

# *Labordia lorenciana* (Loganiaceae): A New Critically Endangered Species from Kaua'i, Hawaiian Islands with Comments on its Conservation

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**ABSTRACT.** *Labordia lorenciana* is described and illustrated from Kaua'i, Hawai'i, U.S.A. This new species most closely resembles the O'ahu endemic species *Labordia kaalae* C. N. Forbes, from which it differs in having leaf bases deeply cordate to auriculate, adaxial leaf surfaces puberulent, and fruit valves 25–37 mm long, and longitudinally striate. Known from only four individuals, *Labordia lorenciana* is amongst ca. 120 other rare Hawaiian taxa that are limited to less than 50 individuals and is currently being cultivated for conservation.

**KEYWORDS:** conservation, Hawai'i, IUCN red list categories, Kaua'i, *Labordia*, Loganiaceae.

*Labordia* Gaudich (Loganiaceae: Gentianales) is one of 31 currently recognized endemic Hawaiian vascular plant genera restricted to the archipelago. Although Conn (1980) regarded *Labordia* as a sub-genus of the pacific genus *Geniostoma* J. R. Forster & G. Forster, morphological and cytological differences indicate that they are best treated as separate genera (Gray 1859; Motley and Carr 1998; Wagner et al. 1999). Morphologically, *Labordia* differs from *Geniostoma* primarily in having terminal inflorescences, larger flowers and capsules, and corolla tubes much longer than the lobes (Conn 1980). Wagner et al. (1999) note that in *Labordia* capsules are 2–3(4)-valved, whereas in *Geniostoma* they are strictly 2-valved. Carr (1978), in his paper on the significance of cytology in selected taxa, notes a ploidy difference between the two groups.

*Labordia* comprises 16 species and three varieties (Motley 1995; Wagner et al. 1999), with 11 species and two varieties being single island endemics and the remaining five species and one variety occurring on several islands. Three species and two varieties are currently listed as Federally Endangered (USFWS 2003). Recent field research within the northwestern canyon region of Kaua'i (i.e., Kawai'iki Valley) has documented another new species that is quite rare and in need of protection.

## TAXONOMIC TREATMENT

***Labordia lorenciana*** K. R. Wood, W. L. Wagner & T. Motley, sp. nov. —TYPE: U. S. A. Hawaiian Islands, Kaua'i: Waimea District, Na Pali-Kona Forest Reserve, upper Kawai'iki, Mohihi-Waialae Trail to Kaluahaulu Ridge and below wind-swept rim into north facing drainage,

3480 ft. [1060 m], 22°05'07.4" N, 159°36'38.6" W, 13 Nov 1998, Wood 7592 (Holotype: PTBG; Isotypes: AD, BISH, F, K, MO, NY, US). Fig. 1.

Differt a *L. kaalae* foliorum basibus profunde cordatis ad auriculata; fructuum valves 25–37 mm longis et longitudiniter striates.

Small trees, 3–4 m tall; trunk 3–7 cm diameter at base, bark grayish brown mottled white or dark brown; stems terete, lateral branches dichotomously branched, younger stems densely tomentose, older stems glabrate. Leaves opposite, pinnately nerved, upper surface medium green, lower surface pale green; blade (5.5–)7.5–12(–16) × (1.8–)3–5.5(–7) cm, chartaceous, membranous, elliptic-ovate, the juvenile leaves elliptic-lanceolate, young leaves densely tomentose, at maturity upper surface hirsute to puberulent, lower surface densely tomentose, margins entire, apex acuminate and slightly falcate, base deeply cordate to auriculate, petioles (1.3–)1.9–3.7 cm long; stipules interpetiolar, hirsute to tomentose, completely connate, forming a truncate sheath 1.5–2 mm long, usually splitting with age, adnate to the petiole at base. Flowers functionally unisexual, plants dioecious, inflorescence open corymbiform cyme, flowers 3–11 in pistillate individuals and 15–34 in staminate plants, peduncles puberulent, weakly recurved, 20–42 mm long, elongating to 60 mm in fruit, pedicels puberulent, 13–32 mm long, elongating to 40 mm in fruit, bracts and bracteoles linear subulate, 1.4–2.4 mm long, 0.4 mm wide; calyx lobes 5–6, connate near base, imbricate, ovate-deltate, puberulent, apex acuminate, 2.0–2.7 mm long, 0.9–1.3 mm wide, 5 to 7 nerved, margin hyaline; corolla narrowly urceolate, 5–6 lobed,

