 2010). From left to right, *B. valida* colonies are Hulua, Kahili, and Haupu. Location of Kauai is indicated by gray box in lower left inset map.

beyond anthers 10–30 mm), and outer involucre bracts linear 9–12(–18) mm × 0.5–1 mm (vs. outer involucre bracts foliaceous 15–25 mm × 3–7 mm).

Distribution and Ecology

Bidens wailele predominantly occurs on vertical seeping basalt walls around waterfalls and along talus rubble littering their bases. Currently, there are three known subpopulations or colonies, which range between 579 and 1524 m elev (fig. 3). These sites

occur within central Kauai, and we estimate 700–800 naturally occurring plants. One site, called Blue Hole by local botanists, is a deep headwater amphitheater (ca. 600–700 m elev) forming the headwaters of the north fork of the Wailua River, eastern Kauai (fig. 4A). We estimate that this colony consists of ca. 350 plants. Blue Hole is almost completely surrounded by vertical cliffs laced with waterfalls that cascade for ca. 975 m down from the summit peaks of Kawaikini and Waialeale. These summit peaks are renowned for being among the wettest terrestrial sites on Earth. Besides the Blue Hole colony, a collection was made around

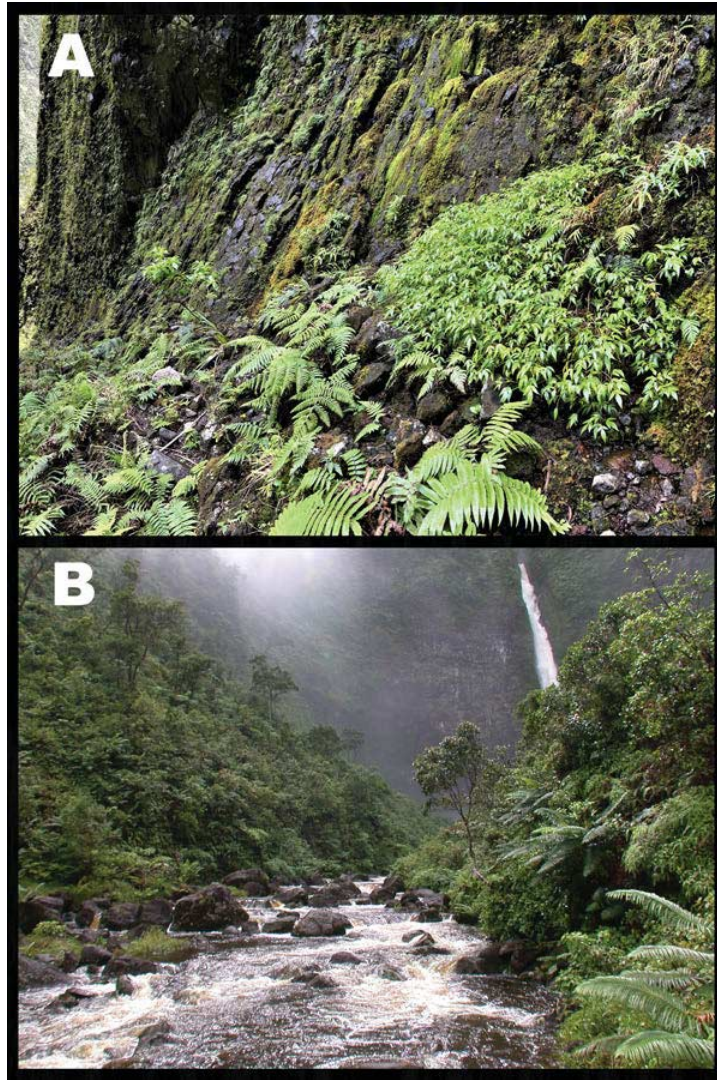


Fig. 4 A, Habitat of *Bidens wailele*, Blue Hole, Kauai, Hawaii. B, Habitat of *B. wailele*, Hinalale Falls, Wainiha River headwaters, Kauai, Hawaii.

the summit peak of Waialeale, directly above Blue Hole at 1524 m elev. We estimated ca. 35 plants there, but we suggest that with further study greater numbers may be observed. The third known location for *B. wailele* is around the perimeter base and surrounding cliffs of Hinalale falls (ca. 579–700 m elev; fig. 4B). Hinalale is a large, thundering waterfall that is fed from the expansive upper Alakai to form the headwaters of the Wainiha River, northern Kauai. We estimate the Wainiha colony to be ca. 350 plants. A fourth historical wet cliff location where the new species once occurred (i.e., Kamanu, just south of Waialeale) was destroyed ca. 2010 by a landslide most likely caused by torrential rains.