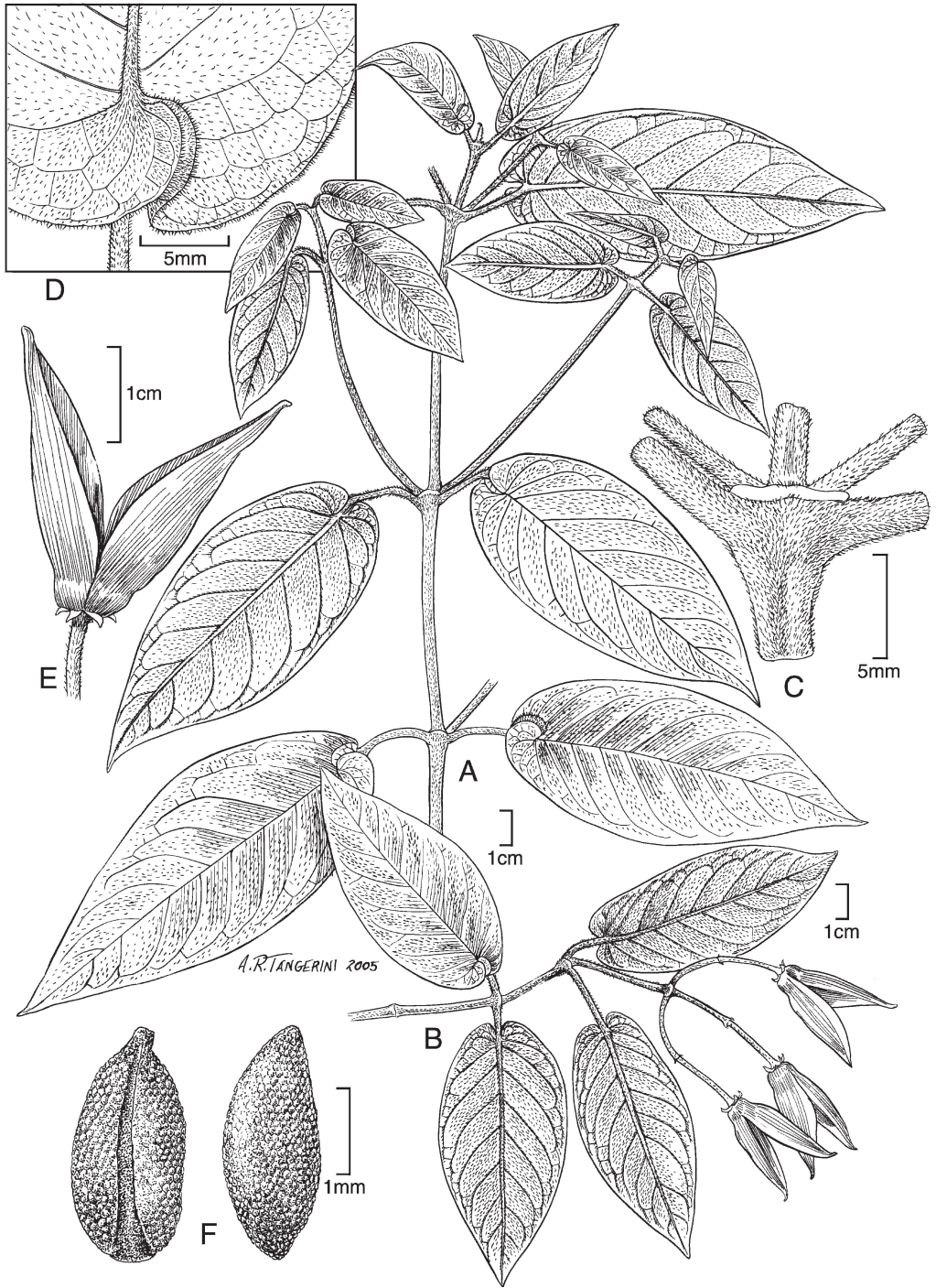


FIG. 1. A–F. *Labordia lorenciana*. A–D. Drawn from holotype, Wood 7592, PTBG). A. Vegetative branch. B. Fruiting branch. C. Internode showing stipule. D. Leaf base, abaxial surface. E–F. Drawn from Wood 9118, PTBG. E. Dehiscent capsule. F. Seeds.

green, fleshy, puberulent; staminate flowers 11.5–15 mm long, the tube 10–13 mm long, 1.1–1.8 mm wide, pilose within, the lobes reflexed at anthesis, deltate-ovate, 1.4–1.7 mm long, apex acuminate to acute; anthers 5–6, adnate to corolla tube, dorsi-

fixed, slightly exerted; reduced female ovary of male flower hirtellous; pistillate flowers not seen. Capsules green, brown at maturity, lanceoloid to ovoid, 25–37 mm long, 2-valved, valves longitudinally striate, not keeled, apex with beak, 3.5 mm

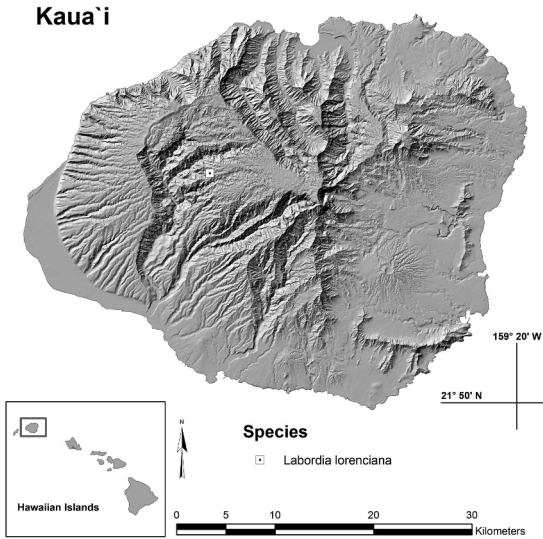


FIG. 2. Single location for *Labordia lorenciana* in Kawai'iki, Kaua'i, Hawai'i.

long. Seeds ellipsoid to ovoid-ellipsoid, unsulcate, 2.0–3.0 mm long, 1.2–1.5 mm wide.

**Paratypes.** U.S.A. Hawaiian Islands, Kaua'i: Waimea District, Na Pali-Kona Forest Reserve, upper Kawai'iki, Mohihi-Waialae Trail to Kaluahaulu Ridge and below wind-swept rim into north facing drainage, 3480 ft. (1060 m) 22°05'07.4" N, 159°36'38.6" W, Wood 7603 (BISH, PTBG, US), Wood et al. 8872 (BISH, PTBG), Wood et al. 8873 (PTBG), Wood et al. 8875 (BISH, PTBG, US), Wood & Perlman 9005 (PTBG), Wood & Perlman 9006 (PTBG), Wood & Perlman 9007 (BISH, PTBG), Wood & Perlman 9061 (BISH, PTBG), Wood 9118 (BISH, PTBG, US).

**Etymology.** We are pleased to name this new species for David H. Lorence, Director of Science at the National Tropical Botanical Garden, who has made many valuable contributions to Pacific botany and to the study of the large tropical family, Rubiaceae.

**Distribution.** *Labordia lorenciana* is known from upper Kawai'iki Valley which lies between the remote central canyon ventricles of Koai'e and Wai'alae, and within the Na Pali-Kona Forest Reserve of northwestern Kaua'i. Only a single population of four individuals is known at 1160 m elevation.

**Phenology.** Flowering March to June; fruiting October to November.

**Conservation Status.** IUCN Red List Category: **Critically Endangered.**

When evaluated using the IUCN criteria for endangerment (IUCN 2001, see also www.iucnredlist.org/info/categories\_criteria2001), *Labordia lorenciana* falls into the Critically Endangered (CR) category, which designates species facing the highest risk of extinction. *Labordia lorenciana* meets the IUCN criteria in having a range of less than 100 km<sup>2</sup>, an area of occupancy of less than 10 km<sup>2</sup>, is known from a single location with a continuing decline inferred for the number of mature individuals, a continuing decline in the quality of habitat, and a population size less than 50 mature individuals. Our formal evaluation can be summarized by the following IUCN hierarchical alphanumeric numbering system of criteria and subcriteria: (CR B1ab(v) + 2ab(iii,v); D).