The lowland to montane wet cliff plant communities where *B. wailele* flourishes are dominated by native sedges, grasses, ferns, herbs, and shrubs, with occasional small trees surviving along cliff ledges. Genera include sedges and grasses, such as *Carex* L., *Cyperus* L., *Machaerina* Vahl (Cyperaceae), *Isachne* R. Br. (Poaceae),

ferns of *Asplenium* L., *Hymenasplenium* Hayata (Aspleniaceae), *Deparia* Hook. & Grev., *Diplazium* Sw. (Athyriaceae), *Sadleria* Kaulf. (Blachnaceae), *Microlepia* C. Presl (Dennstaedtiaceae), *Hoioakula* S.E. Fawc. & A.R. Sm., and *Menisciopsis* (Holttum) S.E. Fawc. & A.R. Sm. (Thelypteridaceae). Herbs and shrubs include *Cyrtandra* J.R. Forst. & G. Forst. (Gesneriaceae), *Gumnera* L. (Gunneraceae), *Plantago* L. (Plantaginaceae), *Lysimachia* Tourn. ex L. (Primulaceae), and *Kadua* Cham. & Schltld. (Rubiaceae). Also on the cliffs are occasional trees or shrubs of *Dubautia* Gaudich. (Asteraceae), *Cyanea* Gaudich., *Lobelia* Plum. ex L. (Campanulaceae), and *Pipturus* Wedd. (Urticaceae).

Around the talus rubble littering the bases of these wet cliff sites are stunted trees of lowland *Metrosideros* Banks ex Gaertn. (Myrtaceae) and *Cheirodendron* Nutt. ex Seem. (Araliaceae) forest with a rich mix of endemic species in genera such as *Polyscias* J.R. Forst. & G. Forst. (Araliaceae), *Dubautia* Gaudich.

(Asteraceae), *Antidesma* L., *Euphorbia* L. (Euphorbiaceae), *Perrottetia* Kunth (Dipentodontaceae), *Phyllostegia* Benth. (Lamiaceae), *Syzygium* Gaertn. (Myrtaceae), *Freycinetia* Gaudich. (Pandanaeae), *Bohea* Gaudich., *Coprosma* J.R. Forst. & G. Forst., *Kadua* Cham. & Schltdl., *Psychotria* L. (Rubiaceae), *Pipturus* Wedd., *Touchardia* Gaudich., and *Urera* Gaudich. (Urticaceae).

The most serious threats to the habitat of *B. wailele* include landslides, pigs (*Sus scrofa*), rats (*Rattus* spp.), slugs, and specific invasive nonnative plants such as *Ageratum conyzoides* L.; *Conyza bonariensis* L.; *Erigeron karvinskianus* DC. (Asteraceae); *Buddleia asiatica* Lour. (Buddlejaceae); *Sphaeropteris cooperi* (Hook. ex F. Muell.) R.M. Tryon (Cyatheaceae); *Juncus planifolius* R. Br. (Juncaceae); *Miconia crenata* (Vahl.) Michelang. (Melastomataceae); *Psidium cattleianum* Sabine (Myrtaceae); *Andropogon glomeratus* (Walter) Britton, Sterns & Poggenb.; *Axonopus fissifolius* (Raddi) Kuhl.; *Sacciolepis indica* (L.) Chase (Poaceae); *Adiantum raddianum* C. Presl (Pteridaceae); *Rubus rosifolius* Sm. (Rosaceae); and *Hedychium gardnerianum* Ker Gawl. (Zingiberaceae).

Etymology

The specific epithet *wailele* is the Hawaiian word for “water-fall” (Pukui et al. 1974), indicating the inferred habitat preference and where the type collections were made.

Conservation Status

Utilizing the IUCN criteria for endangerment (IUCN 2012), we find that *B. wailele* falls into the critically endangered (CR)

category and faces a very high risk of extinction in the wild. The IUCN alphanumeric summary of our evaluation of criteria and subcriteria is CR B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v), which reflects the species’ severely fragmented subpopulations, along with having both a limited and declining extent of occurrence of ca. 17 km² and area of occupancy of ca. 8 km², declining quality of habitat, number of individuals, and decreasing subpopulations. Conservation collections of *B. wailele* are currently being cultivated in the NTBG Horticultural Center, Kalaheo, Kauai, Hawaii (NTBG accession ID 20220240).