**Systematic Affinities.** *Labordia lorenciana* falls into the section *Darbolia* (Baill.) Sherff with branches terete, rarely angled, leaves widely spaced, flowers in open, paniculate, pedunculate cymes and corolla narrowly urceolate, pale green to greenish yellow, sometimes white, the lobes deltate-ovate, and apex acute to acuminate (Wagner et al. 1999). Preliminary phylogenetic studies (Motley 2005) using nrDNA internal transcribed spacer (ITS) sequence data have also placed *L. lorenciana* as a strongly supported member of section *Darbolia*. Resolution among the taxa of the *Darbolia* clade is poor; however, *L. lorenciana* sequences tend to share more similarity to the sequences of the other Kaua'i endemics. Morphologically, *L. lorenciana* resembles the O'ahu, Wai'anae Mountain, endemic species *L. kaalae* C. Forbes in having leaves densely soft pubescent with bases auriculate and the Kaua'i endemic species *L. helleri* Sherff in having longitudinally striate fruit walls. However, *L. kaalae* lacks pubescence on the adaxial leaf surface and has smaller capsules with transversely wrinkled fruit walls. Additionally *L. lorenciana* has more narrow elliptic-ovate to elliptic-lanceolate leaves rather than broadly elliptic leaves. *L. helleri* differs from *L. lorenciana* in having glabrous leaves with cuneate bases and smaller capsules.

KEY TO SECTION *DARBOLIA* (*LABORDIA*; LOGANIACEAE)

1. Leaves glabrous ..... 2
2. Capsule valves transversely wrinkled, corolla lobes 1.5–2.5 (–4) mm long ..... 3
2. Capsule valves longitudinally striate, corolla lobes 2–3.5 mm long, (Kaua'i) ..... *L. helleri*
3. Leaf base cordate, petioles 1–3 mm long; peduncles 40–50 mm long, elongating to 70–80 mm in fruit; plants often scandent in habit, (SE Moloka'i) ..... *L. triflora*
3. Leaf base cuneate, petioles 6–22(–40) mm long; peduncles 9–22 mm long, elongating to 13–25(–35) mm in fruit; plants treelike in habit, (All major islands) ..... *L. tinifolia*

1. Leaves hispid, hirsute, puberulent, or tomentose at least on lower surface ..... 4
4. Capsule valves transversely wrinkled, 12–20 mm long; corolla urceolate and enlarged near base; leaves broadly elliptic or oblong-elliptic to elliptic-ovate, base weakly cordate to obliquely truncate, lower surface hispid, (Wai'anae Mts., O'ahu) ..... *L. kaalae*
4. Capsule valves longitudinally striate, 25–37 mm long; corolla narrowly urceolate; leaves elliptic-ovate to elliptic-lanceolate, base strongly auriculate, upper surface hirsute to puberulent and lower densely tomentose, (Kaua'i) ..... *L. lorenciana*

**Habitat.** *Labordia lorenciana* occurs on a 330° north-facing slope in association with montane mixed mesic forest and is restricted to the lower drainage banks. The slope is moderate (ca. 20°) with a substrate composed of brown granular soil with basalt talus and abundant leaf litter. The dominant canopy trees of this region are *Acacia koa* A. Gray and *Metrosideros polymorpha* Gaudich. The mesic forest subcanopy trees include *Perrottetia sandwicensis* A. Gray, *Claoxylon sandwicense* Mull. Arg, *Psychotria mariniana* (Cham. & Schlechtend.) Fosb., *Scaevola procer* Hillebr., *Pipturus kauaiensis* A. Heller, *Chamaesyce atrococca* (A. Heller) Croizat & Degener, *Melicope arisata* (H. Mann) T. Hartley & B. Stone, *Melicope barbiger* A. Gray, *Melicope feddei* (H. Lév.) T. Hartley & B. Stone, *Antidesma platyphyllum* H. Mann var. *hillebrandii* Pax & K. Hoffm., *Pittosporum glabrum* Hook. & Arn., *Bobea brevipes* A. Gray, *Xylosma hawaiiense* Seem., and *Cryptocarya mannii* Hillebr. The understory contains a few shrubs including *Rubus hawaiiensis* A. Gray, *Schiedea stellarioides* H. Mann, and the recently re-discovered *Phyllostegia waimeae* Wawra. Some terrestrial sedges, grasses and ferns include *Carex meyenii* Nees, *Poa sandwicensis* (Reichardt) Hitchc., *Panicum nephelophilum* Gaudich., *Dryopteris wallichiana* (Spreng.) Hyl., *Asplenium polyodon* Forst., and *Pteridium decompositum* (Gaudich.) W. H. Wagner. The lead author has spent several decades exploring the interior regions of Kaua'i, yet no other individuals of *L. lorenciana* have been located. Still, there are a few regions that may potentially have additional trees of this taxon, especially to the east of the type locality and above the canyon of Koai'e where similar rich montane mesic forests occur.

#### DISCUSSION

Having biologically rich ecosystems rapidly assessed, disseminating floristic data, and creating conservation collections of the world's endangered flora is considered by the authors to be extremely important at this point in time. This process of discovering, describing, and conserving the diversity of our island ecosystems becomes ever so much more important as we witness the disappearance of this biodiversity in many tropical areas. Other authors concur that the description and mapping of the world's biota is directly linked

to human welfare, and point out that the very tips of our phylogenetic branches are disappearing (Wilson 2000; Landrum 2001).

We estimate the likelihood of extinction for *Labordia lorenciana* to be considerable over the next ten years or so without the utilization of conservation techniques. There is no in situ seedling recruitment, which is a direct line to extinction over time. In addition, several other factors that are threatening many of Hawaii's rare taxa have put *Labordia lorenciana* into the critically endangered category. These threats include habitat degradation and destruction by feral goats (*Capra hircus* L.) and pigs (*Sus scrofa* L.); predation of seeds by rats (*Rattus rattus* L. and *R. exulans* Peale); catastrophic extinction through environmental events (e.g., land slides, flash floods, fallen limbs that crush understory species, and fire); competition with non-native plant taxa such as *Rubus argutus* Link, *Passiflora tarminiana* Coppens & Barney, *Psidium cattleianum* Sabine, and *Lantana camara* L., all of which possess the ability to spread rapidly and cover effectively large areas in the forest understory (Smith 1985); and reduced reproductive vigor as the result of limited numbers of existing individuals.

The recent rediscovery and subsequent habitat degradation of a rare Kaua'i mint, *Phyllostegia waimeae* Wawra, in the same vicinity exemplifies the serious threat that non-native animals have when set loose within the biologically diverse forests of Hawaii. *Phyllostegia waimeae* was rediscovered in August 2000 within a few hundred meters of *Labordia lorenciana*. On return to the site to collect propagation material of *P. waimeae* for conservation, it was found that four of the six known *P. waimeae* individuals were uprooted by pig disturbance leaving only two individuals in the population. The National Tropical Botanical Garden (NTBG) Kaua'i, Hawai'i, has since been able to grow this mint ex situ, yet when numbers of in situ individuals representing a rare taxon fall below the threshold for minimal viable populations, each and every plant and population colony is of profound genetic importance for the survival of the species (CPC 1991; Neel and Cummings 2003).

The fact that the Hawaiian flora has the highest level of dioecy worldwide at 14.7 % (Sakai et al. 1995) adds another level of danger to many

fragmented populations of rare species in the Hawaiian Islands, whereby sexual exchange becomes minimized. Species of *Labordia* are crypto-dioecious (Motley and Carr 1998). The flowers appear perfect, but only one sexual whorl is functional making them unisexual. Pistillate flowers contain ovules and no pollen grains in the anthers, the latter small and necrotic, and staminate flowers contain pollen grains and lack ovules in the ovary.

All four trees of *Labordia lorenciana* have been tagged for accuracy of provenance and their sex was determined by examining reproductive characters. Tree #1 is staminate, 3 m tall, with upright stems 5 cm diameter at base with two basal stems and four upper branches of 1 m length (Wood *et al.* 8872; Wood & Perlman 9006); tree #2 is presumed pistillate and has produced viable seed, 4 m tall leaning over gulch bottom with five diffuse branches of 1 m, 7 cm diameter at base (Wood 7592; Wood *et al.* 8873; Wood & Perlman 9007; 9061; Wood 9118); tree #3 of uncertain sex, 3.5 m tall, two stems at base, with the larger branch dead (no voucher); tree #4 is staminate, 3.5 m tall, two basal stems, one of 5 cm and the other of 3 cm (Wood *et al.* 8875; Wood & Perlman 9005).