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Literature Cited

- Ahrens CD 2009 Meteorology today: an introduction to weather, climate, and the environment. 9th ed. Brooks/Cole, London.
- Baldwin BG, MJ Sanderson 1998 Age and rate of diversification of the Hawaiian silversword alliance (Compositae). *Proc Natl Acad Sci USA* 95:9402–9406.
- Carr GD 1987 Beggar’s ticks and tarweeds: masters of adaptive radiation. *Trends Ecol Evol* 2:192–195.
- Florence J, S Waldren, AJ Chepstow-Lusty 1995 The Pitcairn Islands: biogeography, ecology and prehistory. *Biol J Linn Soc* 56:79–119.
- Funk VA, A Susanna, TF Stuessy, eds 2009 Systematics, evolution, and biogeography of Compositae. International Association for Plant Taxonomy, Vienna.
- Funk VA, KR Wood 2014 *Bidens meyeri* (Asteraceae, Coreoideae): a new critically endangered species from Rapa, Austral Islands. *Phytokeys* 42:39–47.
- Ganders FR, KM Nagata 1984 The role of hybridization in the evolution of *Bidens* in the Hawaiian Islands. Pages 179–194 in WF Grant, ed. *Plant biosystematics*. Chapman & Hall, New York.
- 1990 *Bidens*. Pages 267–283 in WL Wagner, DR Herbst, SH Sohmer, eds. *Manual of the flowering plants of Hawaii*. University of Hawaii Press/Bishop Museum Press, Honolulu.
- Gillett GW, EKS Lim 1970 An experimental study of the genus *Bidens* (Asteraceae) in the Hawaiian Islands. *Univ Calif Publ Bot* 56:1–63.
- Givnish TJ, KC Millam, AR Mast, TB Patterson, TJ Theim, AL Hipp, JM Henss, JF Smith, KR Wood, KJ Sytsma 2008 Origin, adaptive radiation and diversification of the Hawaiian lobeliads (Asterales: Campanulaceae). *Proc R Soc B* 165:407–416.
- Helenurm K, FR Ganders 1985 Adaptive radiation and genetic differentiation in Hawaiian *Bidens*. *Evolution* 39:753–765.
- IUCN 2012 IUCN Red List categories and criteria: version 3.1. 2nd ed. IUCN, Gland, Switzerland.
- Kim S, DJ Crawford, M Tadesse, M Berbee, FR Ganders, M Pirseyedi, EJ Esselman 1999 ITS sequences and phylogenetic relationships in *Bidens* and *Coreopsis* (Asteraceae). *Syst Bot* 24:480–493.
- Kimball RT, DJ Crawford 2004 Phylogeny of Coreoideae (Asteraceae) using ITS sequences suggest lability in reproductive characters. *Mol Phylogenet Evol* 33:127–139.
- Knope ML, MR Bellinger, EM Datlof, TJ Gallaher, MA Johnson 2020a Insights into the evolutionary history of the Hawaiian *Bidens* (Asteraceae) adaptive radiation revealed through phylogenomics. *J Hered* 111:119–137.
- Knope ML, VA Funk, MA Johnson, WL Wagner, EM Datlof, G Johnson, DJ Crawford, et al 2020b Dispersal and adaptive radiation of *Bidens* (Compositae) across the remote archipelagoes of Polynesia. *J Syst Evol* 58:805–822.
- Knope ML, CW Morden, VA Funk, T Fukami 2012 Area and the rapid radiation of Hawaiian *Bidens* (Asteraceae). *J Biogeogr* 39:1206–1216.
- Knope ML, RJ Pender, DJ Crawford, AM Wicczorek 2013 Invasive congeners are unlikely to hybridize with native Hawaiian *Bidens* (Asteraceae). *Am J Bot* 100:1221–1226.
- Kroll E 1995 *De Wereld van het Weer*. Teleac, Taal, Netherlands.

- Lorence DH, TW Flynn, WL Wagner 1995 Contributions to the flora of Hawai'i. III. New additions, range extensions, and rediscoveries of flowering plants. Bish Mus Occas Pap 41:19–58.
- Mandel JR, RB Dikow, CM Siniscalchi, T Ramhari, LE Watson, VA Funk 2019 A fully resolved backbone phylogeny reveals numerous dispersals and explosive diversifications throughout the history of Asteraceae. Proc Natl Acad Sci USA 116:14083–14088.
- Palazzesi L, J Pellicer, VD Barreda, B Loeuille, JR Mandel, L Pokorny, CM Siniscalchi, MC Telleria, IJ Leitch, O Hidalgo 2022 Asteraceae as a model system for evolutionary studies: from fossils to genomes. Bot J Linn Soc 200:143–164.
- Price JP, DA Clague 2002 How old is the Hawaiian biota? geology and phylogeny suggest recent divergence. Proc R Soc B 269:2429–2435.
- Price JP, WL Wagner 2018 Origins of the Hawaiian flora: phylogenies and biogeography reveal patterns of long-distance dispersal. J Syst Evol 56:600–620.
- Pukui MK, SH Elbert, ET Mookini 1974 Place names of Hawai'i. 2nd ed. University of Hawaii Press, Honolulu.
- Sayre C 2001 A new species of *Bidens* (Asteraceae: Heliantheae) from Starbuck Island provides evidence for a second colonization of Pacific islands by the genus. MS thesis. University of British Columbia, Vancouver.
- Sherff EE 1937 The genus *Bidens*. Field Mus Nat Hist Bot Ser 1:1–709.
- Strother JL, Weedon RR 2006 *Bidens*. Flora N Am 21:205–218.
- Wagner WL, JR Clark, DH Lorence 2014 Revision of endemic Marquesas Islands *Bidens* (Asteraceae, Coreopsidae). PhytoKeys 38:37–67.
- Wagner WL, DR Herbst, SH Sohmer 1990 Manual of the flowering plants of Hawai'i. University Hawaii Press/Bishop Museum Press, Honolulu.
- Welsh SL 1998 Flora societensis: a summary revision of the flowering plants of the Society Islands. EPS, Orem, UT. 420 pp.
- Wood KR, MD Kirkpatrick 2014 Rediscovery of *Melicope quadrangularis* (Rutaceae) and other notable plant records for the island of Kaua'i, Hawai'i. Bish Mus Occas Pap 115:29–32.