Recently, propagules have been cultivated at the NTBG Lawa'i, Kaua'i Garden including seedlings from the pistillate tree #2 (NTBG Accession # 050606), in addition to rooted cuttings from tree # 1 (#060258), tree # 3 (#060259), and tree # 4 (#060260). It should be noted that the majority of the nine paratype collections were fragments of material left over from tip cuttings collected for propagation trials of this species. In addition, leaf material was sent to the University of Hawaii at Manoa for the Hawaiian Plant DNA Library (Morden *et al.* 1996).

Preventing the extinction of *Labordia lorenciana* will most likely depend on the success of *ex situ* conservation and the ability to raise an interest in protecting the holotype area. The Kawai'iiki region is floristically rich and composed of some 199 taxa of vascular plants from 78 families. Of these, 135 are endemic, 31 indigenous, with 33 representing non-native naturalized species. Forty-seven are Kaua'i single island endemic species, more than half of which represent 18 endemic Hawaiian genera (Wood Unpubl. data). The exclusion of non-native animals from the type locality would be of great benefit to the native flora and fauna of

Kawai'iiki, including conservation for *Labordia lorenciana*.

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#### LITERATURE CITED

- CARR, G. D. 1978. Chromosome numbers of Hawaiian flowering plants and the significance of cytology in selected taxa. *American Journal of Botany* 65: 236–242.
- CENTER FOR PLANT CONSERVATION. 1991. Genetic sampling guidelines for conservation collections of endangered plants. Pp. 225–238 in D. A. Falk and K. E. Holsinger, editors. *Genetics and conservation of rare plants*. New York: Oxford University Press.
- CONN, G. J. 1980. A taxonomic revision of *Geniostoma* subg. *Geniostoma* (Loganiaceae). *Blumea* 26: 245–364.
- IUCN. 2001. *IUCN Red List Categories and Criteria* Version 3.1. Prepared by the IUCN Criteria Review Working Group. Cambridge: International Union for Conservation of Nature and Natural Resources.
- LANDRUM, L. R. 2001. What has happened to descriptive systematics? what would make it thrive? *Systematic Botany* 26: 438–442.
- MORDEN, C. W., V. C. CARAWAY, and T. J. MOTLEY. 1996. Development of a DNA library for native Hawaiian plants. *Pacific Science* 50: 324–335.
- MOTLEY, T. J. 1995. Rediscovery of *Labordia triflora* (Loganiaceae). *Pacific Science* 49: 221–226.
- . 2005. Biogeography and Phylogenetic Relationships of the Pacific Genera *Labordia* and *Geniostoma* (Loganiaceae). Abstracts of Annual Meeting, Austin, Texas, Botany 2005: Abstract 234, <http://www.2005.botanyconference.org/engine/search/index.php?func=detail&aid=234>
- and G. D. CARR. 1998. Artificial hybridization in the Hawaiian endemic genus *Labordia* (Loganiaceae). *American Journal of Botany* 85: 654–660.
- NEEL, M. C. and M. P. CUMMINGS. 2003. Effectiveness of conservation targets in capturing genetic diversity. *Conservation Biology* 17: 219–229.
- SAKAI, A. K., WAGNER, W. L., FERGUSON, D. M., and D. R. HERBST. 1995. Origins of dioecy in the Hawaiian flora. *Ecology* 76: 2517–2529.
- SMITH, C. W. 1985. Impact of alien plants on Hawai'i's native biota. Pp. 180–250 in *Hawai'i's Terrestrial Ecosystems: Preservation and Management*, eds. C. P. Stone and J. M. Scott. Manoa: Cooperative National Park Resources Studies Unit, University of Hawaii.
- USFWS. 2003. *Hawaiian Islands plants: listed and candidate species, as designated under the U.S. Endangered Species Act (Updated 2003)*. Honolulu: United States Fish and Wildlife Service.
- WAGNER, W. L., HERBST, D. R., and S. H. SOHMER. 1999. *Manual of the flowering plants of Hawai'i, revised edition* (Bishop Museum Special Publication 97). Honolulu: University of Hawaii Press.
- WILSON, E. O. 2000. On the future of conservation biology. *Conservation Biology* 14: 1–3.